COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 1111 East Main Street, Suite 1400, Richmond, VA 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
www.deq.virginia.gov

Matthew J. Strickler
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

HAZARDOUS WASTE MANAGEMENT PERMIT
FOR OPEN BURNING (OB) TREATMENT

Permittee: National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility

Wallops Island, VA 23337-5099
EPA I.D. No. VA7800020888

Pursuant to Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended; and regulations promulgated thereunder by the Virginia Department of Environmental Quality, a Hazardous Waste Management Permit is issued to the National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility (hereinafter referred to as the Permittee), for the open burning treatment of hazardous waste. The facility being permitted is located on Wallops Island, Virginia in Accomack County, and with a geographic location of latitude 37º 56" 33" North and longitude 75º 75' 56" West.

The Permittee shall comply with all terms and conditions set forth in this Permit including all Permit Attachments A through H. If the Permit and the Permit Attachments conflict, the wording of the Permit shall prevail. The Permittee shall also comply with all applicable regulations contained in the Virginia Hazardous Waste Management Regulations (VHWMR) as codified in Title 9 of the Virginia Administrative Code, Agency 20, Chapter 60 (9 VAC 20-60), and the *Resource Conservation and Recovery Act (RCRA)* Regulations under 40 CFR Parts 124, 260, 261, 262, 264, 265, 268, and 270 as adopted by reference in the VHWMR. (For convenience, wherever the RCRA regulations that are adopted by reference are cited in this Permit and the Permit Attachments, the regulatory citations will be only those from 40 CFR).

The Commonwealth of Virginia has received authorization for is hazardous waste management program under Section 3006(b) of RCRA, 42 U.S.C. § 6926(b), to administer and enforce the RCRA under the VHWMR in lieu of the federal hazardous waste management program. Applicable regulations are those under the VHWMR (9 VAC 20-60) and the RCRA which are in effect on the date of final administrative action on this Permit and as well as any self-implementing statutory provisions and related regulations which are automatically

applicable to the Permittee's hazardous waste management activities, notwithstanding the conditions of this Permit.

This Permit is based on the administrative record and the assumption that the information submitted by the Permittee and contained in the administrative record is complete and accurate. The Permittee's failure in the application, or during the permit issuance process, to fully disclose all relevant facts, or the Permittee's misrepresentation of any relevant facts at any time, shall be grounds for the modification or termination of this Permit pursuant to 40 CFR § 124.5, § 270.41, §270.42, and §270.43, and shall also be grounds for initiation of an enforcement action. The Permittee shall inform the Department of any deviations from Permit Conditions or changes in the information provided in the application. In particular, the Permittee shall inform the Department of any proposed changes that might affect the ability of the Permittee to comply with applicable regulations and/or Permit Conditions, or which alter any of the conditions of the Permit in any way.

This Permit is effective as of April 13, 2018, and shall remain in effect until April 13, 2028 unless revoked and reissued in accordance with 40 CFR §124.5 and § 270.41, terminated in accordance with40 CFR §270.43, or continued in accordance with 9 VAC 20-60-270.B.15.

Leslie A. Romanchik

April 13, 2018

Date Signed

Leslie A. Romanchik
Hazardous Waste Program Manager
Office of Financial Responsibility and Waste Programs

FINAL PERMIT FOR OPEN BURNING (OB) TREATMENT OF HAZARDOUS WASTE

National Aeronautics and Space Administration
Goddard Space Flight Center

Wallops Flight Facility
Wallops Island, VA 23337-5099

EPA I.D. No. VA7800020888

TABLE OF CONTENTS

MODULE I - STANDARD CONDITIONS I-1

I.A. EFFECT OF PERMIT I-1
I.B. PERMIT ACTIONS I-1
I.C. SEVERABILITY I-1
I.D. DUTIES AND REQUIREMENTS I-2
I.E. MONITORING AND RECORDS I-5
I.F. COMPLIANCE NOT CONSTITUTING DEFENSE I-6
I.G. TRANSFER OF PERMITS I-6
I.H. PERMIT EXPIRATION AND CONTINUATION I-6
I.I. REPORTS, NOTIFICATIONS, AND SUBMISSIONS TO THE DEPARTMENT I-7
I.J. SIGNATORY REQUIREMENTS I-8
I.K. DOCUMENTS TO BE MAINTAINED AT THE FACILITY SITE I-8
I.L. APPROVAL/DISAPPROVAL OF SUBMISSIONS I-8

MODULE II - GENERAL FACILITY CONDITIONS II-1

II.A WASTE ANALYSIS II-1
II.B SECURITY II-1
II.C GENERAL INSPECTION REQUIREMENTS II-1
II.D PERSONNEL TRAINING II-1
II.E GENERAL REQUIREMENTS FOR IGNITABLE AND REACTIVE WASTE II-1
II.F PREPAREDNESS AND PREVENTION II-2
II.G CONTINGENCY PLAN II-2
II.H RECORD KEEPING AND REPORTING II-3
II.I CLOSURE II-6

ATTACHMENT II.A - FACILITY DESCRIPTION II.A-1

ATTACHMENT II.B -WASTE ANALYSIS PLAN II.B-1

EXHIBIT II.B-1 : WASTE ANALYSIS PLAN II.B-1

ATTACHMENT II.C - INSPECTION SCHEDULE II.C-1

EXHIBIT II.C-1 : WORK INSTRUCTIONS II.C-3

EXHIBIT II.C-2 : SOIL MONITORING PLAN II.C-1

ATTACHMENT II.D -SECURITY PROVISION AND PROCEDURES TO PREVENT HAZARDS II.D-1

ATTACHMENT II.E - PERSONNEL TRAINING II.E-1

EXHIBIT II.E-1 : TRAINING AND CERTIFICATION PROCEDURES FOR ORDINANCE HANDLERS II.E-1

EXHIBIT II.E-2 : BASIC EXPLOSIVE SAFETY TRAINING II.E-1

ATTACHMENT II.F - HAZARDOUS WASTE CONTINGENCY PLAN II.F-1

EXHIBIT II.F-1 - CONTINGENCY PLAN II.F-1

ATTACHMENT II.G - CLOSURE PLAN II.G-1

EXHIBIT II.G-1 - CLOSURE AND POST CLOSURE PLAN II.G-1

ATTACHMENT II.H -PLANS AND SPECIFICATIONS FOR OPEN BURN UNITS II.H-1

EXHIBIT II.H-1 - PLANS AND SPECIFICATIONS FOR OPEN BURN UNITS II.H-1

MODULE III - OPERATING CONDITIONS III-1

III.A GENERAL DESCRIPTION OF OPEN BURNING (OB) III-1

III.B STANDARD OPERATING PROCEDURES III-1

III.C ROCKET MOTORS AND IGNITERS III-2

III.D PROPELLANT TREATMENT RATE III-3

III.E WASTE GENERATED OFFSITE III-3

III.F CONTROL OF EJECTED WASTE DURING BURNING III-3

III.G DETERIORATION OR MALFUNCTION PROCEDURES III-4

III.H PREVENTION OF ACCUMULATED PRECIPITATION III-4

III.I RESIDUE AND SOIL MANAGEMENT III-5

III.J FIRE HAZARD MINIMIZATION III-5

III.K MINIMUM PROTECTIVE DISTANCES III-6

III.L REQUIREMENTS FOR IGNITABLE, REACTIVE, OR INCOMPATIBLE WASTES III-6

III.M WASTE MINIMIZATION PLAN III-6

III.N OPEN BURNING OF PEP-CONTAMINATED SOLVENTS..... III-6

MODULE IV - SITE-WIDE CORRECTIVE ACTION IV-1

IV.A MODULE HIGHLIGHTS - BACKGROUND..... IV-1

IV.B CORRECTIVE ACTION UNITS..... IV-2

IV.C PRESENT AND HISTORICAL RELEASES..... IV-5

EXHIBIT IV.A-1 : ADMINISTRATIVE AGREEMENT ON CONSENT IV.A-1

EXHIBIT IV.A-2 : TOPGRAPHIC MAP OF CORRECTIVE ACTION UNIT.....IV.A-58

MODULE V - DETECTION MONITORING..... V-1

V.A. HIGHLIGHTS – BACKGROUND..... V-1

MODULE VI - GROUNDWATER COMPLIANCE MONITORING.....VI-1

VI.A. MODULE HIGHLIGHTS – BACKGROUND..... VI-1

VI.B. COMPLIANCE MONITORING REQUIREMENTS..... VI-1

VI.C. WELL LOCATION, INSTALLATION, AND CONSTRUCTION..... VI-2

VI.D. GROUND WATER PROTECTION STANDARD..... VI-3

VI.E. SAMPLING AND ANALYSIS PROCEDURES..... VI-4

VI.F. ELEVATION OF THE GROUND WATER SURFACE..... VI-4

VI.G. STATISTICAL PROCEDURES..... VI-5

VI.H. MONITORING PROGRAM AND DATA EVALUATION..... VI-5

VI.I. COMPARISON TO GROUNDWATER PROTECTION STANDARDS..... VI-7

VI.J. REPORTING AND RECORDKEEPING..... VI-8

VI.K. ASSURANCE OF COMPLIANCE..... VI-9

VI.L. SPECIAL REQUIREMENTS IF SIGNIFICANT INCREASES OCCUR IN VALUES FOR PARAMETERS OR CONSTITUENTS..... VI-9

VI.M. REQUESTS FOR PERMIT MODIFICATION..... VI-9

ATTACHMENT VI.A - GROUNDWATER MONITORING PROGRAM: SAMPLING AND ANALYSIS PLAN.....VI.A-1

ATTACHMENT VI.B - COMPLIANCE GROUND WATER MONITORING LIST. VI.B-1

ATTACHMENT VI.C - GROUNDWATER PROTECTION STANDARDS VI.C-1

ATTACHMENT VI.D - GROUNDWATER MONITORING CONSTITUENTS.....VI.D-1

NOTE REGARDING ATTACHMENTS:
The above Attachments are incorporated, in their entirety, by reference into this Permit. These incorporated attachments are enforceable conditions of this Permit. The VDEQ has, as deemed necessary, modified specific language from the permit application. Additional modifications are prescribed in the Permit conditions (Modules I, II and III), and thereby supersede the language of the Attachments to the extent that there is a direct conflict between the Attachments and Modules I, II and III of the Permit.

DEFINITIONS

All definitions contained in 40 CFR Sections § 124.2, § 260.10, § 270.2, § 264.141, § 264.1031, § 264.1051, § 264. § 1081, and 9 VAC 20-60 are hereby incorporated, in their entirety, by reference into this Permit. Any of the definitions used below, (a) through (m), shall supersede any definition of the same term given in 40 CFR Sections § 124.2, § 260.10, § 270.2, § 264.141, § 264.1031, § 264.1051 §,264.1081, and 9 VAC 20-60. Where terms are not defined in the regulations or the Permit, the meaning associated with such terms shall be defined by a standard dictionary reference or the generally accepted scientific or industrial meaning of the term.

Throughout the permit, all references to 40 CFR parts § 261-266, §268, § 270, § 273, 279, are as adopted by reference in the Virginia Hazardous Waste Management Regulations, 9 VAC 20-60.

a. The term "Permit" shall mean the Permit issued by the Virginia Department of Environmental Quality, pursuant to Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended, and the Virginia Hazardous Waste Management Regulations (VHWMR) as codified in Title 9 of the Virginia Administrative Code, Agency 20, Chapter 60 (9 VAC 20-60).

b. The term "Director" shall mean the Director of the Virginia Department of Environmental Quality or his designated representative.

c. The term "Department" shall mean the Virginia Department of Environmental Quality (DEQ), (with the address as specified in Permit Condition I.I.1).

d. The terms "facility" or "site" shall mean all contiguous portions of the Wallops Flight Facility as identified in the physical description of the property (including structures, appurtenances, and improvements). This property description is as set forth in Attachment II.A of this Permit.

e. The term "permitted Open Burn (OB) area" shall mean those portions of the facility used for open burning treatment of hazardous waste as described in Permit Attachment II.A.

f. The term "release" shall mean any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment of any hazardous waste or hazardous constituents.

g. The term “Area of Concern” shall mean an area at the facility or an off-site area, which is not at this time known to be a solid waste management unit, where hazardous waste and/or hazardous constituents are present or are suspected to be present as a result of a release from the facility.

h. The term "Hazardous Constituent" shall mean a constituent that is listed in 40 CFR § 261, Appendix.

i. The term "Permittee" shall mean the owner/operator of the facility to which the Permit is issued.

j. The term "Regulated Unit" shall mean the unit for which a permit has been issued by DEQ.

k. The term "EPA" shall mean United States Environmental Protection Agency.

l. The term "Solid Waste Management Unit" shall mean any discernible unit at the facility from which hazardous constituents might migrate, irrespective of whether the units were intended for the management of solid and/or hazardous wastes. Such units include any area at a facility at which solid wastes have been routinely and systematically released. The term "unit" refers to containers, container storage areas, tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, underground injections wells, and other physical, chemicals or biological treatment units.

m. The term "Days" shall mean calendar days except as otherwise provided herein.

MODULE I

STANDARD CONDITIONS

MODULE I - STANDARD CONDITIONS

I.A. EFFECT OF PERMIT

This Permit, issued by the Director pursuant to 40 CFR § 270.1(c)(4), authorizes only the management of hazardous waste in accordance with the conditions of this Permit and with the applicable provisions of the VHWMR under (9 VAC 20-60). Any management of hazardous waste by the Permittee which is not authorized by this Permit or 9 VAC 20-60, and for which a permit is required under Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended, is prohibited (40 CFR §§ 270.30(g) and 270.4(b) and (c)). Compliance with this Permit generally constitutes compliance, for the purposes of enforcement, with Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended. This Permit does not convey any property rights of any sort, or any exclusive privilege. Possession of a permit does not authorize any injury to persons or property or invasion of other private rights, or any infringement of Commonwealth or local laws or regulations. Compliance with terms of this Permit may not constitute a defense to any action brought under Chapter 14, Article 8 of Title 10.1, Code of Virginia (1950) as amended or any other law governing protection of the public or the environment.

I.B. PERMIT ACTIONS

I.B.1. This Permit may be modified, revoked and reissued, or terminated for cause as specified in 40 CFR §§ 124.5, 270.30(f), 270.41, 270.42, and 270. The filing of a request by the Permittee for a permit modification, revocation and reissuance, or termination, or the notification of planned changes or anticipated noncompliance does not stay the applicability or enforceability of any Permit Condition (40 CFR § 270.30(f)).

I.B.2. Permit modifications at the request of the Permittee shall be accomplished as specified by 40 CFR § 270.42.

I.B.3. This Permit may be renewed as specified in 9 VAC 20-60-270.B.6 and 40 CFR 270.10(h), and Permit Condition I.D.2. Review of any application for a permit renewal shall consider improvements in the state of control and measurement technology, as well as changes in applicable regulations.

I.C. SEVERABILITY

I.C.1. The provisions of this Permit are severable, and if any provision of this Permit or the application of any provision of this Permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this Permit shall not be affected thereby. Invalidation of any Commonwealth or Federal statutory or regulatory provision which forms the basis for any condition of this Permit does

not affect the validity of any other Commonwealth or Federal statutory or regulatory basis for said condition. (40 CFR § 124.16(a)(2))

I.C.2. In the event that a condition of this Permit is stayed for any reason, the Permittee shall continue to comply with the conditions of the existing permit which correspond to the stayed conditions until final resolution of the stayed condition unless the Director determines compliance with the related applicable and relevant standards would be technologically incompatible with compliance with other conditions of the Permit which have not been stayed. (40 CFR §124.16(c)(2))

I.D. DUTIES AND REQUIREMENTS

I.D.1. Duty to Comply

The Permittee shall comply with all conditions of this Permit, except that the Permittee need not comply with the conditions of this Permit to the extent and for the duration such noncompliance is authorized by an emergency permit under 40 CFR § 270.61). Any other noncompliance with the Permit, constitutes a violation of Title 10.1 Code of Virginia (1950), as amended and regulations promulgated thereunder is grounds for enforcement action; for Permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. (40 CFR § 270.30(a))

I.D.2. Duty to Reapply

If the Permittee wishes to or is required to continue an activity regulated by this Permit after the expiration date of this Permit, the Permittee shall apply for and obtain a new permit as specified below.

a. The Permittee shall submit a new application at least 180 days before the expiration date of the Permit, unless a later date has been granted by the Director. (40 CFR § 270.30(b))

b. Pursuant to 40 CFR § 270.10(h), the Director shall not grant permission for an application to be submitted later than the expiration date of the existing permit.

I.D.3. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense for the Permittee in an enforcement action to argue that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this Permit. (40 CFR § 270.30(c))

I.D.4. Duty to Mitigate

In the event of noncompliance with the Permit, the Permittee shall take all reasonable steps to minimize releases to the environment, and shall carry out such measures as are reasonable to prevent significant adverse impacts on human health or the environment. (40 CFR § 270.30(d))

I.D.5. Proper Operation and Maintenance

The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this Permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of this Permit. (40 CFR § 270.30(e))

I.D.6. Duty to Provide Information

The Permittee shall furnish, to the Director within a reasonable time, any pertinent information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this Permit, or to determine compliance with this Permit. The Permittee shall also furnish to the Director, upon request, copies of records required to be kept by this Permit. (40 CFR § 270.30(h))

I.D.7. Inspection and Entry

The Permittee shall allow the Director or an authorized representative, upon the presentation of credentials and other documents as may be required by law to:

a. Enter at reasonable times upon the Permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this Permit;

b. Have access to and copy, at reasonable times, any records that must be kept under conditions of this Permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Permit; and

d. Sample or monitor at reasonable times for the purposes of assuring permit compliance or as otherwise authorized by the VHWMR, any substances or parameters at any location. (40 CFR § 270.30(i))

I.D.8. Reporting Planned Changes

The Permittee shall give notice to the Director as soon as possible of any planned physical alterations or additions to the permitted facility. (40 CFR § 270.30(l)(1)) This notice shall include a description of all incidents of noncompliance reasonably expected to result from the proposed changes.

I.D.9. Anticipated Noncompliance

The Permittee shall give advance written notice to the Director of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements. (40 CFR § 270.30(l)(2))

I.D.10. Twenty-four Hour Reporting

The Permittee shall report any noncompliance which may endanger human health or the environment to the Director. Information shall be provided orally within twenty-four (24) hours from the time the Permittee becomes aware of the circumstances. The information specified in "a", "b" and "c" below shall be included as information which shall be reported orally within 24 hours.

a. Information concerning the release of any hazardous waste that may cause an endangerment to public drinking water supply sources shall be reported.

b. Any information of a release or discharge of hazardous waste or of a fire or explosion at the facility, which could threaten the environment or human health outside the facility, shall be reported.

c. The description of the occurrence and its cause shall include:

   i. Name, address, and telephone number of the owner or operator;

   ii. Name, address, and telephone number of the facility;

   iii. Date, time, and type of incident;

   iv. Names and quantities of material(s) involved;

   v. The extent of injuries, if any;

   vi. An assessment of actual or potential hazard to the environment and human health outside the facility, where this is applicable; and

   vii. Estimated quantity and disposition of recovered material that resulted from the incident. (40 CFR § 270.30(l)(6))

d. A written submission shall also be provided to the Director within five (5) days of the time the Permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the periods of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance. The Permittee need not comply with the 5-day written notice requirement only if the Director waives that requirement following verbal notification and the Permittee submits a written report within (15) days of the time the Permittee becomes aware of the circumstances. (40 CFR § 270.30(l)(6)(iii)

I.D.11. Other Noncompliance

The Permittee shall report all other instances of noncompliance not otherwise reported pursuant to Permit Conditions I.D.10, I.D.12, and I.E.1 at the time monitoring reports are submitted. The reports shall contain the information listed in Permit Condition I.D.10. (40 CFR § 270.30(l)(10)

I.D.12. Other Information

Whenever the Permittee becomes aware that he failed to submit any relevant facts in the permit application, or submitted incorrect information in a permit application or in any report to the Director, the Permittee shall promptly submit such facts or information to the Director. (40 CFR § 270.30(l)(11)

I.E. MONITORING AND RECORDS

I.E.1. Monitoring shall be performed and results shall be reported at the intervals specified in the Permit.

I.E.2. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. (40 CFR § 270.30(j)(1) The method used to obtain a representative sample of the waste to be analyzed must be the appropriate method specified in 40 CFR § 261, Appendix I, or an equivalent method approved by the EPA. Laboratory methods must be those specified in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (SW-846, 3rd ed., November, 1986, as updated), *Standard Methods of Wastewater Analysis* (16th ed., 1985, as updated), or an equivalent method approved by the EPA. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

I.E.3. The Permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for

continuous monitoring instrumentation, copies of all reports required by this Permit, all certifications required by 40 CFR § 264.73(b)(9) and records of all data used to complete the application for this Permit, for a period of at least 3 years (or longer if specified elsewhere in this Permit) from the date of the sample collection, measurement, report, certification, or application. These retention periods may be extended by the request of the Director at any time and are automatically extended during the course of any unresolved enforcement actions regarding this facility. The Permittee shall maintain records from all ground-water monitoring wells and associated ground-water surface elevations for the active life of the facility.

I.E.4. Records of monitoring information shall include at a minimum:

a. The date, exact place, and time of sampling or measurements;

b. The individual(s) who performed the sampling or measurements;

c. The date(s) analyses were performed;

d. The individual(s) who performed the analyses;

e. The analytical techniques or test methods used; and

f. The results of such analyses. (40 CFR § 270.30(j))

I.F. COMPLIANCE NOT CONSTITUTING DEFENSE

Compliance with the terms of this Permit does not constitute a defense to any action brought under Chapter 14, Article 8 of Title 10.1, Code of Virginia (1950), as amended, or any other Commonwealth law governing protection of the public or the environment.

I.G. TRANSFER OF PERMITS

This Permit is not transferable to any person, except after notice to the Director (40 CFR § 270.30(l)(3)). The Director may require modification or revocation and reissuance pursuant to 40 CFR § 124.5, 270.40, 270.41, 270.42, and 270.43 to change the name of the Permittee and incorporate such other requirements as may be necessary. Before transferring ownership or operation of the facility during its operating life, the Permittee shall notify the new owner or operator in writing of the requirements of 9 VAC 20-60-264 and 40 CFR Part 264 and shall at the same time send a copy of such notice to the Director (40 CFR § 264.12(c)).

I.H. PERMIT EXPIRATION AND CONTINUATION

Pursuant to 9 VAC 20-270.B.15, this Permit will remain in force until the effective date of a new permit, if the Permittee has submitted a timely, complete application pursuant to Permit Condition I.D.2.a and through no fault of the Permittee, the Director has not issued a new permit with an effective date on or before the expiration date of this Permit. All conditions of the continued permit shall remain fully effective and enforceable.

I.I. REPORTS, NOTIFICATIONS, AND SUBMISSIONS TO THE DEPARTMENT

I.I.1. The Permittee shall submit biennial report to the Department, which covers facility activities during the previous calendar year. At a minimum this report will include:

a. The generator biennial report pursuant to 40 CFR § 262.41; and

b. The hazardous waste management facility biennial report pursuant to 40 CFR § 270.30(l)(9) and § 264.75.

All reports, notifications or other submissions which are required by this Permit to be sent or given to the Director should be sent or be given hand-delivered to:

For Corrective Action and Groundwater:

Department of Environmental Quality
Groundwater/Corrective Action Program Team Leader
Office of Remediation Programs
P. O. Box 1105
Richmond, VA 23218

For Permit Modifications:
Department of Environmental Quality
Hazardous Waste Program Manager
Office of Financial Responsibility and Waste Programs
P. O. Box 1105
Richmond, VA 23218

And one (1) copy of all such correspondence, report and submission shall also be sent to:

Land Protection Manager, Tidewater Regional Office
Department of Environmental Quality
5636 Southern Blvd
Virginia Beach, VA 23462

Virginia Program Manager (3CL50)

Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

I.J. SIGNATORY REQUIREMENTS

All applications, reports, or information submitted to the Director shall be signed and certified as specified by 40 CFR § 270.119.

I.K. DOCUMENTS TO BE MAINTAINED AT THE FACILITY SITE

Current copies of the following documents, as amended, revised, and modified, shall be maintained at the facility (or other location approved by the Director). These documents shall be maintained during the term of this Permit, including any reissued permit, unless a lesser time is specified in the Permit.

a. The Permit including all attachments, revisions and modifications;

b. The Part A and Part B Permit Applications;

b. The facility's operating record required by 40 CFR § 264.73 and Permit Condition II.H.2.

c. Inspection schedules and logs required by 40 CFR § 264.15(b)(2) and § 264.15(d)(16) and this Permit;

d. Personnel training documents and records required by 40 CFR 264.16 and this Permit;

e. Closure Plans as required by 40 CFR 264.112(a) and this Permit.

f. Post-Closure Plans, as required by 40 CFR § 264.118(a); and

g. All other documents required by Permit Conditions I.D.8 through I.D.12 and I.E.

I.L. APPROVAL/DISAPPROVAL OF SUBMISSIONS

The VDEQ will review the plans, reports, schedules and other documents (hereinafter collectively referred to as "submission") submitted which require the Director's or VDEQ's approval. The VDEQ will notify the Permittee in writing of the VDEQ's approval, conditional approval or disapproval of each submission.

Each submission required by this Permit is, upon approval by the Director, incorporated into this Permit. Any noncompliance with such VDEQ-approved submission shall be deemed noncompliance with this Permit. A conditionally

approved submission, including any terms of such conditional approval set forth in VDEQ's decision, shall constitute the VDEQ-approved submission and shall be incorporated into this Permit.

In the event of VDEQ's conditional approval of submission, the VDEQ shall specify in writing any deficiencies in the submission and the terms upon which approval of the submission is conditioned. If the Permittee disputes any term upon which approval of the submission was conditioned, the Permittee may initiate Dispute Resolution pursuant to permit condition I.M

In the event of VDEQ's disapproval of a submission, the VDEQ shall specify the deficiencies in writing. The Permittee shall modify the submission to correct/address the specified deficiencies within a reasonable time period established by the VDEQ taking into account the tasks to be performed, and submit the revised submission to VDEQ for approval.

If the revised submission is disapproved, the VDEQ will notify the Permittee of the deficiencies in writing and specify a schedule for the Permittee to correct the deficiencies and resubmit the submission to VDEQ. The Permittee shall correct the deficiencies as directed by VDEQ, and forward the revised submission within the time period specified by VDEQ. In the event the Permittee disagrees with VDEQ's disapproval of the revised submission, the Permittee shall notify the VDEQ in writing and the disagreement shall be resolved in accordance with the Dispute Resolution provisions in permit condition I.M.

I.M. Except as otherwise provided in this Permit, in the event the Permittee disagrees, in whole or in part, with VDEQ's disapproval of any submission required by this Permit, the Permittee shall notify the VDEQ in writing of its objections, and the basis thereof, within fourteen (14) days of receipt of the VDEQ's disapproval. Such notice shall set forth the specific matters in dispute, the position(s) the Permittee asserts which should be adopted as consistent with the requirements of the Permit, the basis for the Permittee's position, and supporting documentation considered necessary for the VDEQ's determination.

The VDEQ and the Permittee shall have an additional fourteen (14) days from the VDEQ's receipt of the notification to meet or confer to resolve any disagreement/dispute. In the event agreement is reached, the Permittee shall submit the revised submission and implement the same in accordance with such agreement.

In the event the Permittee disagrees with VDEQ's disapproval of a submission or revised submission and the VDEQ's written decision regarding dispute items, the Permittee may file an appeal with the Director within 30 days of the disapproval (as provided for in Rule 2A:2 of the Supreme Court of Virginia).

MODULE II

GENERAL FACILITY CONDITIONS

MODULE II - GENERAL FACILITY CONDITIONS

II.A WASTE ANALYSIS

II.A.1. General Waste Analysis

The Permittee shall follow the procedures described in the Waste Analysis Plan, Attachment II.B. Waste analysis shall require, at a minimum, the maintenance of proper functioning instruments, use of approved sampling and analytical methods, verification of the validity of sampling and analytical procedures, and correct calculations. If the Permittee does not have the sufficient capability for analysis, then the Permittee shall inform the laboratory performing the analysis that the laboratory must operate under the waste analysis conditions placed on the Permittee. Additionally, the laboratory must be accredited for the analytical method, matrix and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

II.B SECURITY

The Permittee shall comply with the security provisions of 40 CFR § 264.14. The security provisions shall follow the outline in Attachment II.D.

II.C GENERAL INSPECTION REQUIREMENTS

The Permittee shall follow the inspection schedule set out in Attachment II.C. The Permittee shall remedy any deterioration or malfunction discovered by an inspection as required by 40 CFR § 264.15 Records of inspections shall be kept as required by 40 CFR § 264.15(d) and Permit Conditions II.H.2.c.v.

II.D PERSONNEL TRAINING

The Permittee shall conduct personnel training as required by 40 CFR § 264.16. This training program shall follow the Training Outline, Attachment II.E. The Permittee shall maintain training documents and records as required by 40 CFR § 264.16(d) and Permit Conditions II.H.2.a.xi and II.H.2.c.iii.

II.E GENERAL REQUIREMENTS FOR IGNITABLE AND REACTIVE WASTE

The Permittee shall comply with the requirements of 40 CFR § 264.17. The Permittee shall follow the procedures for the handling of ignitable and reactive waste as specified in the Module III.

II.F PREPAREDNESS AND PREVENTION

II.F.1. Design and Operation of Facility

The Permittee shall maintain and operate the facility to minimize the possibility of a fire, explosion, or any unplanned sudden or non-sudden release of hazardous waste constituents to air, soil, groundwater, or surface water which could threaten human health or the environment.

II.F.2. Required Equipment

At a minimum, the Permittee shall equip the facility with the equipment set forth in Attachment II.F, as required by 40 CFR § 264.32.

II.F.3. Testing and Maintenance of Equipment

The Permittee shall test and maintain the equipment specified in Permit Condition II.F.2 and in Attachment II.F as necessary to assure its proper operation in time of emergency (40 CFR § 264.33).

II.F.4. Access to Communications or Alarm System

The Permittee shall maintain access to the communication or alarm system as required by 40 CFR § 264.34.

II.F.5. Arrangements with Local Authorities

The Permittee shall maintain arrangements with State and local authorities as required by 40 CFR § 264 Subpart C, and Attachment II.F.6. If State and local officials refuse to enter into or renew existing preparedness and prevention arrangements with the Permittee, the Permittee shall document this refusal in the operating record pursuant to Permit Condition II.H.2.d.iv.

II.G CONTINGENCY PLAN

II.G.1. Implementation of Plan

The Permittee shall immediately carry out the provisions of the Contingency Plan, Attachment II.F, and follow the emergency procedures described by 40 CFR § 264.56, whenever there is an imminent or actual fire, explosion, or release of hazardous waste or constituents which threaten or could threaten human health or the environment.

II.G.2. Copies of Plan

The Permittee shall comply with the requirements of 40 CFR § 264.53.

II.G.3. Amendments to Plan

The Permittee shall review and immediately amend, if necessary, the Contingency Plan, as required by 40 CFR § 264.54.

II.G.4. Emergency Coordinator

The Permittee shall comply with the requirements of 40 CFR § 264.52(d) and 40 CFR § 264.55.

II.G.5. Emergency Procedures

The Permittee shall comply with the requirements of 40 CFR § 264.56 including the record keeping and reporting requirements specified in Permit Condition II.H.2.a.iv.

II.H RECORD KEEPING AND REPORTING

II.H.1. Notification, Certification, and Recordkeeping Requirements

In addition to the record keeping and reporting requirements specified elsewhere in this Permit, the Permittee shall comply with all the applicable notification, certification, and record keeping requirements described in 40 CFR § 264.73.

II.H.2. Operating Record

The Permittee shall maintain a written operating record at the facility, consisting of records kept for the lengths of time specified below. The record can be a compilation of various documents. The operating record shall include, but not be limited to, the information listed below.

a. The following records shall be maintained until closure is complete and certified:

   i. A current map showing the location of hazardous waste management units and non-regulated units within the facility;

   ii. A map showing all locations of past hazardous waste management units if different from present locations;

   iii. Pursuant to 40 CFR § 264.73, a description and the quantity of each hazardous waste received, and the method(s) and date(s) of its treatment, storage, or disposal at the facility;

iv. The time, date, and details of any incident that requires implementation of the Contingency Plan, including copies of all reports prepared pursuant to 40 CFR § 264.56(i) and Permit Condition I.D.11.c or II.H.2.iv;

v. Records of spills and releases;

vi. Written reports and records of verbal notification to the Director and the Administrator to address releases, fires, and explosions;

vii. All reports of noncompliance pursuant to Permit Condition I.D.12;

viii. All submittals prepared pursuant to Permit Condition I.D.13;

ix. Records and results of waste analyses required by 40 CFR § 264.73(b)(3), which shall include at a minimum:

A. The date(s), exact place, and times of sampling or measurements;

B. The name of the individual(s) who performed the sampling or measurements;

C. The date(s) analyses were performed, demonstrating that EPA SW-846 holding times were satisfied;

D. The name(s) of the individual(s) who performed the analyses;

E. The analytical techniques or method used;

F. The analytical results;

G. The QA/QC summary; and

H. The type(s) and model number(s) of the equipment used for analysis.

x. All waste determinations, waste profiles, and waste feed composition determinations made pursuant to the Waste Analysis Plan, Attachment II.B.

xi. Training records of current facility personnel;

xii. Certifications pursuant to 40 CFR § 264.73(b)(9) (Waste Minimization Plan);

xiii. The notice and certification required by a generator under 40 CFR § 264.73 and 268.7 (Land Disposal Restrictions); and

xiv. Records of the rocket motor inspections and the DoD Motor Surveillance Program as detailed in Attachment II.B, Appendix C (Sounding Rocket Motor Inspection Process).

b. The following records shall be maintained for a minimum of 5 years. This time period may be extended by the Department in the event of enforcement action or notification by the Department that an investigation is ongoing.

i. Facility operation and maintenance records and reports prepared pursuant to this Permit; and

ii. Progress reports and any required notifications prepared pursuant to this Permit.

c. The following records shall be maintained for a minimum of 3 years. This time period may be extended by the Department in the event of enforcement action or notification by the Department that an investigation is ongoing.

i. Generator biennial reports submitted in compliance with 40 CFR § 262.41;

ii. Facility biennial reports submitted in compliance with 40 CFR § 264.75;

iii. Training records of former facility personnel;

iv. Records of all monitoring information pursuant to Permit Condition I.E.3; and

v. Records of all inspections, pursuant to 40 CFR § 264.15, which shall include at a minimum:

A. The date and time of the inspection;

B. The name of the person performing the inspection;

C. A notation of the observations made; and

D. The date and nature of any repairs or remedial actions.

d. Current copies of the following documents as amended, revised, and modified shall be maintained at the facility until closure is complete and certified:

i. Waste Analysis Plan;

ii. Personnel Training Plan;

iii. Contingency Plan;

iv. Documentation of arrangements made with local authorities pursuant to 40 CFR § 264.37;

v. Closure Plan; and

vi. Documentation pertaining to the storage of ignitable and reactive wastes required pursuant to 40 CFR § 264.17.

II.H.3. Revised Treatment Alternatives Analysis Report

Five years after the effective date of this permit the facility shall submit a report providing an analysis of alternative treatment technology to the thermal treatment by open burning.

II.I CLOSURE

II.I.1 Performance Standard

The Permittee shall close the permitted Open Burn (OB) area as required by 40 CFR § 264.111 and 264.118, and in accordance with the Closure Plan, Attachment II.G.

II.I.2 Amendments to Closure Plan

The Permittee shall amend the Closure Plan in accordance with 40 CFR § 264.112(c) whenever necessary.

II.I.3 Notification of Closure

The Permittee shall notify the Director at least 45 days prior to the date he expects to begin closure as required by 40 CFR § 264.112(d).

II.I.4 Time Allowed for Closure

After receiving the final volume of hazardous waste, the Permittee shall treat or remove from the permitted areas all hazardous waste and shall complete closure activities in accordance with the schedules specified in the Closure Plan, Attachment II.G and 40 CFR § 264.113.

II.I.5 Disposal or Decontamination of Equipment

The Permittee shall decontaminate and/or dispose of all facility equipment as required by 40 CFR § 264.114 and the Closure Plan, Attachment II.G.

II.I.6 Certification of Closure

The Permittee shall certify that the permitted Open Burn (OB) area has been closed in accordance with the specifications in the Closure Plan, Attachment II.G, as required by 40 CFR § 264.115.

II.I.7 Post-Closure Plan

If the Permittee cannot demonstrate "clean" closure of soils and/or groundwater, the requirements of 40 CFR § 264.118 shall become applicable.

LIST OF ATTACHMENTS

The following Attachments are incorporated, in their entirety, by reference into this Permit. These incorporated attachments are enforceable conditions of this Permit. Some of the documents contain excerpts from the Permittee's Hazardous Waste Permit Application. The Department has, as deemed necessary, modified specific language excerpted from the Permit application. Additional modifications are prescribed in the Permit Conditions (Modules I through IV), and thereby supersede the language of the attachments. Facility operations shall be in accordance with the contents of the Attachments and this Permit.

Attachment II.A Description of the Hazardous Waste Management Facility

Attachment II.B Waste Analysis Plan

Attachment II.C Inspection Schedule

Attachment II.D Security Provisions and Procedures to Prevent Hazards

Attachment II.E Personnel Training

Attachment II.F Contingency Plan

Attachment II.G Closure Plan

Attachment II.H Plans and Specifications for Open Burn Units

ATTACHMENT II.A

FACILITY DESCRIPTION

ATTACHMENT II.A - FACILITY DESCRIPTION

II.A.1 General Description

WFF is owned and operated by the National Aeronautics and Space Administration. It is located in Virginia on the Atlantic Coast of the Delmarva Peninsula approximately 64 kilometers (40 miles) southeast of Salisbury, Maryland, and 113 kilometers (70 miles) north of the Chesapeake Bay Bridge Tunnel. Chincoteague Island is approximately 8 kilometers (5 miles) east of the Main Base. Figure II.A-1 shows the relationship of the Wallops Flight Facility to major eastern cities.

The Main Base basic facilities were constructed in 1941 through 1958 by the Government as a Navy base for flight operations and for Naval Ordnance testing. In 1959, the Navy closed the base and the National Aeronautics and Space Administration acquired the Main Base and purchased the Wallops Mainland site. Since 1959, NASA has demolished obsolete buildings, renovated other buildings for adaptability to their missions, and built new facilities.

In 1945, a launch site was constructed on Wallops Island on land acquired by the National Advisory Committee for Aeronautics. Historically, research at Wallops was concentrated on obtaining aerodynamic data at transonic and low supersonic speeds, as part of the effort to penetrate the sound barrier of flight. Today, Wallops is used primarily to obtain scientific data about the atmosphere and the space environment, conduct aeronautical research, and perform space and terrestrial applications experiments.

WFF is a complex of three separate land areas known as the Main Base, Wallops Island, and Wallops Mainland. WFF is a facility of the Goddard Space Flight Center located in Greenbelt, Maryland.

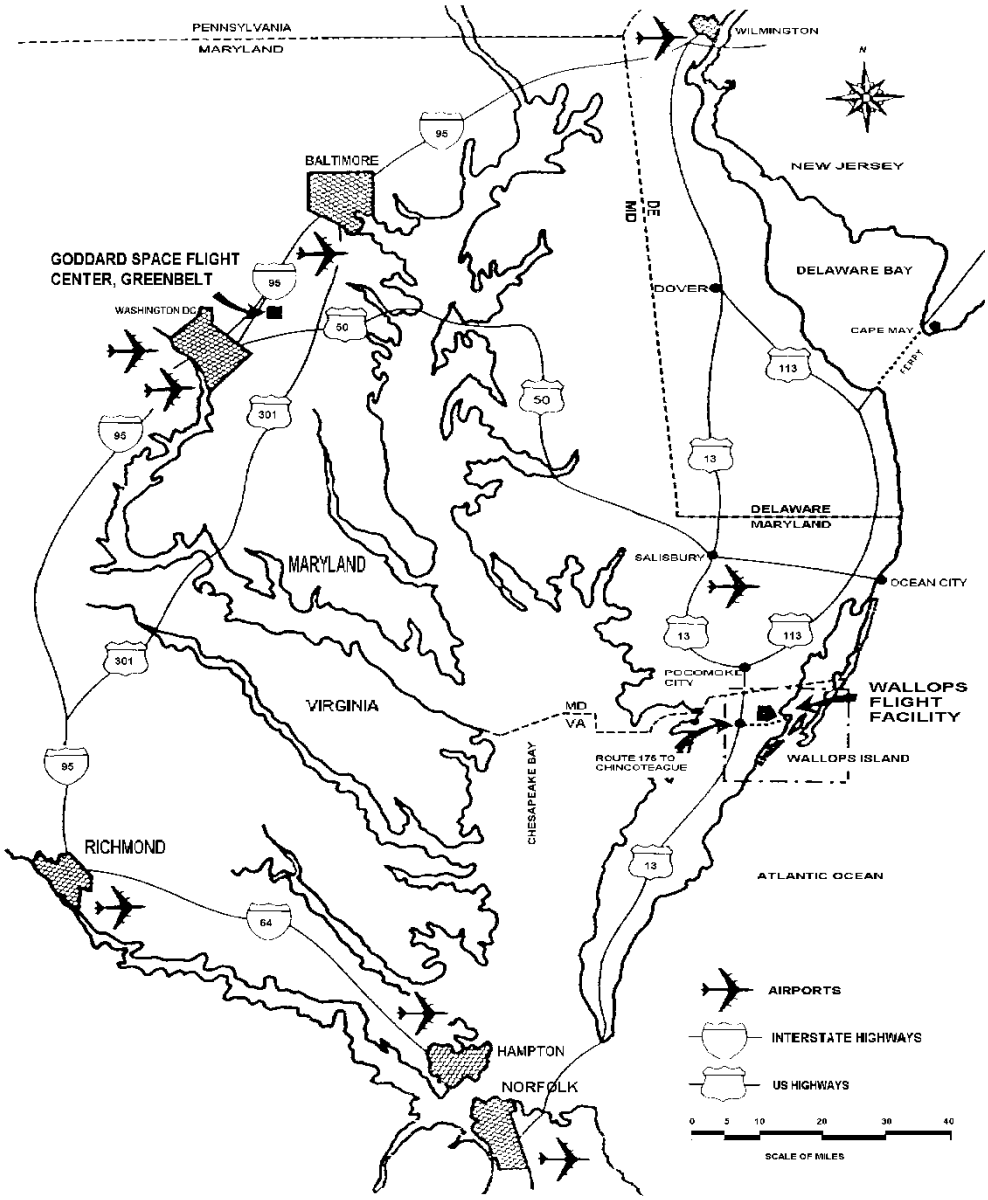


Figure II.A-1 Site Location Map

The Main Base is a land area of 902 hectares (2,230 acres), bordered on the east by 6 kilometers (4 miles) of marshland, which separates it from Chincoteague Island. This area contains Wallops Headquarters, Administrative Offices, some tracking facilities, a range control center, rocket and fuel storage depots, rocket vehicle inspection facilities, several support shops, an approved FAA Airport, military family housing units, and bachelor's quarters.

Wallops Island and Wallops Mainland jointly comprise a land area of 1740 hectares (4,300 acres), and are located approximately 11 kilometers (7 miles) southeast of the Main Base. Wallops Island is connected to Wallops Mainland by a causeway and bridge that cross 3 kilometers (2 miles) of salt marsh, which is interlaced with small creeks and is bisected by the Intracoastal waterway. Wallops Island is approximately 11 kilometers (7 miles) long and 0.8 kilometers (0.5 miles) in width at its widest point. Wallops Island borders the Atlantic Ocean on the east, and the Chincoteague inlet on the north. Wallops Island was joined with Assawoman Island to the south when the inlet between them was closed by a storm in 1986. The inlet was temporarily reopened in 1987 but has since filled in and remains closed today.

Wallops Island contains the OB area, launch sites, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, U. S. Navy facilities, Virginia Commercial Spaceport Facilities, tracking facilities, and other related service support facilities. In 2003, an Unmanned Aerial Vehicle (UAV) runway was built on the access road just north of the OB Area. Wallops Mainland provides a site for long-range radar, communications, and optical tracking installations. The relative locations and area boundaries of these three land areas of the Wallops Flight Facility and the OB Area are illustrated on Figures II.AA-2 and II.AA-3.

The OB Area located on the shoulder of the dike road at the southwestern corner of Wallops Island, consists of four subunits (ground embedded cylinders) and one open burn pad assembly. Two subunits, Subunit 1 and 3, are 0.6 meters (1.9 feet) in diameter, stand 0.8 meters (2.6 feet) above the ground surface, and are embedded 2.3 meters (7.5 feet) below the ground. Subunit 2 is 0.4 meters (1.4 feet) in diameter, stands 1.1 meters (3.5 feet) above the ground surface, and is embedded 2.2 meters (7.1 feet) below the ground surface. Subunit 4 is 0.7 meters (2.4 feet) in diameter, stands 1.10 meters (3.6 feet) above the ground surface, and is embedded 3.1 meters (10.2 feet) below the ground surface. The subunits are covered when not in use to prevent entry and accumulation of precipitation. The subunits also have concrete bases to prevent contact between constituents, subsurface soils, and groundwater. The open burning pad assembly is a 4.6 meters (15 feet) square by 46 centimeters (18 inches) thick concrete pad with a steel plate in the center for motor head attachment. Four cable tie downs are used to stabilize the motors.

Trucks carrying waste rocket motors from the Main Base to the OB Area would proceed along the access road on WFF Main Base that services the rocket storage area (M area), to the perimeter road, which intersects the main road about 61 meters

(200 feet) east of the WFF main gate. From the WFF main gate, the trucks proceed south on the access road that crosses State Route 175 and joins State Route 679 about 1.4 kilometers (0.9 miles) south of the main gate. The trucks continue across State Route 679 to State Route 803 east. State Route 803 ends at the guard gate to the WFF Mainland. The trucks proceed eastward through the gate, along the causeway to the dike road on the Wallops Island, then south to the southern end of the island. Road crossings and intersections on the facility are controlled by stop signs. Signal lights and stop signs control Road crossings and intersections on State roads

Speed limits on these roads range between 40 kilometers per hour (25 miles per hour) and 63 kilometers per hour (40 miles per hour). All roads, including the WFF roads, are paved with asphalt. State roads, maintained by the Virginia Department of Highways and Transportation, are 6.7 meters (22 feet) wide and are consistent with State highway standards. The distance from the Main Base to Wallops Island via this route is 13.5 kilometers (8.4 miles), with travel time estimated at 16 minutes at an average speed of 48 kilometers per hour (30 miles per hour).

WFF roads were constructed in the 1940's in accordance with existing design criteria, therefore, some streets do not accommodate two-way traffic. Both the perimeter road and the main road do accommodate two-way traffic, and the bearing capacity is sufficient for the vehicles used, according to Virginia highway standards. The roadways on the island were constructed more recently and consist of asphalt over a stone base, and also meet Virginia Department of Highways and Transportation standards. However, the road within the OB Area has been impacted by storms and is primarily a sand covered surface.

The traffic volume near the OB Area is low. Routine vehicular traffic includes roving security patrols several times per day, and during Piping Plover nesting season, United States Fish and Wildlife employees passing through the OB Area daily, to observe nesting areas. Other less frequent vehicular traffic results from camera stand use, groundwater monitoring, inspections, and OB operations. Heavy equipment in the form of fire trucks, cranes, flat bed trucks, or bush hogs typically access the OB Area less than four times per year each. None of these varied traffic types interfere with internal traffic on the Main Base or Wallops Island. Roads east of the perimeter road used to access the OB Area, provide alternate access to other facilities on Wallops Island.

Estimated traffic volumes are shown below:

Table A-1 Estimated Annual Vehicular Traffic at the OB Area

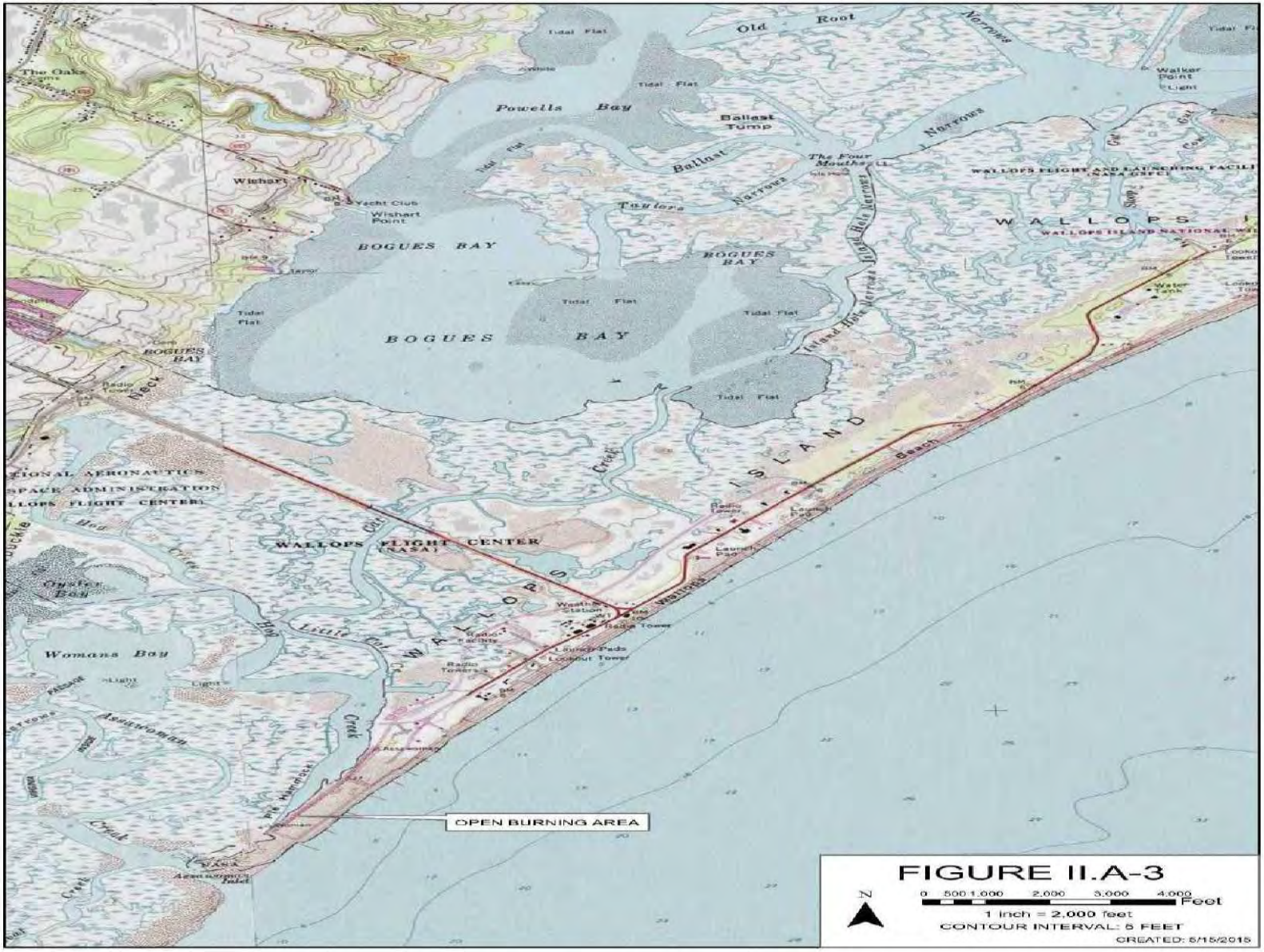
Car and Light Truck Annual Activity	Vehicles per year
USFW (1 vehicle)(1 time per day)(6 months per year)(30 days per	180

month)	
Security (1 vehicle)(2 times per day)(365 days per year)	730
Camera Stand (2 vehicles)(12 times/year)	24
Inspections (2 vehicles)(12 times/year)	24
OB operations (4 vehicles)(4 times per year)	16
Heavy Equipment Annual Activity	
Fire trucks	8
Bush hog	1
Cranes	4
Flatbed trucks	4
Total Annual Car and Light Truck Activity	978
Total Annual Heavy Equipment Activity	17

Heavy truck tire pressures for vehicles used on public highways is a maximum of 827 kilopascals (120 pounds per square inch). These vehicles generally carry loads that average less than 2,268 kilograms (5,000 pounds) per tire. Loaded trucks at WFF do not exceed these loads. The roads at WFF were designed to meet these loads as well as the above traffic counts.

Traffic of these volumes fall into category I for design purposes. Category I roads have a 10 centimeter (4 inch) bituminous concrete Type B-1 or B-3 base with a 2.5 centimeter (1 inch) bituminous concrete Type S-4 or S-5 surface. In addition, WFF has maintenance personnel who are capable of repairing potholes as they appear.

Figure II.A-2 WFF Land Masses


OPEN BURNING AREA
FIGURE II.A-3
0 500 1,000 2,000 3,000 4,000 Feet
1 inch = 2,000 feet
CONTOUR INTERVAL: 5 FEET
CREATED: 5/15/2015
N
Powells Bay
Ballast Tump
Ballast
Tsulora
Narrows
The Four Mouths
Old Root
Walker Point
Wishart
Yacht Club
Wishart Point
BOGUES BAY
BOGUES BAY
BOGUES BAY
Tidal Flat
WALLOPS ISLAND
WALLOPS FLIGHT CENTER (NASA)
Little Gut
Womans Bay
Assawoman
Oyster Bay
Beach
Creek

Any rocket motor treated at the OB Area, follows guidelines and measures, which have been approved by the WFF Safety Office. These procedures are included in Attachment II.C. Simply stated, rocket motor and igniter are placed inverted into a cylinder or attached to the pad motor head assembly. The igniter is set off by battery hook-up behind a protective barrier. The distance between the barrier and burn area is specified in a ground safety plan prepared for each type rocket motor. Burned motors and igniters are inspected for visible signs of untreated material. If untreated material is present in the motor, then the motor is reignited or the material is reignited on the burn pad.

Occasionally, propellant is trimmed from a motor(s) when modifications are required. Propellant trimmings (not in a motor casing), ash, residue, or ejected material, are placed on the burn pad in a burn pan, a squib igniter is fabricated, and the material is ignited. Any unburnable material is containerized, sampled for characterization, if necessary, and any hazardous waste is disposed of through WFF's hazardous waste disposal contractor.

II.A.2 Topographic Map

The topographic map, (Figure II.A-3) developed by the United States Geological Survey, is a 7.5 minute series topographic quadrangle of Wallops Island. The contour interval is 1.5 meters (5 feet) with a scale of 2.54 centimeters equals 8,572.5 meters (1 inch:28,125 feet). Figure II.A-4 shows the OB area and a distance of 305 meters (1000 feet) around it. The map also includes map date, 100-year floodplain area, surface waters, map orientation, legal boundaries, monitoring wells, structures, and hazardous waste management units within the 1305-meter (1000-foot) surrounding area.

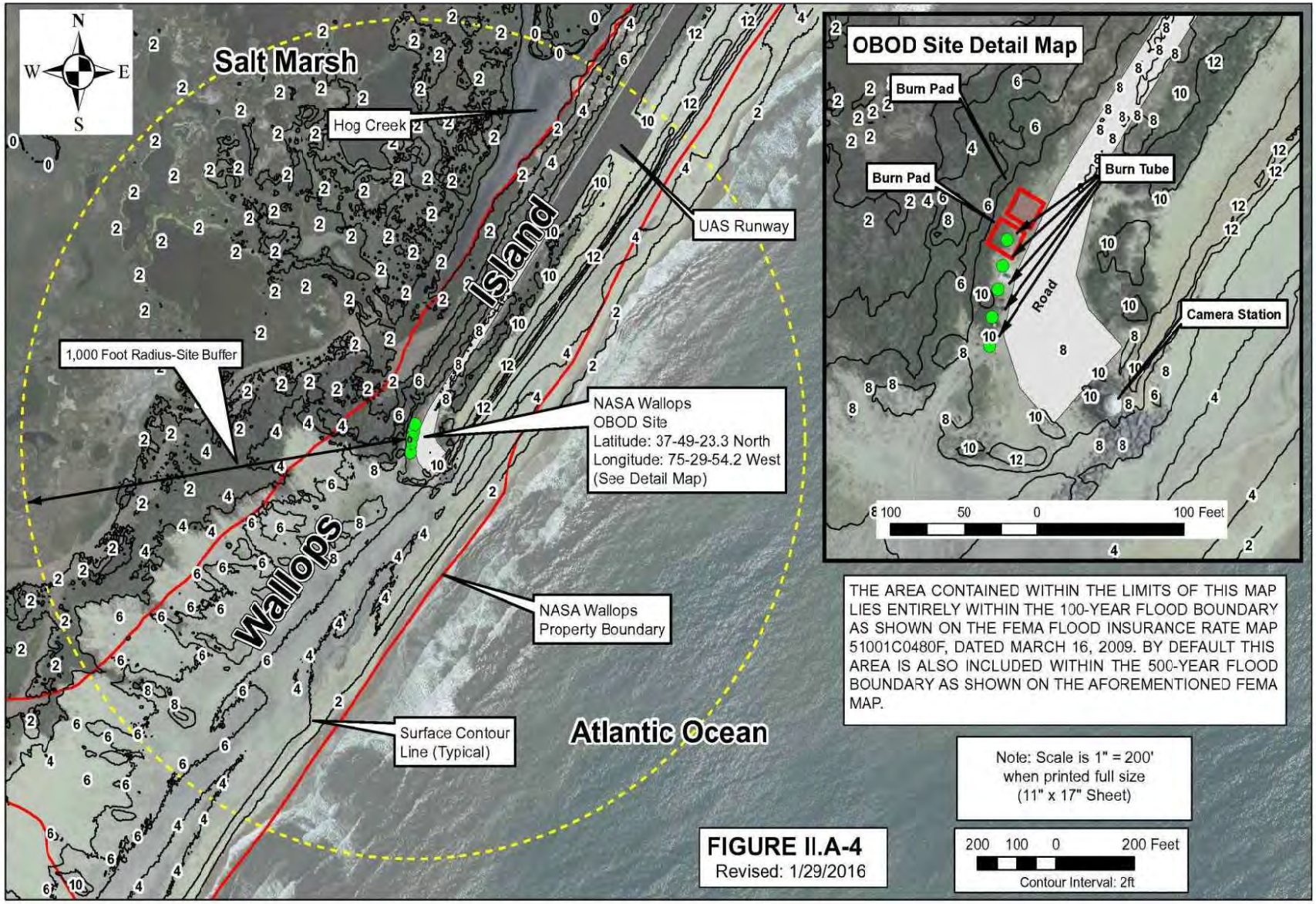
Access control (Figure II.A-7), buildings (Figure II.A-7), sanitary sewers (Figures II.A-8 thru A-15), Fire Department, Building X-15 (Figure II.A-7), flood control (Figure II.A-6), and solid waste management units (Figures II.A-8 thru A-15) are shown on separate maps. There are no storm sewers, process sewers, or runoff control systems on Wallops Island or the Mainland. Surrounding land uses are described in the following paragraphs.

The entire OB Area is located within NASA property boundaries. All of Wallops Island is located within the 100-year and 500-year floodplain. Refer to Figure II.A-5 for the 100-year and 500-year floodplain maps for the Wallops Island. Maps delineating the floodplain were developed in 1984 by the Federal Emergency Management Agency.

Land uses in the vicinity of WFF and the OB Area vary. Sparsely populated agricultural lands, marshes, and woodlands surround Wallops Island. The exception is the commercial seafood center and resort town of Chincoteague, Virginia.

Chincoteague Island is located approximately 8.0 kilometers (5.0 miles) north of the OB Area.

The Main Base, Mainland, and Wallops Island are zoned industrial by Accomack County, with one exception. The County has designated the land between Wallops Island and the Mainland as marshland.


N
W
E
S
Salt Marsh
Hog Creek
Wallops
Island
UAS Runway
1,000 Foot Radius-Site Buffer
NASA Wallops
OBOD Site
Latitude: 37-49-23.3 North
Longitude: 75-29-54.2 West
(See Detail Map)
NASA Wallops
Property Boundary
Surface Contour
Line (Typical)
Atlantic Ocean
OBOD Site Detail Map
Burn Pad
Burn Pad
Burn Tube
Road
Camera Station
100 50 0 100 Feet
THE AREA CONTAINED WITHIN THE LIMITS OF THIS MAP LIES ENTIRELY WITHIN THE 100-YEAR FLOOD BOUNDARY AS SHOWN ON THE FEMA FLOOD INSURANCE RATE MAP 51001C0480F, DATED MARCH 16, 2009. BY DEFAULT THIS AREA IS ALSO INCLUDED WITHIN THE 500-YEAR FLOOD BOUNDARY AS SHOWN ON THE AFOREMENTIONED FEMA MAP.
Note: Scale is 1" = 200'
when printed full size
(11" x 17" Sheet)
200 100 0 200 Feet
Contour Interval: 2ft
FIGURE II.A-4
Revised: 1/29/2016

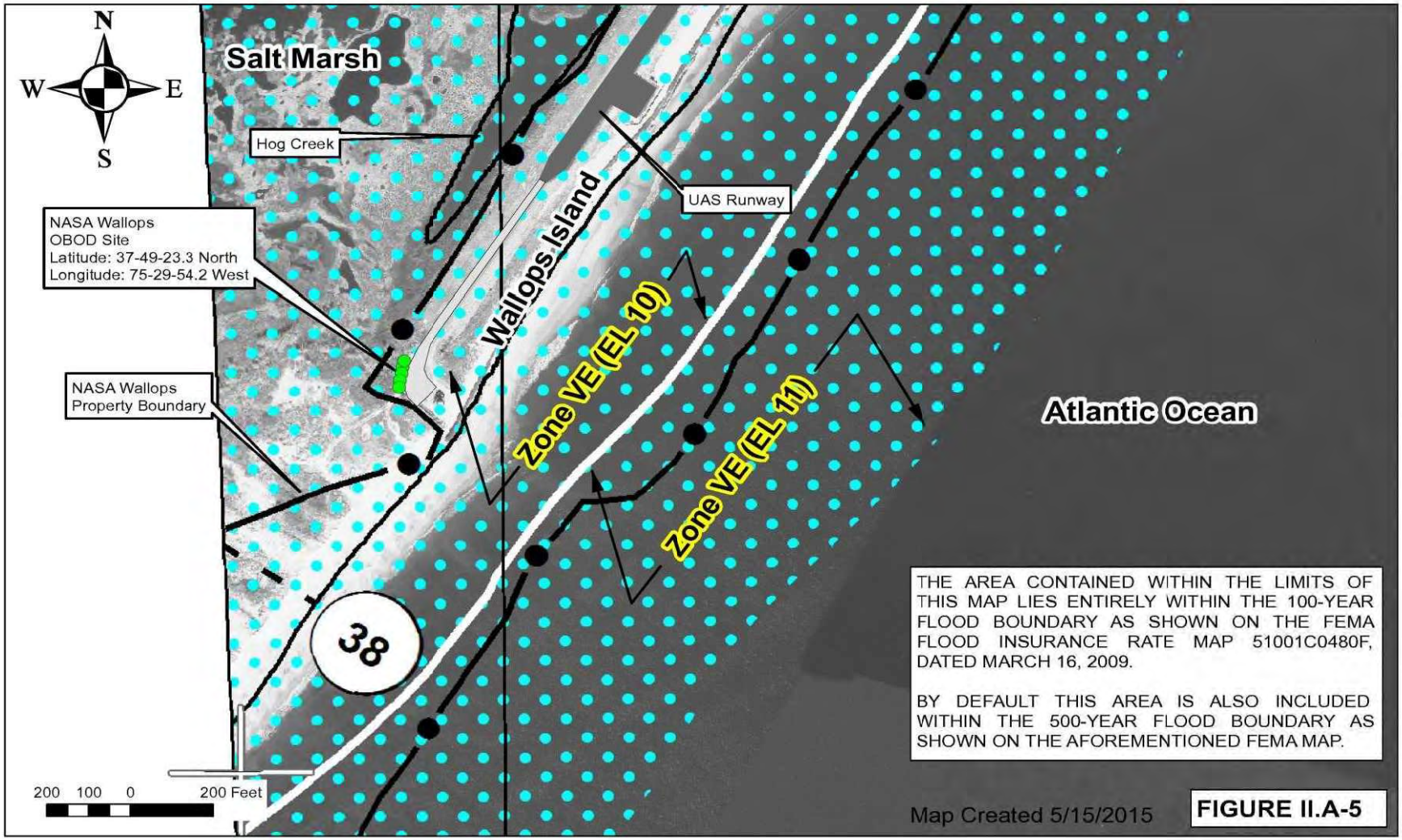
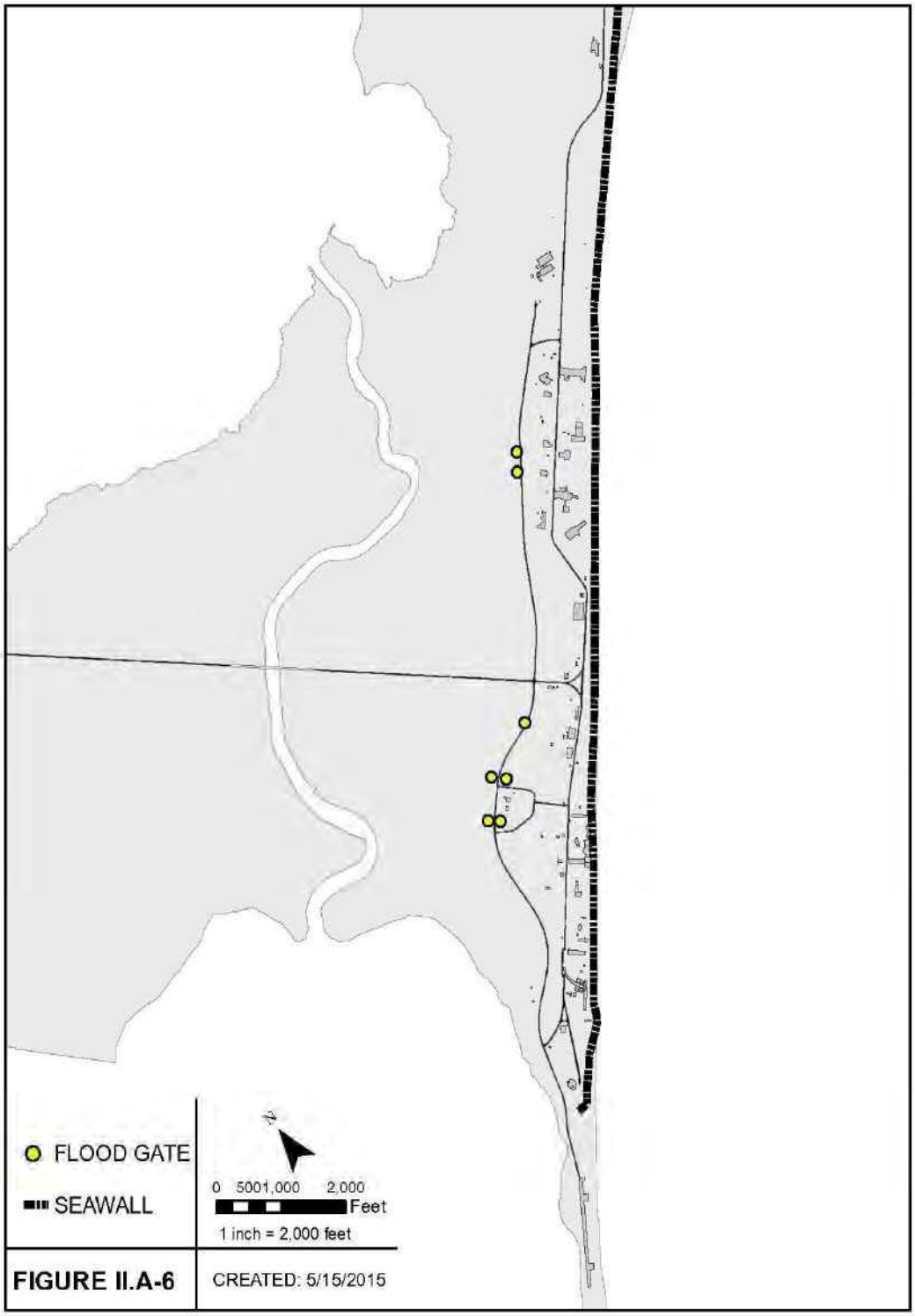
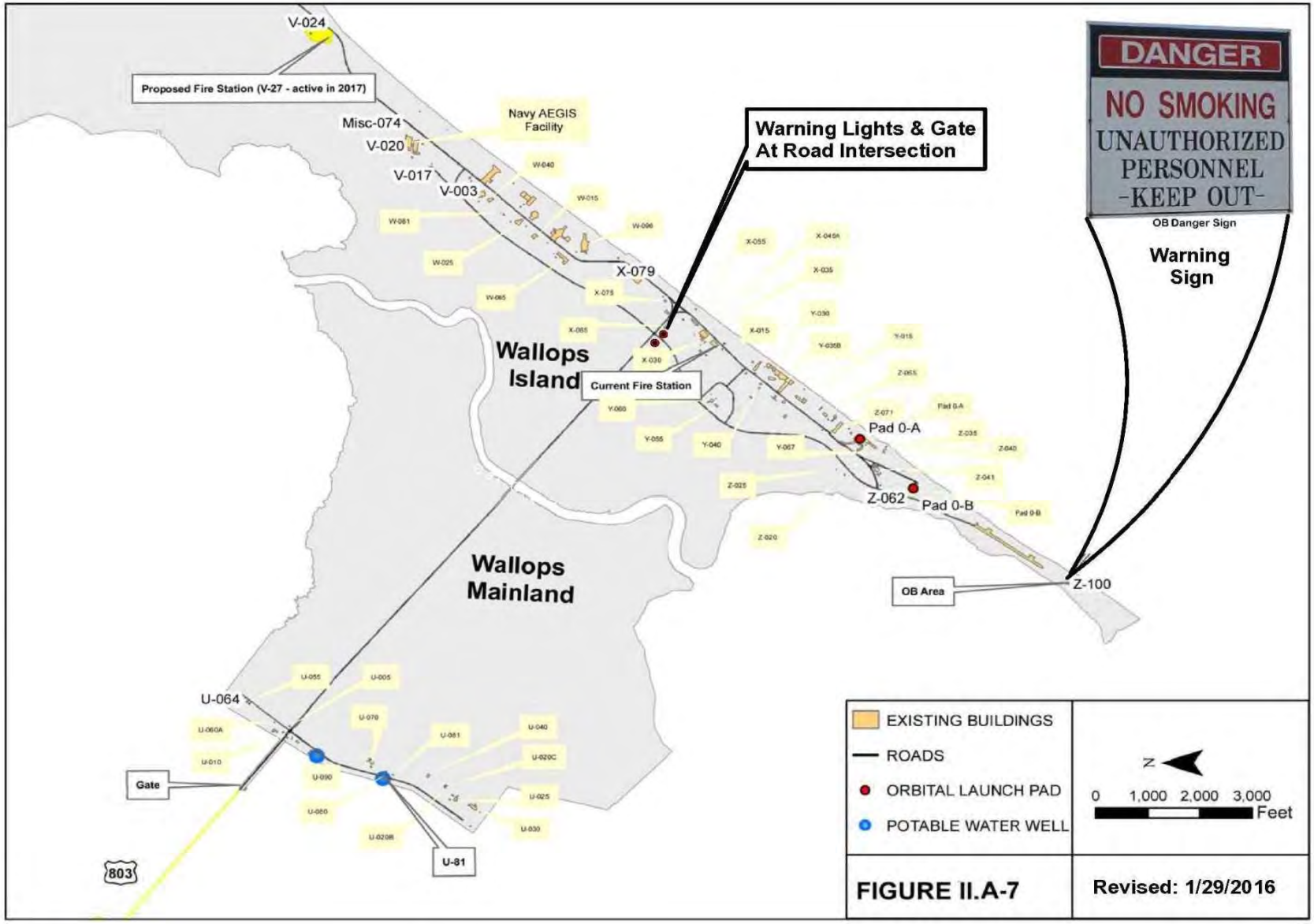
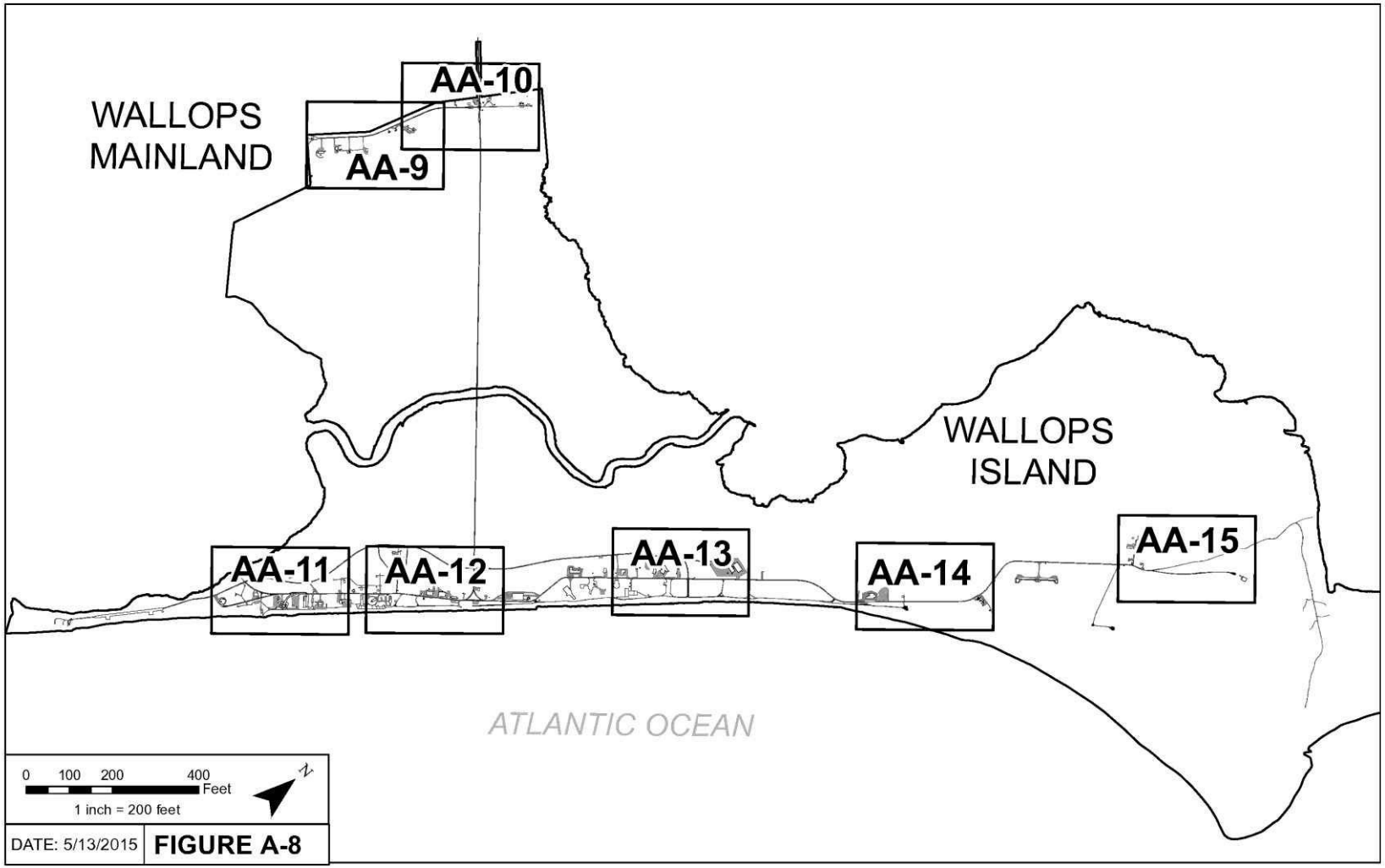
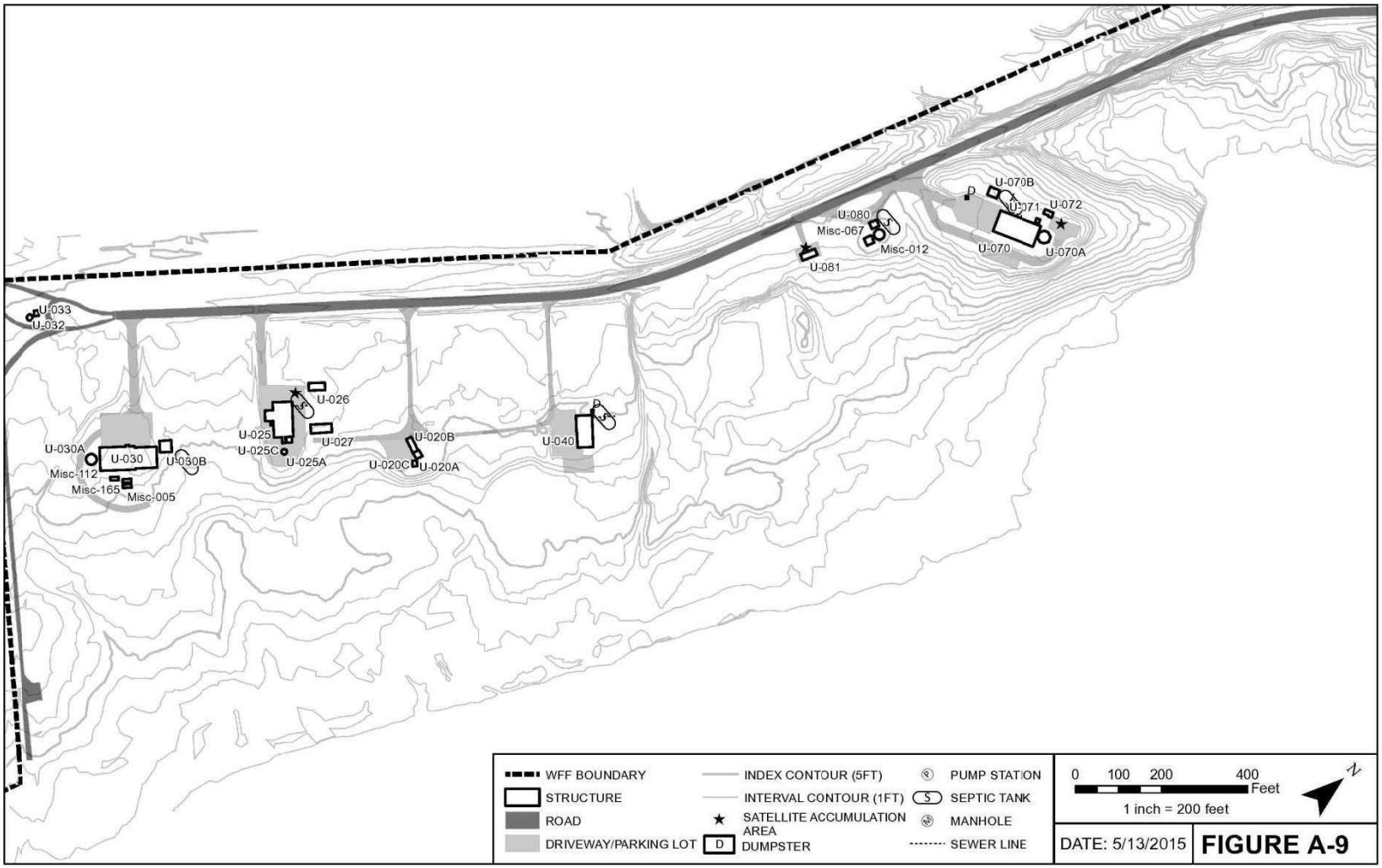

N
W
E
S
Salt Marsh
Hog Creek
UAS Runway
Wallops Island
NASA Wallops
OBOD Site
Latitude: 37-49-23.3 North
Longitude: 75-29-54.2 West
NASA Wallops
Property Boundary
Zone VE (EL 10)
Zone VE (EL 11)
Atlantic Ocean
38
THE AREA CONTAINED WITHIN THE LIMITS OF THIS MAP LIES ENTIRELY WITHIN THE 100-YEAR FLOOD BOUNDARY AS SHOWN ON THE FEMA FLOOD INSURANCE RATE MAP 51001C0480F, DATED MARCH 16, 2009.
BY DEFAULT THIS AREA IS ALSO INCLUDED WITHIN THE 500-YEAR FLOOD BOUNDARY AS SHOWN ON THE AFOREMENTIONED FEMA MAP.
200 100 0 200 Feet
Map Created 5/15/2015

FIGURE II.A-5


FLOOD GATE
SEAWALL
N
0 500 1,000 2,000
Feet
1 inch = 2,000 feet
FIGURE II.A-6
CREATED: 5/15/2015


V-024
Proposed Fire Station (V-27 - active in 2017)
Misc-074
V-020
V-017
V-003
Navy AEGIS Facility
Warning Lights & Gate At Road Intersection
DANGER
NO SMOKING
UNAUTHORIZED PERSONNEL
-KEEP OUT-
OB Danger Sign
Warning Sign
X-079
Wallops Island
Current Fire Station
Pad 0-A
Z-062
Pad 0-B
OB Area
Z-100
Wallops Mainland
U-064
Gate
U-81
803
EXISTING BUILDINGS
ROADS
ORBITAL LAUNCH PAD
POTABLE WATER WELL
N
0 1,000 2,000 3,000 Feet
FIGURE II.A-7
Revised: 1/29/2016


WALLOPS
MAINLAND
AA-10
AA-9
WALLOPS
ISLAND
AA-11
AA-12
AA-13
AA-14
AA-15
ATLANTIC OCEAN
0 100 200 400
Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-8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Misc-112
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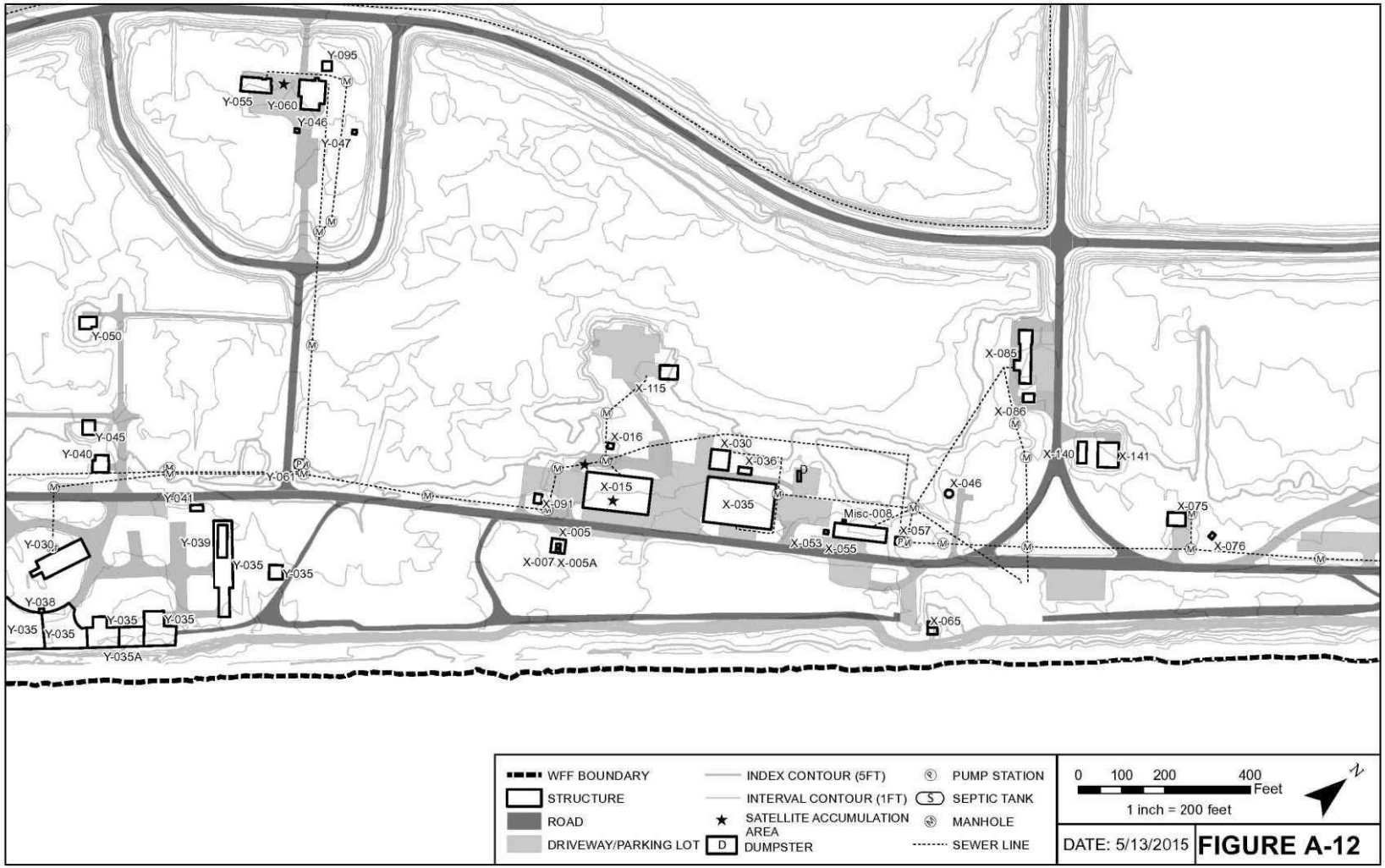
U-027
U-020B
U-020C
U-020A
U-040
U-081
U-080
Misc-067
Misc-012
U-070B
U-071
U-072
U-070
U-070A
WFF BOUNDARY
STRUCTURE
ROAD
DRIVEWAY/PARKING LOT
INDEX CONTOUR (5FT)
INTERVAL CONTOUR (1FT)
SATELLITE ACCUMULATION AREA
DUMPSTER
PUMP STATION
SEPTIC TANK
MANHOLE
SEWER LINE
0 100 200 400 Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-9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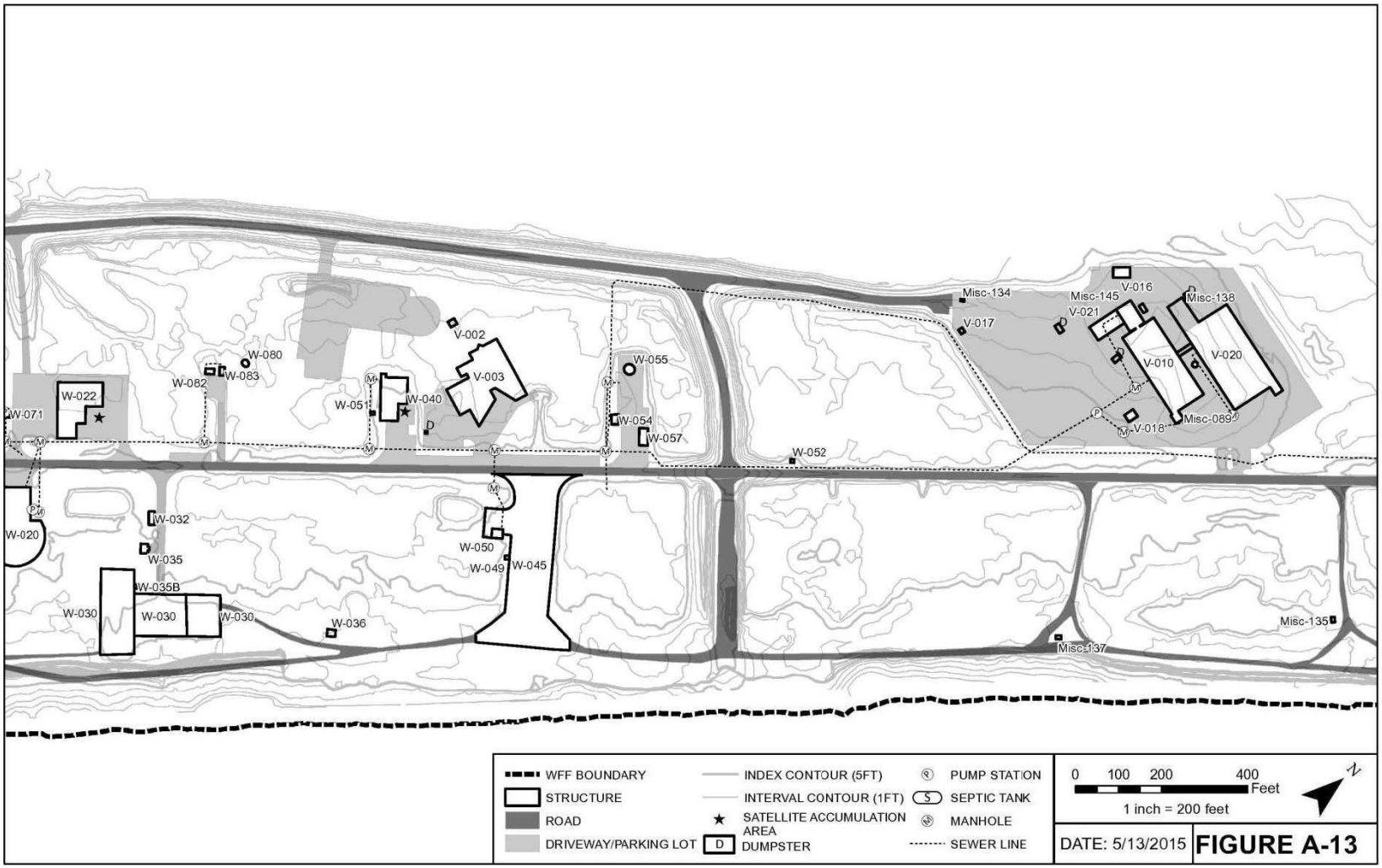
Y-038
Y-035A
X-115
X-016
X-015
X-091
X-005
X-007
X-005A
X-030
X-036
X-035
Misc-008
X-053
X-055
X-057
X-046
X-065
X-085
X-086
X-140
X-141
X-075
X-076
WFF BOUNDARY
STRUCTURE
ROAD
DRIVEWAY/PARKING LOT
INDEX CONTOUR (5FT)
INTERVAL CONTOUR (1FT)
SATELLITE ACCUMULATION AREA
DUMPSTER
PUMP STATION
SEPTIC TANK
MANHOLE
SEWER LINE
0 100 200 400 Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-12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W-020
W-080
W-082
W-083
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W-040
V-002
V-003
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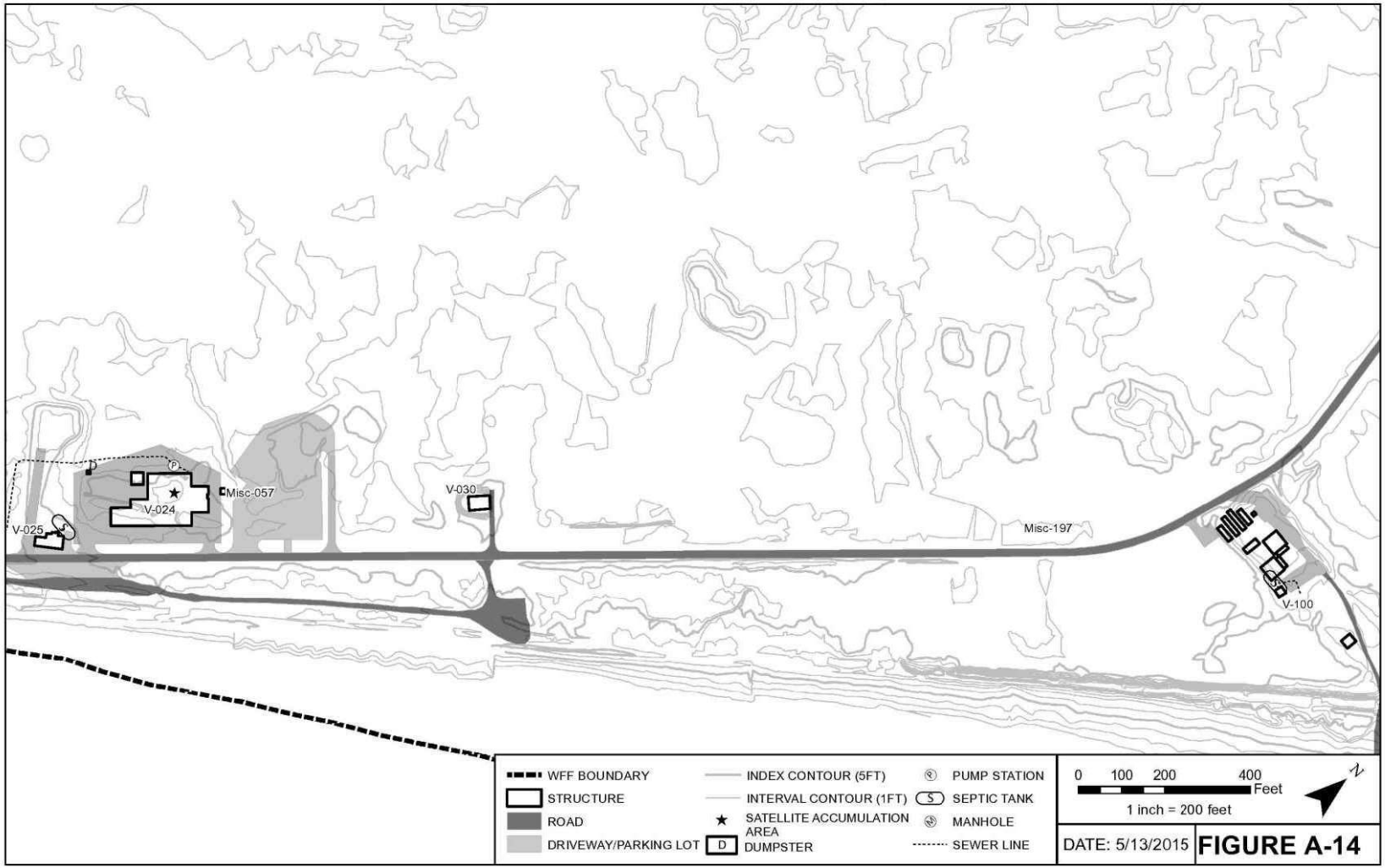
W-057
W-052
Misc-134
V-017
V-016
Misc-145
V-021
Misc-138
V-010
V-020
V-018
Misc-089
W-032
W-035
W-035B
W-030
W-036
W-050
W-049
W-045
Misc-137
Misc-135
WFF BOUNDARY
STRUCTURE
ROAD
DRIVEWAY/PARKING LOT
INDEX CONTOUR (5FT)
INTERVAL CONTOUR (1FT)
SATELLITE ACCUMULATION AREA
DUMPSTER
PUMP STATION
SEPTIC TANK
MANHOLE
SEWER LINE
0 100 200 400 Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-13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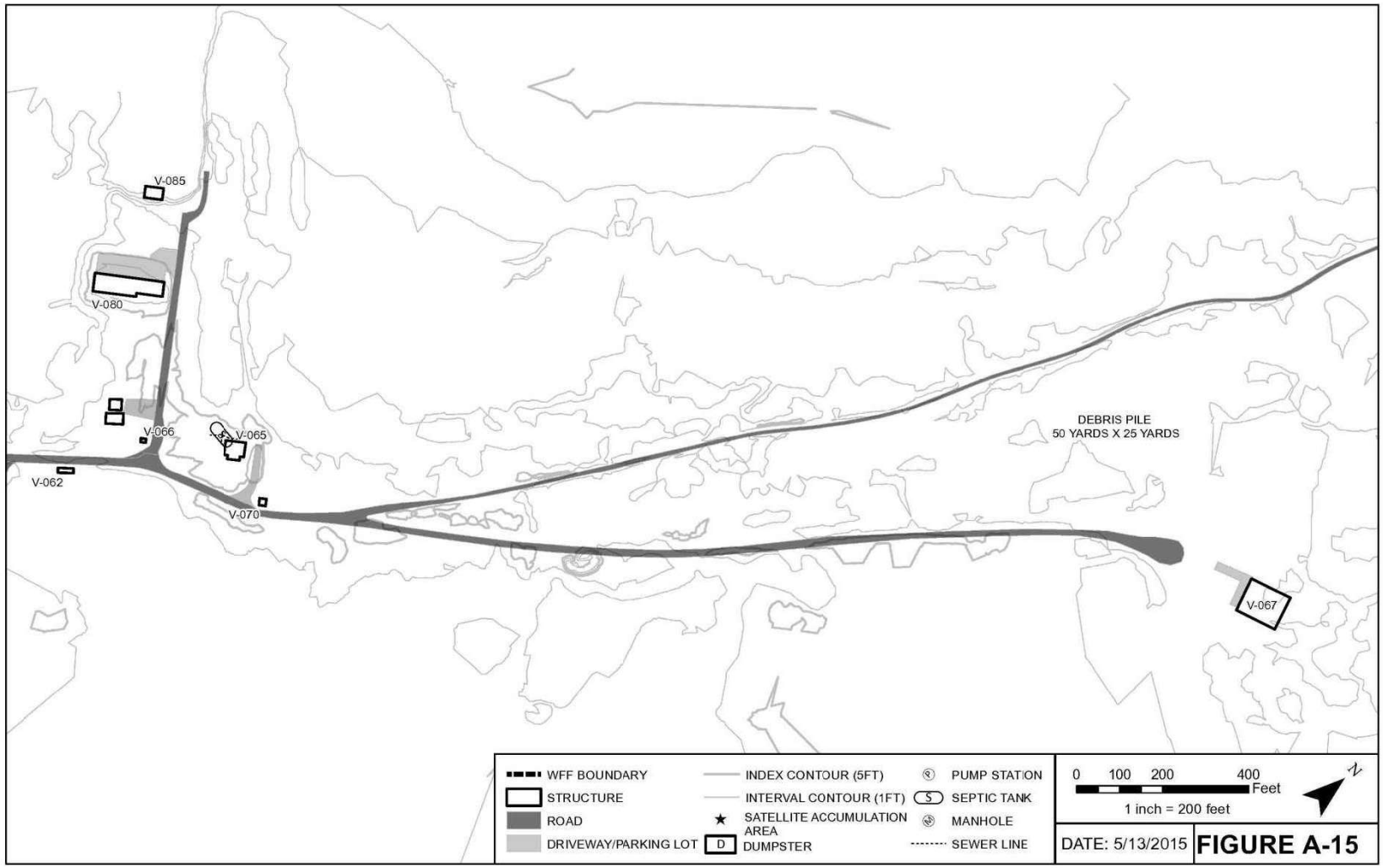
V-025
V-030
Misc-197
V-100
WFF BOUNDARY
STRUCTURE
ROAD
DRIVEWAY/PARKING LOT
INDEX CONTOUR (5FT)
INTERVAL CONTOUR (1FT)
SATELLITE ACCUMULATION AREA
DUMPSTER
PUMP STATION
SEPTIC TANK
MANHOLE
SEWER LINE
0 100 200 400 Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-14


V-085
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V-065
V-062
V-070
V-067
DEBRIS PILE
50 YARDS X 25 YARDS
WFF BOUNDARY
STRUCTURE
ROAD
DRIVEWAY/PARKING LOT
INDEX CONTOUR (5FT)
INTERVAL CONTOUR (1FT)
SATELLITE ACCUMULATION AREA
DUMPSTER
PUMP STATION
SEPTIC TANK
MANHOLE
SEWER LINE
0 100 200 400 Feet
1 inch = 200 feet
N
DATE: 5/13/2015
FIGURE A-15

ATTACHMENT II.B

WASTE ANALYSIS PLAN

ATTACHMENT II.B -WASTE ANALYSIS PLAN

II.B.1 Waste Analysis Plan

The Open Burning Area Waste Analysis Plan is used to gather information that will aid in:

- The safe treatment of propellants and igniters,
- Characterizing any residue remaining after OB treatment,
- Characterization of soil, and
- Subsequent handling, storing and disposing of residues.

The Open Burning Area Waste Analysis Plan, included in Exhibit II.B-1, contains Material Safety Data Sheets for the rocket motors to be open burned at WFF.

II.B.1.1 Additional Requirements for Waste Generated Offsite

Rocket motor propellants and igniters designated for thermal treatment may originate from storage buildings on the WFF Main Base or Wallops Island. Manifests and shipping documents will be inspected and reviewed to ensure that the materials received match the identity of the waste designated for thermal treatment. Rocket motor propellants and igniters are delivered directly to the OB area for burning. They are delivered to the OB area when scheduled for open burning. Rocket motor propellants and igniters are not stored at the OB area.

II.B.1.2 Additional Requirements for Ignitable, Reactive, or Incompatible Wastes

The waste propellants and igniters to be treated by OB are of similar composition and are compatible. The residue remaining after OB will be considered reactive until proven otherwise. The requirements for handling this material are stated in Attachment II.D - Procedures to Prevent Hazards.

EXHIBIT II.B-1

OPEN BURNING AREA
WASTE ANALYSIS PLAN

OPEN BURNING AREA
WASTE ANALYSIS PLAN

NASA GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337

EPA ID# VA7800020888

January 2017

EXHIBIT II.B-1: WASTE ANALYSIS PLAN

TABLE OF CONTENTS

1. INTRODUCTION II.B-2
1.1. Facility Description II.B-2
1.2. Process Description II.B-2
1.3. Quantity of Waste II.B-3
2. WASTE DETERMINATION II.B-3
2.1 Solid Waste Determination II.B-3
2.2 Hazardous Waste Determination II.B-4
3. WASTE CHARACTERIZATION II.B-4
4. ADDITIONAL REQUIREMENTS II.B-17
4.1 Additional Requirements for Waste Generated Off Site II.B-17
4.2 Additional Requirements for Ignitable, Reactive or Incompatible Wastes II.B-17
4.3 Land Disposal Requirements II.B-17
5. TREATMENT EFFECTIVENESS II.B-18
5.1. Suitability of Rocket Motors and Igniters for Open Burning II.B-18
5.2. Analysis of Post Treatment Wastes II.B-18
5.2.1. Parameters II.B-18
5.2.2. Sampling Methods II.B-19
5.2.3. Frequency of Analysis II.B-19
5.2.4. Historical Post Treatment Sampling II.B-19
6. WASTE MINIMIZATION PLAN II.B-20
APPENDIX A - MATERIAL SAFETY DATA SHEETS II.B-21
APPENDIX B - CERTIFICATES OF ANALYSES II.B-124
APPENDIX C: SOUNDING ROCKET MOTOR INSPECTION PROCESS II.B-153

1. INTRODUCTION

This Waste Analysis Plan is required as part of the Resource Conservation and Recovery Act (RCRA) Part B Permit for Thermal Treatment of rocket motor propellants and igniters at the National Aeronautics and Space Administration Goddard Space Flight Center's Wallops Flight Facility (NASA GSFC's WFF) located at Wallops Island, Virginia. At Wallops Island, NASA uses Open Burning (OB) as the preferred method of treatment for rocket propellants and igniters because of the highly reactive nature of these materials. This method is considered the safest treatment method and is conducted in a manner to minimize impacts to the environment. In addition to addressing the waste analysis requirements, specified under 40 Code of Federal Regulations (CFR) Parts 264 and 270, this document addresses the specific requirements of the Subpart X regulations for "Miscellaneous Units".

1.1. Facility Description

The OB Area located on the shoulder of the dike road at the southwestern corner of Wallops Island, consists of four subunits (ground embedded cylinders) and one open burn pad assembly. One subunit, subunit 1, is 0.6 meters (1.9 feet) in diameter, stands 0.8 meters (2.6 feet) above the ground surface, and is embedded 2.3 meters (7.5 feet) below the ground. One cylinder, Subunit 2, is 0.4 meters (1.4 feet) in diameter, stands 1.1 meters (3.5 feet) above the ground surface, and is embedded 2.2 meters (7.1 feet) below the ground surface. Subunit 3 is identical to Subunit 1. Subunit 4 is 0.7 meters (2.4 feet) in diameter, stands 1.10 meters (3.6 feet) above the ground surface, and is embedded 3.1 meters (10.2) feet below the ground surface. The subunits are covered when not in use to prevent entry and accumulation of precipitation. They also have concrete bases to prevent contact between constituents and subsurface soils. Subunit Assembly Drawings and Burn Pad Assembly Drawings can be found in Attachment II.H of the OB Permit. The OB pad assembly is 4.6 meters (15 feet) square by 46 centimeters (18 inches) thick concrete pad with a steel plate in the center for motor head attachment. Four cable tie downs are used to stabilize the motors.

1.2. Process Description

The rocket motor and igniter are placed inverted into a cylinder or attached to the pad motor head assembly. The igniter is set off by battery hook-up behind a protective barrier. The distance between the barrier and burn area is specified in a ground safety plan prepared for each type of rocket motor. Burned motors and igniters are inspected for visible signs of untreated material. If untreated material is present in the motor, then the motor is re-ignited or the material removed and re-ignited on the burn pad.

1.3. Quantity of Waste

The maximum amount of propellant to be disposed of per year is 30.4 metric tonnes (33.5 tons) based on Virginia Synthetic Minor Air Permit 40909. To date, the maximum amount of propellant burned in a year has been 20 metric tonnes (22 tons) in 1998 and 2013. Operationally up to eight small motors, i.e. Super Arcas, or 4 medium size motors, e.g. Taurus or Black Brant, could be burned in one day.

2. WASTE DETERMINATION

2.1 Solid Waste Determination

To minimize waste and decrease pollution, many alternative uses are investigated for each rocket motor, before being classified as a solid waste or characterized as a hazardous waste. All rocket motors at WFF are tracked by owner's name and organization. Rocket motors are kept in storage until they are needed for launch.

Prior to launching a sounding rocket, the rocket motor is inspected by contract personnel to determine if they meet contract performance standards. Rocket motors that do meet these performance standards are classified as flight worthy and are stored or used as part of a launch. Stored, flight worthy, rocket motors are also evaluated to determine if an overstock condition exists. The contractor may request permission from NASA to search for other users for overstock motors as described in the next paragraph. Rocket motors that do not meet contract performance standards may still be used on missions where minor flight performance is not an issue. Rocket motors designated for this type of mission, may also be returned to storage or used for a launch.

Another alternative for rocket motors, which do not meet performance standards, would be to request permission from NASA to remove them from contract inventory and to search for other users. NASA may deny this request because they have a current or future use for these rocket motors and thereby tracked in inventory as owner, NASA. These rocket motors will still be managed by the contractor and stored at the same location, but designated differently. Yearly, the contractor will request from NASA permission to search for other rocket motor users.

If this request is granted, the contractor will search for a new user until all prospects have been exhausted. If a user is found, the rocket motors will be transferred and shipped to the new user. When a user cannot be found for a rocket motor, the contractor will notify NASA and the Environmental Office. At this point, NASA will determine if they would like to test the rocket motor to evaluate it for other uses, return it to NASA inventory, or classify it as a solid waste. Although alternative methods have been researched, no other suitable method has been found to replace open burning and to meet the needs of WFF's rocket motor inventory. This analysis

entitled, Alternative Methods for Solid Rocket Disposal, has been included with the 2015 OB permit renewal application.

Accordingly, rocket motors classified as a solid waste will immediately be characterized as a hazardous waste, based on generator knowledge, dated, and scheduled for OB in less than 90 days.

2.2 Hazardous Waste Determination

The rocket motors and igniters are considered hazardous waste primarily because they meet the characteristic of reactivity. In 40 CFR § 261.23 (a) (6 and 8) defines reactivity as follows:

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(8) It is a forbidden explosive as defined in 49 CFR § 173.54, or a Division 1.1, 1.2, or 1.3 explosive as defined in 49 CFR § 173.50 and 173.53.

Rocket motors treated at the OB area are reactive because they are Class 1.1 through 1.3 explosives.

Certain rocket motors or igniters may also exhibit the toxicity characteristic for chromium (D007) or lead (D008) because based on their MSDS it is assumed that they would fail the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels found in 40 CFR § 261.24 Table 1.

3. WASTE CHARACTERIZATION

The general chemical constituents of typical propellants, igniters, and devices that are thermally treated at the OB Area is given in Table 1. Each item varies in the type and quantity of reactive constituents. Hazardous waste codes for individual constituents are listed in Table 1; however, U codes would not apply to the propellant mixtures containing these constituents. Applicability of Toxic waste codes D007 and D008 would depend on the percentage of the constituent in the propellant composition. The percent composition of the chemicals is proprietary/classified information and, therefore, not provided in most cases by the manufacturer.

Reactant formulations, which may be present in the various items treated by OB, are summarized in Tables 2 and 3. Typical rocket motors and igniters thermally treated at this facility and the amount of propellant in each rocket motor are summarized in Table 4.

Chemical analysis need not be performed because the wastes remain chemically unchanged from their formulation as a useful product. The material safety data sheets

(MSDS) or safety data sheets (SDS) describing these formulations are included in Appendix A. In addition, as stated in the Draft Final Open Burning/ Open Detonation Permitting Guidelines, February 2002, "Reactivity tests are dangerous to conduct and are not available commercially or at most Department of Defense (DoD) installations. In addition, it is generally dangerous, infeasible, or impractical to disassemble munition items to sample or test their energetic composition. Therefore, a facility may use generator knowledge to determine whether a waste is appropriate for OB treatment. If generator knowledge is used, the generator should demonstrate that the waste is explosive through means other than the use of test data. Documentation may consist of material safety data sheets (MSDS), chemical formulations, manufacturer specifications, or DoD documents that attest to the explosive nature of the material." Therefore, hazard characteristics analyses will not be performed to avoid the dangers associated with the handling of reactants.

Qualifications of those personnel shipping waste, accepting waste, and treating waste will be discussed in Attachment II.E Personnel Training of the WFF OB Area Permit.

Based on the information in Tables 1, 2, 3, 4, MSDS or SDS sheets, and inventory logs, the waste accepted for thermal treatment will be considered hazardous prior to treatment because of its reactivity characteristic. This information will be reviewed prior to treatment. If there is a question as to the suitability of a particular motor or igniter for OB, additional data will be gathered to resolve the issue. The rocket motor or igniter will be visually inspected prior to treatment to ensure that it can be safely and effectively treated. Those inspection procedures are found in Attachment II.C Inspections Schedule of the WFF OB Area Permit,

Table 1: Rocket Propellant and Igniter Constituents

Name	Chemical Formula	Hazardous Waste Codes
(Al) Aluminum Al	C8H8O8N8	D003
(AP) Ammonium Perchlorate	NH4ClO4	D003
Bis-Neopentyl Glycol Azelate	Proprietary Formula	Unlisted
(BPN) Boron Potassium Nitrate	BKNO3	D003
Candelilla wax	C13H64	Unlisted
Carbon Black	C	Unlisted
Circo Light Oil	C15H32	Unlisted
Copper chromate	CuCrO4 .2CuO .2H2O	D007
Cupric Oxide	CuO	Unlisted
(CTPB) Carboxy-terminated Polybutadiene	(C4H6)100C2H2O4	Unlisted
(DDI) Desmodour diiocyanate	C38H72N2O2	Unlisted
Dibutylphthalate	C16H22O4	U069
(DEP) Diethyl phthalate	C6H4(CO2C2H5)2	U088

Table 1: Rocket Propellant and Igniter Constituents

Name	Chemical Formula	Hazardous Waste Codes
Di Functional Aziridine	Proprietary Formula	Unlisted
Di(2-ethylhexyl) Adipate	C22H42O4	Unlisted
Di (Butoxyethoxy) Formal	C17H36O6	Unlisted
Diphenylguanidine	(C6H5NH)2C=NH	Unlisted
(DDI) Dimeryl Diisocyanate	C12H18N2O2	
Dioctyl Sebacate	(CH2)8(COOC8H17)2	Unlisted
Di-n-Propyl Adipate	C3H7OOC(CH2)4COOC3H7	Unlisted
(DMP) Dimethylaminomethyl- substituted phenols	C6H4OHCH2N(CH3)2	Unlisted
(DOA) Dioctyladipate	[CH2CH2COOH2CH(C2H5)C4H9]2	Unlisted
(DOS) Dioctylsebacate	(C4H8COOC8H17)2	Unlisted
(DOZ) Dioctyl azelate	C25H48O4	Unlisted
(DPA) di-n-propyl adipate	(C6H5)2 NH	Unlisted
(DTBHQ)2,5-Di-Tert-Butylhydroquinine	[(CH3)3C]2C6H2-1,4-(OH)2	Unlisted
Epon 812		Unlisted
Epoxy/(ERL 2795) Epoxy resin	-OCH2CHOCH2	Unlisted
Ethyloxyrane polymer		Unlisted
(FeAA) Iron acetylacetate	C15H21O6Fe	Unlisted
Ferric (iron) oxide	Fe2O3	Unlisted
(Flexzone-6H) n-phenyl-n'cyclohexyl-p-phenylenediamine	C18H22N2	Unlisted
(Flexzone/DTBH) Phenylene diamine/ hydroquinone	C6H4(NH2)2	Unlisted
Graphite	C	Unlisted
(HDI) 1 6-Hexamethylene Diisocyanate	C8H12N2O2	Unlisted
(HMX) "Her majesty's explosive", cyclotetramethylenetetranitramine	C4H8N8O8	D003
(HTPB) Hydroxy Terminated Polybutadiene	C73H110O6*	Unlisted
(HX-752) Propylene imine product of isophalic acid	CH2HCNHCH2	Unlisted
Hycar 1300 Synthetic elastomers	C70H100N3.5O1.5*	Unlisted
(IPDI) Isophorone diisocyanate	C12H18N2O2	Unlisted
Isophorone Diisocyanate Polymer with Hydroxyl Terminated Polybutadiene	C85H128N2O8	Unlisted
Isodecyl Pelargonate	C19H38O2	Unlisted
Laminac	Proprietary formula	Unlisted
(LBR) Lead beta-resorcylate	C14H10O8Pb	D008

Table 1: Rocket Propellant and Igniter Constituents

Name	Chemical Formula	Hazardous Waste Codes
Lead 2-ethyl hexoate	PbC5H11COOC2H4	D008
Lead salicylate	Pb(OOCC6H4OH)2.H2O	D008
Lead stearate	C36H70O4Pb	D008
(MAPO) tris 1-(2-methyl) aziridinyl phosphine oxide	C9H18N3OP	Unlisted
Magnesium	Mg	D003
Maleic Anhydride	C2H2(CO)2O	U147
Methylene Bis-Di-t-Butyl-P-Cresol	C15H24O	Unlisted
Monobasic copper salicylate	Cu(OOCC6H4ON)2.H2O	Unlisted
MT-4 bonding agent	Proprietary formula	Unlisted
(NC) Nitrocellulose	C12H16(ONO2)4 O6	D003
(2-NDPA) 2-nitrodiphenyl amine	C6H5NHC6H4NO2	Unlisted
(NDPA) n-phenyl-beta-napthylamine	C10H7NHC6H5	Unlisted
(NG) Nitroglycerin	C3H5N3O9	D003
(Ngu) Nitroguanidine	CH4N4O2	D003
Octylene oxide	Mixed CH3 (CH2) 5 CHCH2O & CH3 (CH2)4 CHCH(CH3)O	Unlisted
(Parabar 441) 2,6-di-tert-butyl-p-cresol	[C(CH3)3]2CH3C6H2OH	Unlisted
(PBAA) Polybutadiene acrylic acid	C70H104O4*	Unlisted
Pluracol TP	(C3H6O)n (C3H6O)n (C3H6 O)n C6H14O3	Unlisted
(PMAPO) bis 1-(2 methyl) aziridinyl phosphine oxide	C12H17N2OP	Unlisted
Poly 1,4-butylene glycol	HOCH2CH2CH2CH2OH	Unlisted
Polyether Polyol	H-(O-CH2-CH2)n-OH	Unlisted
(PPG) Polypropylene glycol	HO (C3H6O)n H	Unlisted
(PS) Polysulfide	[-CH2S2S2-]n	Unlisted
(PU) Polyurethane	R1NHCOOR2	Unlisted
(PVC) Polyvinylchloride	(-H2CCHCl-)x	Unlisted
Potassium perchlorate	KClO4	D003
1,2-Propanediol	C3H8O2	Unlisted
Quinone Dioxime	C6H6N2O2	Unlisted
(RDX) "Royal daughter's explosive", cyclotrimethyl- enetrinitramine	C3H6N6O6	D003
Resorcinol	C6H4(OH)2	U201
Sodium Nitrate	NaNO2	Unlisted
(S) Sulfur	S	Unlisted
(TA) Triacetin	C3H5(OCOCH3)3	Unlisted
(TDI) Toluene di isocyanate	CH3C6H3 (NCO)2	U223

Table 1: Rocket Propellant and Igniter Constituents

Name	Chemical Formula	Hazardous Waste Codes
(TEA) Triethanol amine	(HOCH2CH2)3N	Unlisted
Teflon resin	(C2F4)n	Unlisted
(TEPAN) Tetraethylene Pentamine Acrylonitrile	C14H32N6O2	Unlisted
Tri-(Monylphenyl) Pyosphite		Unlisted
Tricalcium phosphate	Ca3O8P2	Unlisted
(TPB) Triphenylbismuth	C18H15Bi	Unlisted
Vegetable Oil	C54H100O7	Unlisted
Viton A Copolymer	Proprietary Formula	Unlisted
Zinc Stearate	Zn (C18H35O2)2	Unlisted
(ZrC) Zirconium carbide	ZrC	Unlisted

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
2.75" FFAR MK40/MK66	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	Candelilla wax	Processing aid
	(DPA) di-n-propyl adipate	Plasticizer
	(LBR) Lead beta-resorcylate	Burn rate modifier
	Lead salicylate	Burn rate modifier
	Monobasic copper salicylate	Burn rate modifier
	(NC) Nitrocellulose	Binder/oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
Aerotek Hobby Motors	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
Apache	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(PU) Polyurethane	A class of binder material
Arcas	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(DOA) Dioctyladipate	Plasticizer
	(PVC) Polyvinylchloride	Binder
ATACM MK124	(Al) Aluminum	Metal fuel

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
Black Brant III	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(PU) Polyurethane	Binder
Black Brant MK Series	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
Black Brant Standard	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(DTBHQ)2,5-Di-Tert-Butyl Hydroquinine	
	(Flexzone-6H) n-phenyl-n'cyclohexyl-p-phenylenediamine	
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	MT-4 bonding agent	Binder
	Tricalcium phosphate	Anti-caking agent
	Triphenyl bismuth	Catalyst
Cajun	(AP) Ammonium perchlorate	Oxidizer
	(PS) Polysulfide	Binder
CRV-7/C14	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
CRV-7/C15 and C16	(Al) Aluminum	Metal fuel
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
Improved Malemute	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	Ferric Oxide	Catalyst
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(HX-752) Propylene imine product of isophalic acid	Binder
	(IPDI) Isophorone diisocyanate	Curative
Improved Orion	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HDI) 1,6 Hexamethylene Diisocyanate	Liner
	(Ngu) Nitroguanidine	Oxidizer

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
	1,2-Propanediol	Binder
	Bis-Neopentyl Glycol Azelate	
	Ethyloxyrane polymer	
	Isodecyl Pelargonate	Plasticizer
	Pluracol TP	Binder
	Poly-1-4-butylene glycol	Processing agent
	Polyether Polyol	Binder
Javelin III	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(MAPO) tris 1-(2-methyl) aziridinyl phosphine oxide	Curative
	(Parabar 441) 2,6-di-tert-butyl-p-cresol	Processing aid
	(PBAA) Polybutadiene acrylic acid copolymer	Binder
	(PMAPO) bis 1-(2-methyl) aziridinyl phenyl phosphine oxide	Curative
	Circo light oil	Plasticizer
Lance	(AP) Ammonium perchlorate	Oxidizer
	(PS) Polysulfide	Binder
Lynx MK 104	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HMX) "Her majesty's explosive", cyclotetra-methylenetetranitramine	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
M26	(Al) Aluminum	Metal fuel
	Ammonium Perchlorate	Oxidizer
	Di(2-ethylhexyl) Adipate	Plasticizer
	Ferric Oxide	Catalyst
	Isophorone Diisocyanate Polymer with Hydroxy Terminated Ploybutadiene	Curative/Binder
	Maleic Anhydride	Catalyst
	(TEPAN) Tetraethylene Pentamine Acrylonitrile	Sorbent
	Triphenyl Bismuth	Catalyst
M37A1/E1 Spin Motors	Candelilla wax	Processing aid
	Carbon black	Burn rate modifier
	(DEP) Diethyl phthalate	Plasticizer
	Lead salicylate	Burn rate modifier
	(LBR) Lead beta-resorcylate	Burn rate modifier
	(2-NDPA) 2-nitrodiphenylamine	Stabilizer

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
	(NC) Nitrocellulose	Binder/oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
M37A1 Regrain Spin Motor	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
M57A1	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HMX) "Her majesty's explosive," cyclotetra-methylenetetranitramine	Explosive
	(NC) Nitrocellulose	Binder / oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
	Resorcinol	Plasticizer
Malemute	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(DDI) Desmodour diisocyanate	Curative
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(HX-752) Propylene imine product of isophthalic acid	Bonding agent
MK 12 Terrier	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	(Al) Aluminum	Metal fuel
	(LBR) Lead beta-resorcylate	Burn rate modifier
	(NC) Nitrocellulose	Binder / oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
	Carbon black	Burn rate modifier
	Graphite	GlazeStabilizer
	Lead salicylate	Burn rate modifier
	Lead 2-ethyl hexoate	Burn rate modifier
MK 70 Terrier	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	Dioctyl Adipapte	Binder
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(IPDI) Isophorone Diisocyanate	Curative
Nihka	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
Nike	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	(DMP) Dimethylaminomethyl- substituted phenols	Curing agent
	Graphite	Stabilizer
	Lead stearate	Stabilizer
	(NC) Nitrocellulose	Binder/oxidizer
	(NG) Nitroglycerin	Plasticizer/oxidizer
	(TA) Triacetin	Plasticizer
Oriole	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	Di Functional Aziridine	Binder
	Dimeryl Diisocyanate	Curative
	Dioctyl Sebacate	Plasticizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	Maleic Anhydride	Catalyst
	Methylene Bis-Di-t-Butyl-P-Cresol	Stabliizer
	Tri-(Monylphenyl) Pyosphite	Stabliizer
	Triphenyl Bismuth	Catalyst
Orion	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(Ngu) Nitroguanidine	Oxidizer
	(PU) Polyurethane	Binder
Peregrine	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(DCDA) Dicyandiamide/Cyanoguanidine	Heat Producer
	(DOA) Dioctyladipate	Plasticizer
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(TPB) Triphenylbismuth	Catalyst
Sidewinder	(AP) Ammonium perchlorate	Oxidizer
	(DDI) Desmodour diisocyanate	Curative
	(DOA) Dioctyladipate	Plasticizer
	(Flexzone/DTBH) Phenylene diamine/hydroquinone	Bonding agent
	(HTPB) Hydroxy Terminated Polybutadiene	Binder
	(HX-752) Propylene imine product of isophthalic acid	Bonding agent
	(RDX) "Royal daughter's explosive", cyclotrimethyl- enetrinitramine	Oxidizer
	(ZrC) Zirconium carbide	Refractory Coating
Star 3	(Al) Aluminum	Metal fuel

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
(MERS TIRS)		
	(AP) Ammonium perchlorate	Oxidizer
	(CTPB) Carboxy-terminated Polybutadiene	Binder
	Ferric Oxide	Catalyst
Star 6B	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(CTPB) Carboxy-terminated Polybutadiene	Binder
Star 20	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(CTPB) Carboxy-terminated Polybutadiene	Binder
Super Arcas	(AP) Ammonium perchlorate	Oxidizer
	(PVC) Polyvinylchloride	Binder
Super Loki	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(PS) Polysulfide	Binder
Talos	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	Lead 2-ethyl hexoate	Burn rate modifier
	Lead salicylate	Burn rate modifier
	(NC) Nitrocellulose	Binder / oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
Taurus	Candelilla wax	Processing aid
	Di-u-Propyl Adipate	Plasticizer
	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	(LBR) Lead beta-resorcylate	Burn rate modifier
	(NC) Nitrocellulose	Binder / oxidizer
	(NG) Nitroglycerin	Plasticizer / oxidizer
	(TA) Triacetin	Plasticizer
Tomahawk	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	(CTPB) Carboxy-terminated Polybutadiene	Binder
	Ferric (iron) oxide	Burn rate modifier
Ute I	(AP) Ammonium perchlorate	Oxidizer
	(PS) Polysulfide	Binder
Viper	(Al) Aluminum	Metal fuel
	(AP) Ammonium perchlorate	Oxidizer
	Copper chromite	Burn rate modifier
	Dibutylphthalate	Plasticizer
	(DOS) Dicotylsebacate	Plasticizer
	Diphenyquanadine	Catalyst

Table 2: Chemical Composition of Rocket Motors to be Thermally Treated

Rocket Motor	Propellant Composition	Action
	Epon 812	Processing aid
	(ERL 2795) Epoxy resin	Binder
	Hycar 1300, TM for various types of synthetic elastomers	Plasticizer
	Magnesium Oxide	Burn rate modifier
	(KClO4) Potassium perchlorate	Oxidizer
	(Parabar 441) 2,6-di-tert-butyl-p-cresol	Processing aid
	Octylene oxide	Plasticizer
	Quinone dioximine	Curative
	Sulfur	Catalyst
Zuni	(2-NDPA) 2-nitrodiphenylamine	Stabilizer
	(Al) Aluminum	Metal fuel
	Candelilla wax	Processing aid
	Carbon black	Burn rate modifier
	(DPA) Di-n-propyl adipate	Plasticizer
	(LBR) Lead beta-resorcylate	Burn rate modifier
	Lead salicylate	Burn rate modifier
	Monobasic copper salicylate	Burn rate modifier
	(NC) Nitrocellulose	Binder / oxidizer
	(NG) Nitroglycerin	Plasticizer/oxidizer
	(TA) Triacetin	Plasticizer

Table 3: Chemical Composition of Igniters and Devices to be Thermally Treated

Item	Propellant Composition	Action
Arcas Igniter	(BPN) Boron Potassium Nitrate	Oxidizer
Aerojet Jr. Igniter	(Al) Aluminum	Metal Fuel
	(AP) Ammonium Perchlorate	Oxidizer
	Vegetable Oil	Binder
Black Brant Igniter	(AP) Ammonium Perchlorate	Oxidizer
	(BPN) Boron Potassium Nitrate	Fuel and Oxidizer
	(DOS) Dicotylsebacate	Plasticizer
Improved Malemute Igniter	(BPN) Boron Potassium Nitrate	Fuel and Oxidizer
Javeline III Igniter	(Al) Aluminum	Metal Fuel
	Cupric Oxide	Catalyst
Lance Igniter	T	
Malemute Igniter	(BPN) Boron Potassium Nitrate	Fuel and Oxidizer
MK12 and MK70	(BPN) Boron Potassium Nitrate	Fuel and Oxidizer

Table 3: Chemical Composition of Igniters and Devices to be Thermally Treated

Item	Propellant Composition	Action
Terrier Igniter		
NASA Tracking Flare	Laminac	Plasticizer
	Magnesium Powder	Metal Fuel
	Sodium Nitrate	Oxidizer
	Teflon Resin	Oxidizer
	Viton A Copolymer	Binder
Orion Igniter	(AP) Ammonium Perchlorate	Oxidizer
	(BPN) Boron Potassium Nitrate	Oxidizer
	Di(Butoxyethoxy) Formal	Curative
	Diphenly-Guanidine	Curative
	Iron Oxide	Burn rate modifier
	Magnesium Oxide	Burn rate modifier
	Polysulfide	Binder
	Quinone Dioxime	Curative
	Sulfur	Catalyst
Star 20 Igniter	(Al) Aluminum	Metal Fuel
	(AP) Ammonium Perchlorate	Oxidizer
	(BPN) Boron Potassium Nitrate	Oxidizer
	(CTPB) Carboxy-terminated Polybutadiene	Binder
Super Loki Igniter	Aluminum	Metal Fuel
	Cupric Oxide	Catalyst
Tomahawk Igniter	Same as Orion	
UTE Igniter	T	

T – Thermal Igniter

Table 4: Rocket Motors and Igniters to be Thermally Treated at WFF OB Unit

Motor	Propellant (lbs.)	Length (in.)	Diameter (in.)
2.75" FFAR MK40	5.9	48	2.75
2.75" FFAR MK66	7.2	50	2.75
Aerotek Hobby Motors	0.5	1.8	1.5
Apache	131	107.5	7
Arcas	65	60.7	4.45
Arcas Igniter	<1	1.9	1.3
Aerojet Jr Igniter	0.62	3	2
ATACM MK124	1,600	79	24
Black Brant III	447	147	10.2
Black Brant MK Series	2,198	223	17.2

Table 4: Rocket Motors and Igniters to be Thermally Treated at WFF OB Unit

Motor	Propellant (lbs.)	Length (in.)	Diameter (in.)
Black Brant Standard	2,198	223	17.2
Black Brant Igniter	1.5	8	1.5
Cajun	118.5	107.7	7
CRV-7/C14	10.2	31	2
CRV-7/C15 and C16	10.2	31	2
Improved Malemute	1106	130	16
Improved Malemute Igniter	3	6	3
Improved Orion	647	105.5	14
Javelin III	258	104	9
Javeline III Igniter	0.5	2	1
Lance	2,800	246	21.6
Lance Igniter	2	3	1.5
Lynx MK 104	795	113	13.5
M26	216	78	9
M37 Spin Motor	2	13.5	3.75
M37 Regrain Spin Motor	3	13.5	3.75
M57A1	3,665.2	85.25	38
Malemute	1,115	114	17.25
Malemute Igniter	3	6	3
MK12 Terrier	1202	155	18
MK 70 Terrier	1500	155	18
MK12 and MK70 Terrier Igniter	1.87	9	7.5
NASA Tracking Flare	<1	1.9	1.3
Nihka	756	76	17.2
Nike	750	145.2	16.5
Oriole	2,148	155	22
Orion	604	105.5	14
Orion Igniter	2	6	2
Peregrine	2950	220	20
Sidewinder	60	75.5	5
Star 3A (MER TIRS)	1.0	7.5	3.2
Star 6B	13.5	17	6.5
Star 20	602	58.5	19.7
Star 20 Igniter	1.5	5	2
Super Arcas	40	76	4.5
Super Loki	38	78.1	4
Super Loki Igniter	0.25	2	1
Talos	2,803	134.5	30.9

Table 4: Rocket Motors and Igniters to be Thermally Treated at WFF OB Unit

Motor	Propellant (lbs.)	Length (in.)	Diameter (in.)
Taurus	1,663	166.125	23
Tomahawk	387	142	9
Tomahawk Igniter	4	3	4
Ute I	550	77	16.5
Ute Igniter	0.5	4	3
Viper	148.8	107	6.5
Zuni	50	176.5	5

4. ADDITIONAL REQUIREMENTS

4.1 Additional Requirements for Waste Generated Off Site

Rocket motor propellants and igniters designated for thermal treatment may originate from storage buildings on the WFF Main Base or Wallops Island. Manifests and shipping documents are inspected and reviewed to ensure that the hazardous waste rocket motor received at the Open Burning Area match the shipping name on the accompanying manifest and shipping documents.

4.2 Additional Requirements for Ignitable, Reactive or Incompatible Wastes

The waste propellants/igniters to be treated by OB at WFF are of similar composition and are compatible. The residue remaining after OB will be considered reactive unless chemical analysis proves otherwise. The requirements for handling this material are stated in Section F - Procedures to Prevent Hazards of the WFF OB Area Permit.

4.3 Land Disposal Requirements

Generator knowledge and MSDS are used to classify the rocket motors as reactive hazardous waste. Reactive hazardous wastes are a restricted waste banned from land disposal until they have been treated effectively. Open Burning is designed to effectively treat hazardous waste. The treatment standard, as described in 40 CFR § 268.40 for D003, Explosives Subcategory, non-wastewaters, is deactivation and meeting 40 CFR § 268.48 universal treatment standards. If universal treatment standards cannot be met for underlying hazardous constituents, residue will be disposed of as a hazardous waste off site. Land Disposal Restriction Notification will accompany each hazardous waste manifest.

5. TREATMENT EFFECTIVENESS

Rocket motors are designed for complete combustion of all products. Typically, after OB treatment is complete, no materials remain in the motor or are expelled from the motor. The OB Area will be visually examined after each use to verify that no materials were ejected. If materials are expelled they will be collected for further OB treatment. The OB Area Contingency Plan found in Attachment II.F of the OB Area Permit details these procedures. Rocket motor casings and igniters will be inspected for visible signs of untreated material. The primary constituents of the residue (if present) after thermal treatment will be trace amounts of reactant material and, in some cases, propellant sealant. The residue will be removed and re-ignited on the burn pad. The process will be repeated until thermal treatment is complete.

5.1. Suitability of Rocket Motors and Igniters for Open Burning

Open burning is designed to be used as a treatment option for those waste energetics that would result in a subsonic chemical transformation process (no detonation) and is consistent with the materials open burned at WFF.

5.2. Analysis of Post Treatment Wastes

OB treatment is typically complete so that no materials remain in the motor or are expelled from the motor. The OB Area will be visually examined after each use to verify that no materials were ejected. If materials are expelled they will be collected for further OB treatment. Rocket motor casings and igniters will be inspected for visible signs of untreated material. The primary constituents of the residue (if present) after thermal treatment will be trace amounts of reactant material and, in some cases, propellant sealant. The residue will be removed and re-ignited on the burn pad. The process will be treated until thermal treatment is complete. Any unburnable material is to be containerized, sampled for characterization, if necessary, in accordance with 40 CFR § 261 and the OB Area Waste Analysis plan, and disposed of through WFF's hazardous waste disposal contractor. The container will be stored at Building U-81, less-than-90-day-accumulation area for less than 90 days.

5.2.1. Parameters

Open Burn post treatment residues may have hazardous waste characteristics or characteristics of concern that should be identified. Table 5 identifies target constituents and methods for post treatment waste analysis. The current SW-846 method in Table 5 below will be used unless a revised method has been promulgated by EPA. Only the individual metal Toxic Characteristic Leaching Procedure (TCLP) analysis will be performed as warranted by the propellant constituents. Dioxins, furans and perchlorates will be analyzed on those rocket motors with a perchlorate based fuel. Dioxins and furans are potential emission products associated with the treatment of chlorinated propellants.

Table 5: Post Treatment Test Procedures

Parameter	Method Number	Mass
TCLP metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver)	SW-846 1311/6010D/7000B	1000 grams
Energetics (to determine total energetic concentration relative to 12% explosive criterion)	SW-846 8330A/8332/8321B/ 8095	100-500 grams
Dioxins/Furans (applicable for chlorinated wastes)	SW-846 1311 and 8290A /8270D	100-500 grams
Perchlorates	EPA 314/ SW-846 6850	100-500 grams

Source: Draft Final Open Burning/ Open Detonation Permitting Guidelines, February 2002.

5.2.2. Sampling Methods

Residue samples will be grab samples collected using non-sparking sampling equipment and placed into laboratory provided sampling containers.

5.2.3. Frequency of Analysis

When residues or ash remain after OB operations, post treatment analyses will be conducted at least annually on each different type of rocket motor residue or ash.

5.2.4. Historical Post Treatment Sampling

In the past, only Taurus rocket motors have not burned completely. Based on qualitative observations of residue present after OB operations, treatment of all other rocket motors has been 100 percent effective. In the last 10 years only Taurus residue has been available in sufficient quantities to conduct a series of analysis. The residue was analyzed for metals, semi volatiles, and volatiles. Detected results of analysis are shown below in Table 6. Certificates of Analyses are included in Appendix B.

Table 6: Historical Post Treatment Residue Sampling

Sample Date	Rocket Motor	Analyte	Method	Result	Reporting Limit
11/26/2001	Taurus	nitroglycerin	SW846 8332	6.2 mg/kg	5.0 mg/kg
11/26/2001	Tomahawk	perchlorate	EPA-DW1 314.0	49000 ug/kg	1000 ug/kg

12/3/2003	Taurus	nitocellulose	IAAP	120 mg/kg	15 mg/kg
12/3/2003	Taurus	Flash Point	SW846 1010	BQL	20 C
12/3/2003	Taurus	lead	SW846 6010B	14000 ug/L	100 ug/L
12/3/2003	Taurus	nitroglycerine	SW846 8330	440000 ug/kg	10000 ug/L
12/3/2003	Taurus	cyanide,reactive	SW846 9014R	0.070 mg/kg	0.020 mg/kg
12/3/2003	Taurus	sulfide,reactive	SW846 9034R	BQL mg/kg	9.6 mg/kg
11/1/2013	Taurus	barium	EPA 6010C	0.216 mg/L	0.0100 mg/L
11/1/2013	Taurus	cadmium	EPA 6010C	1.06 mg/L	0.0100 mg/L
11/1/2013	Taurus	chromium	EPA 6010C	0.673 mg/L	0.0100 mg/L
11/1/2013	Taurus	lead	EPA 6010C	6.42 mg/L	0.0100 mg/L

6. WASTE MINIMIZATION PLAN

Waste will be minimized at the OB Area through the extensive process of determining other uses for each rocket motor. As discussed on page C-1, rocket motors, which do not meet contractor performance standards, may be used on missions where minor flight performance is not an issue.

NASA may also use rocket motors on university, student, or other missions. They may be tested to determine the extent of deviation from performance standards. Other users will also be found for rocket motors. In addition, many times rocket motors manufactured by commercial manufacturers can be returned.

Table 7: Summary of OB Operations 2005 - 2014

Year	Rocket Motor Types	N.E.W (lbs)
2005	7 Orion, 2 Nike, 50 Spin Motors, Residue	6,174
2006	No burns	0
2007	6 Improved Orions, 1 Terrier Igniter	1942
2008	1 Arcas, 6 Nike, trimmings	4,850
2009	6 Nike	4,800
2010	2 Super Loki, trimmings	150
2011	No burns	0
2012	1 Orion, 1 Nike	1,425
2013	4 Orion, 25 Taurus	44,175
2014	No burns	0
2015	4 M-37 Spin Motors	8

APPENDIX A - MATERIAL SAFETY DATA SHEETS

[redacted] [redacted] 2.75 FFAR Test Rocket

#1 (#3)

MATERIAL SAFETY DATA SHEET

HERCULES

Page 1 of 3

CHEMICAL NAME N/A
SYNONYMS: N/A
FORMULA: N/A
TRADE NAME AND SYNONYMS: Grade 4 NOSIH-AA-2 Standard

REGULAR TELEPHONE NO. (703)639-7294
EMERGENCY TELEPHONE NO
CHEMICAL FAMILY Double Base Propellant
MOLECULAR WEIGHT

I. PHYSICAL DATA

BOILING POINT, 760mm. Hg N/A
FREEZING POINT N/A

SPECIFIC GRAVITY (H20 = 1) 1.6170
VAPOR PRESSURE @ °C. Negligible

VAPOR DENSITY (AIR = 1) N/A
SOLUBILITY IN WATER, % BY WT @ °C Negligible

PERCENT VOLATILES BY VOLUME N/A
EVAPORATION RATE (BUTYL ACETATE = 1) less than 1

APPEARANCE AND ODOR Flat sheet, brownish in color

II. HAZARDOUS INGREDIENTS

MATERIAL	%	TLV (UNITS)
Nitrocellulose (flammable solid)	51.0	Not established
Nitroglycerin (skin)	38.6	0.05 PPM*
2-Nitrodiphenylamine	2.0	Not established
Di-α-Propyl Adipate	1.6	Not established
Triacetin	2.7	Not established
Lead - Copper - Resorcylate - Salicylate	4.0	Not established
Candelilla Wax	0.1	Not established

Note: *OSHA PEL = 0.20 PPM (ceiling)

III. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (TEST METHOD) N/A
AUTOIGNITION TEMPERATURE 396.5oF

FLAMMABLE LIMITS IN AIR, % BY VOLUME LOWER N/A UPPER N/A

EXTINGUISHING MEDIA: Self-oxidizing; deluge with water. May not be able to extinguish before all material has been consumed unless large quantities of water are used in very short time period.

SPECIAL FIRE FIGHTING PROCEDURES: Evacuate the area

UNUSUAL FIRE AND EXPLOSION HAZARDS: Easily ignited, highly combustible; protect from fire, sparks and extreme heat

HERCULES INCORPORATED
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

MATERIAL SAFETY DATA SHEET

MSDS:
DATE:
PAGE: 3 of

TRADE NAME: PROPELLANT NOSIH-AA-2 STANDARD

IX SPECIAL PRECAUTIONS
PRECAUTIONARY LABELING:

Labeled and packaged in accordance with the Hazardous Materials Regulations of the Department of Transportation for Class B Explosives.

WARNING: FLAMMABLE Solid
Keep away from heat, sparks, and open flame.
Keep containers closed.
Use with adequate ventilation.

FIRST AID:

EYES: In case of contact, immediately flush with plenty of low pressure water for at least 15 minutes. Remove any contact lenses to assure thorough flushing. Call a physician.

Wash with soap and running water.

INHALATION: Remove to fresh air. Treat any irritation symptomatically. Call a physician.

OTHER HANDLING AND STORAGE CONDITIONS:
Storage also must conform to local, state and Federal Regulations including OSHA - 29CFR 1910.109 and BATF, 27CFR55, Subpart K.

2.75" FFAR

Manufacturer: Naval Ordnance Station, Indian Head, MD and
BEI Defense Systems, Camden, AR
System Prime Contractor: US Army Missile Comd, Redstone Arsenal, AL (Mod 1)
Ships Parts Control Ctr, Mechanicsburg, PA (Mod 2)
Sponsoring Agency: Naval Air Systems Command, Washington, DC
Application: Air-to-Ground Rocket

PRINCIPAL DATA

DOT-ICC/Military Explosives Hazard Class; Motor:	Class B/1.3
Igniter:	Class B/1.3
Propellant:	Class B/1.3
Overall Length:	1.062 m (41.8 in.)
Maximum Diameter:	70.9 mm (2.79 in.)
Principal Diameter:	69.9 mm (2.75 in.)
Operational Temperature Limits:	228 to 339 K (-50 to 150°F)
Storage Temperature Limits:	219 to 344 K (-65 to 160°F)
Acceleration Limits at 298 K (77°F); axial:	90 g
Mass Properties:	
case assembly	1.225 kg (2.70 lbm)
nozzle assembly	1.134 kg (2.50 lbm)
igniter and S/A assembly	22.7 g (0.05 lbm)
restrictor	227 g (0.50 lbm)
other inert parts	317 g (0.70 lbm)
total inert mass	2.93 kg (6.45 lbm)
propellant mass, m_p	3.24 kg (7.15 lbm)
motor gross mass	6.17 kg (13.60 lbm)
Propellant Mass Fraction:	0.526
Center of Gravity from Forward End; loaded:	579 mm (22.8 in.)
expended:	663 mm (26.1 in.)
Nominal Operating Altitude:	152 m (500 ft)

BALLISTIC PERFORMANCE (sea level)

	Temperature		
	228 K (-50°F)	298 K (77°F)	339 K (150°F)
Burning Time:	1.0 s	0.97 s	0.9 s
Action Time:	1.1 s	1.07 s	1.0 s

Distribution authorized to U.S. Government agencies only; administrative/operational use; February 1989. Other requests for this data shall be referred to Naval Surface Warfare Center, Indian Head MD 20640-5000.

Published by The Johns Hopkins University, Chemical Propulsion Information Agency (CPIA), 10630 Little Patuxent Parkway, Suite 202, Columbia, MD 21044-3200.

BALLISTIC PERFORMANCE (sea level) (Continued)

	Temperature		
	228 K (-50°F)	298 K (77°F)	339 K (150°F)
Maximum Pressure, P_{max}:	11.514 MPa (1670 psia)	12.24 MPa (1775 psia)	12.65 MPa (1835 psia)
Average Pressure:	9.31 MPa (1350 psia)	9.82 MPa (1425 psia)	10.62 MPa (1540 psia)
Maximum Thrust, F_{max}:	7.67 kN (1725 lbf)	8.01 kN (1800 lbf)	8.23 kN (1850 lbf)
Average Thrust:	5.96 kN (1340 lbf)	6.29 kN (1415 lbf)	6.78 kN (1525 lbf)
Total Impulse: kN•s (lbf-sec)	6.56 (1475)	6.74 (1515)	6.78 (1525)
Propellant Delivered Specific Impulse: $I_{spd} = I/m_p$: (lbf-sec/lbm)	2.020 kN•s/kg (206)	2.079 kN•s/kg (212)	2.088 kN•s/kg (213)

COMPONENT DETAILS

Propellant Composition: 51% Nitrocellulose, 38.6% Nitroglycerin, 6.4% Plasticizers & Stabilizers, 4% Ballistic Modifier

Std SL Theoretical Sp Impulse: I^{o}_{sps}: 2.206 kN•s/kg (225 lbf-sec/lbm)
Burn Rate @ 8.274 MPa (1200 psia) & 298 K (77°F): 17.5 mm/s (0.69 in./s)
Density Measured at 298 K (77°F): 1.605 Mg/m³ (0.058 lbm/in.³)
Chamber Flame Temp at 6.9 MPa (1000 psia): 2 633 K (4280°F)
Grain Configuration: 8 point star internal burner
Method of Manufacture: Extrusion of solventless sheet propellant
Grain Designation: Mk 90 Mod 0
Grain Dimensions, Length: 782 mm (30.8 in.)
Diameter: 63.0 mm (2.48 in.)
Web: 16.0 mm (0.63 in.)
Initial Surface-to-Throat Area Ratio, K_n: 231
Initial Port-to-Throat Area Ratio, 1/J: 1.69
Equilibrium Exhaust Gas Composition, expansion from 6.9 MPa (1000 psia) to 0.1 MPa (14.7 psia) (mole fraction):

CO_2	0.19	CO	0.33	H_2O	0.18
H_2	0.17	N_2	0.12	Cu(s)	0.002
Pb	0.002				

Combustion Products Specific Heat Ratio, γ: 1.23

COMPONENT DETAILS (Continued)

Case Material:	Aluminum alloy, 7075-T8
Length:	932 mm (36.7 in.)
Outside Diameter:	69.9 mm (2.75 in.)
Minimum Thickness:	1.8 mm (0.07 in.)
Fabrication Method:	Impact extrusion
Burst/Proof/MEOP:	24.82/18.27/16.55 MPa (3600/2650/2400 psia)
Nozzle Geometry:	Fluted cone
Divergence Half-Angle:	6.7 deg
Initial Throat Area, A_t:	4.33 cm² (0.671 in.²)
Initial Expansion Ratio, A_e/A_t:	5.77
Thrust Coefficient, C_F:	1.5
Insert Material:	Molded graphite
Other Materials:	Mylar weather seal, plastic insulator, copper-brass contact band

Insulation:

Restrictor:	Ethyl cellulose tape spiral wrap (on propellant grain)
Aft Closure Insulation:	Ethyl cellulose end inhibitor and end sleeve (on propellant grain)
Head End Insulation:	Ethyl cellulose end inhibitor (on propellant grain)
Temperature of Outside Motor Wall, Head End:	533 K (500°F)

Igniter Description:	10 grams of black powder & magnesium powder, Mk 1 Mod 0 Squib
Designation:	Mk 125 Mod 5
Pressure Delay Time:	15.0 msec
Igniter Resistance:	1.0 ohm
Minimum Ignition Current:	1.5 amp

STATUS AND VARIATIONS

Development Completed: Feb 1982 (Mod 1), Aug 1983 (Mod 2)
Production Initiated: Jul 1984 (Mod 1), Aug 1984 (Mod 2)
Number Produced to Date: 90,000 (Mod 1), 30,000 (Mod 2)

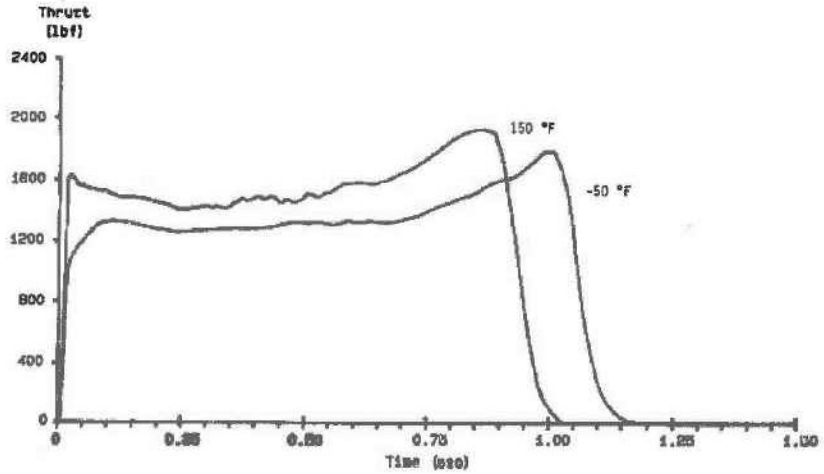
Other Versions of Motor: Mod 0: Never produced; Mod 1: Used by the Army; Mod 2: Used by the Navy. Only difference between the Mod 1 and Mod 2 is that the Mod 2 contains an internal HERO Filter that makes the individual rocket motor HERO Safe Ordnance. The Mk 66 Mod 1 is considered HERO Susceptible.

REFERENCES

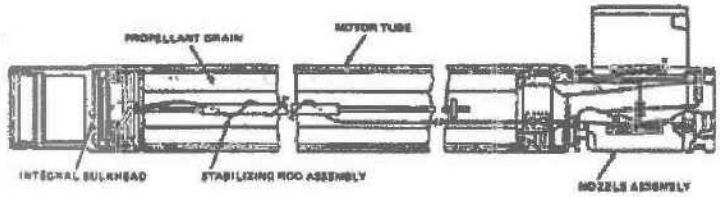
1. CPIA/M1 Questionnaire from Naval Ordnance Station, Code 521, Indian Head, MD, completed by Michael T. Gaunce, Code 5211M, 25 June 1986.

Unit No. 597 page 4
Mark 66 Mods 1 and 2 February 1989 CPIA/M1
2.75-Inch Rocket Motor
Skychief

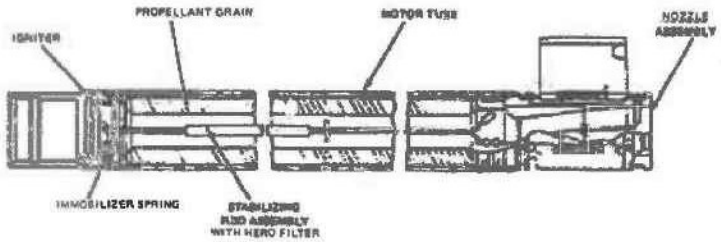
MK 66 MOD 1/2 STATIC FIRING TRACES



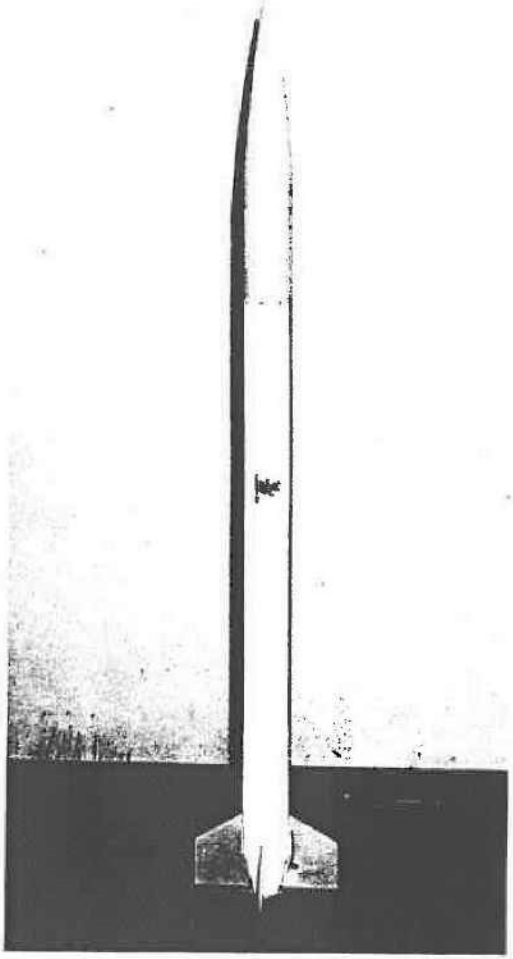
Thrust versus time for Rocket Motor Mk 66 Mod 1 and 2



Rocket Motor Mk 66 Mod 1



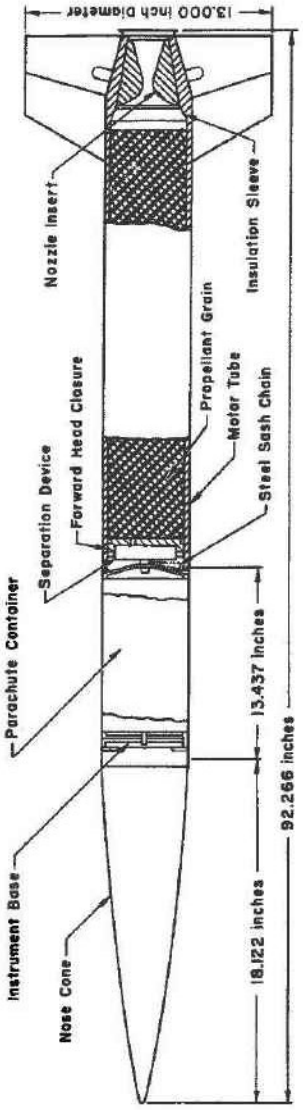
Rocket Motor Mk 66 Mod 2

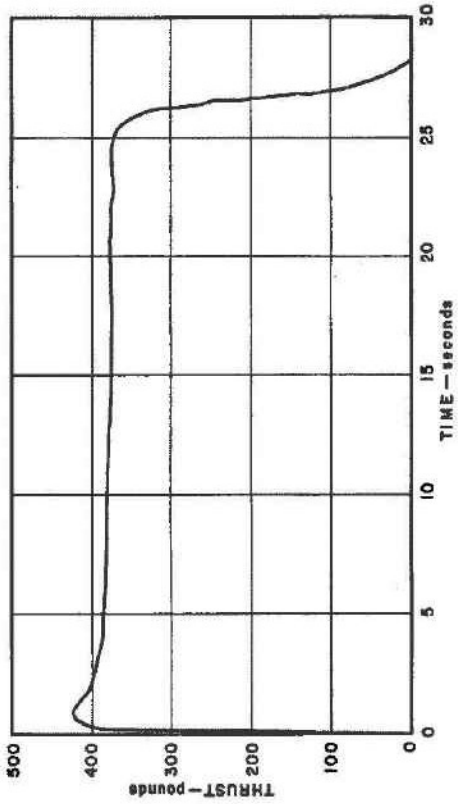


Unit 206
29.2-KS-336
ARCAS

August 1959

SPIA/M1
Page 2





PERFORMANCE CURVE

Purpose: High Altitude Sounding Rocket
Status: Production unit

I. PRINCIPAL DATA:

Length (overall) (in)	60.70
Diameter (in):	
principal	4.45
maximum (fins)	13.00
Weight (lb):	
loaded	64.5
expended	22.38
Time of burning (t_a @ 70°F)	29.2
Thrust (over t_a @ 70°F) (lbf)	336
Total impulse (lbf-sec)	9811
Location of center of gravity (inches from nozzle end):	
loaded	31.54
expended	30.70
Nozzle expansion cone angle	15°
Temperature limits (°F):	
firing	-10 to 110
storage	-10 to 110
Acceleration limits:	
hot	6.4 to 17.8 g
cold	4.3 to 11.9 g

II. WEIGHTS AND DIMENSIONS OF INERT PARTS:

	Wt. (lb)	O.D. (in)	I.D. (in)	Length (in)	Material
Chamber	11.65*	4.45	4.37	60.70	4130 steel
Insulation sleeve	7.0	4.37	4.07	57.3	Asbestos-phenolic
Cap	0.65	4.11		0.83	Aluminum
Nozzle insert	0.93	1.8**	0.50***	3.62	Graphite
Igniter assembly	0.15	1.00		4.50	Plastic
Fins	2.0				Aluminum
Total weight	22.38				

* hydrotest pressure 1500 psi
** exit cone diameter
*** throat diameter

III. PROPELLANT DATA:

Propellant designation	Arcite 373D
Propellant type	Aluminized ammonium perchlorate/polyvinyl chloride
Flame temperature (isobaric)(°F)	5400
Method of manufacture	Cast or extruded
Charge design	End burning with 19 axially oriented silver filaments
Number of grains	One
Physical characteristics of grain:	
length (in)	53.75
diameter (in)	3.91
web (in)	52.50
grain weight (lb)	42.12
propellant weight (lb)	40.12

Restrictor:	
place of attachment	Forward end and periphery
material	Polyurethane
method of application	Cast in place
weight (lb)	2.0
thickness (in)	0.050
Design parameters:	
initial surface-to-throat area ratio, K	234
design progressivity	Neutral

Exhaust-gas composition (wt%):

Atomic hydrogen	0.01	Water	1.28
Atomic chlorine	0.08	Hydrogen chloride	17.50
Carbon monoxide	25.40	Nitrogen	7.02
Carbon dioxide	0.38	Aluminum chloride	6.99
Hydrogen	3.10	Aluminum oxide	37.24

IV. PERFORMANCE:

	70°F
Action time, t_a (sec)	29.2
Maximum pressure, P_{max} (psi)	1259
Average pressure, $\bar{P}$, over t_a (psi)	984
Maximum thrust, F_{max} (lbf)	412
Average thrust, $\bar{F}$, over t_a (lbf)	336
Total impulse, I (lbf-sec)	9811
Propellant specific impulse, I_{sp} (lbf-sec/lbm)	242
Thrust-to-pressure conversion factor	0.342

Temperature of outside motor wall (°F):

	Maximum
nozzle	10° above ambient
nozzle end of motor	274° above ambient
midpoint of motor	160° above ambient
head end of motor	24° above ambient

V. IGNITION:

Igniter designation	Arcas Igniter I
Igniter description	1 U. S. Flare 107A squib, 5 grams, U. S. Flare 2-M igniter pellets, housed in plastic container
Ignition delay, t_d (msec)	30
Igniter resistance (ohm)	0.6 ± 0.1
Minimum current for reliable ignition (amp)	0.5

VI. PROCUREMENT INFORMATION:

Sponsoring agency	Office of Naval Research, Geophysics Branch. Air Force Cambridge Research Center
Design and development agency	Atlantic Research Corporation, Alexandria, Virginia
Status	Qualified and in production
Number and type of Service tests	92 static tests and 17 flight tests
Extent of Service use	Several hundred units on order for atmospheric soundings to be made over next year to eighteen months. Continued large scale production anticipated

VII. REFERENCE:

SPIA/M1 Questionnaire from Atlantic Research Corporation (R. C. Webster), August 1959.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT INFORMATION

Product Name/Identifier BB Mk3 Rocket Motor, P/N 690-16000-1			
Manufacturer's Name Bristol Aerospace Ltd., Rockwood Plant		Supplier's Name Bristol Aerospace Ltd., Rockwood Plant	
Street Address 660 Berry Street		Street Address 660 Berry Street	
City Winnipeg	Province Manitoba	City Winnipeg	Province Manitoba
Postal Code R3C 2S4	Emergency Telephone 204-344-5545	Postal Code R3C 2S4	Emergency Telephone 204-344-5545
Product Use Sounding Rocket			WHMIS Classification

SECTION II - HAZARDOUS INGREDIENTS

Chemical Identity	Concentration	CAS, and Product ID Number	LD 50 (Specify Species and Route)	LC 50 (Specify Species and Route)
Hydroxyl-Terminated Polybutadiene Binder with Ammonium Perchlorate Oxidizer W/ 20% Aluminum Class 1.2C UN 0281	N/A	N/A	N/A	N/A

SECTION IIA - OTHER INGREDIENTS

Chemical Identity	CAS, and Product ID Number	LD 50	LC 50
None			

SECTION III - PHYSICAL DATA

Physical State __ Gas __ Liquid X Solid		Odour and Appearance No Odour	Odour Threshold (p.p.m.) N/A	Specific Gravity N/A
Vapour Pressure (mm/Hg) N/A	Vapour Density (Air=1) N/A	Evaporation Rate N/A	Boiling Point N/A (°C)	Freezing Point N/A
pH N/A		Coefficient of Water/Oil Distribution N/A		

MSDS No. __
PAGE 2 of 3

MATERIAL SAFETY DATA SHEET (CONTINUED)

Product Name/Identifier
26KS20000 BBV Motor

SECTION IV - FIRE OR EXPLOSION HAZARD

Flammability - If yes, under what conditions
_X_ Yes __ No Avoid fire, flame or other ignition sources.

Means of Extinction
NO NOT FIGHT FIRES INVOLVING PROPELLANT. If initiated, propellant burns rapidly producing high temperature flame and gases. Move personnel and equipment at least 1600 m from area. Rocket motor may become propulsive or explode. Net Explosive Weight (NEW) = 2200 LBS. Structural fire fighting clothing will not provide adequate protection against flames from an ignited motor.

Flashpoint (°C) and Method of Determination	Upper Flammable Limit (% by Volume)	Lower Flammable Limit (% by Volume)
N/A	N/A	N/A

Auto-Ignition Temperature (°C)	Hazardous Combustion Products
> 204°C (400°F)	HCl, CO_2

Explosion Data - Sensitivity to Mechanical Impact	Sensitivity to Static Discharge
Avoid drops or rough handling.	Avoid static discharge.

SECTION V - REACTIVITY DATA

Chemical Stability - if no, under what conditions
_X_ Yes __ No

Incompatibility to Other Substances - If yes, which ones (Name or Class of Substance)
_x_ Yes __ No Avoid fire, flame or other ignition Sources.

Conditions of Reactivity
N/A

Hazardous Decomposition Products
HCl, CO_2, CO, Al_2O_3, Minor amounts of Nitric Oxides, Aluminium chlorides and Cyanogen

SECTION VI - TOXICOLOGICAL PROPERTIES

Route of Entry
_X_ Skin Contact __ Skin Absorption _X_ Eye Contact __ Inhalation Chronic _X_ Inhalation Acute
__ Ingestion

Effects of Acute Exposure to Product
Skin: Wash with soap and water. Eye: Flush with water, contact physician. Inhalation: If exposed to smoke from burning material, transport victim to medical facility. Treat for possible exposure to hydrogen chloride (hydrochloric acid).

Effects of Chronic Exposure to Product
N/A

Exposure Limit(s)	Irritancy of Product	Sensitization to Product
N/A	Avoid Inhalation of combustion products.	N/A

Carcinogenicity, Reproductive Toxicity, Teratogenicity, Mutagenicity	Synergistic Products
N/A	N/A

MSDS No. __
PAGE 3 of 3

MATERIAL SAFETY DATA SHEET (CONTINUED)

Product Name/Identifier
26KS20000 BBV Motor

SECTION VII - PREVENTIVE MEASURES

Personal Protective Equipment:
Flame resistant clothing recommended.

Gloves (Specify)	Respiratory (Specify)	Eyes (Specify)	Footwear (Specify)
Latex Gloves (propellant)	None	Industrial Safety Glasses	None

Clothing (Specify)	Other (Specify)
Flame Resistant	

Engineering Controls

Leak and Spill Procedure
A damaged unit may be picked up and returned to original container.

Waste Disposal
Contact Explosive Ordinance Disposal personnel.

Handling Procedures and Equipment
Handle and store as a Class 1.2, Compatibility Group C explosive. Do not expose to heat or open flame. Do not drop or rough handle. Do not expose to electrical discharge of any sort.

Storage Requirements
Keep away from impact, friction and high temperatures. Use precautions against electrostatic build-up

Special Shipping Information
Class 1.2, Compatibility Group C explosive.

SECTION VIII - FIRST AID MEASURES

First Aid Measures
Avoid inhalation of combustion products.

Sources Used

Additional Information

SECTION IX - PREPARATION INFORMATION

Prepared by (Group. Department. Person. etc.)
Kimberly Norrie, Propulsion Engineering

Telephone Number	Date Prepared	Date Reviewed
204-344-5545	14 Dec 2011	14 Dec 2011

Notes
* The toxicological properties of this product are not fully studied, therefore, unknown.
N/A = Not Applicable
N/E = Not Established
Disclaimer: The information contained herein is offered only as a guide to the handling of this specific material, and has been prepared in good faith by technically, knowledgeable personnel. The Company, Bristol Aerospace Ltd., makes no warranty, expressed or implied, regarding the accuracy or completeness of this information or the results to be obtained from the use thereof.

BLACK BRANT MOTOR
Standard

07/19/95 08:58 BRISTOL AEROSPACE → 804 824 2347

Black Brant Motor

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard

U = Undetermined
N/A = Not Available

IDENTITY (As Used on Label and List)	Use
26KS20000-BBV Motor with Nozzle	Sounding Rocket

Section I

Manufacturer's Name Bristol Aerospace Ltd.	Emergency Telephone Number 204-344-5545
Address (Number, Street, City, State, Zip Code) Rockwood Plant Propellant Plant Road Stony Mountain, Manitoba, Canada	Telephone Number for Information 204-344-5545
	Date Prepared March 20, 1995
	Signature of Preparer (Optional)

Section II - Hazardous Ingredients/Identify Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Asbestos (See Note 1)	N/A	2.00ml	N/A	<1.20
Phenyl B-Naphthylamine (PBNA) (See Note 2)	N/A	N/A	N/A	<0.20
Black Brant Propellant Class 1.3C UN0186	N/A	N/A	N/A	85 to 90

Note 1: Asbestos is encapsulated within the motor and is not released during storage or operation. Interior of fired motors will contain surface asbestos which may exceed the percent specified and could be released by uncontrolled cutting, grinding, wire brushing, etc.

Note 2: PBNA is a constituent of the solid propellant. It is not released from the motor during storage and is completely consumed during operation.

Section III - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_2O) = 1)	N/A
Vapour Pressure (Hg)	N/A	Melting Point	N/A
Vapour Density (AIR = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A

Page 1

JUL 19 '95 09:41 204 783 2042 PAGE.03

Solubility in Water	Appearance and Odour
Insoluble - Propellant contains Ammonium Perchlorate which is soluble in water.	Cylindrical - no odour.

Section IV - Fire and Explosive Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
N/A Propellant has auto ignition temperature of 275°C (528°F)		N/A	N/A

Extinguishing Media
None; self sustaining combustion.

Special Fire Fighting Procedure
Do not fight fires, move personnel from area.

Unusual Fire and Explosion Hazards
If initiated, material burns rapidly (deflagrate) producing high temperature flame, hot high velocity gases and particulate matter. Severe damage can be caused to eyes, exposed skin and mucous membranes. Products of reaction are toxic, do not inhale or ingest.

Section V - Reactivity Data

Stability			Conditions to Avoid
	Unstable		Avoid any possible sources of ignition. Observe temperature limits of product.
	Stable	X	

Incompatibility (Materials to Avoid)
Strong acids and bases.

Hazardous Decomposition or Byproducts
HCL, Al_2O_3, CO, CO_2, H_2

Hazardous Polymerization			Conditions to Avoid
	May Occur		
	Will Not Occur	X	

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation? No	Skin? No	Ingestion? No

Health Hazards (Acute and Chronic)
N/A

Carcinogenicity: U	NTP? N/A	IARC Monographs? No	OSHA Regulated? No

Signs and Symptoms of Exposure	Medical Conditions Generally Aggravated by Exposure
If material burns, injuries to personnel may be serious and will involve burns, lacerations, shock and possible inhalation of fumes.	None known.

Emergency and First Aid Procedures
If material burns, trained personnel should treat victims.

Page 2

JUL 19 '98 09:41 304 703 2842 PAGE.04

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled	Waste Disposal Method
- Eliminate all ignition sources. - Structural fire fighters protective clothing does not provide adequate protection, if material burns. - Inspection required before use.	- Dispose of material in accordance with local legislation.
Precautions to be Taken in Handling and Storing Keep material away from impact, friction and high temperatures. Use precautions against electrostatic build up.	**Other Precautions**

Section VIII - Control Measures

Respiratory Protection (Specify Type)
If dust or fumes exist, use NIOSH approved respirators for dust or organic fumes.

Ventilation	Local Exhaust	Special
- Under normal conditions ventilation is not required. - If material burns structural fire fighter's self-contained breathing apparatus will provide reasonably adequate protection against toxic gases produced.	Not Required	Not Required
	Mechanical (General)	Other
	Not Required	Not Required

Protective Gloves	Eye Protection
Latex or vinyl.	Safety Glasses

Other Protective Clothing or Equipment	Work/Hygiene Practices
Structural fire fighter's protective clothing will not provide adequate protection, against flames from an ignited motor.	- Minimize exposure to interior propellant. - Wash hands after exposure to material.

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard

U = Undetermined
N/A = Not Available

IDENTITY (As Used on Label and List)	Use
26KS20000 Igniter 1.3G UN 0315 **Bristol P/N: 615-97149-1 or 615-97149-3**	Black Brant Igniter Assembly Bristol P/N 615-97142-1 or 615-97142-3 Ignition of 26KS20000 MK 1 Rocket Motor

Section I

Manufacturer's Name	Emergency Telephone Number
Bristol Aerospace Limited	204-344-3201
Address (Number, Street, City, State, Zip Code) Rockwood Plant Propellant Plant Road Stony Mountain, Manitoba, Canada	Telephone Number for Information 204-344-3211
	Date Prepared July 19, 2006
	Signature of Preparer (Optional)

Section II - Hazardous Ingredients/Identify Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Boron Potassium Nitrate (BPN) Pellets 447 gms total weight;			Manufacturer suggests TLV of 10 mg/m^3	

Section III - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_2O) = 1)	N/A
Vapour Pressure (Hg)	N/A	Melting Point	N/A
Vapour Density (AIR = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A

Solubility in Water	Appearance and Odour
Assembly is watertight. If seal broken BPN is water soluble.	Fully assembled and sealed - no odour.

Section IV - Fire and Explosive Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Igniter has auto ignition temperature of >221°C (>430°F)	N/A	N/A	N/A

Extinguishing Media
None self sustaining combustion.

Special Fire Fighting Procedure
Do not fight fires involving this material. If quantities are small and safety is not compromised an attempt to limit fire spread can be made.

Unusual Fire and Explosion Hazards
If initiated, material will burn rapidly (deflagrate) producing high temperature flame, hot high velocity gases and particulate matter. Severe damage can be caused to eyes, exposed skin and mucous membranes. Products of reaction are toxic, do not inhale or ingest.

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid
			Fire, flame and other ignition sources.

Page 1

Castor 1 Ignitor

ATK
55 Thiokol Road
Elkton, MD 21921
Tel: 410-392-1000
Fax: 410-392-1592
EMERGENCY: CHEMTREC 1-800-424-9300

MATERIAL SAFETY DATA SHEET

MSDS No. 318
Date Issued: 9/27/99

Approved by: _____
For L. K. Hartwell

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms: Castor I, Igniter Assembly, TE-I-1043-1, E49828

B. DOT Shipping Description and Classification: Igniter, 1.3G, UN0315, EX #9906109.

II. PHYSICAL DATA

A. Appearance and Odor: Pyrotechnic material housed in a phenolic tube. No odor.

B. Volatiles: None.

III. COMPOSITION

Hazardous Ingredients	Percent	OSHA PEL	ACGIH TLV
A. Igniter Assembly			
1. Boron Potassium Nitrate B,KNO_3 2L Pellets (~765 gms)	100	NE	NE

IV. HEALTH HAZARD DATA

A. Threshold Limit Value: See Section III. Materials are contained within the component casing. Exposure is not expected.

B. Effects of Overexposure:
1. Respiratory: If igniter is activated, decomposition products can cause difficulty in breathing and respiratory damage.
2. Eyes: No known hazard unless activated. Decomposition products are irritating to the eyes.

NE = Not established

1

MSDS 31B
TE-I-1043-1

VIII. SPECIAL PRECAUTIONS

A. Protective Measures:

1. Ventilation: Initiated igniter will emit toxic fumes while burning. Firing area should be well ventilated before operators are exposed.
2. Respiratory Protection: If personnel are exposed to exhaust gases use a NIOSH/MSHA approved respirator with organic vapor/acid gas cartridges or positive pressure airline.
3. Protective Clothing: Acid-resistant gloves should be worn when handling decomposition products. Flame-resistant lab coats or coveralls, safety glasses, and safety shoes are recommended when handling explosives.

B. Handling and Storage Precautions: Protect igniter from ignition sources and elevated temperatures (above 200°F).

C. Other Precautions: Live igniters are DOT Class 1.3G Explosive. Access to this igniter should be limited to authorized personnel trained in the handling of pyrotechnic devices.

IX. ENVIRONMENTAL PROTECTION

A. Precautions If Component Is Damaged: Damaged igniter must be protected from sources of ignition. If ignition occurs, toxic fumes, shrapnel, and fire may be emitted. Contact appropriate authorities.

B. Waste Disposal Method: Dispose of in accordance with federal, state and local regulations.

C. Igniter cases are normally consumed when fired but any residual material should be inspected and determined to be free of ignition materials before disposal.

"To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS."

Improved Alternate

MATERIAL SAFETY DATA SHEET MSDS D0087

Latest Revision: January 31, 1986 Page 1 of 4

MORTON THIOKOL, INC.
PO BOX 524
Brigham City, UT 84302 Emergency Phone No. (801) 863-8545
Product Information (801) 863-3325

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms:
C-4 1st Stage Igniter
Alternate igniter

II. PHYSICAL DATA

A. Appearance: Metal cased igniter.

B. Volatiles: None.

III. TYPICAL COMPOSITION

A. Hazardous Ingredients	Percent	PEL	TLV
TP-H1137 Propellant:			
Hydroxyl terminated polybutadiene resin	*	NE	NE
Iron oxide**	*	NE	NE
Isophorone diisocyanate**	*	NE	0.01ppm(skin)
Difunctional Aziridine (HX752)	*	NE	NE
Powdered aluminum**	*	NE	10mg/m^3
Ammonium perchlorate**	*	NE	NE
Igniter granules (UIX 156-02):			
Boron**	*	NE	NE
Potassium Nitrate**	*	NE	NE
Insulation:			
Asbestos-filled Rubber**	*	2 fibers/cc (Asbestos 2 fibers/cc)	2 fibers/cc

*Company Proprietary
**Exposure potential is limited by physical form of material. Once cured, the isocyanate and aziridine are completely reacted.
NE Not Established

IV. HEALTH HAZARD DATA

A. Threshold Limit Value: None established. The TLVs listed above are for individual components in the uncured state. Exposure to the finished product is not known to be hazardous. Decomposition products are considered toxic.

B. Effects of Overexposure:

Inhalation: For burned out igniter, chronic respiratory conditions may result from asbestos fiber exposure. Decomposition products are known to cause breathing difficulty and respiratory damage.

Eyes: Not known. Decomposition products are irritating.

Skin: Not known

Skin Absorption. Not known

Ingestion: Not known.

V. EMERGENCY AND FIRST AID PROCEDURES

A. Inhalation (of decomposition products): Contact physician. Give oxygen or artificial respiration if needed.
B. Eyes: Contact physician.
C. Skin: Wash with soap and water. Contact physician.
D. Skin Absorption: Not applicable.
E. Ingestion: Contact physician.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: Not applicable.

B. Explosion Limits: Not applicable.

C. Extinguishing Media: Do not attempt to extinguish.

D. Special Fire Fighting Procedures: This igniter contains DOT Class A explosives, oxidizers, and fuel. Fire fighting should be limited to evacuating an area proportional to the amount of propellant which may burn and preventing the spread of fire beyond the isolated area.

E. Explosion Hazards: Static discharge, impact, friction and pinch points between hard surfaces may initiate a conflagration or detonation. Overpressures associated with rapidly burning propellant can be explosive-like, creating fireballs and shock waves.

VII. REACTIVITY DATA

A. Stability: Unstable. Conditions to avoid: Temperatures above 250°F, shock, impact, friction, and static charge buildup.

B. Incompatibility (Materials to Avoid): Water soaked propellant may evolve explosive hydrogen gas.

C. Hazardous Decomposition Products: CO, CO_2, HCl, NO_x, unidentified organics.

D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

Ventilation: None required.

Respiratory Protection: For a fired motor, provide sufficient mechanical (general and/or local exhaust) ventilation to maintain asbestos exposure below TLV. If potential exists for exceeding the TLV of asbestos, a NIOSH/MSHA approved air purifying respirator is advised.

Protective Gloves: Impervious gloves are recommended.

Eye Protection: Safety glasses with side shields.

Other Protective Equipment: Clothing combinations which may create static discharges must be avoided. Flame resistant clothing is advised. If propellant is removed it should be contained in conductive containers.

IX. HANDLING AND STORAGE PRECAUTIONS

Buildings and transporting equipment must be protected from lightning and other forms of static discharge. Protect igniter from ignition sources, static charge buildup, mechanical shock or friction and temperatures above 250°F. Igniter should only be fired when the environmental history is known and aging and temperature limits set by design and aging studies have not been exceeded.

Other Precautions: Explosives contained in this igniter are federally controlled. Igniter should be controlled and handled only by personnel properly trained and authorized to handle explosive materials. This igniter must be stored according to the specifications referenced in the contract through which it was manufactured.

Note: This document pertains to the C-4 igniter as shipped from Morton Thiokol Wasatch Operations.

X. ENVIRONMENTAL PROTECTION

A. Precautions if Container is Damaged or Spilled: Igniter must be protected from sources of ignition (See Section VI). Contact appropriate authorities.

B. Waste Disposal Method: This igniter contains explosives. Fired motor residues may include asbestos-containing dust and char. Dispose of in accordance with federal, state, and local regulations.

For industrial use only. To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and must be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, TO INCLUDE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

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AEROJET

HAWK – BOOSTER PROPELLANT
MSDS NO. 500
REVISED: 11/02/00
REVISION: 3

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Trade Name	Hawk – Booster Propellant
Chemical Name	ANP-3148-1
Supplier Name	Aerojet General Corporation
Supplier Address	P.O. Box 13222 Sacramento, CA 95813-6000
Supplier Telephone	(916) 355-6900 (Emergency) (916) 355-3126 (MSDS Request) (916) 355-6560 (Fax)

2. COMPOSITION/INFORMATION ON INGREDIENTS

Product is a: Mixture

Components	%	CAS #
Ammonium Perchlorate (AP)	60-70	7790-98-9
Aluminum Powder	15-20	7429-90-5
Terathane (TM) , Poly-(1,4- butylene) glycol	5-10	25190-06-1
Isodecyl Pelargonate	1-5	109-32-0
Polyether Polyol	1-5	25723-16-4
1,6 Hexamethylene Diisocyanate(HDI)	<2	822-06-0

3. HAZARDS IDENTIFICATION

Emergency Overview	Combustible and explosive. Solid propellant will burn vigorously when ignited. Containers may rupture and material may deflagrate with fire or heat. Material is classified as a Class 1.3 explosive.
Human Health Effects	None expected for cured propellant. Hexamethylene Diisocyanate (HDI) in uncured propellant may cause irritation to skin, eyes, and respiratory tract. Allergic skin or respiratory reaction may occur in some individuals.

4. FIRST-AID MEASURES

Inhalation	Remove victim to fresh air. Get medical attention.
Skin contact	Flush with water for 15 minutes. Remove contaminated clothing. Get medical attention.
Eye Contact	Flush with water for 15 minutes. Get medical attention.
Ingestion	Induce vomiting. Get immediate medical attention.

AEROJET

HAWK – BOOSTER PROPELLANT
MSDS NO. 500
REVISED: 11/02/00
REVISION: 3

5. FIRE-FIGHTING MEASURES

Extinguishing Media	Use flooding quantities of water.
Protection of Fire Fighters	Containers may be propulsive. Water from fixed sprinkler or deluge systems only; use unmanned nozzles if they can be safely deployed. Do not directly fight fires involving solid propellant. Evacuate away a safe distance from fire involving propellant. Use full protective clothing and SCBA. Avoid combustion products. Control runoff.
NFPA Ratings	Health: 4 Fire: 4 Reactivity: 4

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Wear proper personal protective equipment, gloves, and respirator.
Environmental Precautions	Contain spills; keep material from being discharged to land, waterways or air.
Methods for Cleaning Up	Clean up all spills immediately with non-sparking or non-metallic tools and rags dampened with appropriate solvent.

7. HANDLING AND STORAGE

HANDLING

Technical Measures	Clean up spills immediately
Prevention of Worker Exposure	No respiratory equipment needed for cured propellant. Cartridge respirator required (during mixing and scrapedown) for uncured propellant handling procedures.
Prevention of Fire and Explosion	Handle with care to prevent exposure to flame, spark, impact, friction, and heat above 150° F unless reviewed and approved by a Safety Engineer. All propellants and explosives must have Anti-Static covering.
Precautions for Safe Handling	Primary exposure hazard with cured propellant can occur by absorption through skin and inhalation of dust. Wear personal protective equipment to avoid exposure. Personnel should wear safety glasses and gloves (see Section 8).

STORAGE

Technical Measures	Do not store near combustible materials. Keep away from sources of ignition.
Storage Conditions	Strong oxidizer – store separate from acids, alkalies, reducing agents, combustible materials. Keep in a cool, dry, well-ventilated room.
Incompatible Materials	Flammable Solvents
Safe Packing Materials	Fiber bags and drums, steel drums.

AEROJET

HAWK – BOOSTER PROPELLANT
MSDS NO. 500
REVISED: 11/02/00
REVISION: 3

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING MEASURES

Ventilation Requirements	For small quantities general room ventilation is adequate. For large quantities, or prolonged use, use local exhaust.

CONTROL PARAMETERS (Exposure Limits)

COMPONENT NAME	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)
Ammonium Perchlorate (AP)	10	10
Aluminum Powder	5	5
Hexamethylene Diisocyanate (HDI)	.034	.034
All other ingredients	Not established	Not established

PERSONAL PROTECTIVE EQUIPMENT

Respiratory Protection	For uncured propellant, use cartridge respirator during mixing and scrape down. No respirator required for casting uncured propellant or handling cured propellant.
Hand Protection	Neoprene rubber (uncured) / cotton (cured).
Eye Protection	Safety glasses or goggles.
Skin/Body Protection	Where contact is likely, wear protective coveralls.

PERSONAL HYGIENE MEASURES

Wash thoroughly after handling material. Wash thoroughly before any hand to mouth activity such as eating, drinking, smoking, chewing gum, etc.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Color	Dark gray solid, mild sweet hydrocarbon odor		
	NA	Melting Point	NA
		Autoignition Temp.	
	See Section 16	Vapor Pressure	
Vapor Density (Air=1)	NA	Specific Gravity (H20=1)	NA
Solubility in H20 by Wt.	ND	% Volatiles by Volume	Nil
Evaporation Rate	Nil	pH	NA

NA = not applicable Nil = essentially zero ND = no data

10. STABILITY AND REACTIVITY

Stability	Stable
Conditions to Avoid	Flame, heat, impact and friction
Materials to Avoid	Flammable solvents
Hazardous Decomposition Products	Oxides of carbon and nitrogen, hydrochloric acid

AEROJET

HAWK – BOOSTER PROPELLANT
MSDS NO. 500
REVISED: 11/02/00
REVISION: 3

11. TOXICOLOGICAL INFORMATION

Acute Toxicity	None expected for cured propellant. Uncured propellant: Eye and skin irritation. Hexamethylene diisocyanate in uncured propellant can cause a skin or respiratory sensitization reaction. Respiratory sensitization results in an asthma-like reaction. Skin sensitivity results in allergic dermatitis, which may include rash, itching, hives, and swelling of extremities. **Ammonium Perchlorate (AP):** Perchlorates are unstable materials, and are irritants to the body wherever they come into contact with it. Avoid skin and eye contact. Oxidizer. Mixtures with aluminum burn violently when ignited. **Aluminum Powder:** Irritant- May cause a reaction to eyes, skin and respiratory system. **Terathane(TM):** Irritant- May cause a reaction to eyes, skin and respiratory system. Toxic if inhaled, ingested, or skin contact occurs. **Isodecyl Pelargonate:** Irritant- May cause a reaction to eyes, skin and respiratory system. **Polyether Polyol:** Irritant- May cause a reaction to eyes, skin and respiratory system. **HDI:** Poison by inhalation. Can cause respiratory / skin sensitization. Moderately toxic by skin contact.
Chronic Toxicity	Unknown for mixture.
Carcinogenicity	NTP: No IARC: No OSHA: No
Routes of Entry	Inhalation, skin contact, eyes
Toxicology Data	Ammonium perchlorate: LD_{LO} (par, rat) = 3500 mg/kg LD_{LO} (par, mus) = 2,000 mg/kg LD_{50} (par, rabbit) = 750 mg/kg HDI: LD_{50} (oral, mus) =350 mg/kg No toxicology data on Aluminum Powder, Terathane, Isocecyl Pelargonate or Polyether Polyol.

12. ECOLOGICAL INFORMATION

To the best of our knowledge, the ecological effects of this material have not been fully investigated.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with all applicable federal, state and local regulations.

AEROJET

HAWK – BOOSTER PROPELLANT
MSDS NO. 500
REVISED: 11/02/00
REVISION: 3

14. TRANSPORT INFORMATION

Proper Shipping Name: Propellant, Solid
Classification code: 1.3C
UN Number: UN0499
Reference Number: EX-9809121

15. REGULATORY INFORMATION

TSCA (USA)	*Components listed*
CERCLA	Section 302 Hazardous Substances: HDI Section 355 Extremely Hazardous Substances: Not listed
SARA Title III	Section 313 Toxic Chemicals: Aluminum Powder
DSL (Canada)	Unknown status
EINECS (Europe)	Unknown status
Hazard Label	NFPA, Hazcom or other compliant method
Proposition 65 (California)	Not listed

16. OTHER INFORMATION

Explosives tests:	(#01904)
Bureau of Mines Impact:	26cm (2kg weight)
DTA:	430° F exotherm onset
Rotary Friction:	>4000gms @ 2,000 rpm
Spark Ignition:	No data
NOL Test:	Negative @ 0 cards
#8 Blasting Cap:	Burn in 15 –38 seconds
Unconfined burn:	17-38 seconds
Thermal Stability:	No change in 48 hours @75°C

MSDS Prepared by Pete Mendenhall, CIH Date: 11/02/00

Reasonable care has been taken in the preparation of this information, but the supplier makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. The supplier makes no representations and assumes no liability for any direct, incidental, or consequential damages resulting from its use.

AEROJET

HAWK SUSTAINER PROPELLANT
MSDS NO. 501
REVISED: 03/13/01
REVISION: 5

1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Trade Name	Hawk – Sustainer Propellant
Chemical Name	ANP-3196-1
Supplier Name	Aerojet General Corporation
Supplier Address	P.O. Box 13222 Sacramento, CA 95813-6000
Supplier Telephone	(916) 355-6900 (Emergency) (916) 355-3126 (MSDS Request) (916) 355-6560 (Fax)

2. COMPOSITION/INFORMATION ON INGREDIENTS

Product is a: MIXTURE

Components	%	CAS #
Ammonium Perchlorate (AP)	60-75	7790-98-9
Bis-Neopentyl Glycol Azelate	<5	29408-58-0
Pluracol TP	<6	25723-16-4
1,2-Propanediol, Polymer with Ethyloxyrane	5-10	31923-86-1
Isodecyl Pelargonate	5-10	109-32-0
1,6 Hexamethylene Diisocyanate	1-5	822-06-0
1-Nitroguanidine	15-20	556-88-7

3. HAZARDS IDENTIFICATION

Emergency Overview	Combustible and explosive. Solid propellant will burn vigorously when ignited. Containers may rupture and material may deflagrate with fire or heat. Material is classified as a Class 1.3 explosive.
Human Health Effects	None expected for cured propellant. Hexamethylene Diisocyanate (HDI) in uncured propellant may cause irritation to skin, eyes, and respiratory tract. Allergic skin or respiratory reaction may occur in some individuals.

4. FIRST-AID MEASURES

Inhalation	Remove victim to fresh air. Get medical attention.
Skin contact	Flush with water for 15 minutes. Remove contaminated clothing. Get medical attention.
Eye Contact	Flush with water for 15 minutes. Get medical attention.
Ingestion	Induce vomiting. Get immediate medical attention.

AEROJET

HAWK SUSTAINER PROPELLANT
MSDS NO. 501
REVISED: 03/13/01
REVISION: 5

5. FIRE-FIGHTING MEASURES

Extinguishing Media	Use flooding quantities of water.
Protection of Fire Fighters	Containers may be propulsive in a fire. Water from fixed sprinkler or deluge systems only; use unmanned nozzles if they can be safely deployed. Do not directly fight fires involving solid propellant. Evacuate away a safe distance from fire involving propellant. Use full protective clothing and SCBA. Avoid combustion products. Control runoff.
NFPA Ratings	Health: 4 Fire: 4 Reactivity: 4

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Wear proper personal protective equipment, gloves, and respirator.
Environmental Precautions	Contain spills; keep material from being discharged to land, waterways or air.
Methods for Cleaning Up	Clean up all spills immediately with non-sparking or non-metallic tools and rags dampened with appropriate solvent.

7. HANDLING AND STORAGE

HANDLING

	Clean up spills immediately
Prevention of Worker Exposure	No respiratory equipment needed for cured propellant. Cartridge respirator required (during mixing and scrapedown) for uncured propellant handling procedures.
Prevention of Fire and Explosion	Handle with care to prevent exposure to flame, spark, impact, friction, and heat above 150° F unless reviewed and approved by a Safety Engineer. All propellants and explosives must have Anti-Static covering.
Precautions for Safe Handling	Primary exposure hazard with cured propellant can occur by absorption through skin and inhalation of dust. Wear personal protective equipment to avoid exposure. Personnel should wear safety glasses and gloves (see Section 8).

STORAGE

Technical Measures	Do not store near combustible materials. Keep away from sources of ignition.
Storage Conditions	Strong oxidizer – store separate from acids, alkalies, reducing agents, combustible materials. Keep in a cool, dry, well-ventilated room.
Incompatible Materials	Flammable Solvents
Safe Packing Materials	Fiber bags and drums, steel drums.

AEROJET

HAWK SUSTAINER PROPELLANT
MSDS NO. 501
REVISED: 03/13/01
REVISION: 5

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING MEASURES

Ventilation Requirements	For small quantities general room ventilation is adequate. For large quantities, or prolonged use, use local exhaust.

CONTROL PARAMETERS (Exposure Limits)

COMPONENT NAME	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)
Ammonium Perchlorate (AP)	10	10
1,6 Hexamethylene Diisocyanate	.034	.034
All other ingredients	NE	NE

NA Not Available

PERSONAL PROTECTIVE EQUIPMENT

Respiratory Protection	For uncured propellant, use cartridge respirator during mixing and scrape down. No respirator required for casting uncured propellant or handling cured propellant.
Hand Protection	Neoprene rubber (uncured) / cotton (cured).
Eye Protection	Safety glasses or goggles.
Skin/Body Protection	Where contact is likely, wear protective coveralls.

PERSONAL HYGIENE MEASURES

Wash thoroughly after handling material. Wash thoroughly before any hand to mouth activity such as eating, drinking, smoking, chewing gum, etc.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Color	Solid, light tan; mild sweet hydrocarbon odor		
Boiling Point	NA	Melting Point	NA
Flash Point(COC)	NA	Autoignition Temp.	ND
Explosion Properties	See section 16	Vapor Pressure	NA
Vapor Density (Air=1)	NA	Specific Gravity (H_2O=1)	1.6
Solubility in H_2O by Wt.	Nil	% Volatiles by Volume	Nil
Evaporation Rate	Nil	pH	NA

NA = not applicable Nil = essentially zero ND = no data

10. STABILITY AND REACTIVITY

Stability	Stable
Conditions to Avoid	Flame, heat, impact and friction
Materials to Avoid	Flammable Solvents
Hazardous Decomposition Products	Oxides of carbon and nitrogen, hydrochloric acid

AEROJET

HAWK SUSTAINER PROPELLANT
MSDS NO. 501
REVISED: 03/13/01
REVISION: 5

11. TOXICOLOGICAL INFORMATION

Acute Toxicity	None expected for cured propellant. Uncured propellant: Eye and skin irritation. Hexamethylene diisocyanate in uncured propellant can cause a skin or respiratory sensitization reaction. Respiratory sensitization results in an asthma-like reaction. Skin sensitivity results in allergic dermatitis, which may include rash, itching, hives, and swelling of extremities. **Ammonium Perchlorate (AP):** Perchlorates are unstable materials, and are irritants to the body wherever they come into contact with it. Avoid skin and eye contact. Oxidizer. Mixtures with aluminum burn violently when ignited. **Pluracol TP:** Inhalation, eye or skin contact may cause irritation. Ingestion may cause gastric disturbances. **1,2-Propanediol, Polymer with Ethyloxyrane:** May cause eye irritation. Can cause skin irritation if skin is abraded. Causes respiratory irritation in high concentrations. **1,6-Hexamethylene Diisocyanate (HDI):** Poison by inhalation. Can cause respiratory / skin sensitization. Moderately toxic by skin contact. **1-Nitroguanidine:** Poison by inhalation. Can cause eye and skin irritation. Dust and/or vapors can cause irritation to respiratory tract.
Chronic Toxicity	Unknown for mixture.
Carcinogenicity	IARC: No OSHA: No
Routes of Entry	Inhalation, skin contact, eyes
Toxicology Data	Ammonium Perchlorate: LD_{LO} (par, rat) = 3500 mg/kg LD_{LO} (par, mus) = 2,000 mg/kg LD_{50} (par, rabbit) = 750 mg/kg HDI: LD_{50} (oral, mus) = 350 mg/kg 1-Nitorguanadine: LD_{50}(I.P., mouse)= 48mg/kg No toxicology data on Aluminum Powder, Terathane, Isocecyl Pelargonate or Polyether Polyol.

12. ECOLOGICAL INFORMATION

To the best of our knowledge, the ecological effects of this material have not been fully investigated.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with all applicable federal, state and local regulations.

AEROJET

HAWK SUSTAINER PROPELLANT
MSDS NO. 501
REVISED: 03/13/01
REVISION: 5

14. TRANSPORT INFORMATION

Proper Shipping Name: Propellant, Solid
Classification code: 1.3C
UN Number: UN0499
Reference Number: EX-9809120

15. REGULATORY INFORMATION

TSCA (USA)	*Components listed*
CERCLA	Section 302 Hazardous Substances: HDI Section 355 Extremely Hazardous Substances: Not listed
SARA Title III	Section 313 Toxic Chemicals: Not listed
DSL (Canada)	Unknown status
EINECS (Europe)	Unknown status
Hazard Label	NFPA, Hazcom or other compliant method
Proposition 65 (California)	Not listed

16. OTHER INFORMATION

Explosive tests:

Bureau of Mines Impact:	12.6cm (2kg weight)
DTA:	352° F exotherm onset
Rotary Friction:	>4000gms @ 2,000 rpm
Spark Ignition:	>1.0 Joules
NOL Test:	Negative @ 0 cards
#8 blasting cap burn:	46-58 seconds
Unconfined burn:	30-85 seconds

No change of thermal stability at 75°C for 48 hours.

MSDS Prepared by Pete Mendenhall, CIH Date: 03/13/01

Reasonable care has been taken in the preparation of this information, but the supplier makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. The supplier makes no representations and assumes no liability for any direct, incidental, or consequential damages resulting from its use.

Custom Query Form

Page 1 of 1

JHCS LINKS: JHCS MAIN MENU | JHCS CUSTOM QUERY | JHCS DATA ELEMENTS | COMPATIBILITY GROUPS | ESMAM | USATCES | SENSITIVITY GROUPS | LOG OUT

Record 1 of 1		JHCS Data Item Detail		
JHCS ID NO: 7722	NSN:	1337-00-783-5674	DODIC:	V172

Nomenclature:	ROCKET MOTOR, XM22E8
Proper Shipping Name:	ROCKET MOTORS
Technical Name:	
(Change) DOT Reference Number:	EX1988060875
Proper Shipping Description:	ROCKET MOTORS 1.3C UN 0186 PG II

Inhabited Building Distance:		Shipping Label 1:	EXPLOSIVE 1.3C	Primary Hazard 1.3C
DOD Hazard Class/Division:	1.3	Shipping Label 2:		
Compatibility Group:	C	Shipping Label 3:		
UN Number:	0186	Part/Dwg1	9082296	
DOD Component:	UNDETERMINED	Part/Dwg2		
TRI-Service Coordination:	YES	Part/Dwg3		

WEIGHT	POUNDS	KILOGRAMS	TYPE OF WEIGHT
High Explosive Weight (HEW)	0.000000	0.000000	Class 1.1 Material
Net Propellant Weight (NPW)	620.00000	281.22736	Class 1.3 Material
Net Explosive Weight (NEW)	620.00000	281.22736	Transportation Qty
Net Explosive QD Weight (NEWQD)	620.00000	281.22736	Storage Quantity

Record 1 of 1

New Query

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M26 MLRS

FEB-22-1999 08:33 FROM ARC PROGRAM MGMT TO 916028146740 P.02/04

Material Safety Data Sheet

Atlantic Research Corporation **MSDS for:** **Multiple Launch Rocket System Motor - 13026895**	Atlantic Research Corporation P. O. Box 1036 Camden, Arkansas 71711 Emergency Phone: (870) 574-3177 Issue Date: December 16, 1998 Revised Date: Date Printed: December 16, 1998

GENERAL INFORMATION

Chemical Name/Synonym/Trade Name: Multiple Launch Rocket System Motor - 13026895

Manufacturer's Name: Atlantic Research Corporation
Emergency Telephone Numbers: (870) 574-3177
Address: P.O. Box 1036, Highland Industrial Park, Camden, AR 71711

Chemical Family Name: N/A
DOD Classification Number: Class 1.3 C
DOT Classification: ROCKET MOTOR, UN0186, Class 1.3C, EX-8103011

Formula (and/or Chemical Components): The motor contains a monolithic solid propellant and has the following ingredients:.

Chemical Components	CAS No.	Carcinogen
Isophorone Diisocyanate Polymer with Hydroxy Terminated Polybutadiene	68951-41-7	No
Ammonium Perchlorate	7790-98-9	No
Triphenyl Bismuth	603-33-8	No
Maleic Anhydride	108-31-6	No
Iron Oxide	1309-37-1	No
Aluminum Powder	7429-90-5	No
Tetraethylene Pentamine Acrylonitrile (TEPAN)	Not Listed	Unknown
Di(2-ethylhexyl) Adipate	103-23-1	Yes

Disclaimer: The information presented herein is based on data considered to be accurate as of the date of preparation of this Material Safety Data Sheet. However, no warranty or representation, express or implied, is made as to the accuracy or completeness of the foregoing data and safety information, nor is any authorization given or implied to practice any patented invention without a license. In addition, no responsibility can be assumed by vendor for any damage or injury resulting from abnormal use, from any failure to adhere to recommended practices, or from any hazards inherent in the nature of the product.

HEALTH HAZARD DATA

Threshold Limit Value: N/A - The contents of this device are not user accessible.
Symptoms if Ingested, Inhaled, or Contacted with eyes and skin: N/A - This device is a sealed unit and

contact with the explosive does not occur; hence preventing respiration, ingestion and skin exposure.

Recommended First Aid Treatment: None required

PHYSICAL DATA

Boiling Point: Not applicable
Melting Point: Not applicable
Vapor Pressure (mmHg): Not applicable
Vapor Density (Air=1): Not applicable
Specific Gravity (H_2O = 1): Not applicable
Solubility: Not applicable
Evaporation Rate: Not applicable
Appearance and Odor: The explosive within the rocket is a red colored solid with a characteristic polyurethane odor.

FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used): Not applicable
Auto Ignition Temp: Device may auto ignite at temperatures above 450°F
Flammable Limits: LEL: N/A **UEL:** N/A

Extinguishing Media: None

Special Firefighting Procedures: Do not attempt to put out fire. If there is ignition or there is a fire within the immediate area, evacuate personnel from area immediately and take shelter.

Unusual Fire and Explosion Hazards: This material is a reactive solid and under certain conditions, the material can explode. Combustion products are toxic and should not be inhaled or ingested. The propellant is static sensitive, therefore, the unit should be grounded and bonded in accordance with normal safe ordnance practice. Material exposed to temperatures above 450°F may autoignite.

Combustion Products: Combustion products contain aluminum oxides, nitrogen oxides, carbon monoxide, carbon dioxide, water vapor and hydrogen chloride.

REACTIVITY DATA

Stability (Conditions to Avoid): Stable

Incompatibility (Materials to avoid): Avoid contact of material with materials that create or induce static electricity.

Hazardous Polymerization: Not applicable.

SPILL AND LEAK PROCEDURES

Steps to be Taken in Case Material is Released or Spilled: This device contains no material that can be spilled or released.

Waste Disposal Method: Special procedures apply. Contact Atlantic research Corporation for proper disposal of obsolete or damaged units. The explosive material must be disposed of in accordance with Federal, State, DOD and Local regulations.

SPECIAL PROTECTION INFORMATION

Respiratory Protection (Specific Type): Not applicable

Ventilation: Not applicable

Protective Gloves: Not applicable

Eye Protection: Industrial grade safety glasses are required as a minimum.

Other Protective Equipment: Conductive safety shoes, flame resistant clothing. Appropriate SCBA or full-face respirator with acid gas, particulate and organic vapor cartridge must be selected before entering areas containing combustion by-products.

SPECIAL PRECAUTIONS

Special Handling, Storage and Packaging: Recommended classification is 1.3C. DOT container marking: Rocket Motors, UN0186, 1.3C, EX-8103011. In process hazard classification is DOD Class 1.3C. When not used, the motor should be stored in original shipping containers. Do not drop motor. Do not impact motor, Do no subject to friction. Keep motor away from sources of electricity or static. Motor should be stored between 30°F and 120°F.

Other Recommendations and Precautions: Strict adherence to the instructions regarding handling, use and disposal of energetic materials as presented in the Department of Defense Contractors' Safety Manual for Ammunition and Explosives, DOD 4145.26M (Latest Edition), and all other data sources listed therein are recommended. Other applicable safety directives may take precedence over this document; it shall be treated as the source of minimum requirements.

malemute

MATERIAL SAFETY DATA SHEET MSDS D0059 Page 1 of 4

Latest Revision: May 29, 1990 Superseding: August 6, 1985

Thiokol Corporation
P.O. Box 707
Brigham City, UT 84302-0707

Emergency Phone No. (801) 863-8545
Product Information (801) 863-3325

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms:
TP-H1194 Malemute Propellant

II. PHYSICAL DATA

A. Appearance and Odor: Gray, rubbery, solid propellant with an aromatic odor.

B. Volatiles: None.

III. TYPICAL COMPOSITION

Hazardous Ingredients	Percent	TWA (PEL)	STEL (PEL)	TLV
Hydroxyl terminated polybutadiene polymer	*	NE	NE	NE
Dimeryl diisocyanate	*	NE	NE	0.005 ppm
Difunctional aziridine (HX-752)	*	NE	NE	NE
Aluminum powder** CAS No. 7429-90-5	*	5 mg/m^3	NE	5 mg/m^3
	EPA section 313 toxic chemical (1989)			
Ammonium perchlorate**	*	NE	NE	NE

* Percentages are confidential.
** Exposure potential is limited by physical form of material.
NE: Not established.

IV. HEALTH HAZARD DATA

A. Threshold Limit Value (TLV): Not known for cured material. As an uncured mixture, this material has a TLV of 0.005 ppm, due to the presence of dimeryl diisocyanate.

B. Effects of Overexposure

Inhalation: The diisocyanate contained in this mixture in the uncured state may cause serious lung damage and death if inhaled in large volume. HX-752 may also irritate the upper respiratory tract. There is evidence that HX-752 may be carcinogenic. Once cured, this material poses no known inhalation risk until it is burned.

Eyes: Diisocyanate in the uncured material will cause serious injury to the eyes if directly exposed.

Skin: Causes skin irritation in uncured state.

Ingestion: Highly toxic in uncured form. See Inhalation. Cured hazard is not known.

Existing conditions which may be aggravated: Uncured isocyanates may trigger severe reactions in people with asthma or other respiratory ailments.

V. EMERGENCY FIRST AID PROCEDURES

A. Inhalation: Contact physician. Give oxygen or artificial respiration if needed. For thermal burns contact physician.

B. Eyes: Flush immediately with water for at least 15 minutes. Contact physician.

C. Skin: Wash with soap and water. Contact physician.

D. Ingestion: Contact physician.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: Not applicable.

B. Explosion Limits: Not applicable.

C. Extinguishing Media: Do not attempt to fight burning propellant. Water, CO_2 or foam may be used to restrict the spread of fire.

D. Special Fire Fighting Procedures: Propellant and igniter materials contain oxidizer and fuel. Do not fight fires involving this material. If ignited, thrust created while burning may give this propellant uncontrollable ballistic properties. Fire fighting should be limited to preventing the spread of fire.

E. Explosion Hazards: Static discharge, impact, friction and pinch points between hard surfaces can initiate propellant fires. Overpressures associated with rapidly burning propellant can be explosive-like, creating fireballs and shock waves.

VII. REACTIVITY DATA

A. Stability: Unstable.
Conditions to Avoid: Temperatures above 250°F, shock, impact, friction and static charge buildup.

B. Incompatibility (materials to avoid): Water-soaked propellant may evolve Hydrogen gas.

C. Hazardous Decomposition Products: CO, CO_2, HCl and NO_x.

D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

Protective Measures

A. Ventilation: General recommended for cured material. With uncured material, provide sufficient mechanical (general and/or exhaust) ventilation to keep vapors below the TLV.

B. Respiratory Protection: None required for cured propellant. For uncured propellant, a NIOSH/MSHA approved air purifying respirator is advised in the absence of proper environmental control. Engineering and/or administrative controls may be implemented to reduce exposure.

C. Protective Gloves: Wear nonporous gloves such as natural rubber or neoprene for handling.

D. Eye Protection: Chemical monogoggles in compliance with OSHA regulations are advised.

E. Other Protective Equipment: Flame resistant clothing is advised.

F. Other Precautions: Propellant should be controlled and handled only by personnel properly trained to handle pyrotechnic materials.

IX. HANDLING AND STORAGE PRECAUTIONS

Handling and Storage Precautions: Protect propellant from ignition sources, static charge buildup, mechanical shock, friction and temperatures above 250°F. Motor should only be fired when the environmental history is known, and aging and temperature limits set by design and aging studies have not been exceeded.

X. ENVIRONMENTAL PROTECTION

A. Precautions if Container is Damaged or Materials Spilled: Propellant must be protected from sources of ignition (see Section VI). If ignited, unpredictable ballistic properties should be anticipated, releasing pressure and spreading flaming, burning material over a wide area, and producing toxic decomposition fumes. Contact appropriate authorities.

B. Waste Disposal Method: This material is highly reactive and flammable. Dispose of in accordance with federal, state and local regulations.

For industrial use only. To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and must be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, TO INCLUDE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

Malemute Ignitor

MATERIAL SAFETY DATA SHEET MSDS D0087

Latest Revision: January 31, 1986 Page 1 of 4

MORTON THIOKOL, INC.
PO BOX 524
Brigham City, UT 84302 Emergency Phone No. (801) 863-8545
Product Information (801) 863-3325

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms:
C-4 1st Stage Igniter
Malemute Igniter

II. PHYSICAL DATA

A. Appearance: Metal cased igniter.

B. Volatiles: None.

III. TYPICAL COMPOSITION

A. Hazardous Ingredients	Percent	PEL	TLV
TP-H1137 Propellant:			
Hydroxyl terminated polybutadiene resin	*	NE	NE
Iron oxide**	*	NE	NE
Isophorone diisocyanate**	*	NE	0.01ppm(skin)
Difunctional Aziridine (HX752)	*	NE	NE
Powdered aluminum**	*	NE	10mg/m^3
Ammonium perchlorate**	*	NE	NE
Igniter granules (UIX 156-02):			
Boron**	*	NE	NE
Potassium Nitrate**	*	NE	NE
Insulation:			
Asbestos-filled Rubber**	*	2 fibers/cc (Asbestos 2 fibers/cc)	2 fibers/cc

*Company Proprietary
**Exposure potential is limited by physical form of material. Once cured, the isocyanate and aziridine are completely reacted.
NE Not Established

IV. HEALTH HAZARD DATA

A. Threshold Limit Value: None established. The TLVs listed above are for individual components in the uncured state. Exposure to the finished product is not known to be hazardous. Decomposition products are considered toxic.

B. Effects of Overexposure:

Inhalation: For burned out igniter, chronic respiratory conditions may result from asbestos fiber exposure. Decomposition products are known to cause breathing difficulty and respiratory damage.

Eyes: Not known. Decomposition products are irritating.

Skin: Not known

Skin Absorption. Not known

Ingestion: Not known.

V. EMERGENCY AND FIRST AID PROCEDURES

A. Inhalation (of decomposition products): Contact physician. Give oxygen or artificial respiration if needed.
B. Eyes: Contact physician.
C. Skin: Wash with soap and water. Contact physician.
D. Skin Absorption: Not applicable.
E. Ingestion: Contact physician.

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: Not applicable.

B. Explosion Limits: Not applicable.

C. Extinguishing Media: Do not attempt to extinguish.

D. Special Fire Fighting Procedures: This igniter contains DOT Class A explosives, oxidizers, and fuel. Fire fighting should be limited to evacuating an area proportional to the amount of propellant which may burn and preventing the spread of fire beyond the isolated area.

E. Explosion Hazards: Static discharge, impact, friction and pinch points between hard surfaces may initiate a conflagration or detonation. Overpressures associated with rapidly burning propellant can be explosive-like, creating fireballs and shock waves.

VII. REACTIVITY DATA

A. Stability: Unstable. Conditions to avoid: Temperatures above 250°F, shock, impact, friction, and static charge buildup.

B. Incompatibility (Materials to Avoid): Water soaked propellant may evolve explosive hydrogen gas.

C. Hazardous Decomposition Products: CO, CO_2, HCl, NO_x, unidentified organics.

D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

Ventilation: None required.

Respiratory Protection: For a fired motor, provide sufficient mechanical (general and/or local exhaust) ventilation to maintain asbestos exposure below TLV. If potential exists for exceeding the TLV of asbestos, a NIOSH/MSHA approved air purifying respirator is advised.

Protective Gloves: Impervious gloves are recommended.

Eye Protection: Safety glasses with side shields.

Other Protective Equipment: Clothing combinations which may create static discharges must be avoided. Flame resistant clothing is advised. If propellant is removed it should be contained in conductive containers.

IX. HANDLING AND STORAGE PRECAUTIONS

Buildings and transporting equipment must be protected from lightning and other forms of static discharge. Protect igniter from ignition sources, static charge buildup, mechanical shock or friction and temperatures above 250°F. Igniter should only be fired when the environmental history is known and aging and temperature limits set by design and aging studies have not been exceeded.

Other Precautions: Explosives contained in this igniter are federally controlled. Igniter should be controlled and handled only by personnel properly trained and authorized to handle explosive materials. This igniter must be stored according to the specifications referenced in the contract through which it was manufactured.

Note: This document pertains to the C-4 igniter as shipped from Morton Thiokol Wasatch Operations.

X. ENVIRONMENTAL PROTECTION

A. Precautions if Container is Damaged or Spilled: Igniter must be protected from sources of ignition (See Section VI). Contact appropriate authorities.

B. Waste Disposal Method: This igniter contains explosives. Fired motor residues may include asbestos-containing dust and char. Dispose of in accordance with federal, state, and local regulations.

For industrial use only. To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and must be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, TO INCLUDE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

M37A1 Spin motor

HERCULES INC -- PROPELLANT M8 STANDARD -- 9135-00N017019

========== Product Identification ==========

Product ID:PROPELLANT M8 STANDARD
MSDS Date:06/11/1991
FSC:9135
NIIN:00N017019
MSDS Number: BKSCK
=== Responsible Party ===
Company Name:HERCULES INC
Address:RADFORD ARMY AMMUNITION PLANT
City:RADFORD
State:VA
ZIP:24141
Country:US
Info Phone Num:703-639-7294
Emergency Phone Num:703-639-7294
CAGE:2D881
=== Contractor Identification ===
Company Name:HERCULES INC
Address:RADFORD ARMY AMMUNITION PLANT
Box:City:RADFORD
State:VA
ZIP:24141
Country:US
Phone:703-639-7294
CAGE:2D881

========== Composition/Information on Ingredients ==========

Ingred Name:NITROGLYCERIN (NG) (SARA III)
CAS:55-63-0
RTECS #:QX2100000
Fraction by Wt: 43%
OSHA PEL:S,C, 0.2 MG/M3 STEL
ACGIH TLV:S, 0.46 MG/M3; 9293
EPA Rpt Qty:10 LBS
DOT Rpt Qty:10 LBS

Ingred Name:DIETHYL PHTHALATE (SARA III)
CAS:84-66-2
RTECS #:TI1050000
Fraction by Wt: 3%
OSHA PEL:5 MG/M3
ACGIH TLV:5 MG/M3; 9192
EPA Rpt Qty:1000 LBS
DOT Rpt Qty:1000 LBS

Ingred Name:POTASSIUM NITRATE

CAS:7757-79-1
RTECS #:TT3700000
Fraction by Wt: 1.25%

Ingred Name:CARBANILIDE, N-N'-DIETHYL; (ETHYL CENTRALITE)
CAS:85-98-3
RTECS #:FE0350000
Fraction by Wt: 0.60%

Ingred Name:NITROCELLULOSE
CAS:9004-70-0
RTECS #:QW0970000
Fraction by Wt: 52.15%

========== Hazards Identification ==========

LD50 LC50 Mixture:NONE SPECIFIED BY MANUFACTURER.
Routes of Entry: Inhalation:NO Skin:YES Ingestion:NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:NITROGLYCERIN (SKIN).
Explanation of Carcinogenicity:NOT RELEVANT
Effects of Overexposure:THROBBING HEADACHE AND UPSET STOMACH.
Medical Cond Aggravated by Exposure:NONE SPECIFIED BY MANUFACTURER.

========== First Aid Measures ==========

First Aid:EYES: IN CASE OF CONTACT, FLUSH THOROUGHLY WITH PLENTY OF LOW PRESSURE WATER FOR AT LEAST 15 MINUTES. REMOVE ANY CONTACT LENSES TO ENSURE ADEQUATE FLUSHING. CALL MD. SKIN: WASH WITH SOAP AND RUNNING W ATER. INHAL: REMOVE TO FRESH AIR. TREATANY IRRITATION SYMPTOMATICALLY. CALL MD. INGEST: CALL MD IMMEDIATELY .

========== Fire Fighting Measures ==========

Extinguishing Media:SELF-OXIDIZING; DELUGE W/WATER. MAY NOT BE ABLE TO EXTING BEFORE ALL MATL HAS BEEN CONSUMED UNLESS LRG QTYS OF(SUPP DATA
Fire Fighting Procedures:WEAR NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT . EVACUATE THE AREA.
Unusual Fire/Explosion Hazard:EASILY IGNITED, HIGHLY COMBUSTIBLE; PROTECT FROM FIRE, SPARKS AND EXTREME HEAT.

========== Accidental Release Measures ==========

Spill Release Procedures:CLEAN UP SPILLS IMMEDIATELY USING A SOFT BRISTLE BRUSH AND A CONDUCTIVE RUBBER OR PLASTIC SHOVEL. USE CAUTION, MATERIAL IS SENSITIVE TO FRICTION IMPACT AND ELECTROSTATIC DISCHARGE.
Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.

Handling and Storage

Handling and Storage Precautions:AVOID PROLONGED TEMPERATURES ABOVE 52C (125F). RECOMMENDED STORAGE: 21C (70) AT 50% HUMIDITY.
Other Precautions:WARNING! FLAM SOLID. KEEP AWAY FROM HEAT, SPARKS & OPEN FLAME. KEEP CNTNRS CLOSED. USE W/ADEQ VENT. STORAGE MUST ALSO COMPLY W/LOC, ST, FED, OSHA 29 CFR 1910.109 AND BATF 27 CFR 55, SUBPART K.

Exposure Controls/Personal Protection

Respiratory Protection:NOT REQUIRED.
Ventilation:ADEQUATE VENTILATION.
Protective Gloves:COTTON OR LEATHER.
Eye Protection:CHEMICAL WORKERS GOGGLES .
Other Protective Equipment:FLAME RETARDANT COVERALLS AND CONDUCTIVE SHOES.
Work Hygienic Practices:NONE SPECIFIED BY MANUFACTURER.
Supplemental Safety and Health
EXTING MEDIA: WATER ARE USED IN VERY SHORT TIME PERIOD.

Physical/Chemical Properties

HCC:E1
Vapor Pres:NEGLIGIBLE
Evaporation Rate & Reference:<1 (BUTYL ACETATE = 1)
Solubility in Water:NEGLIGIBLE
Appearance and Odor:FLAT INCREMENT, WHITE TO CLEAR IN COLOR WITH NO ODOR.
Percent Volatiles by Volume:<0.40

Stability and Reactivity Data

Stability Indicator/Materials to Avoid:YES
ACIDS AND BASES (ORGANIC AND INORGANIC).
Stability Condition to Avoid:AVOID OPEN FLAME, SPARKS AND HEAT.
Hazardous Decomposition Products:NO*X AND CO*X.

Disposal Considerations

Waste Disposal Methods:BURN ON OPEN BURNING GROUND IN ACCORDANCE WITH STATE AND LOCAL REGULATIONS. MAY ALSO BE BURNED IN AN INCINERATOR APPROVED FOR EXPLOSIVES.

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assume responsibility for the suitability of this information to their particular situation.

07/21/97 12:59 ☎301 743 4108 TED/NSWC
05/29/96 13:09 ☎301 743 4792 NSWC/IH CAST DIV --> THR/NSWC 002
From: Nancy Thompson Safety Department NL Cast Division To: Tim Grunson Page 1 of 4 Tuesday, April 30, 1996 12:57:16 AM

MK12 Terrier

MATERIAL SAFETY DATA SHEET (MSDS)

Serial No. 3280
(Assigned by Code 04)

Identity (As Used on Label): Cast Double Base Propellant	Trade Name(s)/Synonyms: MARK 12 TERRIER
Section I	
Manufacturer: Naval Ordnance Station, Indian Head, MD 20640-5000	Emergency Telephone Number: (301)-743-4438
	Telephone Number for Information: (301)-743-4484
Date Prepared: 7/22/91	

Section II – Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED	% (optional)
Casting Powder				60 – 70
Casting Solvent				30 – 40

Section III – Physical/Chemical Characteristics

Impact Sensitivity (cm)		Specific Gravity (H2O)=1	
Friction Sensitivity (psig)		Heat of Explosion	
ESD Sensitivity (joules)		Evaporation Rate (Butyl Acetate=1)	
Solubility in Water: Non-Soluble			
Appearance and Odor: Red or Black Grain, Sweet Odor			

Section IV – Fire and Explosion Hazard Data

Flash Point (Method Used)		Autoignition Temperature	
Extinguishing Media: Water			
Special Fire Fighting Procedures:	Use extreme caution in fire-fighting situations. Self-contained breathing apparatus must be used.		
Unusual Fire and Explosion Hazards:	This material is a Class 1, Division 3 Explosive. This material gives off toxic fumes when burning.		

NDW-NAVORDSTA 5100/1 (10/85) *Note: Blank Spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.*

Rocket Motor, 1.3C, UN0186, EGII EX 8803051 NAIC V298 NSN: 3887-LI-990-0145
NASA Modified Rocket Motor Mk12

NAVORDSTA
MATERIAL SAFETY DATA SHEET

Page 1 of 3

CHEMICAL NAME N/A
SYNONYMS: N/A
FORMULA: N/A
TRADE NAME AND SYNONYMS: ABL
DATE OF PREPARATION/CHANGE: 12/22/87

REGULAR TELEPHONE NO. (301) 743-4484
EMERGENCY TELEPHONE NO. (301) 743-4836
CHEMICAL FAMILY Double Base Propellant
MOLECULAR WEIGHT N/A
ABL 1362, ABL 1631 CASTING POWDERS

I. PHYSICAL DATA

References

BOILING POINT: @ 760 mm Hg. N/A
SPECIFIC GRAVITY (H2O = 1) 1.6-1.69 typical
VAPOR DENSITY (AIR = 1) N/A
PERCENT VOLATILES BY VOLUME Negligible
APPEARANCE AND ODOR Small Granular Solids

References

FREEZING POINT: N/A
VAPOR PRESSURE @ °C Negligible
SOLUBILITY IN WATER % BY WT @ °C Negligible
EVAPORATION RATE (BUTYL ACETATE = 1) N/A

II. HAZARDOUS INGREDIENTS

Material	%	PEL or TLV (UNITS)	References
* Nitrocellulose	65.30 - 68.40	Not established	
* Nitroglycerine	10.60 - 19.00	0.2 ppm	
* 2-Nitrodiphenylamine	0.80 - 2.20	Not established	
* Lead Salicylate	2.00 - 3.30	50 ug/m3	
* Lead Beta Resorcylate	0.00 - 3.30	50 ug/m3	
Lead 2-Ethyl Hexoate	0.00 - 2.60	50 ug/m3	
Aluminum Powder	0.00 - 9.46	10 mg/m3	
* Carbon Black	0.00 - 0.37	3.5 mg/m3	
Graphite (Glaze)	0.08	3.5 mg/m3	

III. FIRE AND EXPLOSION HAZARD DATA

References

FLASH POINT (TEST METHOD) N/A
AUTOIGNITION TEMPERATURE 145°C
FLAMMABLE LIMITS IN AIR, % BY VOLUME LOWER N/A UPPER N/A

EXTINGUISHING MEDIA: Self oxidizing. Deluge with water. May not be able to extinguish before all material has been consumed unless large quantities of water are used in a very short time period.

SPECIAL FIRE FIGHTING PROCEDURES: Evacuate the area.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Easily ignited, highly combustible; protect from fire, sparks and extreme heat.

NAVORDSTA 8000/2 (8/88) TEST

NAVAL ORDNANCE STATION
INDIAN HEAD, MD 20640-5000
Telephone (301) 743-4484

Prepared by: [illegible]
Date Prepared: [illegible]

Approved by: [illegible]
Date: [illegible]

NAVORDSTA MATERIAL SAFETY DATA SHEET

IV. HEALTH HAZARD DATA

References

THRESHOLD LIMIT VALUE or PERMISSIBLE EXPOSURE LIMIT Not established See Section II

EFFECTS OF OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES	EYES: In case of contact, flush thoroughly with plenty of low pressure water for at least 15 minutes. Remove any contact lenses to assure thorough flushing. If flushing water does not relieve irritation, seek medical attention. SKIN: Wash with soap and running water. INHALATION: Remove to fresh air. If symptoms listed above develop, seek medical attentio

V. REACTIVITY DATA

References

STABILITY				
UNSTABLE	STABLE	CONDITIONS TO AVOID	Avoid open flame, sparks and heat.	Sax
	X			
INCOMPATIBILITY (MATERIALS TO AVOID)	Acid and bases (Organic and inorganic)			N/A
HAZARDOUS DECOMPOSITION PRODUCTS	Oxides of Nitrogen and Carbon			SAX
HAZARDOUS POLYMERIZATION				
MAY OCCUR	WILL NOT OCCUR	CONDITIONS TO AVOID	NONE	N/A

VI. SPILL OR LEAK PROCEDURES

References

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED	Clean up spills immediately using a soft bristle brush and a conductive rubber or plastic shovel. Use caution, material is sensitive to friction, impact and electrostatic discharge.
WASTE DISPOSAL METHOD	Burn on open burning ground in accordance with state and local regulations. May also be burned in an incinerator approved for explosives.

VII. SPECIAL PROTECTION INFORMATION

References

RESPIRATORY PROTECTION (SPECIFY TYPE)	Selection of type respirator shall be lead exposure specified in accordance w/OPNAVINST 5100.23B, Cha.21, Par. 2100A (d)(2)		
VENTILATION	LOCAL EXHAUST	SPECIAL	
	MECHANICAL (GENERAL)	OTHER	Adequate Ventilation
PROTECTIVE GLOVES	Cotton or leather	EYE PROTECTION	Safety glasses
OTHER PROTECTIVE EQUIPMENT	Flame retardant coveralls and conductive shoes		

VIII. SPECIAL PRECAUTIONS

References

PRECAUTIONARY LABELING	Nitrocellulose (flammable solid) Nitroglycerine (skin) Lead Salicylate, Lead Beta Resorcylate, Lead 2-Ethyl Hexoate Aluminum Powder
OTHER HANDLING AND STORAGE CONDITIONS	Avoid prolonged temperatures above 50°C (125°F) Recommended storage: 21°C (70°F) at 50% Humidity.

NAVORDSTA 8000/2 (6-86) TEST

NAVORDSTA
MATERIAL SAFETY DATA SHEET

IX. LABEL

DATE:
PAGE: 3 of 3

TRADE NAME:
Chemical Name or Common Name

DOUBLE BASE PROPELLANT

ABL 785, ABL 917, ABL 1362, ABL 1491, ABL 2434

DANGER!

EXTREMELY FLAMMABLE SEVERE
FIRE AND EXPLOSIVE HAZARD

KEEP AWAY FROM HEAT, SPARKS AND FLAME. AVOID CONTACT WITH EYES, SKIN AND CLOTHING. AVOID BREATHING DUST AND VAPORS. DO NOT STORE IN DIRECT SUNLIGHT.

WHEN HANDLING WEAR SAFETY GLASSES, GLOVES AND PROTECTIVE CLOTHING. USE WITH ADEQUATE VENTILATION AND EMPLOY RESPIRATORY PROTECTION WHEN EXPOSED TO DUST AND VAPORS. WASH THOROUGHLY AFTER HANDLING.

EFFECTS OF OVEREXPOSURE:
CONTACT CAN CAUSE IRRITATION TO THE EYES AND SKIN. INHALATION OF DUST OR VAPORS CAN CAUSE IRRITATION TO MUCOUS MEMBRANES, DRYNESS OF MOUTH AND THROAT, HEADACHE, NAUSEA AND DIZZINESS.

FIRST AID PROCEDURES:

EYES:
IMMEDIATELY FLUSH WITH WATER. IF FLUSHING WITH WATER DOES NOT RELIEVE IRRITATION SEEK MEDICAL ATTENTION.

SKIN:
WASH WITH SOAP AND WARM WATER. REMOVE CONTAMINATED CLOTHING. IF IRRITATION DEVELOPS SEEK MEDICAL ATTENTION.

INHALATION:
REMOVE PERSON FROM CONTAMINATED AIR. IF SYMPTOMS LISTED ABOVE DEVELOP SEEK MEDICAL ATTENTION.

INGESTION:
SEEK MEDICAL ATTENTION.

NAVAL ORDNANCE STATION
INDIAN HEAD, MD 20640-5000
Telephone (301) 743-4484

NAVORDSTA-8000 (6-86) TEST

MK-70 Tender

THIOKOL SAFETY DATA SHEET NO: 3074***

THIOKOL CORPORATION
Tactical Operations
Huntsville Division
Huntsville, AL 35815-1506
Telephone: ~~205~~ 256/882-8000
Date Revised: July 27, 1989

5201

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms: MK 70 Propellant
B. Propellant Formulation: TPH 8238

II. PHYSICAL DATA

A. Appearance: Rubbery/solid/grey propellant.

III. HAZARDOUS INGREDIENTS

MATERIAL (Note 1)	CAS # (Note 2)	RTECS (Note 3)	PEL (Note 4)	TLV (Note 5)
Aluminum Powder	7429905	BD0330000	None	5 mg/m3
Ammonium Perchlorate	779089	SC7520000	None	None
Isophorone Diisocynate	4098719	NQ9370000	.005ppm (skin)	.005ppm (skin)
Dioctyl Adipate (Note 6)	103231	AU9700000	None	None
Hydroxyl Terminated Polybutadiene	6910295	None	None	None

NOTES:
1. The physical form of solid propellant limits exposure to the individual ingredients
2. Chemical Abstract Service Number
3. Registry of Toxic Effects of Chemical Substances
4. Permissible Exposure Limit - published by OSHA
5. Threshold Limit Value - published by ACGIH.
6. Suspected Animal Carcinogen - IARC

IV. HEALTH HAZARD DATA

A. Threshold Limit Value: See Section III.
B. Effects of Overexposure:
   1. Inhalation: Decomposition products could cause breathing difficulty and respiratory damage.
   2. Eyes: Decomposition products are extremely irritating.
   3. Skin: No known hazard.
   4. Skin Absorption: No known hazard.

C. Primary Route of Entry: Inhalation

V. EMERGENCY AND FIRST AID PROCEDURES

A. Inhalation: If decomposition products are inhaled, remove victim to fresh air. Obtain immediate medical attention.
B. Eyes: If irritated, flush with large quantities of water for at least 15 minutes, obtain immediate medical attention.
C. Skin: If burned, obtain immediate medical attention.
D. Ingestion: Obtain immediate medical attention.

VI. FIRE AND EXPLOSION HAZARD

A. Flash Point: Not Applicable
B. Explosive Limits: Not Applicable
C. Extinguishing Media: DO NOT ATTEMPT TO FIGHT FIRE INVOLVING AFTER PROPELLANT HAS BURNED OUT, water, CO_2, or foam may be used to restrict the spread of fire.
D. Special Fire Fighting Procedures: DO NOT ATTEMPT TO FIGHT FIRE INVOLVING PROPELLANT. Propellant contains both oxidizer and fuel and cannot readily be extinguished. Fire fighting should be limited to preventing the spread of other fires.
D. Explosion Hazards: Static discharge, impact, friction, or pinch points between hard surfaces can initiate propellant fires and should be avoided.

VII. REACTIVITY DATA

A. Stability: Unstable. Conditions to avoid: Temperatures above 200 degrees F. Avoid shock, impact, friction, and static charge buildup.
B. Incompatibility (Materials to Avoid): Strong acids, alkalies.
C. Hazardous Decomposition Products: CO_2, CO, HCl, Al_2O_3, H_2, N_2
D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

A. Protective Measures: For handling a loaded rocket motor, wear cotton or other static-free clothing.
B. Handling and Storage Precautions: Protect propellant from static charge buildup, mechanical shock, impact, friction or temperatures over 200 degrees F. (See Section VII)
C. Other Precautions: This propellant is a DOT Class B Explosive and a Military Class 1.3 explosion hazard.
Access to propellant should be limited to personnel trained in the handling of pyrotechnic and explosive devices.

IX. ENVIRONMENTAL PROTECTION

A. Precautions if Component is Damaged: Damaged motor propellant must be protected from sources of ignition. (See Section VI.) Damaged propellant may be more susceptible to ignition.
B. Proper DOT Classification: EXPLOSIVE B
C. Waste Disposal Method: Dispose of in accordance with federal, state and local regulations.

FOR INDUSTRIAL USE ONLY. To the best of our knowledge, the information contained herein is correct. All chemicals may present unknown health hazards and must be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of the suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, TO INCLUDE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

Prepared by: Wayne Throneberry
Wayne Throneberry,
Engineer

Date: 7/28/88

Approved by: E. J. Krupko
E. J. Krupko
Manager, Safety

Date: 8/1/89

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PAGE.08

NASA Tracking Flare

KILGORE FLARES CO. LLC
MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURER'S NAME Kilgore Flares Co.,LLC	EMERGENCY TELEPHONE NO. 1-800-535-5053 & 731-658-5231
ADDRESS (Street, City, State, and Zip Code) Kilgore Drive, Toone, TN 38381	DOT SHIPPING NOMENCLATURE Flares Aerial, UN0093, 1.3G, PGII
NET EXPLOSIVE WEIGHT 0.3 lb/unit	TRADE NAME & SYNONYMS #CBP-4855, NASA Tracking Flare
CHEMICAL FAMILY Pyrotechnic	DOCUMENT NUMBER/DATE REV. MSD-251 11/18/13

SECTION II HAZARDOUS INGREDIENTS

NFPA HAZARDOUS MATERIAL CODE ID

HEALTH	1
FLAMMABILITY	2
REACTIVITY	1

HAZARD INDEX:
0 - MINIMAL HAZARD
1 - SLIGHT HAZARD
2 - MODERATE HAZARD
3 - SERIOUS HAZARD
4 - SEVERE HAZARD

HAZARDOUS MIXTURES OF LIQUIDS, SOLIDS, OR GASES

Pyrotechnic Composition (as applicable to modification) Consisting Of:

Magnesium Powder	CAS#	7439-95-4	Teflon Resin	CAS#	25101-45-5
Viton A Copolymer	CAS#	9011-17-0			
Laminac	CAS#	Mixture			
Sodium Nitrate	CAS#	7631-99-4			

SECTION III FIRE AND EXPLOSION HAZARD DATA

AUTO IGNITION	FLAMMABLE LIMITS	LEL	UEL
752 Degrees F	N/A		

EXTINGUISHING MEDIA
Large volumes of water. Do not approach closer than 2500 feet.

SPECIAL FIRE FIGHTING PROCEDURES
N/A

UNUSUAL FIRE AND EXPLOSION HAZARDS
N/A

SECTION IV HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
None established.

EFFECTS OF OVEREXPOSURE
N/A

EMERGENCY AND FIRST AID PROCEDURES
N/A

SECTION V REACTIVITY DATA

STABILITY: [ ] UNSTABLE [X] STABLE

CONDITIONS TO AVOID:
Sparks, high heat, or open flame.

INCOMPATIBILITY (MATERIALS TO AVOID): Store in accordance with Hazard Class 1.3G, UN0093 quantity distance class and storage compatibility group.

HAZARDOUS DECOMPOSITION PRODUCTS: N/A

HAZARDOUS POLYMERIZATION: [X] WILL NOT OCCUR [ ] MAY OCCUR

SECTION VI SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Handle carefully to avoid ignition of units. Do not smoke in area.

WASTE DISPOSAL METHOD: Open pit burning in accordance with applicable local, state, and federal air pollution and hazardous waste regulations.

SECTION VII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: Do not burn inside building -- Open areas only.

VENTILATION: N/A PROTECTIVE: [ ] GLOVES [ ] GLASSES

OTHER PROTECTIVE EQUIPMENT: N/A

SECTION VIII SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Keep away from open flames or flame production sources. Store in a cool, dry area. Units should be stored and handled in accordance with regulations governing 1.3G explosives, UN0093.

Nihka

Material Safety Data Sheet

U = Undetermined
N/A = Not Available or Not Applicable

IDENTITY (As Used on Label and List)	USE
17KS12000 Nihka Rocket Motor	Sounding Rocket

Section I

Manufacturer's Name Bristol Aerospace Ltd.	Emergency Telephone Number 204-344-5545
Address (Number, Street, City, State, Zip Code) Rockwood Plant Propellant Plant Road Stony Mountain, Manitoba, Canada	Telephone Number for Information 204-344-5545
c/o P.O. Box 874, 660 Berry Street, Winnipeg, Manitoba, Canada, R3C 2S4	Date Prepared , 2008
	Prepared by: Rockwood Plant Technical Services Lab

Section II - Hazardous Ingredients/Identify Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Asbestos (See Note 1)	0.1 fibre/cc TWA 8 hrs			<1.20
Solid Propellant UN TDG Hazards Class 1.3C UN0272 (See Note 2)	N/A			85 to 90

Note 1: Asbestos is encapsulated within the insulation liner on the motorcase interior and is not released during storage or operation. Interior of fired motors may contain exposed asbestos which could be released by uncontrolled cutting, grinding, wire brushing, etc. Type of asbestos not known with certainty – assume most hazardous form.

Note 2: Propellant is a solid composed chiefly of a mixture of polymeric binder, ammonium perchlorate and aluminum powder.

Section III - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_20) = 1)	N/A
Vapour Pressure (Hg)	N/A	Melting Point	N/A
Vapour Density (AIR = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A

Solubility in Water	Appearance and Odour
Propellant contains ammonium perchlorate which is highly soluble in water.	N/A

Section IV - Fire and Explosive Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Propellant has autoignition temperature of 275°C (528°F)		N/A	N/A

Extinguishing Media
None; self sustaining combustion which typically cannot be extinguished once initiated.

Special Fire Fighting Procedure
Do not fight fires, evacuate general area. If possible, move any adjacent flammable items to prevent spread of fire.

Unusual Fire and Explosion Hazards
If initiated, propellant burns rapidly (deflagrates) producing high temperature flame, hot high velocity corrosive gases and hot particulate matter. Products of reaction are toxic. Rocket will become propulsive if initiated. Confinement of the propellant results in more rapid combustion. Plugging or constricting of motor case exhaust throat may cause sufficient pressure build up to burst case, resulting in explosion. Detonation is highly unlikely.

Section V - Reactivity Data

Stability			Conditions to Avoid
	Unstable		Highly stable during normal storage. Avoid any possible sources of ignition such as temperature extremes, open flames, sparks, shocks, drops, etc. This is especially important if motor is open and propellant is exposed. Observe temperature limits of product: -10 °F to +125 °F.
	Stable	X	

Incompatibility (Materials to Avoid)
Strong acids and bases (propellant).

Hazardous Decomposition or Byproducts
HCl, Al_2O_3, CO, CO_2, H_2 gases formed on propellant combustion.

Hazardous Polymerization			Conditions to Avoid
	May Occur		
	Will Not Occur	X	

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
All chemical components are encased in the rocket motor and should not be a health hazard during normal handling. Only foreseeable health hazard is exposure to exhaust gases during motor combustion.	Not during normal handling.	Not during normal handling.	Not during normal handling.

Health Hazards (Acute and Chronic)
Asbestos is a health hazard but exposure should not occur during normal handling of the rocket motor. Ensure that fired motors are sealed prior to post-fire handling to prevent any inadvertent release of asbestos from exposed insulating liner.

Ammonium perchlorate is a potential health hazard but exposure should not occur during normal handling of rocket motor.

Carcinogenicity: Asbestos (potential carcinogen)	IARC Monographs? Yes: asbestos	OSHA Regulated? N/A	

Signs and Symptoms of Exposure	Medical Conditions Generally Aggravated by Exposure
Exposure to exhaust gases produced during motor combustion will produce severe thermal burns. Corrosive nature of gases may produce acid burns.	None known.

Emergency and First Aid Procedures
In event of exposure to exhaust gases, treat for thermal burns, acid burns/inhalation.

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled	Waste Disposal Method
Accidental release of solid propellant or asbestos liner is highly unlikely. In the event this does occur, due to an event such as motor case rupture, ensure any dispersed propellant is not exposed to sources of ignition. Propellant should be placed in anti-static plastic bags for authorized disposal. Rainwater will leach ammonium perchlorate from any dispersed propellant, creating potential environmental contamination.	Fired motors must be inspected to ensure all propellant has been combusted prior to disposal. Fired motors should be disposed of in accordance with local regulations governing asbestos-containing items. Unused or time expired motors must be disposed of by trained individuals in accordance with any applicable legislation. Motors aged beyond certified shelf life should be inspected for defects prior to disposal by burning.
Precautions to be Taken in Handling and Storing	**Other Precautions**
This rocket motor must be handled by individuals aware of the special hazards and precautions required when working with explosives. Protect motor from heat extremes, sparks, electrostatic discharge, shocks, drops, open flames, etc. Keep rocket motor sealed whenever possible. Use of non-sparking tools and explosion-proof electrical apparatus on or around the motor is recommended. Temperature limit: -10 °F to +125 °F. Store in approved magazine.	Motors stored past manufacturer's warranted shelf life should be reinspected and certified safe prior to use. Personnel must be well removed from rocket motor during use (i.e. during ignition and/or launch) to ensure no exposure to hot/corrosive exhaust gases. Motor function may deposit residue of aqueous hydrochloric acid droplets and aluminum oxide particulate on nearby surfaces.

Section VIII - Control Measures

Respiratory Protection (Specify Type)
Respirator suitable for protection from asbestos fibres may be considered when working with unsealed post-fire motorcase.

Ventilation	Local Exhaust	Special
Some ventilation may be required when working with unsealed motor pre and post fire.	As required.	None
Ensure adequate time lapse following motor ignition/launch to allow for complete dispersal of exhaust gases prior to approaching motor.	Mechanical (General) Not Required	Other Not Required

Protection Gloves	Eye Protection
Gloves recommended when working with exposed propellant grain.	Not required.

Other Protective Clothing or Equipment	Work/Hygiene Practices
Electrostatic discharge (ESD) protection may be necessary when handling in some circumstances, such as when the propellant is exposed. Flame-proof coveralls recommended.	Wash hands after working with exposed propellant. Acidic residue may be present on nearby surfaces after motor combustion. Wear gloves and suitable protective clothing if necessary.

Nihka Ignitor

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard

U = Undetermined
N/A = Not Available

IDENTITY (As Used on Label and List)	USE
1. 26KS20000 Igniter 1.3G UN 0315 Bristol P/N: 600-04862-3	1. Black Brant VC Rocket Motor High Altitude Igniter
2. 26KS20000 Igniter 1.3G UN 0315 Bristol P/N: 600-04850-1	2. Black Brant Igniter Kit 600-04005-1, Black Brant High Altitude Igniter
3. 26KS20000 Igniter 1.3G UN 0315 Bristol P/N: 600-00339-1	3. Black Brant Igniter Assy 600-00335-1, Black Brant High Altitude Igniter

Section I

Manufacturer's Name Bristol Aerospace Limited	Emergency Telephone Number 204-344-3201
Address (Number, Street, City, State, Zip Code) Rockwood Plant Propellant Plant Road Stony Mountain, Manitoba, Canada	Telephone Number for Information 204-344-3211
	Date Prepared August 20, 2001
	Signature of Preparer (Optional)

Section II - Hazardous Ingredients/Identify Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
1) Boron Potassium Nitrate Pellets (BPN) 380 gms total weight 1.3L explosive UN 0359			Manufacturer suggests TLV of 10 mg/m^3.	
2) Asbestos Insulator		2f/cc asbestos	Insulator encapsulated in ablative sealant material	

Section III - Physical/Chemical Characteristics

Boiling Point	N/A	Specific Gravity (H_2O) = 1)	N/A

Page 1

Vapour Pressure (Hg)	N/A	Melting Point	N/A
Vapour Density (AIR = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A
Solubility in Water Assembly is watertight. If seal broken BPN is water soluble.		Appearance and Odour Fully assembled and sealed - no odour.	

Section IV - Fire and Explosive Hazard Data

Flash Point (Method Used) Igniter has auto ignition temperature of 221°C (430°F)	Flammable Limits N/A	LFL N/A	UEL N/A

Extinguishing Media
None self sustaining combustion.

Special Fire Fighting Procedure
Do not fight fires involving this material. If quantities are small and safety is not compromised an attempt to limit fire spread can be made.

Unusual Fire and Explosion Hazards
If initiated, material will burn rapidly (deflagrate) producing high temperature flame, hot high velocity gases and particulate matter. Severe damage can be caused to eyes, exposed skin and mucous membranes. Products of reaction are toxic, do not inhale or ingest.

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid Fire, flame and other ignition sources.
	Stable	X	

Incompatibility (Materials to Avoid)
BPN pellets are incompatible with strong oxidizers, or active fuels.

Hazardous Decomposition or Byproducts
Boric Oxide, Potassium Oxide, Nitrogen in the form of hot particles and gases.

Hazardous Polymerization	May Occur		Conditions to Avoid N/A
	Will Not Occur	X	N/A

Section VI - Health Hazard Data

Route(s) of Entry: N/A	Inhalation? N/A	Skin? N/A	Ingestion? N/A

Health Hazards (Acute and Chronic)
Sealed unit does not pose a health hazard. If opened dust from BPN pellets may irritate eyes, respiratory system.

Carcinogenicity: No	NTP? No	IARC Monographs? No	OSHA Regulated? No

Signs and Symptoms of Exposure BPN Dust - irritation of eyes, nose, coughing, sneezing, nausea.	Medical Conditions Generally Aggravated by Exposure None known.

Emergency and First Aid Procedures
1) For irritation - remove to fresh air. Flush affected area with soap and water.

Page 2

2) For burns - treat for burn, shock, lacerations and possible inhalation of combustion products.

Section VII - Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled	Waste Disposal Method
Eliminate all ignition sources, carefully clean-up spilled material. Place in conductive container.	Burn under approved controlled conditions.
Precautions to be Taken in Handling and Storing	**Other Precautions**
Store in approved magazine for 1.2 explosive in shipping container at ambient temperature and humidity.	N/R

Section VIII - Control Measures

Respiratory Protection (Specify Type)
In the event of a spill use NIOSH approved dust type respirator for dust exposure.

Ventilation	Local Exhaust	Special
N/R - sealed unit		N/R
	Mechanical (General)	Other N/R
Protection Gloves N/R		Eye Protection Safety glasses.
Other Protective Clothing or Equipment Flame resistant clothing	Work/Hygiene Practices If dust present (spill) wash clothing, hands, face.	

Page 3

Oriole

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ATK

ATK Tactical Systems Company LLC
Allegany Ballistics Laboratory
210 State Route 956
Rocket Center, WV 26726-3548
Information Phone: (304) 726-5000

MSDS No: ABL-064 Rev 0
ISSUE DATE: February 20, 2004
SUPERCEDES:

24 Hour Emergency (Chemtrec): 1-800-424-9300

SECTION 1: PRODUCT IDENTIFICATION

PRODUCT NAME: ORIOLE ROCKET MOTOR

APPEARANCE: Black cylindrical tube approx. 14 ft. long, 23 in. diameter

COLOR: Black

CASRN: NA

CHEMICAL DESCRIPTION: Rocket motor containing composite propellant.

HMIS RATINGS

Health hazard:	2
Flammability hazard:	3
Reactivity hazard:	3

SECTION 2: HAZARDOUS COMPONENT INFORMATION

Routine maintenance, inspection, or repair operations may result in dermal exposure to the propellant contained inside this motor. Thus, information relevant to that potential exposure is provided.

Hazardous Ingredients	CASRN	Wt %
Ammonium perchlorate (AP)	007790-98-9	58
Aluminum powder	007429-90-5	16

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: *DANGER!*

Rocket Motors, Explosive 1.3C, UN0186.
Accidental ignition may cause severe injury or death.

POTENTIAL HEALTH EFFECTS:

Inhalation is not an expected route of exposure under normal industrial conditions. Dust, which may be created during dry machining may irritate the upper respiratory tract. Inhalation of combustion products may cause severe irritation of the respiratory system.

Ingestion is not an expected route of exposure under normal industrial conditions.

Skin contact may cause redness and irritation.
Eye contact may cause redness and irritation.

Medical conditions generally recognized as being aggravated by exposure:
None known by expected routes of exposure to the propellant.
Ammonium perchlorate – Severe overexposure by ingestion may aggravate reduced thyroid activity.

Refer to Section 5 for Hazardous Combustion Products and Section 10 for Hazardous Decomposition/Hazardous Polymerization Products.

SECTION 4: FIRST AID PROCEDURES

FIRST AID PROCEDURES:

EYES: Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get medical attention if irritation persists.

SKIN: Wash thoroughly with soap and water. Remove contaminated clothing. Wash lightly contaminated clothing before reuse. Discard highly contaminated clothing. Render unusable and discard contaminated shoes and leather articles.

INHALATION: Remove to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention.

INGESTION: If conscious, drink large quantities of liquid to dilute the material. Induce vomiting. Get immediate medical attention. NEVER give anything by mouth to an unconscious person. NEVER induce vomiting in an unconscious person.

SECTION 5: FIRE HAZARDS

FIRE FIGHTING PROCEDURES:

EVACUATE AREA IMMEDIATELY. DO NOT fight fire. Toxic gases are produced when propellant burns.

EXTINGUISHING MEDIA:

None.

UNUSUAL FIRE & EXPLOSION CONDITIONS:

This material provides its own oxygen and will burn under any environmental conditions once ignited.

CONDITIONS TO AVOID:

Avoid exposure to heat, flame, friction, electrostatic discharge, and other ignition sources.

HAZARDOUS COMBUSTION PRODUCTS:

Combustion products will vary depending on the fire conditions and other combustibles present in the fire. Predominant products will be hydrogen chloride, aluminum oxides, carbon dioxide, and carbon monoxide, and chlorine-containing compounds. Under some conditions, methane, irritating aldehydes and carboxylic acids and hydrogen cyanide may be formed.

AUTOIGNITION TEMPERATURE: 390°F (200°C)

SECTION 6: ACCIDENTAL RELEASE MEASURES

Not applicable – See Section 13: Waste Disposal

In case of accidental spill or release, refer to Section 8, Personal Protective Equipment and General Hygiene Practices.

SECTION 7: HANDLING AND STORAGE

GENERAL MEASURES:

Store between –23 and 48°C (-10 and 120°F).
Avoid friction, impact, or electrostatic discharge.
Do not drop or impart mechanical shock.
Do not expose to heat, flames, or other ignition sources.
Follow appropriate D.O.D. explosive safety requirements.

MATERIALS OR CONDITIONS TO AVOID:

This product may react with acids, alkalies, transition metal compounds, or oxidizers and should not be stored near such materials. See Section 10.

SECTION 8: EXPOSURE CONTROL/PERSONAL PROTECTION

GENERAL HYGIENIC PRACTICES:

Do not allow skin or eye contact.
Avoid breathing propellant machining (dry) exhaust or combustion products.
Wash thoroughly after handling, and before eating, drinking, or smoking.
Remove contaminated clothing promptly and clean thoroughly before reuse.

RECOMMENDED EXPOSURE LIMITS:

Hazardous Component		Wt %	Limit	Basis
Ammonium perchlorate	58	not established		
Aluminum powder	16	10 mg/m^3	ACGIH TLV	

Ammonium perchlorate has no established exposure limit. However, ACGIH lists limits for nuisance dust at 10 mg/m^3 and 5 mg/m^3 for respirable dusts.

PERSONAL PROTECTIVE EQUIPMENT:

Wear conductive safety shoes.
Static-free clothing.
Appropriate protective clothing for flash and fire hazard.
Safety glasses.
Impervious gloves.
Appropriate respiratory protection is required when exposure to airborne contaminants may exceed acceptable limits. Respirators should be selected and used in accordance with OSHA, Subpart I (29CFR1910.134) and manufacturer's recommendations.

WORK PRACTICES AND ENGINEERING CONTROLS:

Material is shock sensitive. Use care when handling.
Prevent build-up of static electric charges.
Keep away from ignition sources.
Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Discharge from the ventilation system should comply with applicable air pollution control regulations.
Eyewash fountains and safety showers should be easily accessible.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE:

Remove all product prior to repair or maintenance in the work area.
Request approval for any maintenance work in explosive areas prior to beginning work.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

As a unit, physical and chemical properties of this product are not applicable.

SECTION 10: STABILITY AND REACTIVITY

GENERAL STABILITY CONSIDERATIONS:

Stable at temperatures between –23 and 48°C (-10 and 120°F).
This material is sensitive to friction, shock, impact, and electrostatic discharge.
This material provides its own oxygen and will burn under any environmental conditions once ignited.

INCOMPATIBLE MATERIALS:

Acids, alkalies, transition metal compounds, and oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS:

None anticipated under normal or recommended handling and storage conditions.

If heated to decomposition, the following substances may be formed: hydrogen chloride, aluminum oxides, carbon dioxide, carbon monoxide, or chlorine compounds.

HAZARDOUS POLYMERIZATION:

Will not occur.

SECTION 11: TOXICOLOGICAL INFORMATION

REPORTED HUMAN EFFECTS:

ATK Tactical Systems Company LLC has not received any reports of adverse effects from workers handling this product.

COMPONENT – Ammonium perchlorate (AP): Perchlorate ion (ClO_4^-) has a significant reversible pharmacological effect on human thyroid tissue through competitive inhibition of thyroid iodine transport. To our knowledge there is no lethal dose or low dose data reported for humans.

COMPONENT – Aluminum powder: High exposure to aluminum powder may produce irritation of eyes and respiratory system. No effects of chronic exposure are known. Exposure to material may aggravate existing upper respiratory and lung diseases such as bronchitis, emphysema, and asthma.

REPORTED ANIMAL EFFECTS:

No animal toxicity studies have been carried out with this product.

COMPONENT – AP: Material has exhibited an oral LD_{50} of 4200 mg/kg in rats and 1900 mg/kg in rabbits.

CARCINOGENICITY INFORMATION:

The components of this product are not listed as carcinogens by NTP; not regulated as carcinogens by OSHA; and not listed by IARC.

MUTAGENICITY/GENOTOXICITY INFORMATION:

No mutagenicity studies have been carried out with this product.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICITY:

No ecological studies have been carried out on this product.

SECTION 13: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:

Disposal of explosives should be carried out under the direct supervision of a qualified person. For industrial disposal, federal waste regulations allow open burning of explosive wastes in permitted facilities. Call ATK Tactical Systems Company LLC for assistance if required.

SECTION 14: TRANSPORTATION INFORMATION

Rocket Motors, Explosive 1.3C, UN0186.

For other information regarding transportation of this product, please contact ATK Tactical Systems Company LLC's Transportation Department at (304) 726-5532.

SECTION 15: REGULATORY INFORMATION

CHEMICAL INVENTORIES:

U.S. TSCA Status: This product is considered to be an article under TSCA definition.

SARA TITLE III

Sections 302 and 304:

This product is not an Extremely Hazardous Substance subject to reporting under 40CFR355.

Component	Wt %	RQ (lb)
None.		

Sections 311 and 312:

HC-1: Acute health hazard
HC-3: Fire hazard
HC-4: Sudden release of pressure hazard
HC-5: Reactive hazard

Section 313:

Component	Wt %	RQ (lb)
Aluminum powder	16	

CERCLA

Component	Wt %	RQ (lb)
None.		

RCRA

This product exhibits the following characteristics listed in 40CFR261, Subpart C: ignitability and reactivity (D001 and D003).

SECTION 16: OTHER INFORMATION

LIST OF ACRONYMS:
ACGIH: American Conference of Governmental Industrial Hygienists
AICS: Australian Inventory of Chemical Substances
AIHA WEEL: American Industrial Hygienists Association - Workplace Environmental Exposure Level
ANSI: American National Standards Institute
C: Ceiling
CASRN: Chemical Abstracts service Registry Number
CERCLA: Comprehensive Emergency Response, Compensation and Liability Act
DSL: Domestic Substances List (Canadian)
EINECS: European Inventory of Existing Commercial Chemical Substances
HMIS: Hazardous Materials Identification System
IARC: International Agency for Research on Cancer
MITI: Ministry of International Trade and Industry (Japanese)
N/A: Not Applicable
NDSL: Non-domestic Substances List (Canadian)
NOR: Not Otherwise Regulated
NTP: National Toxicology Program
OSHA: Occupational Safety and Health Administration
PEL: OSHA Permissible Exposure Limit
RCRA: Resource Conservation and Recovery Act
RQ: Reportable Quantity
SARA: Superfund Amendment Reauthorization Act
STEL: Short-Term Exposure Limit
TLV: Threshold Limit Values (registered trademark of ACGIH)
TPQ: Threshold Planning Quantity

TSCA: Toxic Substances Control Act
TWA: Time Weighted Average

The information and recommendations contained in this Material Safety Data Sheet have been compiled from sources believed to be reliable and to represent the most reasonable current opinion on the subject when the MSDS was prepared. No warranty, guaranty or representation is made as to the correctness or sufficiency of the information. The user of this product must decide what safety measures are necessary to safely use this product, either alone or in combination with other products, and determine its environmental regulatory compliance obligations under any applicable federal or state laws.

Approved by: Karen L Weakley Title: Director, Quality Safety & Environmental

ABL064R0

** TOTAL PAGE.09 **

Orion igniter

Thiokol Corporation
Elkton Division
P.O. Box 241
Elkton, Maryland 21922-0241
Emergency Phone (410) 392-1000

MSDS 157B
TE-P-372-7

MATERIAL SAFETY DATA SHEET

MSDS NO. 157 Rev. B
Date Issued: 09/12/89
Date Revised: 07/23/93

Revised By: L. K. Hartwell
L. K. Hartwell

Approved By: K. W. Phillips

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms: Orion Igniter (TE-P-372-7)

B. DOT Shipping Description and Classification: Igniter, rocket motor, Class B explosive, EX #8906180, UN0315, 1.3G.

II. PHYSICAL DATA

A. Appearance and Odor: Pyrotechnic material housed in a silica phenolic case with an aluminum closure. No odor.

B. Volatiles: None.

III. COMPOSITION

Hazardous Ingredients	Percent	OSHA PEL	ACGIH TLV
A. Propellant TP-E-8035 (0.4 lb)			
1. Thiokol Polysulfide Polymer (LP-33 base)	23.0	NE	NE
2. Magnesium Oxide	1.0	15mg/m^3(fume)	10mg/m^3(fume)
3. Iron Oxide	2.0	10mg/m^3(fume)	5mg/m^3(fume)
4. Ammonium Perchlorate	74.0	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 5mg/m^3(resp.)
B. Boron Potassium Nitrate (3 gms) B_2KNO_3, 2A Pellets	100.0	NE	NE

1

A. Threshold Limit Value: See section [illegible] only pertain to materials when in raw form. Materials are contained within the propellant by a binder system.

B. Effects of Overexposure:
1. Respiratory: If igniter is activated, decomposition products can cause difficulty in breathing and respiratory damage.
2. Eyes: No known hazard unless activated. Decomposition products are irritating to the eyes.
3. Skin: Fired igniter residue may contain hydrochloric acid and other corrosive compounds which can cause skin irritation.
4. Skin Absorption: No known hazard.
5. Ingestion: No known hazard.
6. Other: N/A

V. **EMERGENCY AND FIRST-AID PROCEDURES**

A. Inhalation: If decomposition products are inhaled, remove victim to fresh air. Call a physician and/or emergency facility immediately.

B. Eyes: If irritated, flush with water and contact physician.

C. Skin: Thermal burns or reaction from exposure to decomposition products, flush with water for 15 minutes and call a physician.

D. Other: N/A

VI. **FIRE AND EXPLOSION HAZARD DATA**

A. Flash Point: N/A

B. Explosive Limits: DOT Class B explosive.

C. Extinguishing Media: Do not attempt to extinguish an initiated igniter. Static discharge, impact, and friction can cause igniter to ignite internally and emit toxic fumes, shrapnel, and fire. CO_2, H_2O, or foam may be used to restrict fire from spreading after igniter has burned.

VI. FIRE AND EXPLOSION HAZARD DATA (continued)

D. Special Fire Fighting Procedures: Igniter contains pyrotechnic materials. Do not fight fires involving these materials. Evacuate area immediately if ignition occurs. Fire fighting should be limited to preventing the spread of other fires.

E. Explosion Hazards: Static discharge, impact, and friction can initiate igniter and should be avoided. Igniter and operators should be grounded when handling this device.

VII. REACTIVITY DATA

A. Stability: Unstable. Conditions to avoid: Ignition materials become unstable when exposed to temperatures above 200°F.

B. Avoid shock, impact, and static charge buildup.

C. Hazardous Decomposition Products: CO, CO_2, COS, $FeCl_2$, H_2, H_2S, MgO, SO_2, S_2, and N_2 are theoretical exhaust products.

D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

A. Protective Measures:
1. Ventilation: Initiated igniter will emit toxic fumes while burning. Firing area should be well ventilated before operators are exposed.
2. Respiratory Protection: If personnel are exposed to exhaust gases use a NIOSH/OSHA approved respirator with organic vapor/acid gas cartridges or positive pressure airline.
3. Protective Clothing: Acid-resistant gloves should be worn when handling decomposition products. Flame-resistant lab coats or coveralls, safety glasses, and safety shoes are recommended when handling explosives.

B. Handling and Storage Precautions: Protect igniter from ignition sources and elevated temperatures (above 200°F).

C. Other Precautions: Live igniters are DOT Class B Explosive. Access to this igniter should be limited to authorized personnel trained in the handling of pyrotechnic devices.

IX. ENVIRONMENTAL PROTECTION

A. Precautions if Component is Damaged: Damaged igniter must be protected from sources of ignition. If ignition occurs, toxic fumes, shrapnel, and fire may be emitted. Contact appropriate authorities.

B. Waste Disposal Method: Dispose of in accordance with federal, state and local regulations.

C. Fired igniter cases should be inspected and determined propellant-free before disposal.

WARNING:	Manufactured with 1,1,1-trichloroethane, a substance which harms public health and environment by destroying ozone in the upper atmosphere.

"To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS."

Perchlorate

AEROJET

UTP-31,500 PROPELLANT
MSDS NO. 14184
REVISED: 10/3/2012
REVISION: 2

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name	UTP-31,500 PROPELLANT
Synonyms	Booster Propellant
Supplier Name	Aerojet General Corporation
Supplier Address	P.O. Box 13222 Sacramento, CA 95813-6000
Supplier Telephone	(916) 355-6900 (Emergency) (916) 355-3126 (MSDS Request) (916) 355-6560 (FAX)

2. COMPOSITION / INFORMATION ON INGREDIENTS

Product is a: Pure Substance ____ Mixture _X_

Components	%	CAS #
Ammonium Perchlorate (AP)	45-70	7790-98-9
Aluminum Powder	10-20	7429-90-5
Hydroxy-terminated Polybutadiene (HTPB)	5-12	69102-90-5
Dioctyl Adipate (DOA)	0-3	103-23-1
Cyanoguanidine (Dicyandiamide / DCDA)	0-2	461-58-5

3. HAZARDS IDENTIFICATION

Emergency Overview	Combustible / Class HD1.3 explosive. Cured or uncured propellant will burn vigorously when ignited. Containers may rupture and material may deflagrate with fire or heat.
Human Health Effects	None expected for cured propellant. Contact with uncured propellant may cause irritation to skin, eyes and respiratory tract with allergic skin or respiratory reactions for some individuals.

4. FIRST-AID MEASURES

Inhalation	Remove victim to fresh air. Get medical attention.
Skin contact	Flush with water for 15 minutes. Remove contaminated clothing. Get medical attention.
Eye Contact	Flush with water for 15 minutes. Get medical attention.
Ingestion	Induce victim to vomit. Get immediate medical attention.

5. FIRE-FIGHTING MEASURES

Extinguishing Media	Use flooding quantities of water.
Protection of Fire Fighters	Fight fire from protected location or maximum possible distance. Water from fixed sprinkler or deluge system only; use unmanned nozzles if they can be safely deployed. Do not directly fight fires

AEROJET

UTP-31,500 PROPELLANT
MSDS NO. 14184
REVISED: 10/3/2012
REVISION: 2

	involving cured or uncured propellant. Evacuate a safe distance away from fires involving propellant. Use full protective clothing and SCBA. Avoid combustion products. Control runoff.
NFPA Ratings	Health: __4__ Fire: __4__ Reactivity: __4__ Explosive (Exp)

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Wear proper personal protective equipment, gloves and respirator.
Environmental Precautions	Contain spills; keep material from being discharged to land, waterways or air.
Methods for Clean-Up	Place solids into appropriate waste containers, packaged in keeping with local requirements. After removing the bulk, clean-up uncured material residue using an appropriate solvent.

7. HANDLING AND STORAGE

HANDLING

Technical Measures	Clean up spills immediately.
Prevention of Worker Exposure	No respiratory equipment needed for cured propellant. Local exhaust ventilation or airline respirator required (during mixing and scrape-down).
Prevention of Fire and Explosion	Handle with care to prevent exposure to flame, spark, impact, friction and heat exceeding 150°F unless reviewed and approved by Energetic Safety Engineer. Shield exposed propellant surfaces with anti-static covering.
Precautions for Safe Handling	Primary exposure hazard for cured propellant occurs by absorption through skin or mucous membranes and/or inhalation of dust. Wear personal protective equipment to avoid exposure. Wear safety glasses and gloves.

STORAGE

Technical Measures	Do not store near combustible materials. Keep away from sources of ignition.
Storage Conditions	Contains strong oxidizer – store away from acids, alkalis, reducing agents, combustible materials. Store in a cool, dry room.
Incompatible Materials	Reducing agents, acids, alkalis.
Safe Packing Materials	Fiber drums and bags, steel drums.

AEROJET

UTP-31,500 PROPELLANT
MSDS NO. 14184
REVISED: 10/3/2012
REVISION: 2

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING MEASURES

Ventilation Requirements	For small quantities, general room ventilation is adequate. Use local exhaust for large quantities, or for prolonged exposure.

CONTROL PARAMETERS (Exposure Limits)

COMPONENT NAME	ACGIH TLV (mg/m^3)	OSHA PEL (mg/m^3)
Aluminum (Pyro powder)	5	5
All other ingredients	Not Established	Not Established

PERSONAL PROTECTIVE EQUIPMENT

Respiratory Protection	For uncured propellant, use airline respirator during mixing and scrape down. No respirator required for casting uncured propellant or for handling cured propellant.
Hand Protection	Neoprene, nitrile, or nitrile-coated cotton gloves (uncured) / cotton (cured).
Eye Protection	ANSI-Z87 approved safety glasses or goggles.
Skin / Body Protection	Wear protective coveralls if contact is likely. Otherwise, as appropriate to prevent accidental contact.

PERSONAL HYGIENE MEASURES

Wash thoroughly after handling material. Wash thoroughly before any hand to mouth activity such as eating, drinking, smoking, chewing gum, etc.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and color	Rubbery putty or solid with sweet odor, gray color.		
Boiling Point	ND	Melting Point	ND
Flash Point (COC)	ND	Autoignition Temp.	ND
Explosion Properties	ND	Vapor Pressure	ND
Vapor Density (Air = 1)	ND	Specific Gravity (H_2O = 1)	ND
Solubility in H_2O by Wt.	ND	% Volatiles by Volume	NA
Evaporation Rate	ND	pH	NA

NA = not applicable Nil = essentially zero ND = no data

10. STABILITY AND REACTIVITY

Stability	Stable

Conditions to Avoid	Sources of ignition.
Materials to Avoid	Acids, alkalis, reducing agents, combustible materials.
Hazardous Decomposition Products	Oxides of Carbon and Nitrogen, unstoichiometric oxides of carbon and nitrogen.

11. TOXICOLOGICAL INFORMATION

Acute Toxicity	Cured propellant: None expected. Uncured propellant: Eye and skin irritation. Components of uncured propellant can cause a skin or respiratory sensitization reaction. Respiratory sensitization results in as asthma-like reaction. Skin sensitivity results in allergic dermatitis, which may include rash, itching, hives and swelling of extremities. • **Ammonium Perchlorate (AP)** – Perchlorates are irritating to the body through all routes of exposure. Avoid skin and eye contact. Oxidizer. Mixtures with Aluminum burn vigorously when ignited. • **Hydroxy-terminated Polybutadiene (HTPB)** Slight eye and skin irritation is possible. Inhalation and ingestion are unlikely routes of exposure and no adverse effects are known. • **Dioctyl Adipate (DOA)** – Repeated or prolonged skin contact may cause irritation. May cause slight eye irritation in sensitive individuals. May be harmful if swallowed. May irritate mouth, throat, and stomach. Inhalation may cause dizziness. • **Cyanoguanidine (Dicyandiamide / DCDA)** – Can cause irritation.
Chronic Toxicity	Unknown for mixture.
Carcinogenicity	NTP: No IARC: No OSHA: No
Routes of Entry	Inhalation, skin contact
Toxicology Data	Aluminum: systemically non-toxic to humans. AP: LD_{Lo} (par, rat) = 3500 mg/kg LD_{Lo} (Par, Mus) = 2,000 mg/kg LD_{50} (par, rabbit) = 750 mg/kg DOA: LD_{50} (oral, rat) = 9000 mg/kg LD_{50} (dermal, rabbit = 16,300 mg/kg DCDA: LD_{50} (ipr, mouse) >4000 mg/kg

12. ECOLOGICAL INFORMATION

To the best of our knowledge, the ecological effects of this material have not been fully investigated.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with all applicable federal, state, and local regulations.

AEROJET

UTP-31,500 PROPELLANT
MSDS NO. 14184
REVISED: 10/3/2012
REVISION: 2

14. TRANSPORT INFORMATION

This material not manufactured for shipment except as part of an article, or as samples for property characterization.

15. REGULATORY INFORMATION

TSCA (USA)	Components listed
CERCLA	Section 302 Hazardous Substances: Section 355 Extremely Hazardous Substances: Not listed
SARA Title III	Section 313 Toxic Chemicals: Aluminum, DOA
DSL (Canada)	Unknown status
EINECS (Europe)	Unknown status
Hazard Label	NFPA, Hazcom or other compliant method
Proposition 65 (California)	Not listed

16. OTHER INFORMATION

ENERGETIC HAZARD PROPERTIES		
Test	Value	Unit of Measure
Bureau of Mines Impact:	22	cm/2kg
DTA (thermal):	489	°F, exothermic onset
	600	°F, exothermic peak
Rotary Friction:	>4000	gm @ 2,000 rpm
Spark:	>1.0	joules

MSDS Prepared by: James D Pinkowski: Technical Principle, EHS

Date: 10/3/12

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STAR 3A (MER TIRS)

Alliant Missile Products Company LLC
Elkton Operations
55 Thiokol Road
Elkton, MD 21921
Tel 410-392-1251
Fax 410-392-1592

MATERIAL SAFETY DATA SHEET

MSDS No. 346
Date Issued: 12/5/01

Approved by: L. K. Hartwell
L. K. Hartwell

I. **Product Identification**

A. Trade Name and Synonyms: MER TIRS Rocket Motor, TE-M-1082 (E53231)

B. DOT Shipping Description and Classification: Rocket motors, UN0186, 1.3C, EX #0108109

II. **Physical Data**

A. Appearance and Odor: Rubber/solid propellant and pyrotechnic igniter housed in a steel or titanium case. No odor.

B. Volatiles: None.

III. **Composition**

Hazardous Ingredients	%	OSHA PEL	ACGIH TLV
A. Propellant TP-H-3498 (Max. N.E.W. = 3.00 lbs)			
1. Carboxy Terminated Polybutadiene Binder	14.0	NE	NE
2. Aluminum Powder	2.0	5mg/m^3	5mg/m^3
3. Ammonium Perchlorate	83.5	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 3mg/m^3(resp.)
4. Iron Oxide	0.5	10mg/m^3 (fume & dust)	5mg/m^3 (fume & dust)

NE = Not Established

III. **Composition (continued)**

Hazardous Ingredients	%	OSHA PEL	ACGIH TLV
B. Igniter Components			
1. Propellant Grain, TP-H-3498 (Max. N.E.W. = 0.25 lb)			
a. Carboxy Terminated Polybutadiene Binder	14.0	NE	NE
b. Aluminum Powder	2.0	5mg/m^3	5mg/m^3
c. Ammonium Perchlorate	83.5	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 3mg/m^3(resp.)
d. Iron Oxide	0.5	10mg/m^3 (fume & dust)	5mg/m^3 (fume & dust)
2. Boron Potassium Nitrate (Max. N.E.W. = 3.0 grams) 2A or 2D Pellets, B,KNO_3	100	NE	NE

IV. **Health Hazard Data**

A. Threshold Limit Value: See Section III. Note: TLV's or PEL's only pertain to materials when in raw form. Materials are contained within the propellant by a binder system.

B. Effects of Overexposure:

1. Respiratory: None known for live motor. Decomposition products are known to cause breathing difficulty and respiratory damage.

2. Eyes: No known hazard unless burned. Decomposition products are extremely irritating.

3. Skin: Fired rocket motor residue contains hydrochloric acid and other corrosive compounds which can cause skin irritation.

4. Skin Absorption: No known hazard.

5. Ingestion: No known hazard.

NE = Not Established

V. Emergency and First-Aid Procedures

A. Inhalation: If decomposition products are inhaled, remove victim to fresh air. Call a physician and/or emergency facility immediately.

B. Eyes: If irritated, flush with water and contact physician.

C. Skin: Thermal burns and/or exposure to decomposition products; call physician and/or emergency facility immediately.

D. Other: N/A

VI. Fire and Explosion Hazard Data

A. Flash Point: N/A

B. Explosive Limits: DOT Class 1.3C explosive (1.3 hazard symbol).

C. Extinguishing Media: Do not attempt to fight burning motor. Water, CO_2, or foam may be used to restrict spreading of fire after bulk of propellant has burned.

D. Special Fire Fighting Procedures: Propellant and igniter materials contain oxidizer and fuel. Do not fight fires involving these materials. If ignited, thrust created while burning may give this propellant uncontrollable ballistic properties. Fire fighting should be limited to preventing the spread of other fires.

E. Explosion Hazards: Static discharge, impact, friction, and pinch points between hard surfaces can initiate propellant fires and should be avoided. See VII, B.

VII. Reactivity Data

A. Stability: Unstable. Conditions to avoid (stability): Propellant and ignition components become unstable when exposed to temperatures above 200°F.

B. Incompatibility (Materials to Avoid): Water-soaked propellant may liberate hydrogen gas, creating an explosive hazard.

C. Hazardous Decomposition Products: CO, CO_2, HCl, H_2O, N_2, H_2, $FeCl_2$, and Al_2O_3 are theoretical exhaust products.

D. Hazardous Polymerization: Will not occur.

VIII. **Special Precautions**

A. Protective Measures:

1. Ventilation: For fired motor, provide sufficient mechanical (general and/or local exhaust) ventilation.

2. Respiratory Protection: None for cured propellant. If exposed to exhaust gases, use NIOSH/MSHA approved respirator with organic vapor/acid gas cartridges or positive-pressure airline.

3. Protective Clothing: Acid-resistant gloves should be worn when handling decomposition products. Flame-resistant lab coats or coveralls, safety glasses, and safety shoes are recommended when handling explosive devices.

B. Handling and Storage Precautions:

1. Protect motor from ignition sources, static charge buildup, mechanical shock or friction, and elevated temperatures (above 200°F).

2. Approved quantity/distance requirements for storage of explosives should be observed.

C. Other Precautions: Access to this motor should be limited to authorized personnel trained in the handling of pyrotechnic devices and explosives.

IX. **Environmental Protection**

A. Precautions if Component is Damaged: Damaged motor must be protected from sources of ignition. If ignition occurs in a damaged motor, unpredictable ballistic properties may be exhibited releasing pressure and spreading burning material over a wide area. Contact appropriate authorities.

B. Waste Disposal Method: Dispose of in accordance with federal, state, and local regulations.

C. Fired rocket motor case should be inspected and determined propellant-free before disposal.

MSDS 346
TE-M-1082

"To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

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STAR 6B

Thiokol Corporation
Elkton Division
P.O. Box 241
Elkton, Maryland 21922-0241
Emergency Phone (410) 392-1000

MSDS 26 Rev. A
TE-M-790

MATERIAL SAFETY DATA SHEET

MSDS No.: 26 Rev. A
Date Issued: 12/10/85
Date Revised: 03/26/92

Written By: R. L. Jenkins

Approved By: for T.R. Cessario
T. R. Cessario

I. PRODUCT IDENTIFICATION

A. Trade Name and Synonyms: STAR 6B Rocket Motor (TE-M-790)

B. DOT Shipping Classification and Description: Rocket Motor, DOT Class B explosive, EX #8406093.
HM-181: Rocket Motors, UN0186, 1.3C

II. PHYSICAL DATA

A. Appearance and Odor: Rubber/solid propellant in a titanium case. No odor.

B. Volatiles: None.

III. COMPOSITION

Hazardous Ingredients	Percent	OSHA PEL	ACGIH TLV
A. Main Propellant Grain TP-H-3237 (N.E.W. ~15 lbs.)			
1. Ammonium Perchlorate	84	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 5mg/m^3(resp.)
2. Aluminum Powder	2	5mg/m^3	5mg/m^3
3. Hydroxyl Terminated Polybutadiene Binder	14	NE	NE

NE = Not established
N/A = Not applicable

MSDS 26 Rev A
TE-M-790

III. COMPOSITION (continued)

Hazardous Ingredients	Percent	OSHA PEL	ACGIH TLV
B. Igniter Pyrogen			
1. Pyrogen Propellant TP-H-3174 (N.E.W. ~.5 lb)			
a. Hydroxyl Terminated Polybutadiene Binder	23	NE	NE
b. Ammonium Perchlorate	77	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 5mg/m^3(resp.)
2. Boron, Potassium Nitrate B,KNO_3 (2A) Pellets (N.E.W. 1.4 gms)	100	NE	NE

IV. HEALTH HAZARD DATA

A. Threshold Limit Value: See Section III. Note: TLV's or PEL's only pertain to materials when in raw form. Materials are contained within the propellant by a binder system.
B. Effects of Overexposure:
1. Respiratory: None known for live motor. Decomposition products are known to cause breathing difficulty and respiratory damage.
2. Eyes: No known hazard unless burned. Decomposition products are extremely irritating.
3. Skin: Fired rocket motor residue contains hydrochloric acid and other corrosive compounds which can cause skin irritation.
4. Skin Absorption: No known hazard.
5. Ingestion: No known hazard.
6. Other: N/A

V. EMERGENCY AND FIRST-AID PROCEDURES

A. Inhalation: If decomposition products are inhaled, remove victim to fresh air. Call a physician and/or emergency facility immediately.
B. Eyes: If irritated, flush with water and contact physician.
C. Skin: Thermal burns and/or exposure to decomposition products; call physician and/or emergency facility immediately.
D. Other: N/A

NE = Not established
N/A = Not applicable

VI. FIRE AND EXPLOSION HAZARD DATA

A. Flash Point: N/A
B. Explosive Limits: DOT Class B explosive (1.3 hazard symbol)
C. Extinguishing Media: Do not attempt to fight burning motor. Water, CO_2, or foam may be used to restrict spreading of fire after bulk of propellant has burned.
D. Special Fire Fighting Procedures: Propellant and igniter materials contain oxidizer and fuel. Do not fight fires involving these materials. If ignited, thrust created while burning may give this propellant uncontrollable ballistic properties. Fire fighting should be limited to preventing the spread of other fires.
E. Explosion Hazards: Static discharge, impact, friction, and pinch points between hard surfaces can initiate propellant fires and should be avoided. See VII, B.

VII. REACTIVITY DATA

A. Stability: Unstable. Conditions to avoid: Propellant and ignition components become unstable when exposed to temperatures above 200 degrees F.
B. Incompatibility (Materials to Avoid): Water-soaked propellant may liberate hydrogen gas, creating an explosive hazard.
C. Hazardous Decomposition Products: AL_2O_3, CO, CO_2, H_2, CH_4, HCl, N_2 and NO_x are theoretical exhaust products.
D. Hazardous Polymerization: Will not occur.

VIII. SPECIAL PRECAUTIONS

A. Protective Measures:
1. Ventilation: For fired motor, provide sufficient mechanical (general and/or local exhaust) ventilation.
2. Respiratory Protection: None for cured propellant. If exposed to exhaust gases, use NIOSH/OSHA approved respirator with organic vapor/acid gas cartridges or positive pressure airline.
3. Protective Clothing: Acid-resistant gloves should be worn when handling decomposition products. Flame-resistant lab coats or coveralls, safety glasses, and safety shoes are recommended when handling explosive devices.

B. Handling and Storage Precautions:
1. Protect motor from ignition sources, static charge buildup, mechanical shock or friction, and elevated temperatures (above 200 degrees F).
2. Approved quantity/distance requirements for storage of explosives should be observed.

VIII. SPECIAL PRECAUTIONS (continued)

C. Other Precautions: Live motors are DOT Class B explosives. Access to this motor should be limited to authorized personnel trained in the handling of pyrotechnic devices.

IX. ENVIRONMENTAL PROTECTION

A. Precautions if Component is Damaged: Damaged motor must be protected from sources of ignition. If ignition occurs in a damaged motor, unpredictable ballistic properties may be exhibited releasing pressure and spreading burning material over a wide area. Contact appropriate authorities.
B. Waste Disposal Method: Dispose of in accordance with federal, state, and local regulations.
C. Fired rocket motor case should be inspected and determined propellant-free before disposal.

WARNING:	Manufactured with 1,1,1-trichloroethane, a substance which harms public health and environment by destroying ozone in the upper atmosphere.

"To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

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STAR 20B

02/19/2004 10:04 4103921592 SAFETY PAGE 01

ATK Elkton LLC
55 Thiokol Road
Elkton, MD 21921

MATERIAL SAFETY DATA SHEET

MSDS No. 301A
Date Issued: 2/10/98
Date Revised: 3/27/01

Approved by: L. K. Hartwell
L. K. Hartwell

I. Product Identification

A. Trade Name and Synonyms: STAR™ 20B Rocket Motor, TE-M-640-4

B. DOT Shipping Description and Classification: Rocket motors, UN0186, 1.3C, EX #8111026.

II. Physical Data

A. Appearance and Odor: Rubber/solid propellant in a fiberglass composite case with aluminum attachments, aromatic in odor.

B. Volatiles: None.

III. Composition

Hazardous Ingredients	%	OSHA PEL	ACGIH TLV
A. Propellant TP-H-3062M (N.E.W. 602 lbs)			
1. Carboxy Terminated Polybutadiene Binder	14	NE	NE
2. Ammonium Perchlorate	70	15mg/m^3(total) 5mg/m^3(resp.)	10mg/m^3(total) 3mg/m^3(resp.)
3. Aluminum Powder	16	5mg/m^3(TWA)	5mg/m^3(TWA)
B. Igniter (Optional)			
1. Boron Pellets (N.E.W. 5 gms) B_4KNO_3	100	NE	NE
2. Propellant TP-H-3062M (N.E.W. 0.25 lb.)	(See III, A for ingredients)		

NE = Not established.

1

FEB 19 '04 09:26AM THIOKOL/ELKTON MD P.2/6

MSDS 301A
TE-M-640-4

IV. **Health Hazard Data**

A. Threshold Limit Value: See Section III. Note: TLV's or PEL's only pertain to materials when in raw form. Materials are contained within the propellant by a binder system.

B. Effects of Overexposure:

1. Respiratory: None known for live rocket motor. Decomposition products are known to cause breathing difficulty and respiratory damage.
2. Eyes: No known hazard unless burned. Decomposition products are extremely irritating.
3. Skin: Fired rocket motor residue contains hydrochloric acid and other corrosive compounds which can cause skin irritation.
4. Skin Absorption: No known hazard.
5. Ingestion: No known hazard.
6. Other: N/A

V. **Emergency and First-Aid Procedures**

A. Inhalation: If decomposition products are inhaled, remove victim to fresh air. Call a physician and/or emergency facility immediately.

B. Eyes: If irritated, flush with water and contact physician.

C. Skin: Thermal burns and/or exposure to decomposition products; call physician and/or emergency facility immediately.

D. Other: N/A

VI. **Fire and Explosion Hazard Data**

A. Flash Point: N/A

B. Explosive Limits: DOT 1.3 hazard symbol.

C. Extinguishing Media: Do not attempt to fight burning rocket motor. Water, CO_2, or foam may be used to restrict spreading of fire after bulk of propellant has burned.

MSDS 301A
TE-M-640

VI. **Fire and Explosion Hazard Data (continued)**

D. Special Fire Fighting Procedures: Propellant contains oxidizer and fuel. Do not fight fires involving these materials. If ignited, thrust created while burning may give this propellant uncontrollable ballistic properties. Fire fighting should be limited to preventing the spread of other fires.

E. Explosion Hazards: Static discharge, impact, friction, and pinch points between hard surfaces can initiate propellant fires and should be avoided. See VII, B.

VII. **Reactivity Data**

A. Stability: Unstable. Conditions to avoid (stability): Propellant becomes unstable when exposed to temperatures above 200°F.

B. Incompatibility (Materials to Avoid): Water-soaked propellant may liberate hydrogen gas, creating an explosive hazard.

C. Hazardous Decomposition Products: Al_2O_3, CO, CO_2, HCl, H_2, and N_2 are theoretical exhaust products.

D. Hazardous Polymerization: Will not occur.

VIII. **Special Precautions**

A. Protective Measures:

1. Ventilation: For fired rocket motor, provide sufficient mechanical (general and/or local exhaust) ventilation.

2. Respiratory Protection: None for cured propellant. If exposed to exhaust gases, use NIOSH/MSHA approved respirator with organic vapor/acid gas cartridges or positive-pressure airline.

3. Protective Clothing: Acid-resistant gloves should be worn when handling decomposition products. Flame-resistant lab coats or coveralls, safety glasses, and safety shoes are recommended when handling explosive devices.

MSDS 301A
TE-M-640

VIII. **Special Precautions (continued)**

B. Handling and Storage Precautions:
1. Protect rocket motor from ignition sources, static charge buildup, mechanical shock or friction, and elevated temperatures (above 200°F).
2. Approved quantity/distance requirements for storage of explosives should be observed.
3. DoD Storage Compatibility Group C.
4. DoD Hazard Class 1.3.

C. Other Precautions: Live rocket motors are DOT Class 1.3C explosives. Access to this rocket motor should be limited to authorized personnel trained in the handling of pyrotechnic devices.

IX. **Environmental Protection**

A. Precautions if Component is Damaged: Damaged rocket motor must be protected from sources of ignition. If ignition occurs in a damaged rocket motor, unpredictable ballistic properties may be exhibited releasing pressure and spreading burning material over a wide area. Contact appropriate authorities.

B. Waste Disposal Method: Dispose of in accordance with federal, state, and local regulations.

C. Fired rocket motor should be inspected and determined propellant-free before disposal.

"To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitability of the chemical is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS."

talos

07/21/97 12:59 ☎301 743 4108 IHD/NSWC ☑002/005
05/29/96 13:09 ☎301 743 4792 NSWC/IH CAST DIV →→→ IHD/NSWC ☑002
From: Nancy Thompson Safety Department at: East Division To: Tim Brewster Page 1 of 4 Tuesday, April 22, 1997 10:27:58 AM

MATERIAL SAFETY DATA SHEET (MSDS)

Serial No. 3280
(Assigned by Code 04)

Identity (As Used on Label)	Trade Name(s)/Synonyms
Cast Double Base Propellant	MARK 11 TALOS

Section I

Manufacturer	Emergency Telephone Number
Naval Ordnance Station Indian Head, MD 20640-5000	(301)-743-4438
	Telephone Number for information (301)-743-4434
Date Prepared 7/22/91	

Section II – Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity: Common Name(s))	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED	% (optional)
Casting Powder				60 – 70
Casting Solvent				30 – 40

Section III – Physical/Chemical Characteristics

Impact Sensitivity (mm)		Specific Gravity (H2O)=1	
Friction Sensitivity (psig)		Heat of Explosion	
ESD Sensitivity (joules)		Evaporation Rate (Butyl Acetate=1)	

Solubility in Water: Non-Soluble

Appearance and Odor: Red or Black Grain, Sweet Odor

Section IV – Fire and Explosion Hazard Data

Flash Point (Method Used)		Autoignition Temperature	

Extinguishing Media: Water

Special Fire Fighting Procedures: Use extreme caution in fire-fighting situations. Self-contained breathing apparatus must be used.

Unusual Fire and Explosion Hazards: This material is a Class 1, Division 3 Explosive. This material gives off toxic fumes when burning.

NDW-NAVORDSTA 5100/11 (10/89)

Note: Blank Spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

JUL 21 '97 13:18 301 743 4108 PAGE.02

07/21/97 13:00 ☎301 743 4108 IHD/NSWC ☎003/005
05/29/96 13:10 ☎301 743 4792 NSWC/IH CAST DIV →→→ IHD/NSWC

NAVORDSTA
MATERIAL SAFETY DATA SHEET

CHEMICAL NAME N/A
SYNONYMS: N/A
FORMULA: N/A
TRADE NAME AND SYNONYMS: ABL [redacted] ABL 1357 ABL 1381 CASTING POWDERS
DATE OF PREPARATION/CHANGE: 12/22/87

REGULAR TELEPHONE NO. (301) 743-4484
EMERGENCY TELEPHONE NO. (301) 743-4430
CHEMICAL FAMILY Double Base Propellant
MOLECULAR WEIGHT N/A

I. PHYSICAL DATA

	References		References
BOILING POINT: @ 760 mm Hg. N/A		FREEZING POINT: N/A	
SPECIFIC GRAVITY (H2O = 1) 1.6-1.69 typical		VAPOR PRESSURE @ °C Negligible	
VAPOR DENSITY (AIR = 1) N/A		SOLUBILITY IN WATER, % BY WT @ °C Negligible	
PERCENT VOLATILES BY VOLUME Negligible		EVAPORATION RATE (BUTYL ACETATE = 1) N/A	
APPEARANCE AND ODOR Small Granular Solids			

II. HAZARDOUS INGREDIENTS

Material	%	PEL or T.V. (UNITS)	References
* Nitrocellulose	65.30 - 66.40	- Not established	
* Nitroglycerine	10.00 - 15.00	- 0.2 ppm	
* 2-Nitrodiphenylamine	0.80 - 2.20	- Not established	
* Lead Salicylate	2.00 - 3.30	- 50 ug/m3	
* Lead Beta Resorcylate	0.00 - 3.30	- 50 ug/m3	
Lead 2-Ethyl Hexoate	0.00 - 2.60	- 50 ug/m3	
Aluminum Powder	0.00 - 9.46	- 10 mg/m3	
* Carbon Black	0.00 - 0.37	- 3.5 mg/m3	
Graphite (Glaze)	0.04	- 3.5 mg/m3	

III. FIRE AND EXPLOSION HAZARD DATA

		References
FLASH POINT (TEST METHOD) N/A	AUTOIGNITION TEMPERATURE 145°C	
FLAMMABLE LIMITS IN AIR, % BY VOLUME	LOWER N/A	UPPER N/A

EXTINGUISHING MEDIA: Self oxidizing, Deluge with water. May not be able to extinguish before all material has been consumed unless large quantities of water are used in a very short time period.

SPECIAL FIRE FIGHTING PROCEDURES: Evacuate the area.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Easily ignited, highly combustible; protect from fire, sparks and extreme heat.

NAVORDSTA 8000/2 (6/86) TEST

NAVAL ORDNANCE STATION
INDIAN HEAD, MD 20640-5000
Telephone (301) 743-4484

Prepared by: S. Cirillo
Date Prepared: 3-8-88

Approved by: [illegible]
Date: [illegible]

JUL 21 '97 13:10 301 743 4108 PAGE.03

07/21/97 13:00 ☎301 743 4108 IHD/NSWC ☑004/005
05/29/96 13:10 ☎301 743 4792 NSWC/IH CAST DIV ←→ IHD/NSWC ☑004
From: Nancy Thompson Safety Department at Cast Division To: Tim Bowman Page 3 of 4 Tuesday, April 23, 1996 10:38:17 AM

NAVORDSTA MATERIAL SAFETY DATA SHEET Page 2 of 3

IV. HEALTH HAZARD DATA

References

THRESHOLD LIMIT VALUE or PERMISSIBLE EXPOSURE LIMIT Not established See Section II

EFFECTS OF OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES: EYES: In case of contact, flush thoroughly with plenty of low pressure water for at least 15 minutes. Remove any contact lenses to assure thorough flushing. If flushing water does not relieve irritation, seek medical attention. SKIN: Wash with soap and running water. INHALATION: Remove to fresh air. If symptoms listed above develop, seek medical attention

V. REACTIVITY DATA

References

STABILITY				
UNSTABLE	STABLE	CONDITIONS TO AVOID	Avoid open flame, sparks and heat.	Sax
	X			
INCOMPATIBILITY (MATERIALS TO AVOID)	Acid and bases (Organic and inorganic)			N/A
HAZARDOUS DECOMPOSITION PRODUCTS	Oxides of Nitrogen and Carbon			SAX
HAZARDOUS POLYMERIZATION				
MAY OCCUR	WILL NOT OCCUR	CONDITIONS TO AVOID	NONE	N/A

VI. SPILL OR LEAK PROCEDURES

References

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Clean up spills immediately using a soft bristle brush and a conductive rubber or plastic shovel. Use caution, material is sensitive to friction, impact and electrostatic discharge.

WASTE DISPOSAL METHOD: Burn on open burning ground in accordance with state and local regulations. May also be burned in an incinerator approved for explosives.

VII. SPECIAL PROTECTION INFORMATION

References

RESPIRATORY PROTECTION (SPECIFY TYPE): Selection of type respirator shall be lead exposure specified in accordance W/OPNAVINST 5100.23B, Cha.21, Par. 21004 (d)(2)

VENTILATION	LOCAL EXHAUST	SPECIAL	
	MECHANICAL (GENERAL)	OTHER	Adequate Ventilation

PROTECTIVE GLOVES	Cotton or leather	EYE PROTECTION	Safety glasses

OTHER PROTECTIVE EQUIPMENT: Flame retardant coveralls and conductive shoes

VIII. SPECIAL PRECAUTIONS

References

PRECAUTIONARY LABELING: Nitrocellulose (flammable solid)
Nitroglycerine (skin)
Lead Salicylate, Lead Beta Resorcylate, Lead 2-Ethyl Hexoate
Aluminum powder

OTHER HANDLING AND STORAGE CONDITIONS: Avoid prolonged temperatures above 50°C (125°F)
Recommended storage: 21°C (70°F) at 50% Humidity.

NAVORDSTA 8000/2 (6-86) TEST

JUL 21 '97 13:11 301 743 4108 PAGE.04

07/21/97 13:00 ☎301 743 4108 IHD/NSWC 005/005
05/29/98 13:11 ☎301 743 4792 NSWC/IH CAST DIV ---- IHD/NSWC 005

NAVORDSTA
MATERIAL SAFETY DATA SHEET

IX. LABEL

DATE:
PAGE: 3 of 3

TRADE NAME:
Chemical Name or Common Name

DOUBLE BASE PROPELLANT

ABL 705, ABL 917, ABL 1362, ABL 1491, ABL 2434

DANGER!

EXTREMELY FLAMMABLE. SEVERE
FIRE AND EXPLOSIVE HAZARD.

KEEP AWAY FROM HEAT, SPARKS AND FLAME. AVOID CONTACT WITH EYES, SKIN AND CLOTHING. AVOID BREATHING DUST AND VAPORS. DO NOT STORE IN DIRECT SUNLIGHT.

WHEN HANDLING WEAR SAFETY GLASSES, GLOVES AND PROTECTIVE CLOTHING. USE WITH ADEQUATE VENTILATION AND EMPLOY RESPIRATORY PROTECTION WHEN EXPOSED TO DUST AND VAPORS. WASH THOROUGHLY AFTER HANDLING.

EFFECTS OF OVEREXPOSURE
CONTACT CAN CAUSE IRRITATION TO THE EYES AND SKIN. INHALATION OF DUST OR VAPORS CAN CAUSE IRRITATION TO MUCOUS MEMBRANES, DRYNESS OF MOUTH AND THROAT, HEADACHE, NAUSEA AND DIZZINESS.

FIRST AID PROCEDURES:

EYES:
IMMEDIATELY FLUSH WITH WATER. IF FLUSHING WITH WATER DOES NOT RELIEVE IRRITATION SEEK MEDICAL ATTENTION.

SKIN:
WASH WITH SOAP AND WARM WATER. REMOVE CONTAMINATED CLOTHING. IF IRRITATION DEVELOPS SEEK MEDICAL ATTENTION.

INHALATION:
REMOVE PERSON FROM CONTAMINATED AIR. IF SYMPTOMS LISTED ABOVE DEVELOP SEEK MEDICAL ATTENTION.

INGESTION:
SEEK MEDICAL ATTENTION.

NAVAL ORDNANCE STATION
INDIAN HEAD, MD 20640-5000
Telephone (301) 743-4484

NAVORDSTA-8000 (6-86) TEST

JUL 21 '97 13:11 321 743 4128 PAGE.05

JUL-25-1996 07:30 FROM TO 8048242741 P.02

TAURUS

MATERIAL SAFETY DATA SHEET

HERCULES

Page 1 of 3

REGULAR TELEPHONE NO. (703) 639-7294
EMERGENCY TELEPHONE NO.
CHEMICAL FAMILY Double-Base Propellant
MOLECULAR WEIGHT ---

CHEMICAL NAME N/A
SYNONYMS: N/A
FORMULA: N/A
TRADE NAME AND SYNONYMS: Propellant NOSIN-18-2 Standard

I. PHYSICAL DATA

BOILING POINT, 760mm. Hg N/A
FREEZING POINT N/A
SPECIFIC GRAVITY (H2O = 1) 1.6170
VAPOR PRESSURE @ °C Negligible
SOLUBILITY IN WATER, % BY WT @ °C Negligible
VAPOR DENSITY (AIR = 1) N/A
PERCENT VOLATILES BY VOLUME N/A
EVAPORATION RATE (BUTYL ACETATE = 1) less than 1

APPEARANCE AND ODOR Flat shaft, brownish in color

II. HAZARDOUS INGREDIENTS

MATERIAL	%	TLV (UNITS)
Nitrocellulose (flammable solid)	51.0	Not established
Nitroglycerin (skin)	38.6	0.05 PPM*
2-Nitrodiphenylamine	2.0	Not established
Di-n-Propyl Adipate	1.4	Not established
Triacetin	2.7	Not established
Lead - Copper - Resorcylate - Salicylate	4.0	Not established
Candelilla Wax	0.1	Not established

Note: *OSHA PEL = 0.20 PPM (ceiling)

III. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (TEST METHOD) N/A
AUTOIGNITION TEMPERATURE 356.5oF
FLAMMABLE LIMITS IN AIR, % BY VOLUME LOWER N/A UPPER N/A

EXTINGUISHING MEDIA: Self-oxidizing; deluge with water. May not be able to extinguish before all material has been consumed unless large quantities of water are used in very short time period.

SPECIAL FIRE FIGHTING PROCEDURES: Evacuate the area.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Easily ignited, highly combustible; protect from fire, sparks and extreme heat.

HERCULES INCORPORATED
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

39
575

JUL 25 '96 09:58 PAGE.02
JUL 22 '97 16:05 8048242741 PAGE.02

1

Page 2 of 3

IV. HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE	Not established. See Section II
EFFECTS OF OVEREXPOSURE	Throbbing headache and upset stomach
EMERGENCY AND FIRST AID PROCEDURES	Eyes: In case of contact, flush thoroughly with plenty of low pressure water for at least 15 minutes. Remove any contact lenses to assure thorough flushing. Call a physician. Skin: Wash with soap and running water. Inhalation: Remove to fresh air. Treat any irritation symptomatically. Call a physician.

V. REACTIVITY DATA

STABILITY	UNSTABLE	STABLE X	CONDITIONS TO AVOID: Avoid open flame, sparks and heat
INCOMPATIBILITY (MATERIALS TO AVOID)	Acids and bases (organic and inorganic)		
HAZARDOUS DECOMPOSITION PRODUCTS	Oxides of nitrogen and carbon		
HAZARDOUS POLYMERIZATION	MAY OCCUR	WILL NOT OCCUR X	CONDITIONS TO AVOID: None

VI. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED	Clean up spills immediately using a soft bristle brush and a conductive rubber or plastic shovel. Use caution, material is sensitive to friction impact and electrostatic discharge.
WASTE DISPOSAL METHOD	Burn on open burning ground in accordance with state and local regulations. May also be burned in an incinerator approved for explosives.

VII. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFY TYPE)	Not required.			
VENTILATION	LOCAL EXHAUST	—	SPECIAL	—
	MECHANICAL (GENERAL)	—	OTHER	Adequate ventilation
PROTECTIVE GLOVES	Cotton or Leather		EYE PROTECTION	Safety glasses
OTHER PROTECTIVE EQUIPMENT	Flame retardant coveralls and conductive shoes			

VIII. SPECIAL PRECAUTIONS

PRECAUTIONARY LABELING	Nitrocellulose (flammable solid) Nitroglycerin (skin) Lead-Copper-Resorcylate-Salicylate
OTHER HANDLING AND STORAGE CONDITIONS	Avoid prolonged temperatures above 50°C (125°F) Recommended storage: 21°C (70°F) at 50% humidity

JUL 25 '95 09:58 PAGE.03
JUL 22 '97 16:05 9049242741 PAGE.03

07-22-1997 15:42 JUL-25-1995 09:30 8868242341 FROM LV & AS DRIVE 10 9186886418876 P.04

MATERIAL SAFETY DATA SHEET

MSDS:
DATE:
PAGE: 3 of 3

TRADE NAME: PROPELLANT MOSIN-AA-2 STANDARD

IX SPECIAL PRECAUTIONS
PRECAUTIONARY LABELING:

Labeled and packaged in accordance with the Hazardous Material: Regulations of the Department of Transportation for Class B Explosives.

WARNING: FLAMMABLE Solid
Keep away from heat, sparks, and open flame.
Keep containers closed.
Use with adequate ventilation.

FIRST AID:

EYES: In case of contact, immediately flush with plenty of low pressure water for at least 15 minutes. Remove any contact lenses to assure thorough flushing. Call a physician.

SKIN: Wash with soap and running water.

INHALATION: Remove to fresh air. Treat any irritation symptomatically. Call a physician.

OTHER HANDLING AND STORAGE CONDITIONS:
Storage also must conform to local, state and Federal Regulations including OSHA - 29CFR 1910.109 and BATF, 27CFR55, Subpart K.

559

JUL 25 '95 09:59 PAGE.04
JUL 22 '97 16:05 8868242341 PAGE.04

Viper III

VIPER III
MSDS #: EXP37

ORBITAL SCIENCES CORP ARIZ
PAGE 1

SECTION I

Trade Name: VIPER III
Common Name: ROCKET MOTOR

Manufacturer's Name: UNIVERSAL PROPULSION CO., INC.
Address: 25401 NORTH CENTRAL AVENUE
PHOENIX, AZ 85027-9801

Emergency Telephone No.: 24 HOUR 602-234-6663
Information Telephone No.: 602-869-8067
Preparer: W. Roberts

Date Received:
Date Prepared: 07/08/91

Chemical Name: NA

Supplier's Generic Name: NA

Synonyms: NA

Hazard Class: EXPLOSIVE

Other Identifying Data: UN 0186, PROPER SHIPPING NAME= ROCKET MOTORS

Explosive Class = 1.3C, COMPETENT AUTHORITY CA-9212010, EX-8805252

N.E.W. = 57.5 lbs

NFPA-704 =

HMIS =

This product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. Those chemicals are: Dibutyl Phthalate, CAS #84-74-2, 2.8% by weight.

SECTION II - HAZARDOUS INGREDIENTS/IDENTIFY INFORMATION

Chemical Name	OSHA-PEL (ppm)	ACGIH-TLV (ppm)	CAS Number	Percent
Polysulfide Rubber			NDA	<18
Dibutylphthalate	5MG/M3	5MG/M3	NDA	<3
Magnesium Oxide 15mg/m3dust	5MG/M3	10MG/M3	NDA	<1
Sulfur			NDA	<.1
Diphenylguanidine (DPG)			NDA	<.2
Aluminum	5MG/M3	5MG/M3	NDA	<2
Ammonium Perchlorate			NDA	77

NOTE: If PEL or TLV is followed by the letter M, value is Mg/Cubic Meter

APPENDIX B - CERTIFICATES OF ANALYSES

5

EG&G TECHNICAL SERVICES INCORPORATED

Client Sample ID: TAURUS

HPLC

Lot-Sample #...: H2K060267-001
Date Sampled...: 11/26/01
Prep Date.....: 11/15/02
Prep Batch #...: 2318216
Dilution Factor: 2
% Moisture.....:

Work Order #...: FCHR51AA
Date Received..: 11/05/02
Analysis Date..: 11/21/02

Matrix.....: SOLID

Method.....: SW846 8332

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Nitroglycerin	6.2	5.0	mg/kg

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1-Chloro-3-nitrobenzene	110	(70 - 130)

6

METHOD BLANK REPORT

HPLC

Client Lot #...: H2K060267
MB Lot-Sample #: H2K140000-216

Work Order #...: FC3PF1AA

Matrix.....: SOLID

Analysis Date..: 11/21/02
Dilution Factor: 1

Prep Date.....: 11/15/02
Prep Batch #...: 2318216

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD
Nitroglycerin	ND	2.5	mg/kg	SW846 8332

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1-Chloro-3-nitrobenzene	112	(70 - 130)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

HPLC

Client Lot #...: H2K060267
LCS Lot-Sample#: H2K140000-216
Prep Date.....: 11/15/02
Prep Batch #...: 2318216
Dilution Factor: 1

Work Order #...: FC3PF1AC-LCS
FC3PF1AD-LCSD
Analysis Date..: 11/21/02

Matrix.....: SOLID

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD
Nitroglycerin	92	(70 - 130)			SW846 8332
	92	(70 - 130)	0.91	(0-25)	SW846 8332

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1-Chloro-3-nitrobenzene	108	(70 - 130)
	110	(70 - 130)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Bold print denotes control parameters

LABORATORY CONTROL SAMPLE DATA REPORT

HPLC

Client Lot #...: H2K060267
LCS Lot-Sample#: H2K140000-216
Prep Date.....: 11/15/02
Prep Batch #...: 2318216
Dilution Factor: 1

Work Order #...: FC3PF1AC-LCS
FC3PF1AD-LCSD
Analysis Date..: 11/21/02

Matrix.....: SOLID

PARAMETER	SPIKE AMOUNT	MEASURED AMOUNT	UNITS	PERCENT RECOVERY	RPD	METHOD
Nitroglycerin	25.0	23.1	mg/kg	92		SW846 8332
	25.0	22.9	mg/kg	92	0.91	SW846 8332

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1-Chloro-3-nitrobenzene	108	(70 - 130)
	110	(70 - 130)

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Bold print denotes control parameters

EG&G TECHNICAL SERVICES INCORPORATED

Client Sample ID: TOMAHAWK

General Chemistry

Lot-Sample #...: H2K060267-002
Date Sampled...: 11/26/01
% Moisture.....:

Work Order #...: FCHTC
Date Received..: 11/05/02

Matrix.....: SOLID

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate	49000	1000	ug/kg	EPA-DW1 314.0	12/12/02	2350196

Dilution Factor: 25

10

METHOD BLANK REPORT

General Chemistry

ient Lot #...: H2K060267

Matrix.....: SOLID

PARAMETER	RESULT	REPORTING LIMIT	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate	ND	Work Order #: FEW121AA 40.0	ug/kg	MB Lot-Sample #: EPA-DW1 314.0	H2L160000-196 12/12/02	2350196

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

11

LABORATORY CONTROL SAMPLE EVALUATION REPORT

General Chemistry

Client Lot #...: H2K060267

Matrix.....: SOLID

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate	95	(85 - 115)	Work Order #: FEW121AC LCS Lot-Sample#: H2L160000-196 EPA-DW1 314.0 Dilution Factor: 1	12/12/02	2350196

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

12

LABORATORY CONTROL SAMPLE DATA REPORT

General Chemistry

Client Lot #...: H2K060267

Matrix.....: SOLID

PARAMETER	SPIKE AMOUNT	MEASURED AMOUNT	UNITS	PERCNT RECVRY	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate	1000	945	ug/kg	95	EPA-DW1 314.0	12/12/02	2350196

Work Order #: FEW121AC LCS Lot-Sample#: H2L160000-196

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

13

MATRIX SPIKE SAMPLE EVALUATION REPORT

General Chemistry

ient Lot #...: H2K060267
te Sampled...: 11/20/02 Date Received..: 11/22/02 Matrix.....: SOLID

PARAMETER	PERCENT RECOVERY	RECOVERY LIMITS	RPD	RPD LIMITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate						% Moisture.....: 22	
		WO#: FDPE51AC-MS/FDPE51AD-MSD				MS Lot-Sample #: H2K220234-007	
	81	(80 - 120)			EPA-DW1 314.0	12/12/02	2350196
	87	(80 - 120)	6.7	(0-20)	EPA-DW1 314.0	12/12/02	2350196
		Dilution Factor: 1					

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.
Results and reporting limits have been adjusted for dry weight.

MATRIX SPIKE SAMPLE DATA REPORT

General Chemistry

ient Lot #...: H2K060267
ate Sampled...: 11/20/02 Date Received..: 11/22/02 Matrix.....: SOLID

PARAMETER	SAMPLE AMOUNT	SPIKE AMT	MEASRD AMOUNT	UNITS	PERCNT RECVRY	RPD	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Perchlorate								% Moisture.....: 22	
			WO#: FDPE51AC-MS/FDPE51AD-MSD				MS Lot-Sample #: H2K220234-007		
	ND	386	314	ug/kg	81		EPA-DW1 314.0	12/12/02	2350196
	ND	386	335	ug/kg	87	6.7	EPA-DW1 314.0	12/12/02	2350196
			Dilution Factor: 1						

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.
Results and reporting limits have been adjusted for dry weight.

Analytical Report For 312057

for

EG & G Technical Services, Inc.

Project Manager : Monica Borowicz

Project Name : T-2 Sampling

December 17, 2003

GPL

Laboratories

GPL Laboratories, LLLP Certifies that the test results meet all requirements of the NELAC Standards unless otherwise noted.

Reviewed by, Project Manager	Approved by, Laboratory Director

202 Perry Parkway Gaithersburg, MD 20877 Phone (301) 926-6802 Fax: (301) 840-1209
www.gplab.com

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-004-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method:
Prep Date:
Prep Time:
Prep Batch:

Analytical Method: CLP_SOLIDS
Date Analyzed: 12/10/2003
Time Analyzed: 15:00
Analysis Batch: 65127

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Percent Solids	92	1.0	%		1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-001-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method:
Prep Date:
Prep Time:
Prep Batch:

Analytical Method: IAAP
Date Analyzed: 12/16/2003
Time Analyzed: 09:23
Analysis Batch: 65228

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Nitrocellulose	120	15	mg/kg		1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-004-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method:
Prep Date:
Prep Time:
Prep Batch:

Analytical Method: SW1010
Date Analyzed: 12/11/2003
Time Analyzed: 00:00
Analysis Batch: 65124

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Flash Point	BQL	20	DC	U	1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-003-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method: SW3010A
Prep Date: 12/13/2003
Prep Time: 00:00
Prep Batch: 64136

Analytical Method: SW6010B_TCLP
Date Analyzed: 12/16/2003
Time Analyzed: 00:27
Analysis Batch: 15866

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Lead	14000	100	ug/L		1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-002-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method: EXT_SW8330
Prep Date: 12/11/2003
Prep Time: 00:00
Prep Batch: 64095

Analytical Method: SW8330
Date Analyzed: 12/12/2003
Time Analyzed: 21:03
Analysis Batch: 65231

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Nitroglycerine	440000	10000	ug/kg		1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-004-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method:
Prep Date:
Prep Time:
Prep Batch:

Analytical Method: SW9014R
Date Analyzed: 12/11/2003
Time Analyzed: 16:00
Analysis Batch: 65214

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Cyanide, Reactive	0.070	0.020	mg/kg		1

GPL LABORATORIES, LLLP

Summary of Analytical Results

Client ID: T-2
GPL ID: 312057-001-004-1/1
Matrix: SOIL
Date Collected: 12/03/2003
Date Received: 12/04/2003

Prep Method:
Prep Date:
Prep Time:
Prep Batch:

Analytical Method: SW9034R
Date Analyzed: 12/15/2003
Time Analyzed: 12:30
Analysis Batch: 65212

Parameter	Result	Rep Limit	Units	Qualifier	D.F.
Sulfide, Reactive	BQL	9.6	mg/kg	U	1

GPL LABORATORIES, LLP
ANALYTICAL RESULTS

Project Name : T-2 Sampling
Date Printed December 17, 2003

GPL ID	Client ID
312057-001-001-1/1	T-2
312057-001-002-1/1	T-2
312057-001-003-1/1	T-2
312057-001-004-1/1	T-2

QCL
QC LABORATORIES

Analytical Report

Serialized: 12/05/2013 06:39pm

GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN,DE 19709-0138

Regarding:

ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

PROJECT ID:

AL0085

LABORATORY REPORT NUMBER:

L4823838

M15 Taurus
Cleanout

Authorized by: Dominen V. Kappil, QA Director

QCL Accreditations: Southampton Div: EPA ID PA00016; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. #: 2515238
Delaware Division: State ID's: DE 00011, MD 138
Vineland Division: State ID: NJ 06005; Reading Div: State ID: PA 08-03543
Wind Gap Division: State ID's: PA 48-01334, NJ PA001
E. Rutherford Division: State ID: NJ 02015

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 · Phone: 215-355-3900 · Toll Free: 800-289-8378 · Fax: 215-355-7231 · www.qclaboratories.com

QC Laboratories

Analytical Report

Printed 12/05/13 18:39

GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

Regarding:
GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

Account No: AL0085, ENVIRONMENTAL TESTING, INC.
Project No: AL0085, ENVIRONMENTAL TESTING, INC.
P.O. No:
Inv. No: 1570819
PWSID No:

Sample ID	Sample Description	Samp. Date/Time/Temp	Sampled by
L4823838-1	13-233, FISHER ENVIRONMENTAL, NASA TAURUS WALLOPSIS, VA COMP	11/01/13 00:00am NA C	Customer

Received Date/Time/Temp 11/05/13 07:35pm 0.9 C **Iced (Y/N):** Y

Parameter	Method	Result	RLs	Test Date, Time, Analyst
GENERAL CHEMISTRY				
TCLP EXTRACTION	EPA 1311	COMPLETE		11/07/13 11:25AM KR
TCLP-O HEADSPACE EXTRACTION	EPA 1311	COMPLETE		11/11/13 06:30AM KR
METALS				
ARSENIC-TCLP	EPA 6010C	ND mg/l	0.0100 mg/l	11/14/13 08:20AM B B
BARIUM-TCLP	EPA 6010C	0.216 mg/l	0.0100 mg/l	11/14/13 08:20AM B B
CADMIUM-TCLP	EPA 6010C	1.06 mg/l	0.0100 mg/l	11/14/13 08:20AM B B
CHROMIUM-TCLP	EPA 6010C	0.673 mg/l	0.0100 mg/l	11/14/13 08:20AM B B
LEAD-TCLP	EPA 6010C	6.42 mg/l	0.0100 mg/l	11/14/13 08:20AM B B
SELENIUM-TCLP	EPA 6010C	ND mg/l	0.0500 mg/l	11/14/13 08:20AM B B
SILVER-TCLP	EPA 6010C	ND mg/l	0.0100 mg/l	11/14/13 08:20AM B B
MERCURY-TCLP	EPA 7470A	ND mg/l	0.00100 mg/l	11/12/13 02:56PM RMP
GAS CHROMATOGRAPHY MASS SPECTROMETRY; SEMI-VOLATILES				
1,4-DICHLOROBENZENE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
2,4,5-TRICHLOROPHENOL-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
2,4,6-TRICHLOROPHENOL-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
2,4-DINITROTOLUENE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
2-METHYLPHENOL-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
3&4-METHYLPHENOL-TCLP	EPA 8270C	ND mg/l	0.200 mg/l	11/15/13 03:39AM GRM
HEXACHLOROBENZENE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
HEXACHLOROBUTADIENE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
HEXACHLOROETHANE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
NITROBENZENE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
PENTACHLOROPHENOL-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
PYRIDINE-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM
TOTAL CRESOL-TCLP	EPA 8270C	ND mg/l	0.100 mg/l	11/15/13 03:39AM GRM

Sample Comments:

PP 22365

Serial Number: 3247887

L4823838

ENVIRONMENTAL TESTING, INC.
AL0085

CHAIN OF CUSTODY RECORD

100 SOUTH CASS STREET
MIDDLETOWN DELAWARE
19709

PHONE (302) 378-9881
FAX (302) 378-9882

SAMPLE TURN AROUND TIME: Standard

PROJ. NO. 13-233 PROJ. NAME: 13 Fisher Bendiamolt

SAMPLERS: (SIGNATURE) Lance Fisher

STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Full TCLP except herbicides & pesticides	REMARKS
1	11/1/13		✓		NASA - Taurus, Wallops Is, VA	1	✓	No Herbicides or Pesticides

#___ Ascorbic/HCl Vials #___ HCl Vials
#___ $Na_2S_2O_3$
#___ Na OH/Zn acetate pH
#___ HNO_3 pH
#___ H_2SO_4 pH
#___ NaOH pH
#1 Unpreserved Ziploc bag
#___ Hcl pH
#___ NH4Cl

Sample submitted in plastic ud 11/6/13

Lab Volume rec'd GO 11/6/13

0.9 QC omitted

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)
[signature]					11/1/13	11:55	[signature]
RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)
[signature]	11/1/13	12:00	Cooler # 92	92	11/5/13	1935	[signature]
RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY: (SIGNATURE)		DATE	TIME	REMARKS

Note: Lead Wipe Sample Media meets ASTM criteria.

QC Laboratories

Analytical Report

Printed 12/05/13 18:39

Account No:AL0085, ENVIRONMENTAL TESTING, INC. **P.O. No:** **Inv. No:** 1570819
Project No: AL0085, ENVIRONMENTAL TESTING, INC. **PWSID No:**

L4823838-1 :

The TCLP extraction was performed in accordance with 40 CFR parts 261.24 and 268.7.
For the 8270C fraction, a dilution was required to be performed on this sample because of the sample matrix and/or interferences by nontarget compounds. The surrogate recoveries may have been impacted. The RLs have been adjusted to reflect the dilution.

For the 8270 TCLP fraction, Phenol_d5 (14%, limits 16% to 37%), 2_Fluorobiphenyl (105%, limits 54% to 91%), and 2,4,6_Tribromophenol (44%, limits 46% to 100%) surrogate recoveries were outside of the laboratory quality control limits due to matrix effects. The sample needed a 20x dilution due to the presence of matrix interference and/or non_target analytes.

For method 8270 fraction, the continuing calibration verification standard 11/14/13 recovered Hexachlorobutadiene (130%) outside of the method criteria (80% to 120%). This compound was not detected in the associated sample.

General Notes:

A result of "ND" indicates that the analyte tested was either not detected or the concentration was below the RLs.
Definitions: NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC= Too numerous to count; pres=presumptive
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
MCL= EPA recommended "maximum contaminant level", PLs = Customer-specific permit limits.
The test results meet all requirements of NELAC, where applicable, unless otherwise specified.
The report shall not be reproduced except in full without the written consent of the laboratory.
Unless otherwise specified, the Environmental testing except Field Parameters was performed by QC Inc. located at 1205 Industrial Blvd., Southampton, PA 18966; Pharmaceutical, Dairy, Food Chemistry and Food Microbiological tests were performed by QC Inc. located at 702 Electronic Dr., Horsham, PA 19044.
QCL Accreditations: Southampton Div: EPA ID PA00018; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
Delaware Div: State ID's: DE 00011, MD 130; Wind Gap Div: State ID's: PA 48-01334, NJ PA001
E. Rutherford Div: State ID: NJ 02015; Vineland Div: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
The reported results relate only to the samples.
All samples are collected as "grab" samples unless otherwise identified.

Regulatory authorities are assessing substantial fines for testing omissions. Please track your sample collections and results on a weekly, monthly, or quarterly basis to ensure compliance. QC's internet program 'LIVE ACCESS' will provide you with real-time access to collection dates and results. Please contact Customer Service for further information on acquiring LIVE ACCESS.

PP 22365 Serial Number: 3247887

QC Laboratories
1205 Industrial Highway, Southampton, PA 18966

DELAWARE

Inter-Laboratory Transport Form: DE110513

Coolers for Transport

To be completed by person sealing coolers					Complete Section Upon Delivery	
Cooler ID No.	Custody Seal No.	Date	Time	Initials	Temp °C	Iced Y/N
92	110513-1	11-5-13	17:45	PD	0.9	Yes
F12	110513-2	11-5-13	17:45	PD	18.6	Yes
D14	110513-3	11-5-13	17:45	PD	4.3	Yes
E24	110513-4	11-5-13	17:45	PD	1.3	Yes

Please Note the Following:

Individual sample chains of custody must accompany this form.

Once a cooler is sealed, custody seals may not be broken until samples are received at the designated QCL laboratory.

Water Max in Cooler #014

Laboratory use only

Custody Seals intact upon receipt? (Y) N Initials: C M

List ID of any seal found broken upon receipt below:

A full legal signature is required. Record all times in military time (24-HR Clock, 4:00 PM=1600)

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
[signature]	11-5-13	17:45	Secure Office	11/5/13	17:45
Secure Office [signature]	11/5/13	17:55	[signature]	11/5/13	17:55
[signature]	11/5/13	19:35	[signature]	11513	1935
Relinquished by:	Date:	Time:	Received by:	Date:	Time:

Page 1 of 1

QC LABORATORIES

Analytical Report

Serialized: 12/09/2013 03:28pm

GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN,DE 19709-0138

Regarding:

ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

PROJECT ID:

AL0085

JOB ID:

FISHERS ENVIRONMENTAL

LABORATORY REPORT NUMBER:

L4838414

Authorized by: Oommen V. Kappil, QA Director

QCL Accreditations: Southampton Div: EPA ID PA00018; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
Delaware Division: State ID's: DE 00011, MD 138
Vineland Division: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
Wind Gap Division: State ID's: PA 48-01334, NJ PA001
E. Rutherford Division: State ID: NJ 02015

1205 Industrial Blvd., P.O. Box 514, Southampton, PA 18966-0514 · Phone: 215-355-3900 · Toll Free: 800-289-8378 · Fax: 215-355-7231 · www.qclaboratories.com

QC Laboratories

Analytical Report

Printed 12/09/13 15:28

GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

Regarding:
GARY HAYES
ENVIRONMENTAL TESTING, INC.
100 SOUTH CASS STREET
PO BOX 138
MIDDLETOWN, DE 19709-0138

Account No: AL0085, ENVIRONMENTAL TESTING, INC.
Project No: AL0085, ENVIRONMENTAL TESTING, INC.
P.O. No:
Inv. No: 1571275
PWSID No:

Sample ID	Sample Description	Samp. Date/Time/Temp	Sampled by
L4838414-1	13-0084-001 NASA TAURUS	11/14/13 00:00am NA C	Customer

Received Date/Time/Temp 11/25/13 08:00am 16.6 C **Iced (Y/N):** Y

Parameter	Method	Result	RLs	Test Date, Time, Analyst
GENERAL CHEMISTRY				
TCLP EXTRACTION	EPA 1311	COMPLETE		12/02/13 11:15AM KR
TCLP-O HEADSPACE EXTRACTION	EPA 1311	COMPLETE		11/26/13 11:50AM KR
GAS CHROMATOGRAPHY MASS SPECTROMETRY; VOLATILES				
1,1-DICHLOROETHENE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
1,2-DICHLOROETHANE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
2-BUTANONE-TCLP	EPA 8260B	ND mg/l	0.0500 mg/l	12/05/13 06:17PM JFM
BENZENE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
CARBON TETRACHLORIDE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
CHLOROBENZENE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
CHLOROFORM-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
TETRACHLOROETHENE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
TRICHLOROETHENE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM
VINYL CHLORIDE-TCLP	EPA 8260B	ND mg/l	0.0250 mg/l	12/05/13 06:17PM JFM

Sample Comments:

L4838414-1 :

The TCLP extraction was performed in accordance with 40 CFR parts 261.24 and 268.7.
For the TCLP ZHE fraction, the ZHE blank associated with the sample had 0.0009 mg/L of chloroform.

For the 8260 TCLP ZHE fraction, the recovery of tetrachloroethene (117%) in the laboratory control sample was above laboratory quality control limits (77 to 114%). Any detected results of this analyte in the associated samples may be biased high.

General Notes:

A result of "ND" indicates that the analyte tested was either not detected or the concentration was below the RLs.
Definitions: NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC= Too numerous to count; pres=presumptive
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.

PP 22365 Serial Number: 3251205

QC Laboratories

Analytical Report

Printed 12/09/13 15:28

Account No: AL0085, ENVIRONMENTAL TESTING, INC.
Project No: AL0085, ENVIRONMENTAL TESTING, INC.

P.O. No:

Inv. No: 1571275
PWSID No:

MCL= EPA recommended "maximum contaminant level", PLs = Customer-specific permit limits.
The test results meet all requirements of NELAC, where applicable, unless otherwise specified.
The report shall not be reproduced except in full without the written consent of the laboratory.
Unless otherwise specified, the Environmental testing except Field Parameters was performed by QC Inc. located at 1205 Industrial Blvd., Southampton, PA 18966; Pharmaceutical, Dairy, Food Chemistry and Food Microbiological tests were performed by QC Inc. located at 702 Electronic Dr., Horsham, PA 19044.
QCL Accreditations: Southampton Div: EPA ID PA00018; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
Delaware Div: State ID's: DE 00011, MD 138; Wind Gap Div: State ID's: PA 48-01334, NJ PA001
E. Rutherford Div: State ID: NJ 02015; Vineland Div: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
The reported results relate only to the samples.
All samples are collected as "grab" samples unless otherwise identified.

PP 22365

Serial Number: 3251205

L4838414

ENVIRONMENTAL TESTING, INC.

100 SOUTH CASS STREET
MIDDLETOWN DELAWARE
19709

PHONE (302) 378-9881
FAX (302) 378-9882

CHAIN OF CUSTODY RECORD

SAMPLE TURN AROUND TIME: Standard

PROJ. NO. 13-233 PROJ. NAME: Fishers Environmental

SAMPLERS: (SIGNATURE) Chuck Brodell

STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Full TCLP, except herbicides and pesticides							REMARKS
13-0684-001 -1	11/14/13		✓		NASA Tanks, Wallops Island, VA	1	✓							No herbicides or pesticides

#____ Ascorbic/HCl Vials #____ HCl Vials
#____ $Na_2S_2O_3$
#____ Na OH/Zn acetate pH____
#____ HNO_3 pH____
#____ H_2SO_4 pH____
#____ NaOH pH____
#1 Unpreserved
#____ Hcl pH____
#____ NH4Cl____
1.3 OC CM iced

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)
	11/20/13	8:00			11/20/13	13:50	Cooler 821
RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)
821	11/25/13	1915					
RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY: (SIGNATURE)		DATE	TIME	REMARKS

16.6

QC Laboratories
1205 Industrial Highway, Southampton, PA 18966

DELAWARE

Inter-Laboratory Transport Form: DE112513

Coolers for Transport

To be completed by person sealing coolers					Complete Section Upon Delivery	
Cooler ID No.	Custody Seal No.	Date	Time	Initials	Temp °C	Iced Y/N
821	112513-1	11-25-13	17:00	PD	1.3	Yes
82	112513-2	11-25-13	17:00	PD	3.2	Yes
28	112513-3	11-25-13	17:00	PD	4.5	yes

Please Note the Following:

Individual sample chains of custody must accompany this form.

Once a cooler is sealed, custody seals may not be broken until samples are received at the designated QCL laboratory.

Rush metals in Cooler #821
SPC in cooler 28

Laboratory use only
Custody Seals intact upon receipt? (Y / N) Initials: CM
List ID of any seal found broken upon receipt below:

A full legal signature is required. Record all times in military time (24-HR Clock; 4:00 PM=1600)

Relinquished by:	Date:	Time:	Received by:	Date:	Time:
[signature]	11-25-13	17:00	Secure Office	11/25/13	17:00
Secure Office	11/25/13	17:15	[signature]	11/25/13	17:15
[signature]	11/25/13	19:15	[signature]	11/25/13	1915
Relinquished by:	Date:	Time:	Received by:	Date:	Time:

Page 1 of 1

APPENDIX C: SOUNDING ROCKET MOTOR INSPECTION PROCESS

810-PROC-0001-A

National Aeronautics and Space Administration
Goddard Space Flight Center/Wallops Flight Facility
Wallops Island, VA 23337

810/Sounding Rocket Program Office

Sounding Rocket Motor Inspection Process

Effective Date: May 2017

Check with the 810/Sounding Rocket Program Office to verify that this is the correct version prior to use

810-PROC-0001-A

Sounding Rockets Program Motor Inspection Process

Reviewed by:

PHILIP EBERSPEAKER

Digitally signed by PHILIP EBERSPEAKER
DN: c=US, o=U.S. Government, ou=NASA, ou=People, 0.9.2342.19200300.100.1.1=peberspe, cn=PHILIP EBERSPEAKER
Date: 2017.05.10 09:51:36 -04'00'

Chief, Sounding Rockets Program Office

Shad Combs

Digitally signed by Shad Combs
DN: c=US, o=U.S. Government, ou=NASA, ou=People, cn=Shad Combs, 0.9.2342.19200300.100.1.1=skcombs
Date: 2017.05.09 13:08:46 -04'00'

GSFC Explosive Safety Officer

CHARLES BRODELL

Digitally signed by CHARLES BRODELL
DN: c=US, o=U.S. Government, ou=NASA, ou=People, cn=CHARLES BRODELL, 0.9.2342.19200300.100.1.1=cbrodell
Date: 2017.05.05 12:39:23 -04'00'

Magazine Facility Operations Manager

DANIEL WALSH

Digitally signed by DANIEL WALSH
DN: c=US, o=U.S. Government, ou=NASA, ou=People, cn=DANIEL WALSH, 0.9.2342.19200300.100.1.1=dlwalsh
Date: 2017.05.05 12:59:15 -04'00'

V-67 Facility Operations Manager

810-PROC-0001-A

Sounding Rockets Program Motor Inspection Process

1.0 Background

The NASA Wallops Flight Facility (WFF) Sounding Rockets Program is based on utilizing surplus Department of Defense (DoD) rocket motor assets in conjunction with commercial sustainers to enable a low cost fleet of vehicles to support a variety of sub-orbital scientific research and technology demonstration applications. The DoD assets are transferred free of charge to NASA after their tactical shelf life date has expired. Repurposing these surplus assets benefits DoD by reducing their disposal liability. The NASA family of Sounding Rockets include various combinations of 1 to 4 stage rocket motor configurations (see Figure 1) capable of altitudes of up to 950 miles.
In the 20 flight per year mission model the program may utilize up to 45 different motors including 30 that are surplus DoD assets.

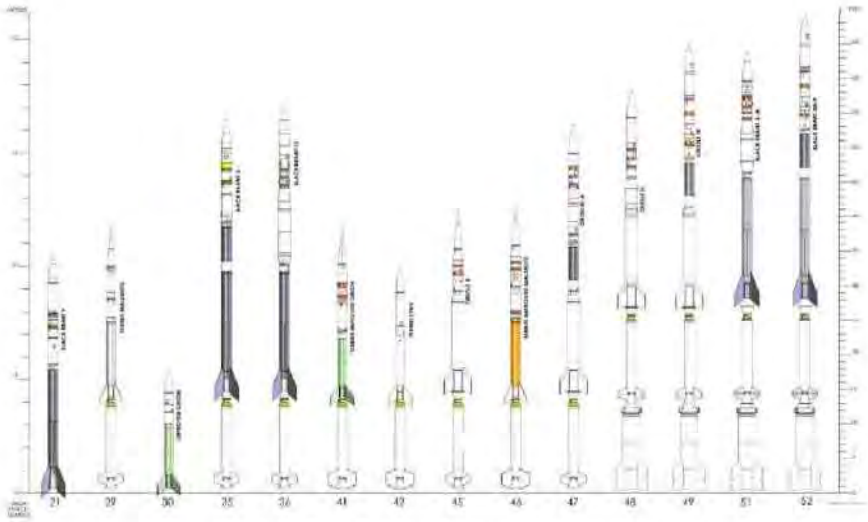

Figure 1, Sounding Rockets Program Stable of Vehicles

2.0 DoD Motor Surveillance Program

The DoD conducts surveillance programs on DoD rocket motor assets including those utilized by the Sounding Rockets Program. The surveillance program supports storage depots across the country. Samples are taken from representative lots of all types of motors for chemical analysis to determine stabilizer content and overall safe state.

3.0 Motor Refurbishment by the Navy

The MK11 and MK12 Navy boosters used in the Sounding Rockets Program are refurbished at the Naval Surface Warfare Center (NSWC) at Indian Head, MD, prior to

use on NASA launches. NSWC completely removes the cartridge propellant grains for full inspections, replaces seals/O-rings and convert the hardware from a tactical to NASA ready configuration. The MK11 motors are transferred from Hawthorne to NSWC prior to arriving at NASA in a flight ready state. MK12 motors are transferred from a DoD account at McAlester and refurbished at NSWC prior to supporting NASA missions.

4.0 Receipt of Motors at the Wallops Flight Facility

All incoming motor hardware is inspected upon receipt. The inspection includes removal of the box lid, serial number verification, verification of safe state, and visual inspection of the container contents including the exterior of the motor. Hardware is inspected for any indications of damage or degradation. Any discrepancies are noted on the Memorandum of Receipt and the Launch Vehicle Engineering group is notified to determine if any specific action(s) are required.

5.0 Motor Storage

The Sounding Rockets Program's motors are stored at offsite DoD depots in earth covered magazines and in the WFF magazine area. The WFF magazine area includes earth covered magazines and buildings that are climate-controlled to keep motors close to typical room temperature conditions. Typical storage temperature limits for DoD assets are between a range of 10° to 130° F. Motors stored in the magazine are kept at approximate room temperature conditions +/- 20° F.

5.1 WFF's Facility Environmental Condition Monitoring

Temperature and humidity recorders are utilized to monitor environmental conditions at motor storage locations. Recorders are set to record one data sample of temperature and humidity hourly. The data from the environmental recorders is downloaded monthly and reviewed with the information being maintained in the NASA Sounding Rockets Operations Contract (NSROC) Safety and Mission Assurance (SMA) Office's records. Recorder batteries are replaced as needed monthly at the time of data download. The recorders are calibrated annually with calibration records maintained within NSROC's records. Visual facility/inventory inspections are conducted by the NSROC logistics group at the time of data collection activities. Any discrepancies observed are noted and the Launch Vehicle Engineering group is notified to determine if any specific actions are required including generation of an appropriate Non Conformance Report.

5.2 Facility/Inventory Inspections

A number of independent organizations conduct facility and inventory inspections. As inspections are conducted, the condition of all facility contents are visually inspected for any abnormal or suspicious conditions. In addition to formal inspections, the magazine personnel conduct visual inspections of all stored materials as they work around/in those areas. Facility monitoring and inspections activities are listed in Table 1.

Table 1, Facility and Inventory Inspections

Inspection	Procedure, Reference	Frequency
Receipt Inspection	*Memorandum of Receipt generated by NSROC logistics team	Periodically as assets are received on station
NSROC environment monitoring	*Data downloaded from each building in file RH520_DWNLD_date_bldg.xls NSROC SMA office	Monthly
Explosive Safety Officer Inspection(s)	*NASA-STD 8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics *GSFC-STD-8715.1, Goddard Space Flight Explosive Safety Program *Observation(s) notification provided to FOM	Annual full inspection and random spot inspections
NSROC Safety walkthrough inspections	*Facility Safety Walk down Inspection Checklist, QS90737-F01	Quarterly
NASA Safety walkthrough	*NPR 8715.3, NASA General Safety Program Requirements *29 CFR Part 1960, Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters *GPR 1700.1, Occupational Safety Program at Goddard Space Flight Center *Document findings with 803-FORM-0002 *GSFC WFF Safety Office Facility Safety Inspection Reference Checklist, Form 803-FORM-0002	Annual

Inspection	Procedure, Reference	Frequency
Fire Department Inspections	*Fire extinguisher inspection *Facility inspection *Inspections documented by email to FOM	<30 days 60-90 days
Random management walkthroughs	*Random inspections, Observation(s) notification to FOM	>Monthly
NASA Safety Center QAAR (Quality Audit, Assessment, and Review) IFOSA (Institutional, Facility, Operational Safety Audit)	*Compliance audit/assessment verifying NASA Safety and Mission Assurance requirements	At least once every four years with interim assessments midway between the schedules to ensure a review is conducted every other year as necessary.

6.0 Motor Inspection Procedures

All motors undergo some level of inspection and refurbishment at WFF prior to flight to fulfill quality assurance and safety requirements. Inspection work includes replacing O-rings/seals and conducting visual grain/hardware inspections where feasible. If for some reason a motor fails to meet any specific requirement, it's identified as suspect and held for further evaluation and/or repair. If any motor defects or discrepancies are identified during inspections, engineering is notified and a Non Conformance (NC) is generated. The Nonconforming Product Control procedure is QS50750 Rev C 10/27/2016. If hardware is deemed as suspect for flight use, it is flagged for future review. Suspect hardware is identified as such and may be kept in storage for future use on missions with lower mission assurance needs, repair, or used for replacement components. If safety concerns are identified they will be followed to closure through the NC process. This may include taking a small sample of propellant and conducting material testing at the NSWC in Indian Head, MD (or other facility) to verify safe state.

All motor types stored at the facility are of similar vintage and storage history. Random sampling of the inventory occurs as motors are processed for flight. Motors determined to have no useful application are disposed of at the Open Burn Area. Motor inspection procedures for the motors currently utilized in the program are listed in Table 2. Procedures for other motor hardware are developed as needed

Table 2, Current Motor Inspection Procedures

Motor	Inspection Procedure #
M37E1	Spin Motor Inspection & Modification VS46137 Rev B 1/30/2008
Orion	Improved Orion Rocket Motor Removal, Inspection, and Modification VS55106 Rev D 6/8/2016
Malemute	Malemute Rocket Motor Inspection VS120214 Rev – 09/29/2016
Improved Malemute	Improved Malemute Rocket Motor Inspection and Modification VS75636 Rev G 04/13/2015
Mk12	Terrier MK 12 Mod. 1 Motor Removal, Inspection, & Installation in Shipping Container VS46138 Rev G 5/18/2015
MK70	Terrier MK 70 Rocket Motor Inspection and Modification VS55751 Rev L 11/9/2016
Talos	Talos Booster Removal, Inspection, Modification, & Installation in Shipping Container VS56158 Rev D 01/06/2016
Taurus	Taurus Motor Removal, Inspection & Installation in Container VS55943 Rev B 5/16/2012
Black Brant	Black Brant Motor Removal, Inspection, and Installation in Shipping Container VS59260 Rev J 07/25/2016
Nihka	Inspection of Nihka Rocket Motor VS47537 Rev B 9/3/2015
Oriole	Oriole Motor Removal, Inspection, and Installation in Shipping Container VS91679 Rev C 11/13/2013

7.0 Obsolete Assets

The motor inventory is continually reviewed by the Sounding Rockets Program Office to determine if a particular type of motor is deemed as obsolete based on age, degradation, or other available booster systems. For example, the Nike booster was replaced with the Terrier motor because of performance improvement and the age of the Nike motors. In a

waste minimization effort, the motors were traded with the China Lake sled track for some desirable Talos boosters instead of disposal in the Open Burn Area. If no other options are available, rocket motors may be used for training, performance tests or disposed of at the Open Burn Area. Onsite disposal minimizes handling, shipping, and transportation risk.

ATTACHMENT II.C

INSPECTION SCHEDULE

ATTACHMENT II.C- INSPECTION SCHEDULE

II.C.1. Inspection Schedule

General inspections are routinely performed on buildings and structures located on Wallops Island. These inspections include the OB Area and related facilities. Roving security patrol on the Island check for unauthorized entry onto the facility and report obvious building damage when it is encountered. The fire department performs fire drills and water supply systems inspections on a semi-annual schedule. Unplanned fire drills are also used to ensure proper preparation of fire-fighting capabilities on the Island. Prior to each semiannual OB groundwater monitoring event, the condition of monitoring wells and OB structures are noted in the site field book. In addition, OB subunits and pad assembly are inspected prior to each burn. After each burn, a Post Burn inspection is conducted.

II.C.2. Types of Problems

The OB Area is located on a remote part of the Island. An inspection of the area is performed prior to OB operations to determine if the subunits are in a vertical position and in sound shape to support the rocket motor with waste propellant. A visual inspection of the pad is also performed. Three subunits and one burn pad are available for OB operation. In the event a subunit is determined unfit for OB, one of the other subunits is used to support the rocket motor. In the event the burn pad is determined unfit for OB, the pad is not used until necessary repairs are made.

Rocket motors are inspected prior to, and after shipping to OB. This ensures that the rocket motor's integrity is not compromised in any way that could lead to an unplanned explosion or other release of waste constituents. The inspection also includes a survey of personal protective equipment, calibration of equipment, malfunctions, and weather conditions.

Groundwater monitoring equipment will be inspected prior to well purging for each groundwater monitoring sampling event.

A Post Burn visual inspection of the three subunits, pad, pan, and cover is performed after each burn event. If any of the units are damaged as a result of the OB operations, the damage is documented on the POST BURN OB AREA INSPECTION LOG and the damage is repaired prior to the next OB event. The POST BURN OB AREA INSPECTION LOG form has been incorporated into each work instruction.

II.C.3. Frequency of Inspections

An equipment/site inspection log has been incorporated into the work instructions (Exhibit II.C-1) developed for the static firing of rocket motors. The work instruction identifies equipment associated with the OB process. Prior to any operation

involving ordnance disposal at WFF, the site designated for hazardous waste disposal shall be inspected to detect any possible deterioration of equipment. The following will also be inspected: (a) rocket motors, (b) monitoring equipment's calibration, (c) safety and emergency equipment, and (d) other devices to be utilized during the operation. The inspection includes date, weather conditions, notations of any observations, and nature of corrective actions, if any.

The POST BURN OB AREA INSPECTION LOG form has been incorporated into each of the work instructions. The post burn inspection will identify any wear and tear to the units after the completion of the OB operations.

OB personnel shall maintain the logs for a minimum of 3 years, from the date of inspection. A copy of all inspections will be kept at Building X-55 General Services in the OB record storage area.

The frequency of inspections is based upon the number of OB operations. Inspections are made prior to any thermal treatment of rocket motors. Any deterioration or malfunction is corrected prior to thermal treatment.

If a type of rocket motor has not been inspected by Wallops, either as preparation for open burning or as part of another process, for more than five years a visual inspection shall be scheduled for the following calendar year to verify deterioration of the propellant has not occurred. This requirement will take effect one year after permit issuance and thereafter.

II.C.4. Soil Monitoring

Soil monitoring will be conducted as described in the Soil Monitoring Plan found in Exhibit II.C-2.

EXHIBIT II.C-1: WORK INSTRUCTIONS

Code 840 Range and Mission Management Office

Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016
Expiration Date:	8/29/2021

COMPLIANCE IS MANDATORY

Responsible Office: 840/ Range and Mission Management Office

Title: Open Burning Procedure

PREFACE

P.1 PURPOSE

This procedure describes how solid propellant is burned (disposed) at Wallops Flight Facility.

P.2 APPLICABILITY

This directive applies to the Range and Mission Management Range support team. Operations performed under this procedure will be overseen by a Launch Pad Manager (LPM) named by the Range and Mission Management Office (RMMO). This WI may be performed by members of the range support team. Contractors tasked by RMMO may also be tasked with providing support of this WI as a member of the Range Support Team.

P.3 REFERENCES

800-PG-8715.1.1 *Unmanned Roadblocks for Hazardous Operations*

P.4 CANCELLATION

840-WI-8072.1.6

P.5 TOOLS, EQUIPMENT, AND MATERIALS

Amptec 601ES igniter circuit tester or equivalent
Approved and Certified Ordnance Ground
Belden Cable (15', 2 conductor, shielded)
Circuit Tester
Ground Braid at Disposal Site
Igniter
Portable Firing Box
Transport Trailer

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P.6 SAFETY PRECAUTIONS AND WARNINGS

1. Prior to any operation involving ordnance disposal at Wallops Flight Facility, the site designated for hazardous waste disposal shall be inspected to (a) detect any possible deterioration of equipment, (b) verify calibration of monitoring equipment, and (c) ensure any necessary safety and emergency equipment and other devices to be utilized during the operation are available. Equipment/Site Inspection Log (Attachment 1) must be completed.

2. Prior to commencing Open Burn/Open Detonation (OBOD) operations verify the following:

   a. Coordinate with the Test Director's office to ensure the operation is listed on the Wallops Range Operations Schedule.

   b. Roadblocks have been set and the area is clear of all nonessential personnel in accordance with 800-PG-8715.1.1 Unmanned Roadblocks for Hazardous Operations procedure.

   c. Notification to all Island Personnel (in the immediate area) and emergency personnel that an OBOD operation is about to commence.

   d. The available emergency personnel shall have Haz-Mat training located at the disposal area barricade during the OBOD operations.

   e. Operations Safety Specialist (OSS) is present with an approved Ground Safety Plan.

   f. Launch Pad Manager's verification that the above items as complete and in place. This is indicated by their consent to begin the procedure.

SAFETY/SECURITY ITEMS REQUIRED:

Standby Fire Protection
Standby Emergency First Aid
Haz-Mat Personnel
Barricade
Road Block Stands
2-Way Communications
Warning Signs

Wrist-straps
Wrist-strap checker
Grounding Straps
Safety Coats/Coveralls/Shoes
Safety Glasses/Goggles
Protective Head Gear/Face Shields
Hearing Protection

P.7 TRAINING

- On-the-Job training during at least two previous static burn operations is required to manage this operation. (Note: On-the-Job training is permitted for training purposes when supervised by a Team Lead or Team Member)
- HAZWOPER training and annual refresher for island personnel performing the operation
- Explosive Handler Certification (at a minimum for a Team Member)

P.8 RECORDS

Record Title	Record Custodian	Retention
Approved Procedure signed off by the Technician when completing the procedure.	Technician completing the procedure in accordance with respective organizational practices.	* NRRS 8/103 Temporary. Destroy/delete between 5 and 30 years after program/project termination.

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 MEASUREMENT/VERIFICATION

N/A

INSTRUCTIONS:

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

DATE: _____

REQUESTED BY: _____

TYPE OF PROPELLANT: _____

NET EXPLOSIVE WEIGHT: _____

REASON FOR DESTROYING: _____

TASK A – Igniter Checkout
TASK B – Preparation for Open Burn/Open Detonation
TASK C – Open Burn Open Detonation Operation
TASK D – No Fire Operation

Code 840 Range and Mission Management Office

Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016

TASK A - IGNITER CHECKOUT

The following steps are to be completed prior to transferring the igniter to the disposal area.

WARNING: Personnel shall wear static dissipative clothing and wrist-straps. Verify wrist-straps have been tested (1 to 10 MΩ opposite hand or wrist-strap to ground).

1. Obtain RF Avoidance. Coordinate with Test Director's Office to obtain RF Avoidance.

_____
TECHNICIAN

WARNING: A circuit anomaly in some igniter circuit testers make the device capable of initiating the electro-explosive device bridgewire. Before each use of an AMPTEC-601ES or an Alinco igniter circuit tester, a confidence test must be performed.

AMPTEC-601ES Confidence Test

a. Switch multi-meter on and verify "LO BAT" indicator on LCD is not illuminated.

b. Rotate the range function knob to the 2.0 OHM position. Verify the "2 WIRE/4WIRE" switch is in the 2WIRE position and the test leads are installed in VLO and VHI terminals. Short the other end of the test leads and adjust the "ZERO" knob until the LCD display reads 0.000. Disconnect the short.

c. Depress the button that reads "Press to Measure" under the milliamp meter. 5 milliamps should be measured.

d. Rotate the range function knob to 2.0 V AC/DC. Depress and hold the signal source button. Approximately 50 mV should be measured. Record the measured value.

mV _____

e. Rotate the range function knob to 2 amp AC/DC. Depress and hold the signal source button and the stray current button. 5 milliamps should be measured. Record the measured value.

mA _____

f. If more than 5 mA or 50 mV are measured at any time, reject the instrument and schedule it for repair before use.

mA_____ mV_____ PASS/FAIL_____ _____
TECHNICIAN

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Code 840 Range and Mission Management Office

Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016

ALINCO Ordnance Circuit - Confidence Test

WARNING: The following Alinco ordnance circuit testers are approved for use. Prior to using any other model Alinco, NASA Safety Office approval must be obtained.

101-5AI 101-5BPG
101-5BF 101-5CPG
101-5BFG 101-5CFG

a. Connect a calibrated pyrotechnic voltmeter (the same voltmeter used for vehicle arming) to the input terminals of the Alinco and verify no AC or DC voltage output. Use 2.5-volt scale on voltmeter.

mA_____ mV_____ PASS/FAIL_____ _____
TECHNICIAN

b. Disconnect voltmeter and connect calibrated 0-25 mA DC milliammeter to the input terminals of the Alinco.

_____
TECHNICIAN

c. Set Alinco "Range" switch to the minimum setting, set the ohms dial indicator to "0.00", and press "key" switch. Milliammeter should indicate less than 5 milliamperes.

_____
TECHNICIAN

d. If milliammeter indicates more than 5 milliamperes at any time, reject the Alinco and schedule it for repair before reuse.

mA_____ mV_____ PASS/FAIL_____ _____
TECHNICIAN

2. Remove igniter from container and place on a grounded workbench. Additionally, ground the igniter. Record the following values:

Igniter Type _____ Igniter Serial Number_____

Igniter Lot Number _____ Date of Manufacturer_____

Measure igniter bridgewire resistance _____

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3. Measure and record the resistance of the 15 ft. shielded Belden cable. Provide this measurement to the Firing Console Operator.

   Resistance: _____

4. Connect the Belden cable to the ignition leads. Short and shield the leads opposite igniter.

   _____
   TECHNICIAN

5. Place igniter back in a **metal** shipping container for transportation to the disposal area.

6. Release RF Avoidance through the Test Director's office.

   _____
   TECHNICIAN

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TASK B – PREPARATION FOR OPEN BURN/OPEN DETONATION

WARNING: Wrist-straps and static dissipative clothing shall be worn when working/handling igniters or open propellant.

1. Place propellant in the transport container.

2. Transport igniter and propellant to the disposal area.

3. Obtain RF Avoidance. Coordinate with the Test Director's office to obtain the RF Avoidance.

   _____
   TECHNICIAN

4. Remove propellant (not to exceed 50 lb.) and the igniter from the transport containers. Ground to the grounding rod located near the OBOD pad.

   _____
   TECHNICIAN

5. Place igniter (with leads protruding) in the bottom of the 3' x 3' x 1-1/4' pre-constructed OBOD cinder-block enclosure (located on the pad). Ground igniter leads.

   _____
   TECHNICIAN

6. Place propellant (not to exceed 50 lb.) in the enclosure.

   _____
   TECHNICIAN

TASK C - OPEN BURN OPEN DETONATION OPERATION

1. Firing Console Operator will perform VA checks in accordance with established procedures.

2. OSS will verify with the Test Director's Office that the RF Avoidance obtained is still in place.

   _____
   OSS

3. OSS will clear the disposal danger area of all non-essential personnel.

_____
OSS

4. Verify AC portable firing box is disconnected from the firing line and is shorted.

_____
TECHNICIAN

5. Verify firing line is shorted at the barricade.

_____
TECHNICIAN

6. Confirm firing line is grounded and shorted (measure resistance).

Record Resistance _____

_____
TECHNICIAN

WARNING: Wrist-straps and static dissipative clothing shall be worn

7. Using an AmpTec 601ES or an Alinco, check for NO VOLTAGE on firing line.

	No-Voltage
Line A to Line B	
Firing Line A to Ground	
Firing Line B to Ground	

_____
TECHNICIAN

8. If NO VOLTAGE is present connect firing cable to the shielded Belden cable (connected to the igniter).

_____
TECHNICIAN

9. OSS will clear ALL personnel from the disposal danger area and proceed to the barricade.

_____
OSS

10. Firing Console Operator will measure total resistance of firing line plus igniter in accordance with established procedures.

11. Release RF Avoidance

_____
TECHNICIAN

12. Launch Pad Manager will notify Range Control that the OBOD operations are ready to commence.

_____
TECHNICIAN

13. OSS shall verify that the disposal area is clear and all personnel are behind the barricade.

_____
OSS

14. Firing Console Operator will perform firing console operation in accordance with established procedures.

15. The Launch Pad Manager shall verbally count down from 10 seconds.

16. At T-0 the Firing Console Operator will ignite the igniter.

17. In the event of a NO-FIRE, proceed to TASK D, of this procedure, and notify Range Control that a NO-Fire has occurred.

_____
TECHNICIAN

18. If propellant has been successfully disposed; wait approximately 15 minutes then commence with clean-up of OBOD site. Store residuals in approved hazardous waste container.

19. Disconnect the firing lead from the portable AC firing box.

20. Notify Range Control that the OBOD operations are complete.

_____
TECHNICIAN

TASK D - NO FIRE OPERATION

IN THE EVENT OF NO-FIRE, ALL PERSONNEL WILL REMAIN BEHIND THE BARRICADE

1. From the barricade measure the line resistance to determine if the squibs have been fired.

Line Resistance _____

_____
TECHNICIAN

2. If the squibs have not fired, the ignition current should be increased (no more than 2 times the recommended firing current) and a second attempt will be made to fire the squibs commencing with the steps in Task C.

Ignition Current _____

_____
TECHNICIAN

3. If the squibs fail again, all operations will stop; Range Control shall be notified that OBOD operations have been terminated.

_____
TECHNICIAN

4. Disconnect and short the firing leads from the portable AC firing box.

_____
TECHNICIAN

5. All personnel shall remain behind the barricade for a minimum of 30 minutes.

6. After the 30 - minute wait, all personnel shall leave the area. Roadblocks positioned at the barricade will be manned for an additional 30 minutes.

7. Obtain RF avoidance through coordination with Test Director's office.

_____
TECHNICIAN

8. After two 30 minute waits proceed to the pad and short the igniter leads (Belden cable).

9. Remove the igniter and examine.

_____
TECHNICIAN

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Appendix A – Definitions

Damage Control – refers to Crash Fire and Rescue (CFR) emergency personnel and on a case by case basis may also refer to launch and safety personnel based on specific duties assigned.

Technician – refers to the individual within an organization/office performing the operation

Appendix B – Acronyms

CFR	Crash, Fired & Rescue
LPM	Launch Pad Manager
mA	milliampres
OBOD	Open Burn/Open Detonation
OSS	Operations Safety Specialist

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Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016

Code 840 Range and Mission Management Office

Attachment 1

EQUIPMENT/SITE INSPECTION LOG

Equipment/Facility	Condition	Corrective Action	Comments
Facility			
Concrete anchors			
Certified pyrotechnic ground			
Safety/Security			
Grounding straps			
Barricade			
Road block stands			
Warning signs			
2-Way Communications			
Stand-by Fire Protection			
Haz-Mat Specialist			
Stand-by Emergency First Aid			
Wrist-stats			
Safety Coats/Coveralls			
Safety Glasses/Goggles			
Safety Shoes			
Protective head gear			
Face Shields			

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Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016

Equipment			
Igniter Circuit Tester			
Firing lines			
(check the appropriate item) ☐Pyro-Voltmeter or ☐ Amptec 601ES ☐ Alinco			
Igniter leads			
Mobile crane			
Lifting Strap			
Torque wrenches			
Miscellaneous			
Weather Conditions			

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Attachment 2

POST BURN OB AREA INSPECTION

Equipment/Facility	Condition	Corrective Action	Comments
Subunits Integrity			
No. 1			
Rain Cap			
No. 2			
Rain Cap			
No. 3			
Rain Cap			
No. 4			
Rain Cap			
Pad Integrity			
Concrete			
Tie-Down Cables			
Tie-Down Anchors			

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Berm Integrity			
Concrete			
Pad Cover Integrity			
Roof			
Structure			
Pan Integrity			
Steel			
Residues			
Soil Survey			

Code 840 Range and Mission Management Office

Number:	WI-840003
CAGE:	36FC1
Revision:	A
Effective Date:	8/29/2016

Pad Survey			
Other/Miscellaneous			

REMARKS:

OB OPERATIONS:

INSPECTED BY: _____ _____
Title

DATE: _____ Day _____ Time _____

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CHANGE HISTORY LOG

RECORD OF REVISIONS			
REVISION	REVISION	DATE	ENTERED
Baseline	Initial Release – transferred from Code 548	October 25, 2010	E. Sudendorf
Rev _	• Administrative - Transferred from GDMS to CMSTAT – no update to formatting; • cross reference cover sheet inserted for traceability	January 22, 2015	K. Littleton
Rev A	• Updated format, updated reference to OSS • Added No. 3 and No. 4 rain caps per Environmental Office review comments • Updated Task 3 (7),(9) and (13) per Safety Office review comments • Updated Task D (2) and (8) per Safety Office • Added HAZWOPER training /annual refresher training. Added Explosive Handler Certification per Safety Office review comments and Code 548. On-the-Job training permitted under the supervision of a Team Lead/Team Member for training purposes • Added "or equivalent" to P.5, deleted all ranges from Task A(d), added ground igniter in Task A(2). Added Alinco to Task C(7) per	August 16, 2016	K. Littleton

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Suborbital & Special Orbital Projects Directorate Electronic Routing System

Item Routed for Review:	840-WI-840003 Rev _A Open Burning Procedure Aug 26 2016.pdf

Details	
Routing ID:	38
Title:	Open Burning Procedure
Status:	Approved
Created Date:	Feb 04, 2016 15:32
Priority:	Routine
Document Control Number:	36FC1-WI-840003 rev A
Change Request Reason:	Revised Document/Form
Misson/Project Number:	N/A
Storage Repository:	CMSTAT
Description:	Prior comments have been reviewed and provided a disposition. (See record 37 and attachments). The item routed contains comments provided by the Approvers. The updated final document is attached.

Point of Contact	
Name:	Kelly K. Littleton
Title:	QUALITY ASSURANCE MANAGER
Employer:	LJT AND ASSOCIATES, INC.
Org:	840.0
Email:	kelly.k.littleton@nasa.gov
Phone:	757.824.1593
On behalf of:	
Final Disposition:	null

Reviewers

Review suspense date:	Tue Feb 09, 2016

External	Reviewed	Reviewer	Email
	✔ ROBERT E. JAMESON Concur Feb 04, 2016 15:57	JAMESON, ROBERT E. (WFF-8400)	robert.e.jameson@nasa.gov
	✘ Gordon D. Marsh Non-concur Feb 08, 2016 13:52	Marsh, Gordon D. (WFF-8030)	gordon.d.marsh@nasa.gov
	No response	Sterling, Jerry (WFF-5480)	jerry.sterling@nasa.gov
	No response	Turlington, Peter N. (WFF-8400)	peter.n.turlington@nasa.gov
	No response	Turner, Carolyn (WFF-8030)	carolyn.turner-1@nasa.gov

Approvers				
Approval suspense date:	Fri Aug 26, 2016			
Order	External	Approved	Approver	Email
1		✔ Carolyn Turner Approved Aug 29, 2016 08:18	Turner, Carolyn (WFF-8030)	carolyn.turner-1@nasa.gov
2		✔ Steven E. Kremer Approved Aug 29, 2016 08:29	Kremer, Steven E. (WFF-8400)	steven.kremer@nasa.gov

Comments		
Comment	Name	Added
All comments by safety have been incorporated	Littleton, Kelly K. (WFF-840.0)[LJT AND ASSOCIATES, INC.]	08/25/2016 14:47
incorporate comments by Steve Kremer	Littleton, Kelly K. (WFF-840.0)[LJT AND ASSOCIATES, INC.]	08/16/2016 10:11
incorporate Alinco Confidence test checkout	Marsh, Gordon D. (WFF-8030)	02/08/2016 13:52

Number	WI-840001
CAGE	36FC1
Rev	_
Effective Date	1/21/15

Code 840 Range and Mission Management Office

The configuration control of this work instruction has been transferred from the Goddard Directives Mangement System (GDMS) to CMSTAT. The Cross Reference information is as follows:

Number	WI-840001
CAGE	36FC1
Rev	_
Effective Date	1/21/15
GDMS Reference Number	840-WI-8072.1.4

This document will remain in the current GDMS format until a change is required. The format for subsequent changes or revisions should utilize an RMMO document template. The document should be accessed from CMSTAT from this point forward at https://roms.wff.nasa.gov.

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Work Instruction (WI)

DIRECTIVE NO.	840-WI-8072.1.4	**APPROVED BY Signature:**	*Original Signed*
EFFECTIVE DATE:	October 16, 2012	**NAME:**	Thomas J. Pittman
EXPIRATION DATE:	October 16, 2017	**TITLE:**	Chief, Range and Mission Management Office

COMPLIANCE IS MANDATORY

Responsible Office: 840/ Range and Mission Management Office

Title: Nike Static Firing

PREFACE

P.1 PURPOSE

This Work Instruction defines the tasks required for preparation and static firing of a Nike Rocket Motor from Wallops Flight Facility. This Work Instruction covers the tasks involving the motor inspection, igniter checkout, preparation for static firing, prerequisite tasks to the static firing operation, static firing operation, and the NO-FIRE operation.

P.2 APPLICABILITY

This directive applies to the Range and Mission Management Support Team. This WI shall be performed or supervised by the Code 548 Mechanical Systems Branch, and/or the Code 803 Safety Office as members of the Range Support Team. NSROC may also be tasked with providing support of this WI as a member of the Range Support Team.

This procedure contains operations that are considered hazardous and thus requires two ordnance certified Technicians (one designated as the work supervisor) and an Operations Safety Supervisor (OSS). The area must be cleared of all non-essential personnel prior to performing this work instruction.

P.3 REFERENCES

800-PG-8715.0.2, Training and Certification Procedures for Ordnance Handlers at GSFC
Drawing D-50-01142, Headcap Ring
Drawing D-50-01247, Nike Static Fire Fixture
Drawing D-50-01139, Nike Static Fire Collar Assembly
Ground Safety Plan
20-6-12, Portable AC Ground Firing Box - Booster A.

P.4 CANCELLATION

548-WI-8072.1.26, Nike Static Firing

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P.5 TOOLS, EQUIPMENT, AND MATERIALS
Also see Section P.6 for Required Safety Items

Portable Firing Box
Igniter Circuit Tester (Alinco, AMPTEC 601E)
Milliammeter
Pyro-Voltmeter
Blasting Galvanometer
Mobile Crane
Forklift (2)
Nylon Lifting Strap, certified (5 ft., 3,000 lbs. capacity, 1 each)
Cargo Strap
Belden Cable (15' , shielded)
5/8 - 18 UNF Bolt (Grade 8, 1 each)
¾ - 16 Bolt (MS20012-66) with Washer (2 each)
Cotter Clip
Cleaning Solvent
Permatex # 2 or Equivalent
Nike Igniter Spanner Wrench, B-467
Torque Wrench, Calibrated (0 - 60 ft. lb.)
Transport Vehicle/Trailer

P.6 SAFETY PRECAUTIONS AND WARNINGS

1. **WARNING:** A circuit anomaly in some igniter circuit testers make the device capable of initiating the electro-explosive device bridgewire. Before using an igniter circuit tester, a confidence test shall be performed to ensure that output currents do not exceed safe levels. Before each use of an igniter circuit tester, TASK A - Igniter Circuit Tester Confidence Test shall be performed.

2. Safety/Security Items Required:
   - Standby Fire Protection
   - Standby Emergency First Aid
   - Haz-Mat Personnel
   - Barricade
   - Road Block Stands
   - 2-Way Communications
   - Warning Signs
   - Wrist-stats
   - Wrist-stat checker
   - Grounding Straps
   - Safety Coats/Coveralls/Shoes
   - Safety Glasses/Goggles
   - Protective Head Gear/Face Shields
   - Rubber Gloves

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3. The Nike is classified by the US Department of Transportation as a Class1.3 explosive and is sensitive to electricity, excessive shock, heat and RF energy. Extreme care is to be taken during the handling to prevent static electricity buildup, which could be discharged into the propellant. The motor case shall be adequately grounded at all times. The permissible storage and operational temperature ranges are:

   Storage Limits: -20° F to +130° F
   Operational Limits: -10° F to +130° F

4. Wrist-stats, static dissipative clothing, and safety glasses shall be worn when checking or handling pyrotechnics.

5. Wrist-stats shall be checked for proper resistance prior to use. If wrist-stats are removed, resistance check shall be repeated. Acceptable wrist-stat resistance measurement shall be 1 MΩ to 10 MΩ opposite hand or wrist-stat to ground.

6. Hard hats and safety clothing are required for motor lifting.

7. Read precautions in Materials Safety Data Sheets (MSDS) prior to using any chemicals.

8. Safety glasses and rubber gloves shall be worn when using cleaning solvents.

9. Safety glasses/visors shall be worn during cutting, sanding, or drilling operations

P.7 TRAINING

Ordnance Task Code #3 & #4, Team Member or Team Leader, Ordnance Hazard Classification 1.3 & 1.4, as specified in 800-PG-8715.0.2

P.8 RECORDS

Record Title	Record Custodian	Retention
Completed and Signed- off Procedure	Designated Technician	* NRRS 8/103. Temporary. Destroy/delete between 5 and 30 years after program/project termination
Equipment/Site Inspection Log (completed)	Designated Technician	NRRS 8/103.
Post Burn Open Burn (OB) Area Inspection Log	Designated Technician	NRRS 8/103

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

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P.9 MEASUREMENT/VERIFICATION

N/A

Instructions

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

TASKS Within this Work Instruction

TASK A - Igniter Circuit Tester Confidence Test
TASK B – Motor Inspection and Igniter Checkout
TASK C – Prerequisite Tasks to the Static Firing Operation
TASK D - Preparation and Static Firing Operations
TASK E – No Fire Operation

Prior to any operation involving ordnance disposal at Wallops Flight Facility, the site designated for hazardous waste disposal shall be inspected to (a) detect any possible deterioration of equipment, (b) verify calibration of monitoring equipment, and (c) inspection of safety and emergency equipment and other devices to be utilized during the operation. The Equipment/Site Inspection Log (Attachment 1) shall be completed to document findings.

Quality Assurance

a. Technician will verify that the required procedural steps are accurately performed and complete. To attest that this has been accomplished, the Technician will enter their name on each sign off indicating satisfactory completion of each step as performed. Discrepancies will be listed at the end of each task and initialed by the Operations Safety Supervisor (OSS).

b. Verify that all handling and lifting devices have been properly load tested and are within certification due date._____(*Technician*)

c. Verify that all measuring equipment has a valid calibration certification._____(*Technician*)
Calibrated Torque Wrench (0 - 100 ft. lb.), Calibration Due Date_____

d. Identification of instrumentation used and verification that all calibrated instrumentation has a valid calibration certification.

Igniter Circuit Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

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Blasting Galvanometer	(type)
Manufacturer	
Model No	
Calibration Due Date	

Milliammeter	
Manufacturer	
Model No	
Calibration Due Date	

Wrist-Stat Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

e. Verify no-voltage on crane hook in building. _____ (*Technician*)

f. All Personnel involved with this procedure must print their name below:

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TASK A - IGNITER CIRCUIT TESTER CONFIDENCE TEST

1. **Alinco Confidence Test**

1a. Connect a calibrated pyrotechnic voltmeter (the same voltmeter used for vehicle arming) to the input terminals of the Alinco. Set the scale to the 2.5 volt range. Verify no AC or DC voltage output.

No Voltage verified:	Technician:

1b. Depress "KEY" switch and verify battery voltage is no more that 0.5 VDC and no less than 0.25 VDC. This test verifies internal battery is good.

Battery Voltage:	Technician:

1c. Disconnect pyrotechnic voltmeter and connect a NASA/WFF calibrated, 0-25 ma DC milliammeter to the input terminals of the Alinco.

_____
Technician

1d. Set Alinco "Range" switch to the minimum setting. Set the "OHMS" dial indicator to "0.00". Depress the "KEY" switch and record the measurement in the block below corresponding to the model being tested.

Alinco Model Number	Maximum Reading (mA)	Measurement	Technician
101-5 A1	10		
101-5 BF	5		
101-5 BFG	5		
101-5-CFG	5		

1e. If milliammeter reading exceeds the maximum reading or equals aero ('0.0") for the model tested, reject the Alinco and schedule it for repair before reuse. Indicate results of test.

Pass	Technician:
Fail	Technician:

2. **Blasting Galvanometer Confidence Test**

2a. Connect a NASA/WFF calibrated, 0-25 mA DC milliammeter to the terminals of the Blasting Galvanometer.

_____
Technician

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2b. If Milliammeter indicates more than 7 mA, or equals aero ('0.000 reject Blasting Galvanometer and schedule it for repair before re-use. Indicate results of test.

	Technician:
mA _____	
Pass/Fail _____	

3. **AMPTEC Research 601E Confidence Test**

3a. Switch multi meter on and verify "LO BAT" indictor on LDC is not illuminated.

3b. Rotate the range function know to the 2.9 ohm position. Verify the "2 WIRE/4WIRE" switch is in the 2 WIRE position and the test leads are installed in "V_{LO} and V_{HI}" terminals. Short the other end of the test leads and adjust the "ZERO" knob until the LDC display reads 0.000. Disconnect the short.

3c. Depress the "press to measure" button under the milliamp meter.
5 milliamps should be measured: mA _____

3d. Rotate the range function knob to 2.0V AC/DC. Depress and hold the signal source button. Approximately 50 mV should be measured for all ranges: mV _____

3e. Rotate the range function knob to 2 amp AC/DC. Depress and hold the signal source button and the stray current button. 5 milliamps should be measured: mA _____

3f. If more than 5 mA or 50 mV are measured at any time, reject the instrument and schedule it for repair before use.

	PASS/FAIL	Technician
mA _____		
mV _____		

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TASK B - MOTOR INSPECTION AND IGNITER CHECKOUT

1. Record the following information on the day of the static firing operation:

DATE: _____

MOTOR: _____

P/N _____ **S/N** _____
(if available)

REQUESTED BY: _____

REASON FOR DESTROYING: _____

_____

The following steps are to be completed at the assembly building prior to transferring the motor to the disposal area.

WARNING: Personnel shall wear static dissipative clothing, safety glasses/visors and wrist-states while performing work associated with pyrotechnics. Verify wrist-stats have been tested (1 to 10 MΩ opposite hand or wrist-stat to ground).
_____
TECHNICIAN

1. Verify transport trailer is equipped with proper pads or cutouts for this motor. Verify proper position of the cutouts.
_____
TECHNICAN

2. Visually inspect the exterior of the shipping container for indications of damage, rough handling, or moisture. Using cutting shears cut and remove the metal straps. Remove lid.

3. Verify the motor fastening devices are installed and secure. Inspect container interior for moisture, shifting of components, or other indications of defects.

4. Remove motor from shipping container and place on transport trailer. Visually inspect the motor case for evidence of nicks, dents, or other defects.
_____
TECHNICIAN

5. Verify provider of motor performed a modified inspection of motor for disposal.

Lot Number _____ Date of Manufacturer _____

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6. Obtain RF Avoidance.

_____
TECHNICIAN

7. Remove igniter from shipping container. Visually inspect igniter for evidence of damage.

   Record Serial Number _____

   Record igniter bridgewire resistance _____

8. Measure and record the resistance of the 15 ft. shielded Belden cable. Provide this measurement to the Firing Console Operator.

   Resistance: _____

9. Connect the Belden cable to the ignition leads. Short and shield the leads opposite igniter.

   _____
   TECHNICIAN

10. Place igniter back in a metal shipping container for transportation to the disposal area.

11. Release RF Avoidance.

    _____
    TECHNICIAN

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TASK C - PREREQUISITE TASKS TO THE STATIC FIRING OPERATION

1. Prior to commencing static firing operations verify the following:

   a. Notification to Range Control to make an announcement on the public address system that static firing is about to commence.

   b. Notification to all Island Personnel (in the immediate area) and Damage Control that static firing is about to commence.

   c. Damage Control has personnel available with Haz-Mat training located at the disposal area barricade during the static firing operations.

   d. Operations Safety Supervisor is present with a Ground Safety Plan.

   e. Verify roadblocks have been set.

Work Supervisor

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TASK D - PREPARATION AND STATIC FIRING OPERATIONS

1. Transport motor and igniter to disposal area.

WARNING: Personnel must wear static dissipative clothing, safety glasses/visor and wrist-stats. Verify wrist-stats have been tested.

2. Ground motor to a certified pyrotechnic ground located near the static firing tube.

_____ TECHNICIAN

3. Obtain RF Avoidance.

_____ TECHNICIAN

4. Remove shipping closure from igniter boss. Visually inspect the igniter and threads for corrosion, burrs, cracks, or other defects. Clean as required with cleaning solvent.

5. Verify, through the presence of FBI paint, that the pressure cap on the forward motor dome has been torqued (45 $\pm$ 5 in. lbs.)

_____ TECHNICIAN

6. Remove igniter from shipping container.

7. Apply a coating of Permatex #2 to igniter boss threads. Screw igniter, hand-tight into igniter boss. Ground the igniter.

_____ TECHNICIAN

8. Secure the igniter using a Nike Igniter Spanner Wrench, B-467.

9. Verify that the igniter is properly seated.

_____ TECHNICIAN

10. With motor in horizontal position on trailer, attach headcap ring to the forward end of Nike motor using a grade 8 5/8 - 18 UNF bolt. (Drawing D-50-01142) Tighten bolt for a snug fit so that the headcap ring has no play on motor. (Approximate torque - 5 ft. lbs.)

NOTE: **Headcap is required to prevent weight of motor being applied to igniter when motor is placed in static firing tube.**

_____ TECHNICIAN

11. Attach a nylon lifting strap to nozzle of motor and lift using a mobile crane or two forklifts. Position motor over static firing tube and carefully lower the motor into the tube until the motor rests on the headcap ring. Remove strap.

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12. Loosely place two ¾ - 16 bolts (MS20012-66) and two washers into the holes marked for "bolts" on the marked half of the fixture (hold down collar). The bolts should face in the direction indicated by the arrows. (Drawing D-50-01139)

13. Each Technician (2) will lift a half (there are two halves) of the collar fixture by the handles and capture the nozzle within the center of each half of the fixture. Push the bolts through the collar fixture and secure with a nut and washer. Torque the nut to 60 ft. lbs., continue tightening the nut until the next slot in the nut is aligned with the hole in the bolt. Secure nut with cotter clip.

    _____
    TECHNICIAN

14. Slide the hooks from the turnbuckle through the slots in the collar from the bottom with the points of the hooks pointing away from the motor. Secure the hooks in place with the stainless steel pins. Rotate the collar so that a chain assembly is directly above each lug on the tube. Adjust ratchet mechanism on turnbuckle so that it will tighten. Tighten all turnbuckles so that the hooks on the lower end engage the lug welded on the motor tube. Tighten the turnbuckles hand tight and uniformly. Adjust ratchet mechanism so that the handle is not engaged with the turnbuckle.

    _____
    TECHNICIAN

15. Firing Console Operator will perform volt-amp (VA) checks per 20-6-12, Portable AC Ground Firing Box Booster A.

16. Confirm RF Avoidance.

    _____
    TECHNICIAN

17. Work Supervisor will clear the disposal danger area of all nonessential personnel.

    _____
    TECHNICIAN

18. Verify AC portable firing box is disconnected from the firing line and is shorted.

    _____
    TECHNICIAN

19. Confirm firing line is shorted at the barricade and grounded by measuring the resistance from the motor end.

    Record Resistance _____

    _____
    TECHNICIAN

WARNING: Wrist-stats and static dissipative clothing shall be worn

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20. Using a pyro-voltmeter check for NO VOLTAGE on firing line.

	No-Voltage
Line A to Line B	
Firing Line A to Ground	
Firing Line B to Ground	

_____
TECHNICIAN

21. If NO VOLTAGE is present connect firing cable to the shielded Belden cable, which is connected to the Nike igniter.

_____
TECHNICIAN

22. Work Supervisor will clear ALL personnel from the disposal danger area and proceed to the barricade.

_____
TECHNICIAN

23. Firing Console Operator shall measure total resistance of firing line plus igniter as per 20-6-12, Portable AC Ground Firing Box Booster A.

24. Release RF Avoidance

_____
TECHNICIAN

25. Work Supervisor will notify Range Control that the Static Firing is ready to commence.

_____
TECHNICIAN

26. OSS shall verify that the disposal area is clear, Damage Control is present, and all personnel are behind the barricade. OSS will announce on the Public Address system or radio that static firing is ready to commence.

_____
OSS

27. Firing Console Operator will perform firing console operation in accordance with 20-6-12, Portable AC Ground Firing Box Booster A.

28. The Work Supervisor shall verbally count down from 10 seconds.

29. At T-0 the Firing Console Operator will ignite the igniter.

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30. In the event of a NO-FIRE, proceed to TASK E, of this procedure and notify Range Control that a NO-Fire has occurred.

_____
TECHNICIAN

31. If motor has been successfully static fired, the case must remain in the tube for approximately 1 hour until the case has cooled sufficiently to be removed.

32. Disconnect the firing leads from the portable AC firing box and remove motor case from tube.

33. Notify Range Control that the static firing operations are complete. _____
TECHNICIAN

34. Complete Attachment 2 Post Burn Open Burn (OB) Area Inspection Log.

35. Discrepancies and Acceptance
List discrepancies below:

_____

_____

_____

_____

36. Technician and Work Supervisor shall sign to indicate satisfactory completion of Task D, except as noted above.

_____	_____
Date	Technician
_____	_____
Date	Work Supervisor

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TASK E - NO FIRE OPERATION

IN THE EVENT OF NO-FIRE, ALL PERSONNEL WILL WAIT 30 MINUTES BEHIND THE BARRICADE

1. From the barricade measure the line resistance to determine if the squibs have been fired.

   Line Resistance _____ _____
   TECHNICIAN

2. If the squibs have not fired, the ignition current should be increased (no more than 2 times the recommended firing current) and a second attempt will be made to fire the squibs.

   Ignition Current _____ _____
   TECHNICIAN

3. If the squibs fail again, all operations will stop. Range Control shall be notified that static firing has been terminated.

   _____
   TECHNICIAN

4. All personnel shall leave the area and road blocks at the barricade will be manned for one hour.

5. After 1 hour, disconnect and short the firing leads from the portable AC firing box.

6. Obtain RF avoidance. _____
   TECHNICIAN

7. Proceed to the motor and short the igniter leads (Belden cable).

8. Remove motor from the tube and examine the igniter. _____
   TECHNICIAN

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Attachment 1

EQUIPMENT/SITE INSPECTION LOG

Equipment/Facility	Condition	Corrective Action	Comments
Facility			
Concrete anchors			
Certified pyrotechnic ground			
Safety/Security			
Grounding straps			
Barricade			
Road block stands			
Warning signs			
2-Way Communications			
Stand-by Fire Protection			
Haz-Mat Specialist			
Stand-by Emergency First Aid			
Wrist-stats			
Safety Coats/Coveralls			
Safety Glasses/Goggles			
Safety Shoes			
Protective Head Gear			
Face Shields			
Equipment			
Igniter Circuit Tester			
Firing lines			
Pyro-Voltmeter			
Igniter leads			
Mobile crane			
Lifting Strap			
Torque wrenches			
Fork Lifts (2)			
Miscellaneous			
Weather Conditions			

Inspector Signature Date

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Attachment 2
POST BURN OB AREA INSPECTION LOG

EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Subunits Integrity			
Subunit 1			
Rain Cap			
Subunit 2			
Rain Cap			
Subunit 3			
Rain Cap			
Subunit 4			
Rain Cap			
Pad Integrity			
Concrete			
Tie-Down Cables			
Tie Down Anchors			
Berm Integrity			
Concrete			
Pad Cover Integrity			
Roof			
Structure			
Pan Integrity			
Steel			
Residues			
Soil Survey			
Pad Survey			

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DIRECTIVE NO. 840-WI-8072.1.4
EFFECTIVE DATE: October 16, 2012
EXPIRATION DATE: October 16, 2017

EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Other Miscellaneous			

REMARKS:

OB OPERATIONS:

INSPECTED BY: _____ **TITLE:** _____

DATE: _____ **TIME:** _____

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Appendix A – Definitions

N/A

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Appendix B – Acronyms

C.G	Center of Gravity
mA	Milli-Amperes
MSDS	Materials Safety Data Sheets
OSS	Operations Safety Supervisor
RF	Radio Frequency
VA	Volt-Amp

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	8/10/2004	Initial Release
-	October 16, 2012	Transferred from Code 548. Previously was 546-WI-8072.1.15B and 548-WI-8072.1.26 (same title). Re-Released as a Code 840-WI

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Code 840 Range and Mission Management Office

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Work Instruction (WI)

DIRECTIVE NO.	840-WI-8072.1.5	**APPROVED BY Signature:**	*Original Signed by*
EFFECTIVE DATE:	October 26, 2012	**NAME:**	Thomas J. Pittman
EXPIRATION DATE:	October 26, 2017	**TITLE:**	Chief, Range and Mission Management Office

COMPLIANCE IS MANDATORY

Responsible Office: 840/ Range and Mission Management Office

Title: Taurus Static Firing

PREFACE

P.1 PURPOSE

This Work Instruction defines the tasks required for preparation and static firing of a Taurus Rocket Motor from Wallops Flight Facility. This Work Instruction covers the tasks involving the motor inspection, igniter checkout, and preparation for static firing, static firing operation, and the NO-FIRE operation.

P.2 APPLICABILITY

This directive applies to the Range and Mission Management Support Team. This WI shall be performed or supervised by the Code 548 Mechanical Systems Branch, and/or the Code 803 Safety Office as members of the Range Support Team. NSROC may also be tasked with providing support of this WI as a member of the Range Support Team.

This procedure contains operations that are considered hazardous and thus requires two ordnance certified Technicians (one designated as the work supervisor) and an Operations Safety Supervisor (OSS). The area must be cleared of all non-essential personnel prior to performing this work instruction.

P.3 REFERENCES

800-PG-8715.0.2, Training and Certification Procedures for Ordnance Handlers at GSFC
Drawing B29854 Taurus Cable Fixture Ring
Ground Safety Plan
20-6-12, Portable AC Ground Firing Box - Booster A.

P.4 CANCELLATION

548-WI-8072.1.30A, Taurus Static Firing (cancelled in 2010)

P.5 TOOLS, EQUIPMENT, AND MATERIALS

Also see Section P.6 for Required Safety Items

Portable Firing Box
Igniter Circuit Tester (Alinco, AMPTEC 601E)

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Milliammeter
Pyro-Voltmeter
Blasting Galvanometer
Mobile Crane
Forklifts (17k & 8k)
Nylon Lifting Strap, certified (5 ft., 3,000 lbs. capacity, 1 each)
Cargo Strap
Belden Cable (15', 2 conductor, shielded)
Torque Wrench (0-100ft lb.)
Taurus Forward Adapter
5/8 x 18 x 3 UNF socket head bolts (4 each)
Cleaning Solvent
Transport Vehicle/Trailer
O-ring (MS-28775-447)

P.6 SAFETY PRECAUTIONS AND WARNINGS

1. **WARNING:** A circuit anomaly in some igniter circuit testers make the device capable of initiating the electro-explosive device bridgewire. Before using an igniter circuit tester, a confidence test shall be performed to ensure that output currents do not exceed safe levels. Before each use of an igniter circuit tester, TASK A - Igniter Circuit Tester Confidence Test shall be performed.

2. Safety/Security Items Required:
   - Standby Fire Protection
   - Standby Emergency First Aid
   - Haz-Mat Personnel
   - Barricade
   - Road Block Stands
   - 2-Way Communications
   - Warning Signs
   - Wrist-stats
   - Wrist-stat checker
   - Grounding Straps
   - Safety Coats/Coveralls/Shoes
   - Safety Glasses/Goggles
   - Steel-toe safety shoes
   - Protective Head Gear/Face Shields
   - Rubber Gloves

3. The Taurus rocket motor is classified by the US Department of Transportation as a 1.1 explosive and can be ignited by an electrical spark, shock or extreme heat. Use extreme caution when handling. The motor case shall be adequately grounded at all times. The permissible storage and operational temperature ranges are:

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Storage Limits: 30°F to 120°F
Operational Limits: 30°F to 120°F

4. Wrist-stats, static dissipative clothing, and safety glasses shall be worn when checking or handling pyrotechnics.

5. Wrist-stats shall be checked for proper resistance prior to use. If wrist-stats are removed, resistance check shall be repeated. Acceptable wrist-stat resistance measurement shall be 1 MΩ to 10 MΩ opposite hand or wrist-stat to ground.

6. Hard hats and safety clothing are required for motor lifting.

7. Read precautions in Materials Safety Data Sheets (MSDS) prior to using any chemicals.

8. Safety glasses and rubber gloves shall be worn when using cleaning solvents.

9. Safety glasses/visors shall be worn during cutting, sanding, or drilling operations.

P.7 TRAINING

Ordnance Task Code #1 & #4, Team Member or Team Leader, Ordnance Hazard Classification 1.1 & 1.4, as specified in 800-PG-8715.0.2

P.8 RECORDS

Record Title	Record Custodian	Retention
Completed and Signed- off Procedure	Designated Technician	* NRRS 8/103. Temporary. Destroy/delete between 5 and 30 years after program/project termination
Equipment/Site Inspection Log (completed)	Designated Technician	NRRS 8/103.
Post Burn Open Burn (OB) Area Inspection Log	Designated Technician	NRRS 8/103

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 MEASUREMENT/VERIFICATION

N/A

Instructions

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

TASKS Within this Work Instruction

TASK A - Igniter Circuit Tester Confidence Test
TASK B – Motor Inspection
TASK C - Prerequisite Tasks to the Static Firing Operation
TASK D – Preparation and Static Firing Operations from Disposal Area
TASK E - No Fire Operation

Prior to any operation involving ordnance disposal at Wallops Flight Facility, the site designated for hazardous waste disposal shall be inspected to (a) detect any possible deterioration of equipment, (b) verify calibration of monitoring equipment, and (c) inspection of safety and emergency equipment and other devices to be utilized during the operation. The Equipment/Site Inspection Log (Attachment 1) shall be completed to document findings.

Quality Assurance

a. Technician will verify that the required procedural steps are accurately performed and complete. To attest that this has been accomplished, the Technician will enter their name on each sign off indicating satisfactory completion of each step as performed. Discrepancies will be listed at the end of each task and initialed by the Operations Safety Supervisor (OSS).

b. Verify that all handling and lifting devices have been properly load tested and are within certification due date._____(*Technician*)

c. Verify that all measuring equipment has a valid calibration certification._____(*Technician*)
Calibrated Torque Wrench (0 - 100 ft. lb.), Calibration Due Date_____

d. Identification of instrumentation used and verification that all calibrated instrumentation has a valid calibration certification.

Igniter Circuit Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

Blasting Galvanometer	(type)
Manufacturer	
Model No	
Calibration Due Date	

Milliammeter	

Manufacturer	
Model No	
Calibration Due Date	

Wrist-Stat Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

e. Verify no-voltage on crane hook in building. _____ (*Technician*)

f. All Personnel involved with this procedure must print their name below:

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TASK A - IGNITER CIRCUIT TESTER CONFIDENCE TEST

1. **Alinco Confidence Test**

1a. Connect a calibrated pyrotechnic voltmeter (the same voltmeter used for vehicle arming) to the input terminals of the Alinco. Set the scale to the 2.5 volt range. Verify no AC or DC voltage output.

No Voltage verified:	Technician:

1b. Depress "KEY" switch and verify battery voltage is no more that 0.5 VDC and no less than 0.25 VDC. This test verifies internal battery is good.

Battery Voltage:	Technician:

1c. Disconnect pyrotechnic voltmeter and connect a NASA/WFF calibrated, 0-25 ma DC milliammeter to the input terminals of the Alinco.

_____
Technician

1d. Set Alinco "Range" switch to the minimum setting. Set the "OHMS" dial indicator to "0.00". Depress the "KEY" switch and record the measurement in the block below corresponding to the model being tested.

Alinco Model Number	Maximum Reading (mA)	Measurement	Technician
101-5 A1	10		
101-5 BF	5		
101-5 BFG	5		
101-5-CFG	5		

1e. If milliammeter reading exceeds the maximum reading or equals aero ('0.0") for the model tested, reject the Alinco and schedule it for repair before reuse. Indicate results of test.

Pass	Technician:
Fail	Technician:

2. **Blasting Galvanometer Confidence Test**

2a. Connect a NASA/WFF calibrated, 0-25 mA DC milliammeter to the terminals of the Blasting Galvanometer.

_____
Technician

2b. If Milliammeter indicates more than 7 mA, or equals aero ('0.000 reject Blasting Galvanometer and schedule it for repair before re-use. Indicate results of test.

	Technician:
mA	
Pass/Fail	

3. **AMPTEC Research 601E Confidence Test**

3a. Switch multi meter on and verify "LO BAT" indictor on LDC is not illuminated.

3b. Rotate the range function know to the 2.9 ohm position. Verify the "2 WIRE/4WIRE" switch is in the 2 WIRE position and the test leads are installed in "V_{LO} and V_{HI}" terminals. Short the other end of the test leads and adjust the "ZERO" knob until the LDC display reads 0.000. Disconnect the short.

3c. Depress the "press to measure" button under the milliamp meter.
5 milliamps should be measured: mA _____

3d. Rotate the range function knob to 2.0V AC/DC. Depress and hold the signal source button. Approximately 50 mV should be measured for all ranges: mV _____

3e. Rotate the range function knob to 2 amp AC/DC. Depress and hold the signal source button and the stray current button. 5 milliamps should be measured: mA _____

3f. If more than 5 mA or 50 mV are measured at any time, reject the instrument and schedule it for repair before use.

	PASS/FAIL	Technician
mA		
mV		

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TASK B - MOTOR INSPECTION

1. Record the following information on the day of the static firing operation:

DATE: _____

MOTOR: _____

P/N _____ **S/N** _____
(if available)

REQUESTED BY: _____

REASON FOR DESTROYING: _____

_____

The following steps are to be completed at the assembly building prior to transferring the motor to the disposal area.

WARNING: Personnel shall wear static dissipative clothing, safety glasses/visors and wrist-states while performing work associated with pyrotechnics. Verify wrist-stats have been tested (1 to 10 MΩ opposite hand or wrist-stat to ground).

_____
TECHNICIAN

2. Verify transport trailer is equipped with proper pads or cutouts for this motor. Verify proper position of the cutouts.

_____
TECHNICAN

3. Visually inspect the exterior of the shipping container for indications of damage, rough handling, or moisture. Using cutting shears cut and remove the metal straps. Remove lid.

4. Verify the motor fastening devices are installed and secure. Inspect container interior for moisture, shifting of components, or other indications of defects.

5. Obtain RF Avoidance.

_____
TECHNICIAN

6. Remove motor from shipping container and place on transport trailer. Ground motor to facility ground. Visually inspect the motor case for evidence of nicks, dents, or other defects.

_____
TECHNICIAN

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7. Verify provider of motor performed a modified inspection of motor for disposal.

   Motor Lot Number _____ Date of Manufacturer _____

   Igniter Lot Number _____ Date of Manufacturer _____

   Igniter Bridgewire Resistance _____
   (obtained from the manufacturer's data sheet)

8. Remove the fin shoes and discard.

   _____
   TECHNICIAN

9. Measure and record the resistance of the 15 ft. shielded Belden cable. Provide this measurement to the Firing Console Operator.

   Resistance: _____

10. Connect the Belden cable to the ignition leads. Short and shield the leads opposite the igniter.

    _____
    TECHNICIAN

11. Place igniter back in a metal shipping container for transportation to the disposal area.

12. Release RF Avoidance.

    _____
    TECHNICIAN

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TASK C - PREREQUISITE TASKS TO THE STATIC FIRING OPERATION

1. Prior to commencing static firing operations verify the following:

   a. Notification to Range Control to make an announcement on the public address system that static firing is about to commence.

   b. Notification to all Island Personnel (in the immediate area) and Damage Control that static firing is about to commence.

   c. Damage Control has personnel available with Haz-Mat training located at the disposal area barricade during the static firing operations.

   d. Operations Safety Supervisor is present with a Ground Safety Plan.

   e. Verify roadblocks have been set.

_____
Work Supervisor

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TASK D - PREPARATION AND STATIC FIRING OPERATIONS FROM DISPOSAL AREA

1. Transport motor and igniter to disposal area.

WARNING: Personnel must wear static dissipative clothing, safety glasses/visor and wrist-stats. Verify wrist-stats have been tested.

2. Ground motor to a certified pyrotechnic ground located near the static firing pad.

_____
TECHNICIAN

3. Obtain RF Avoidance.

_____
TECHNICIAN

4. Remove shipping closure from igniter boss. Visually inspect the igniter and threads for corrosion, burrs, cracks, or other defects. Clean as required with cleaning solvent.

5. Remove igniter from shipping container.

6. Inspect O-ring (MS-28775-447) for cuts, gouges, or other defects.

7. Install O-ring on the igniter. Align igniter alignment key with groove in igniter boss. Push igniter into motor until igniter seats. Short, shield, and ground the igniter leads.

_____
TECHNICIAN

8. Install the Taurus forward adapter using 4 each 4/8 x 18 UNF socket head bolts.

_____
TECHNICIAN

9. Using handle, rotate igniter clockwise until igniter locks. Remove handle. **IGNITER IS NOW ARMED.**

_____
TECHNICIAN

10. Pull the firing lead through the hole in the forward adapter.

_____
TECHNICIAN

11. Attach a nylon lifting strap to nozzle of motor and lift using a 17k forklift. Use an 8k forklift to maintain level lifting until motor has cleared the trailer. Position motor over disposal tube and carefully lower the motor until the motor rests into the headcap fixture. Remove strap.

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12. Loosely place two each ½" x 2" 13 thread bolts and two washers into the holes located in one half of the hold down collar. Hold down collar is a two piece assembly.

13. Align the collar lugs located on the collar with the pad lugs. Push the bolts through both sections of the collar fixture and secure with a nut and washer. Torque the nut to 60-ft. lbs.

_____
TECHNICIAN

14. Slide the hooks from the turnbuckle through the slots in the collar from the bottom with the points of the hooks pointing away from the motor. Secure the hooks in place with the stainless steel pins. Rotate the collar so that the chain assembly is directly above each lug on the tube. Adjust ratchet mechanism on turnbuckle so that it will tighten. Tighten all turnbuckles so that the hooks on the lower end engage the lug welded on the motor tube. Tighten the turnbuckles hand tight and uniformly. Adjust ratchet mechanism so that the handle is not engaged with the turnbuckle.

_____
TECHNICIAN

15. Firing Console Operator will perform volt-amp (VA) checks per 20-6-12, Portable AC Ground Firing Box Booster A.

16. Verify RF Avoidance is still in place.

_____
TECHNICIAN

17. Work Supervisor will clear the disposal danger area of all nonessential personnel.

_____
TECHNICIAN

18. Verify AC portable firing box is disconnected from the firing line and is shorted.

_____
TECHNICIAN

19. Confirm firing line is shorted at the barricade and grounded by measuring the resistance from the motor end.

Record Resistance _____

_____
TECHNICIAN

WARNING: Wrist-stats and static dissipative clothing shall be worn

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20. Using a pyro-voltmeter check for NO VOLTAGE on firing line.

	No-Voltage
Line A to Line B	
Firing Line A to Ground	
Firing Line B to Ground	

_____
TECHNICIAN

21. If NO VOLTAGE is present connect firing cable to the shielded Belden cable, which is connected to the igniter.

_____
TECHNICIAN

22. Work Supervisor will clear ALL personnel from the disposal danger area and proceed to the barricade.

_____
TECHNICIAN

23. Firing Console Operator shall measure total resistance of firing line plus igniter as per 20-6-12, Portable AC Ground Firing Box Booster A.

24. Release RF Avoidance

_____
TECHNICIAN

25. Work Supervisor will notify Range Control that the Static Firing is ready to commence.

_____
TECHNICIAN

26. OSS shall verify that the disposal area is clear, Damage Control is present, and all personnel are behind the barricade. OSS will announce on the Public Address system or radio that static firing is ready to commence.

_____
OSS

27. Firing Console Operator will perform firing console operation in accordance with 20-6-12, Portable AC Ground Firing Box Booster A.

28. The Work Supervisor shall verbally count down from 10 seconds.

29. At T-0 the Firing Console Operator will ignite the igniter.

30. In the event of a NO-FIRE, proceed to TASK E, of this procedure and notify Range Control that a NO-Fire has occurred.

_____
TECHNICIAN

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31. If motor has been successfully static fired, the case must remain on the pad for approximately 1 hour until the case has cooled sufficiently to be removed.

32. Disconnect the firing leads from the portable AC firing box and remove motor case from pad.

33. Notify Range Control that the static firing operations are complete. _____
TECHNICIAN

34. Complete Attachment 2 Post Burn Open Burn (OB) Area Inspection Log.

35. Discrepancies and Acceptance
List discrepancies below:

_____

_____

_____

_____

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36. Technician and Work Supervisor shall sign to indicate satisfactory completion of Task D, except as noted above.

Date	Technician
Date	Work Supervisor

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TASK E - NO FIRE OPERATION

IN THE EVENT OF NO-FIRE, ALL PERSONNEL WILL WAIT 30 MINUTES BEHIND THE BARRICADE

1. From the barricade measure the line resistance to determine if the squibs have been fired.

   Line Resistance _____ _____
   TECHNICIAN

2. If the squibs have not fired, the ignition current should be increased (no more than 2 times the recommended firing current) and a second attempt will be made to fire the squibs.

   Ignition Current _____ _____
   TECHNICIAN

3. If the squibs fail again, all operations will stop. Range Control shall be notified that static firing has been terminated.

   _____
   TECHNICIAN

4. Disconnect and short the firing leads from the portable AC firing box.

   _____
   TECHNICIAN

5. All personnel shall remain behind the barricade for a minimum of 30 minutes.

6. After the 30 minute wait, all personnel shall leave the area. Road blocks at the barricade will be manned for an additional 30 minutes.

7. Obtain RF avoidance.

   _____
   TECHNICIAN

8. Proceed to the motor and short the igniter leads (Belden cable).

9. Remove motor from the pad and examine the igniter.

   _____
   TECHNICIAN

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Attachment 1

EQUIPMENT/SITE INSPECTION LOG

Equipment/Facility	Condition	Corrective Action	Comments
Facility			
Concrete anchors			
Certified pyrotechnic ground			
Safety/Security			
Grounding straps			
Barricade			
Road block stands			
Warning signs			
2-Way Communications			
Stand-by Fire Protection			
Haz-Mat Specialist			
Stand-by Emergency First Aid			
Wrist-stats			
Safety Coats/Coveralls			
Safety Glasses/Goggles			
Safety Shoes			
Protective Head Gear			
Face Shields			
Equipment			
Igniter Circuit Tester			
Firing lines			
Pyro-Voltmeter			
Igniter leads			
Mobile crane			
Lifting Strap			
Torque wrenches			
Forklifts (2 each) (17k & 8K)			
Miscellaneous			
Weather Conditions			

Inspector Signature

Date/Time

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Attachment 2

POST BURN OB AREA INSPECTION LOG

EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Subunits Integrity			
Subunit 1			
Rain Cap			
Subunit 2			
Rain Cap			
Subunit 3			
Rain Cap			
Subunit 4			
Rain Cap			
Pad Integrity			
Concrete			
Tie-Down Cables			
Tie Down Anchors			
Berm Integrity			
Concrete			
Pad Cover Integrity			
Roof			
Structure			
Pan Integrity			
Steel			
Residues			
Soil Survey			
Pad Survey			

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EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Other Miscellaneous			

REMARKS:

OB OPERATIONS:

INSPECTED BY: _____ **TITLE:** _____

DATE: _____ **TIME:** _____

Appendix A – Definitions

N/A

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Appendix B – Acronyms

CG	Center of Gravity
mA	Milli-Amperes
MSDS	Materials Safety Data Sheets
OSS	Operations Safety Supervisor
RF	Radio Frequency
VA	Volt-Amp

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EFFECTIVE DATE:	July 16, 2012	**NAME:**	Thomas J. Pittman
EXPIRATION DATE:	July 16, 2017	**TITLE:**	Chief, Range and Mission Management Office

COMPLIANCE IS MANDATORY

Responsible Office: 840/ Range and Mission Management Office

Title: Improved Orion Static Firing

PREFACE

P.1 PURPOSE

This Work Instruction defines the tasks required for preparation and static firing of an Improved Orion Rocket Motor. This Work Instruction will cover the tasks involving the motor inspection, inspection and installation of the igniter, installation of the initiator, manufacture of igniter (if required), preparation for static firing from the disposal pad, prerequisite tasks to the static firing operation, the static firing operation, and the NO-FIRE operation.

P.2 APPLICABILITY

This directive applies to the Range and Mission Management Support Team. This WI shall be performed or supervised by the Code 548 Mechanical Systems Branch, and/or the code 803 Safety Office as members of the Range Support Team. NSROC may also be tasked with providing support of this WI as a member of the Range Support Team.

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NSROC Procedure 31-15-2, Improved Orion Inspection
20-6-12, Portable AC Ground Firing Box - Booster A
WFF Dwg. B-50-01303, Orion Static Firing Motor Lugs (4 each)

P.4 CANCELLATION

548-WI-8072.1.43, Improved Orion Static Firing

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P.5 TOOLS, EQUIPMENT, AND MATERIALS

Also see Section P.6 for Required Safety Items

Overhead Hoist or Crane System, 3,000 lb. min. capacity
Transport Trailer
Portable Firing Box
Igniter Circuit Tester, (Alinco, AMPTEC 601E)
Milliammeter
Pyro-Voltmeter
Blasting Galvanometer
Mobile Crane
Fork Lift
Nylon Lifting Strap, certified (5 ft., 3,000 lbs. capacity, 1 each)
Cargo Strap
Belden Cable (15', 2 conductor, shielded)
Holex 7900 Initiator
Holex 7900 Mating Connector (if applicable)
Initiator Test Box
Initiator Port Closure Plug
O-Ring MS-28778-5 (initiator port)
O-Ring MS-28775-223 (igniter)
Orion Static Firing Motor Lugs (4 each) WFF Dwg. B-50-01303
7/16 Grade B Shackle (8 each)
Turnbuckle and Cable assembly (4 each)
Orion Static Firing Headcap Fixture
9/16-18 bolts, NAS 464 (8 each)
¾ - 10, grade eight bolts with washers (8 each)
1/4-28 UNF-3A bolts, MS20004 or equal (12 each)
1/4-28 x 1 Socket Head Cap Screw, Unbrako 20097-4F-16B (5 each)
Cleaning Solvent
Dow Corning 33 Lubricant or Equivalent
Calibrated Torque Wrench (0 - 100 ft. lb.)
Calibrated Torque Wrench (0-240 in. lb.)
3/4 in. deep socket
5/8 in. deep socket
Allen Wrench Set
Inspection Mirror
Safety Flashlight
Transport Vehicle
Additional items required for TASK C
- Velostat (cut into 3" x 10" piece to form a cylinder)
- Nike Igniter
- Taurus Spin Motor Igniter or Match Squib

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Igniter Circuit Tester
Wire Stripper
Knife
Anti-static Masking Tape
Butt Connector Lug (wire size: 22 to 16 guage)
Platform Scales

P.6 SAFETY PRECAUTIONS AND WARNINGS

1. **WARNING:** A circuit anomaly in some igniter circuit testers make the device capable of initiating the electro-explosive device bridgewire. Before using an igniter circuit tester, a confidence test shall be performed to ensure that output currents do not exceed safe levels. Before each use of an igniter circuit tester, TASK A - Igniter Circuit Tester Confidence Test shall be performed.

2. Safety/Security Items Required:
   Standby Fire Protection
   Standby Emergency First Aid
   Haz-Mat Personnel
   Barricade
   Road Block Stands
   2-Way Communications
   Warning Signs
   Wrist-stats
   Wrist-stat checker
   Grounding Straps
   Safety Coats/Coveralls/Shoes
   Safety Glasses/Goggles
   Protective Head Gear/Face Shields
   Rubber Gloves

3. The Improved Orion is classified by the US Department of Transportation as a Class 1.3 explosive and is sensitive to electricity, excessive shock, heat and RF energy. Extreme care is to be taken during the handling to prevent static electricity buildup, which could be discharged into the propellant. The motor case shall be adequately grounded at all times. The permissible storage and operational temperature ranges are:

   Storage Limits: -40° F to +140° F
   Operational Limits: -25° F to +125° F

4. Wrist-stats, static dissipative clothing, and safety glasses shall be worn when checking or handling pyrotechnics.

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5. Wrist-stats must be checked for proper resistance prior to use. If wrist-stats are removed, resistance check must be repeated. Acceptable wrist-stat resistance measurement shall be 1 MΩ to 10 MΩ opposite hand or wrist-stat to ground.

6. Hard hats and safety clothing are required for motor lifting.

7. Read precautions in Materials Safety Data Sheets (MSDS) prior to using any chemicals.

8. Safety glasses and rubber gloves shall be worn when using cleaning solvents.

9. Safety glasses/visors shall be worn during cutting, sanding, or drilling operations.

P.7 TRAINING

Ordnance Task Code #3 & #4, Team Member or Team Leader, Ordnance Hazard Classification 1.3 & 1.4, as specified in 800-PG-8715.02.

P.8 RECORDS

Record Title	Record Custodian	Retention
Completed and Signed-off Procedure	Designated Technician	* NRRS 8/103 Temporary. Destroy/delete between 5 and 30 years after program/project termination.

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 MEASUREMENT/VERIFICATION

N/A

Instructions

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

TASKS Within this Work Instruction
TASK A - Igniter Circuit Tester Confidence Test
TASK B- Motor Inspection/Igniter & Initiator Inspection/Installation
TASK C- WFF Manufactured Igniter (if required)
TASK D- Prerequisite Tasks to the Static Firing Operation
TASK E- Preparation for Static Firing from Disposal
TASK F- Static Firing Operation
TASK G- No Fire Operation

Quality Assurance

a. Technician will verify that the required procedural steps are accurately performed and complete. To attest that this has been accomplished, the technician will enter their name on each sign off indicating satisfactory completion of each step as performed. Discrepancies will be listed at the end of each task and initialed by the Operations Safety Supervisor (OSS).

b. Verify that all handling and lifting devices have been properly load tested and are within certification due date._____(*Technician*)

c. Verify that all measuring equipment has a valid calibration certification._____(*Technician*)
Calibrated Torque Wrench (0 - 100 ft. lb.), Calibration Due Date_____
Calibrated Torque Wrench (0-240 in. lb.), Calibration Due Date_____

d. Identification of instrumentation used and verification that all calibrated instrumentation has a valid calibration certification.

Igniter Circuit Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

Blasting Galvanometer	(type)
Manufacturer	
Model No	
Calibration Due Date	

Milliammeter	
Manufacturer	
Model No	
Calibration Due Date	

Wrist-Stat Tester	(type)
Manufacturer	
Model No	
Calibration Due Date	

e. Verify no-voltage on crane hook in building. _____(*Technician*)

f. All Personnel involved with this procedure must print their name below:

TASK A - IGNITER CIRCUIT TESTER CONFIDENCE TEST

1. **Alinco Confidence Test**

1a. Connect a calibrated pyrotechnic voltmeter (the same voltmeter used for vehicle arming) to the input terminals of the Alinco. Set the scale to the 2.5 volt range. Verify no AC or DC voltage output.

No Voltage verified:	Technician:

1b. Depress "KEY" switch and verify battery voltage is no more that 0.5 VDC and no less than 0.25 VDC. This test verifies internal battery is good.

Battery Voltage:	Technician:

1c. Disconnect pyrotechnic voltmeter and connect a NASA/WFF calibrated, 0-25 ma DC milliammeter to the input terminals of the Alinco.

_____
Technician

1d. Set Alinco "Range" switch to the minimum setting. Set the "OHMS" dial indicator to "0.00". Depress the "KEY" switch and record the measurement in the block below corresponding to the model being tested.

Alinco Model Number	Maximum Reading (mA)	Measurement	Technician
101-5 A1	10		
101-5 BF	5		
101-5 BFG	5		
101-5-CFG	5		

1e. If milliammeter reading exceeds the maximum reading or equals aero ('0.0") for the model tested, reject the Alinco and schedule it for repair before reuse. Indicate results of test.

Pass	Technician:
Fail	Technician:

2. **Blasting Galvanometer Confidence Test**

2a. Connect a NASA/WFF calibrated, 0-25 mA DC milliammeter to the terminals of the Blasting Galvanometer.

_____
Technician

2b. If Milliammeter indicates more than 7 mA, or equals aero ('0.000 reject Blasting Galvanometer and schedule it for repair before re-use. Indicate results of test.

	Technician:
mA _____	
Pass/Fail _____	

3. **AMPTEC Research 601E Confidence Test**

3a. Switch multi meter on and verify "LO BAT" indictor on LDC is not illuminated.

3b. Rotate the range function know to the 2.9 ohm position. Verify the "2 WIRE/4WIRE" switch is in the 2 WIRE position and the test leads are installed in "V_{LO} and V_{HI}" terminals. Short the other end of the test leads and adjust the "ZERO" knob until the LDC display reads 0.000. Disconnect the short.

3c. Depress the "press to measure" button under the milliamp meter.
5 milliamps should be measured: mA _____

3d. Rotate the range function knob to 2.0V AC/DC. Depress and hold the signal source button.
Approximately 50 mV should be measured for all ranges: mV _____

3e. Rotate the range function knob to 2 amp AC/DC. Depress and hold the signal source button and the stray current button. 5 milliamps should be measured: mA _____

3f. If more than 5 mA or 50 mV are measured at any time, reject the instrument and schedule it for repair before use.

	PASS/FAIL	Technician
mA _____		
mV _____		

TASK B - MOTOR INSPECTION/IGNITER & INITIATOR INSPECTION/INSTALLATION

The following steps are to be completed at the assembly building prior to transferring the motor to the disposal area.

WARNING: Personnel shall wear static dissipative clothing, safety glasses/visors and wrist-stats while performing work associated with pyrotechnics. Verify wrist-stats have been tested (1 MΩ to 10 MΩ opposite hand or wrist-stat to ground).

_____
TECHNICIAN

1. Verify transport trailer is equipped with proper pads or cutouts for this motor. Verify proper position of the cutouts.

_____
TECHNICIAN

2. Visually inspect the exterior of the shipping container for indications of damage, rough handling, or moisture. Using cutting shears cut and remove the metal straps. Remove lid.

_____
TECHNICIAN

3. Verify that motor fastening devices are installed and secure. Inspect container interior for moisture, shifting of components, or other indications of defects.

_____
TECHNICIAN

4. Remove motor securing material. Place a handling strap around the motor at the approximate center of gravity. Attach the handling strap to an overhead hoist or crane system.

_____
TECHNICIAN

5. Ground motor to a certified pyrotechnic ground.

_____
TECHNICIAN

WARNING: Hard hats and safety clothing are required for motor lifting.

6. Carefully lift the motor from the shipping container, manually supporting nozzle end. Place the motor on the work stand and remove handling strap. Remove crane from work area. Retain shipping container for further use.

_____
TECHNICIAN

7. Visually inspect the motor case for evidence of nicks, dents, or other defects.

_____
TECHNICIAN

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8. Position SAFE/ARM mechanism in "SAFE" position as indicated by flat side of shaft aligned horizontal to thrust axis of motor.

TECHNICIAN

9. Cut initiator leads directly behind the initiator, strip and short.

TECHNICIAN

10. Remove initiator using 5/8 in. deep socket. Set aside for disposal.

TECHNICIAN

11. Remove igniter attaching bolts (5 ea. 1/4-28 x 1 in.) using a 3/16 in. Allen wrench. Remove igniter. Use caution to prevent damaging the vinyl lacquer coating on the igniter basket.

TECHNICIAN

12. Using a #2 Phillips screwdriver, remove seven 1/4 in.-28 screws from the stiffener. Remove stiffener and discard.

TECHNICIAN

13. Visually inspect the forward dome for evidence of nicks, dents, or other defects.

TECHNICIAN

14. Using the safety flashlight, visually inspect propellant through the forward and aft end of motor for evidence of separation, cracks, voids or other defects.

TECHNICIAN

15. Visually inspect the igniter and initiator bosses machined surfaces and threads for corrosion, cracks, or other defects. Clean as required with cleaning solvent and Scotchbrite pad.

TECHNICIAN

16. Visually inspect the igniter for the presence of dirt, rust, corrosion, deterioration, or foreign material.

TECHNICIAN

17. Visually inspect the igniter basket for the presence of cuts, punctures, deterioration or other damage to the vinyl lacquer coating.

TECHNICIAN

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CAGE	36FC1
Rev	
Effective Date	1/21/15

DIRECTIVE NO.	840-WI-8072.1.15	Page 10 of 31
EFFECTIVE DATE:	July 16, 2012	
EXPIRATION DATE:	July 16, 2017	

NOTE: In the event that this igniter is not suitable for static firing, it will be used as a plug. Proceed with following tasks to re-install. Use initiator port closure plug instead of 7900-1 initiator. Use TASK B of this procedure to manufacture an igniter for disposal.

18. Visually inspect the O-ring groove for dirt, rust, corrosion, or other damage. Clean as required with cleaning solvent and Scotchbrite pad.

_____
TECHNICIAN

19. Inspect the new igniter O-ring, P/N MS-28775-223 for cuts, imperfections, or other evidence of damage. Verify that the shelf life of the O-ring has not expired. The expiration date is 5 years from the cure date.
Expiration Date_____

_____
TECHNICIAN

20. Record Igniter Lot Number and date of manufacture.

Igniter Lot Number _____ Date of Manufacture _____

_____
TECHNICIAN

21. Using DC-33, lubricate O-ring, O-ring seat, and O-ring groove on igniter. Install O-ring on igniter.

_____
TECHNICIAN

22. Install igniter using 5 ea. 1/4-28 x 1 socket head cap screws (Unbrako 20097-4F-16B). Torque to 100 -125 in. lb.

_____
TECHNICIAN

23. Exercise the SAFE/ARM mechanism to verify proper operation.

_____
TECHNICIAN

24. Position SAFE/ARM mechanism in "SAFE" position as indicated by flat side of shaft aligned horizontal to thrust axis of motor.

_____
TECHNICIAN

25. Inspect initiator (7900-1) for evidence of damage. Remove initiator from package and attach ground strap.

_____
TECHNICIAN

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26. Place initiator on workbench and perform visual inspection. Install in test box.

_____
TECHNICIAN

27. Remove initiator short. Record serial number of initiator.

Serial Number_____

_____
TECHNICIAN

28. Perform TASK A - Igniter Circuit Tester Confidence Test.

29. Using the Igniter Circuit Tester, perform resistance measurements between Pins A to B, and Pins C to D. Nominal resistance is 1.0 Ω +/- .10.

Initiator Resistance: Pin A to B _____
Pin C to D _____

_____
TECHNICIAN

30. Replace short. Remove initiator from the test box.

_____
TECHNICIAN

31. Inspect the new O-ring, P/N MS-28778-5 for cuts, imperfections, or other evidence of damage. Verify that the shelf life of the O-ring has not expired. The expiration date is 5 years from the cure date.

_____ Expiration Date

_____
TECHNICIAN

32. Using DC-33, lubricate O-ring, O-ring seat, and O-ring groove on initiator. Install O-ring on initiator.

_____
TECHNICIAN

33. Using a 3/4 in. deep socket, install the 7900-1 initiator in the igniter and torque to 120 in.-lb. +/- 5 in.-lb.

_____
TECHNICIAN

34. Re-install plastic shipping safe around igniter.

_____
TECHNICIAN

35. Measure and record the resistance of the 15 ft. shielded Belden cable. Provide this measurement to the Firing Console Operator. Resistance: _____

_____
TECHNICIAN

36. Discrepancies and Acceptance

List discrepancies below:

_____

_____

_____

_____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task B, except as noted above.

Date	TECHNICIAN
Date	SUPERVISOR

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TASK C- WFF MANUFACTURED IGNITER

In the event that an inspected Improved Orion igniter is not available for static firing it will be necessary to manufacture an igniter from Nike igniter powder and an excess Taurus spin motor igniter.

Equipment/Materials Required:

Velostat (cut into 3" x 10" piece to form a cylinder)
Nike Igniter
Taurus Spin Motor Igniter or Match Squib
Igniter Circuit Tester
Wire Stripper
Knife
Anti-static Masking Tape
Butt Connector Lug (wire size: 22 to 16 guage)
Platform Scales

WARNING: Personnel shall wear static dissipative clothing and wrist-stats.
Verify wrist-stats have been tested (1 MΩ to 10 MΩ opposite hand or wrist-stat to ground).

_____ TECHNICIAN

1. Obtain RF Avoidance

_____ TECHNICIAN

2. Ground the Nike igniter to a certified pyrotechnic ground.

_____ TECHNICIAN

3. Short and ground the Taurus spin motor igniter to a certified pyrotechnic ground.

_____ TECHNICIAN

4. Perform TASK A - Igniter Circuit Tester Confidence Test

5. Using an igniter circuit tester, measure the Taurus spin motor's igniter resistance. (Minimum Resistance .47 ohms, Maximum Resistance .77 ohms)

   Resistance _____ _____ TECHNICIAN

6. Measure and record resistance of the 15' shielded Belden cable. Provide this measurement to Firing Control Operator.

   Resistance _____ _____ TECHNICIAN

7. Using wire strippers, strip the spin motor igniter leads and Belden cable leads approximately ½ ". Attach Belden cable to spin motor leads using a butt connector lug. Verify crimped in place.

_____
TECHNICIAN

8. Short and ground the Belden cable.

_____
TECHNICIAN

9. Cut a 3" x 10" piece of Velostat conductive plastic and form it into a cylinder, sealing edges with duct tape.

NOTE: The opening going down the center of the Orion motor grain is approximately 2" in diameter

10. On the Nike igniter, cut around the plastic disk located in the center of the powder cup and pop out the disk.

11. Pour all the igniter powder located in the igniter into a static free paper cup. _____
TECHNICIAN

NOTE: There is approximately two pounds of powder in a Nike igniter

12. Pour 8 oz. of the Nike igniter powder into the Velostat cylinder. _____
TECHNICIAN

13. Insert the spin motor igniter with attached Belden cable into the Velostat cylinder (on top of the igniter powder). _____
TECHNICIAN

14. Add an additional 8 oz. of Nike igniter powder into the Velostat cylinder on top of the igniter.

_____
TECHNICIAN

15. Using anti-static masking tape, seal the cylinder with the Belden cable protruding.

_____
TECHNICIAN

16. Store the WFF manufactured igniter in the Nike igniter storage box located in the assembly area until ready to use in static firing. _____
TECHNICIAN

17. Release RF Avoidance.

_____
TECHNICIAN

18. Discrepancies and Acceptance

List discrepancies below:

_____

_____

_____

_____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task C, except as noted above.

Date	TECHNICIAN
Date	SUPERVISOR

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TASK D- PREREQUISITE TASKS TO THE STATIC FIRING OPERATION

1. Record the following information on the day of the static firing operation:

DATE: _____

MOTOR: _____

P/N _____ **S/N** _____
(if available)

REQUESTED BY: _____

REASON FOR DESTROYING: _____

_____

2. Prior to any operation involving ordnance disposal at Wallops Flight Facility, the site designated for hazardous waste disposal shall be inspected to (a) detect any possible deterioration of equipment, (b) verify calibration of monitoring equipment, and (c) inspection of safety and emergency equipment and other devices to be utilized during the operation. Complete the Equipment/Site Inspection Log (Attachment 1) to document findings.

3. Prior to commencing static firing operations verify the following:

   a. Notification to Range Control to make an announcement on the public address system that static firing is about to commence.

   b. Notification to all Island Personnel (in the immediate area) and Damage Control that static firing is about to commence.

   c. Damage Control will have personnel available with Haz-Mat training located at the disposal area barricade during the static firing operations.

   d. Operations Safety Supervisor is present with a Ground Safety Plan

_____
Work Supervisor

4. Discrepancies and Acceptance

List discrepancies below:

_____

_____

_____

_____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task D, except as noted above.

Date/Time	TECHNICIAN
Date/Time	WORK SUPERVISOR

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TASK E- PREPARATION FOR STATIC FIRING FROM DISPOSAL PAD

1. Transport motor to disposal area. If applicable, transport the WFF manufactured igniter.

WARNING: Personnel must wear static dissipative clothing, safety glasses/visor and wrist-stats. Verify wrist-stats have been tested (1 MΩ to 10 MΩ opposite hand or wrist-stat to ground).

_____
TECHNICIAN

2. Ground motor to the certified pyrotechnic ground located near the static firing pad.

_____
TECHNICIAN

3. Attach headcap fixture to the motor headcap using twelve ¼ - 28 UNF-3A bolts, meeting strength requirements MS2004 (Aircraft). Torque bolts to 10 - 20 ft. lbs. **(Standard igniter only)** Verify access through fixture for means to operate SAFE/ARM mechanism.

_____
TECHNICIAN

4. With motor in horizontal position on trailer, attach motor lugs to motor. Motor lugs are to be attached to the threaded holes located near the longitudinal center of the motor using two 9/16 -18 bolts. Attach one lug to each of the four locations. Torque bolts to 80 ft. lbs.

_____
TECHNICIAN

5. If WFF manufactured igniter is to be used, proceed to step 9.

6. Obtain RF Avoidance

_____
TECHNICIAN

7. Install a Holex 7900 mating connector on the shielded Belden cable. Pass the leads through the hole provided in the adapter. Short and ground the two firing leads to the motor case. Remove shorting cap from initiator and install the Holex 7900 mating connector to the initiator.

_____
TECHNICIAN

8. Release RF Avoidance.

_____
TECHNICIAN

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9. Attach a nylon lifting strap to nozzle of motor and lift using a mobile crane. Slowly lift the motor from the trailer. (Use a forklift to maintain level lifting until the motor has cleared the trailer).

_____ TECHNICIAN

10. Carefully lower Orion motor with forward end down on the pad over the alignment holes. Align motor lugs with pad lugs. Attach headcap fixture to the pad using four grade eight ¾ - 10 bolts with washers. Shim as necessary to maintain good contact between the fixture and the pad. Torque bolts to 100 ft. lbs.

_____ TECHNICIAN

11. Attach pad lugs to concrete anchors at four points using grade eight ¾-10 bolts with washers. Torque bolts to 100 ft. lbs.

_____ TECHNICIAN

12. Attach the swaged cable loop on the free end of the cable assembly to the motor lug using a 7/16 grade B shackle. Verify shackle is embossed with the letters "HS," which identifies them as grade B.

_____ TECHNICIAN

13. Attach the free end of the turnbuckle on cable assembly to the pad lug with a 7/16 grade B shackle. Attach the remaining three cable assemblies in the same manner.

_____ TECHNICIAN

14. Adjust the ratchet on the turnbuckle so that it will tighten the assembly. Tighten turnbuckles uniformly until their cable assembly is taught. Turnbuckles should be hand-tight. Adjust the ratchet mechanism on the turnbuckles so that the handle does not engage the turnbuckle. Release lifting sling and crane.

_____ TECHNICIAN

Perform steps 15 thru 17 only if the WFF manufactured igniter is used

15. Obtain RF Avoidance.

_____ TECHNICIAN

16. Carefully insert the WFF manufactured igniter through the nozzle end. Lower approximately 8 feet. Ground the igniter lead.

_____ TECHNICIAN

17. Release RF Avoidance.

_____
TECHNICIAN

18. Discrepancies and Acceptance

List discrepancies below:

_____
_____
_____
_____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task E, except as noted above.

Date	TECHNICIAN
Date	SUPERVISOR

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TASK F- STATIC FIRING OPERATION

WARNING: Personnel shall wear static dissipative clothing, safety glasses/visor and wrist-stats. Verify wrist-stats have been tested (1 MΩ to 10 MΩ opposite hand or wrist-stat to ground).

_____ **TECHNICIAN**

1. Firing Console Operator will perform VA checks as per Procedure 20-6-12, Portable AC Ground Firing Box Booster A, TASK A - Booster Current Adjustments.

   _____ TECHNICIAN

2. Obtain RF Avoidance.

   _____ TECHNICIAN

3. Work Supervisor will clear the disposal danger area of all unnecessary personnel.

   _____ TECHNICIAN

4. Verify AC portable firing box is disconnected from the firing line and is shorted at the barricade.

   _____ TECHNICIAN

5. Confirm firing line is shorted and grounded by measuring the resistance from the motor end.

   Record Resistance _____ _____ TECHNICIAN

6. Using a pyro-voltmeter check for NO VOLTAGE on firing line.

	No-Voltage
Line A to Line B	
Firing Line A to Ground	
Firing Line B to Ground	

   _____ TECHNICIAN

7. If NO VOLTAGE is present, connect firing cable to the shielded Belden cable which is connected to the igniter.

   _____ TECHNICIAN

8. **(Standard igniter only)** Move the SAFE/ARM mechanism to the "ARM" position.

_____
TECHNICIAN

9. Work Supervisor shall clear ALL personnel from the disposal danger area and proceed to the barricade.

_____
TECHNICIAN

10. Firing Console Operator shall measure total resistance of firing line plus igniter as per Procedure 20-6-12, Portable AC Ground Firing Box Booster A, TASK A - Booster Current Adjustments, Steps 1 and 2.

11. Release RF Avoidance

_____
TECHNICIAN

12. Work Supervisor shall notify Range Control that the Static Firing is ready to commence.

_____
TECHNICIAN

13. Technician shall verify that the disposal area is clear and all personnel are behind the barricade.

_____
TECHNICIAN

14. Firing Console Operator will perform Procedure 20-6-12, Portable AC Ground Firing Box Booster A, TASK B, Steps 3 through 9.

_____
TECHNICIAN

15. The Work Supervisor shall verbally count down from 10 seconds.

16. At T-0 the Firing Console Operator will ignite the igniter.

17. In the event of a NO-FIRE, proceed to TASK G, of this procedure, and notify Range Control that a NO-Fire has occurred.

_____
TECHNICIAN

18. If motor has been successfully static fired, the case must remain on the pad for approximately 1 hour until the case has cooled sufficiently to be removed.

19. Disconnect the firing leads from the portable AC firing box, remove motor from pad.

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20. Notify Range Control that the static firing operations are complete.

_____
TECHNICIAN

21. Complete Attachment 2 Post Burn Open Burn (OB) Area Inspection Log.

22. Discrepancies and Acceptance

List discrepancies below:

_____
_____
_____
_____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task F, except as noted above.

Date	TECHNICIAN
Date	SUPERVISOR

TASK G- NO FIRE OPERATION

IN THE EVENT OF NO-FIRE, ALL PERSONNEL WILL WAIT 30 MINUTES BEHIND THE BARRICADE

1. From the barricade, measure the line resistance to determine if the squibs have been fired.

   Line Resistance _____ _____
   TECHNICIAN

2. If the squibs have not fired, the ignition current should be increased (no more than 2 times the recommended firing current) and a second attempt will be made to fire the squibs.

   Ignition Current _____ _____
   TECHNICIAN

3. If the squibs fail again, all operations will stop. Notify Range Control that static firing has been terminated.

   _____
   TECHNICIAN

4. All personnel shall leave the area and road blocks at the barricade will be manned for one hour.

5. After 1 hour, disconnect and short the firing leads from the portable AC firing box.

6. Obtain RF avoidance.

   _____
   TECHNICIAN

7. Proceed to the motor. Ground the motor case to a certified pyrotechnic ground. Move the SAFE/ARM device to the "SAFE" position. Short the igniter leads (Belden cable) to the motor case.

8. Remove motor from the pad and examine the igniter.

   _____
   TECHNICIAN

9. Discrepancies and Acceptance

   List discrepancies below:

   _____
   _____
   _____
   _____

Technician and Work Supervisor shall sign to indicate satisfactory completion of Task G, except as noted above.

Date	TECHNICIAN
Date	SUPERVISOR

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Attachment 1

EQUIPMENT/SITE INSPECTION LOG

Equipment/Facility	Condition	Corrective Action	Comments
Facility			
Concrete anchors			
Certified pyrotechnic ground			
Safety/Security			
Grounding straps			
Barricade			
Road block stands			
Warning signs			
2-Way Communications			
Stand-by Fire Protection			
Haz-Mat Specialist			
Stand-by Emergency First Aid			
Wrist-stats			
Safety Coats/Coveralls			
Safety Glasses/Goggles			
Safety Shoes			
Protective head gear			
Face Shields			
Equipment			
Igniter Circuit Tester			
Firing lines			
Pyro-Voltmeter			
Igniter leads			
Mobile crane			
Lifting Strap			
Torque wrenches			
Miscellaneous			
Weather Conditions			

Attachment 2

POST BURN OB AREA INSPECTION LOG

EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Subunits Integrity			
Subunit 1			
Rain Cap			
Subunit 2			
Rain Cap			
Subunit 3			
Rain Cap			
Subunit 4			
Rain Cap			
Pad Integrity			
Concrete			
Tie-Down Cables			
Tie Down Anchors			
Berm Integrity			
Concrete			
Pad Cover Integrity			
Roof			
Structure			
Pan Integrity			
Steel			
Residues			
Soil Survey			
Pad Survey			

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Number	WI-840002
CAM#	8MFC1
Rev	
Effective Date	1/21/15

DIRECTIVE NO. 840-WI-8072.1.15
EFFECTIVE DATE: July 16, 2012
EXPIRATION DATE: July 16, 2017

EQUIPMENT/FACILTY	CONDITION	CORRECTIVE ACTION	COMMENTS
Other Miscellaneous			

REMARKS:

OB OPERATIONS:

INSPECTED BY: _____ **TITLE:** _____

DATE: _____ **TIME:** _____

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Appendix A – Definitions
N/A

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Appendix B – Acronyms

mA	Milli Amperes
MSDS	Materials Safety Data Sheets
OB	Open Burn
OSS	Operations Safety Supervisor

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	02/17/2005	Initial Release
-	July 16, 2012	**Re- Released as a Code 840 WI. Previously was 548-WI-8072.1.43 (same title)**

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THE CONFIGURATION & DOCUMENT MANAGEMENT SYSTEM (CDMS) IS LOCATED AT:
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Work Instruction (WI)

DIRECTIVE NO.	548-WI-8072.1.63A	**APPROVED BY Signature:**	Original signed by
EFFECTIVE DATE:	03/12/2013	**NAME:**	David A. Wilcox
EXPIRATION DATE:	03/12/2018	**TITLE:**	Head, Mechanical Systems Branch

COMPLIANCE IS MANDATORY

Responsible Office: 548.W/Mechanical Systems Branch

Title: Pyrotechnic Grounding Survey and 6-Month Visual Inspection of Pyrotechnic Grounding

PREFACE

P.1 PURPOSE

This procedure is a requirement of NSS 1740.12, "Safety Standard for Explosives, Propellants & Pyrotechnics," for an annual inspection and semi-annual visual inspection of pyrotechnic grounding points.

Grounding systems shall be visually inspected semi-annually and shall be tested once each year for adequacy of grounding (Task A) and electrical continuity (Task B). Facility data sheets that record the results obtained from the tests shall be maintained as a Quality Record as assigned by Code 548 Quality Records List.

Any electrical system shall be considered deficient if; a) electrical continuity does not exist, or b) visual inspection reveals deterioration and/or destruction of the hardware that constitutes the ground system. Except where counterpoises are installed, systems shall be considered deficient if resistance to ground exceeds 25 ohms. Systems that fail any of the above criteria will be tagged out of service for use as a pyrotechnic ground, and a "non-conformance report (NCR)" will be entered to the appropriate official for action.

After corrective action(s) have been made to the deficient system(s), the facility shall require a complete ground test of all points, prior to certification for pyrotechnic grounding.

A copy of the GROUND MEASUREMENT DATA SHEET shall be placed in the GROUND MEASUREMENT CERTIFICATION LOG BOOK kept at the main entrance of the facility being tested.

Inspections for signs of deterioration or damage of certified points, and verification that all lightning protection systems are properly grounded, shall be performed 6 months after certification testing. Each point will be checked for condition of labeling, and deterioration or destruction of the hardware that constitutes the grounding system. Any point that fails the inspection shall be tagged out of service for use as a pyrotechnic ground, and a "Non-Conformance Report (NCR)" will be entered to the appropriate official for action.

After corrective action(s) have been made to the deficient system(s), the facility shall require a complete ground test of all points prior to certification for pyrotechnic grounding.

P.2 APPLICABILITY

Code 548 Range Team

P.3 REFERENCES

NSS 1740.12 "Safety Standard for Explosives, Propellants & Pyrotechnics"
GPG 8072.1 Process Control

P.4 CANCELLATION

GDMS 546-WI-8072.1.23 Rev. E
GDMS 548-WI-8072.16
GDMS 546-WI-8072.1.43 Rev. C
GDMS 548-WI-8072.1.40

P5. TOOLS, EQUIPMENT, AND MATERIALS

AEMC 4630 Testing Kit which includes:
Ground Rods (4 each)
300 ft Cable (2 each)
500 ft. Cable (1 each)
AEMC 4630 Ground tester
AEMC 4630 User Manual
6" jumper with banana jacks on each end
6' lead with alligator clip on one end and a banana jack on the other
Small Wire Brush

AEMC 4630 must be calibrated annually. Do not use if out of calibration.

PERSONNEL REQUIRED:

One Technician for 6-month inspection
Two Technicians for annual inspection

P6. SAFETY PRECAUTIONS AND WARNINGS

There shall be no ordnance devices grounded to a system under test.

PPE (Personal Protective Equipment) is required for some of the tasks in this WI. PPE Required: Safety Glasses

P.7 TRAINING

On the job training is required to perform this work instruction.

P.8 RECORDS

Record Title	Record Custodian	Retention
Data Sheets	548 Custodian	*NRRS – NASA Records Retention Schedule (NPR 1441.1)*
		*

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 MEASUREMENT/VERIFICATION

N/A

Instructions

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

PROCEDURE- ANNUAL TEST

1. Print the appropriate data sheets and drawing(s) for the facility or facilities to be surveyed. The data sheets, when completed, will be a Quality Record.
2. Proceed to each facility to be tested. Conduct TASK A and TASK B instructions as required.
3. Complete data sheet by filling in soil conditions observed for the earth electrode test (TASK A), documenting any discrepancies on the remarks line and listing the measurement number of any failed tests.
4. Re-mark any ground point labeling that is not legible.
5. Upon completion of the Ground Measurement data sheet, the inspecting Technician and Task Leader shall sign and date the data sheet, and submit and document by case number, any NCR

submitted for failed ground points. Place a copy of the Ground Measurement Data Sheet in the Ground Measurement Log Book at the entrance of the facility.

6. Upon repair of failed ground points, the facility shall be completely re-tested in accordance with this WI.

PROCEDURE- 6 MONTH VISUAL INSPECTION

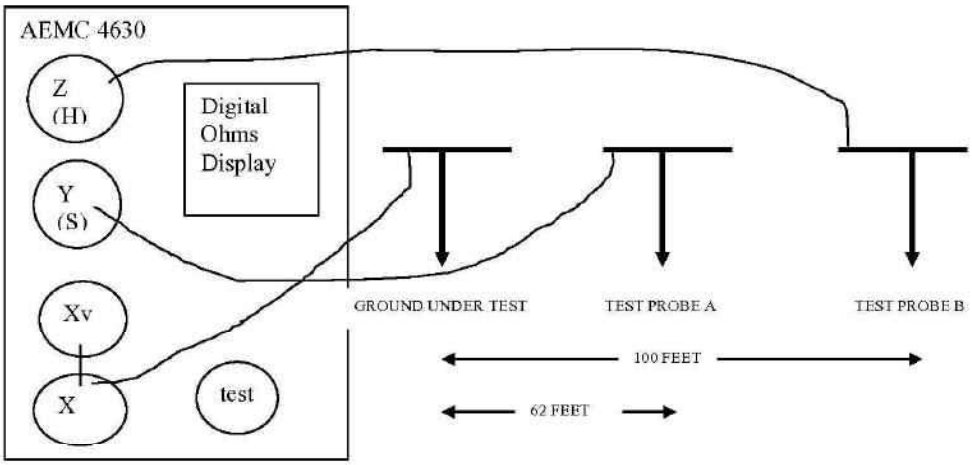
1. Print the appropriate data sheets for the facility or facilities to be inspected. The data sheets, when completed, will be the Quality Record.
2. Proceed to each facility to be inspected. Check each ground point listed on the appropriate facility data sheet for deterioration or destruction of the hardware that constitutes the grounding system.
3. Indicate acceptance of the ground point by checking "Pass" or "Fail" on the data sheet. Write the reason for a "Fail" status under the "Remarks" column.
4. Re-mark any labeling that is not legible. This action does not require an NCR.
5. Upon completion of the Ground Measurement data sheet, the inspecting Technician shall sign and date the data sheet, and submit and document by case number, any NCR submitted for failed ground points.
6. Upon repair of failed ground points, the facility shall be completely re-tested per annual test procedure.

LIST OF CONTENTS:

Data Sheet	Page No.
Launch Area No. 1	8
Assembly Shop No. 1 (Building Y-15)	11
Launch Pad No. 2, South	16
Launch Pad No. 2, East	19
Assembly Shop No. 3 (Building W-65)	22
Launch Pad No. 4	27
Assembly Shop No. 5 (Building W-40)	30
Launch Pad No. 5	33
Environmental Test Facility (Building V-55)	36
Environmental Test Facility (Building V-45)	39
Pyrotechnic Storage Facility (Building V-67)	42
Rocket Motor Storage Facility (Building W-15)	47
Rocket Motor Storage Facility (Building M-15)	50
Rocket Motor Storage Facility (Building M-16)	54
Rocket Motor Storage Facility (Building M-20)	58
Rocket Motor Storage Facility (Building M-22)	62
Aircraft Hangar (Building D-1)	66
Aircraft Pyrotechnic Grounds (Runway 17-35)	70
Aircraft Hangar (Building N-159)	76
OBOD Facility	81
Launch Pad 2- North	84
Building F-10	88
Launch Pad 2 Gun Mount	98
Payload Processing Facility Bldg. H-100	101
F7 Clean Room	106
X-79 (Horizontal Integration Facility) HIF	109
Y-45 Explosive Storage Bunker	116

TASK A Operating Procedure- The Earth Electrode Test

1. Configure the AEMC 4630, test probes, and test leads according to Figure 1.



NOTES: a. Be sure to place a short between Xv and X .
b. The distance between the "Ground Under Test" and "Test Probe A" is 62% of the distance between the "Ground Under Test" and "Test Probe B".
c. The Ground measurement must be less than 25 ohms.

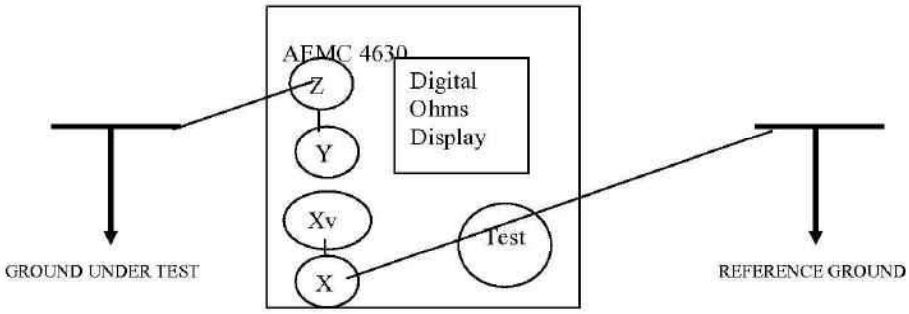
Figure 1

2. a. X and Xv are shorted
   b. Connect X to ground rod to be tested.
   c. Connect Y(S) to the center electrode (test probe A)
   d. Connect Z (H) to the outer electrode (test probe B)
   e. Depress the "Test" button to measure the ground resistance.

f. Record the reading on the Ground Measurement Data Sheet.

TASK B Operating Procedure- The Continuity of an Earth Electrode Test:

1. Configure the AEMC 4630, test probes, and test leads according to Figure 2.



NOTE: All readings must be less than one (1) ohm.

Figure 2

2 a. Measure lead resistance of test lead to be used from X to ground under test.
b. Short X and Xv.
c. Short Y and Z
d. Connect Z to the ground rod to be measured.
e. Connect X to the reference ground.
f. Depress the "test" button and read the resistance.
g. Subtract the lead resistance for the measured ground resistance.
h. Record the product on the Ground Measurement Data Sheet.
i. The Ground Measurement Data Sheet must be signed and dated by the technician and the task leader.

Flow Diagram

N/A

DIRECTIVE NO.	548-WI-8072.1.63A	Page 8 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

GROUND MEASUREMENT DATA
LAUNCH AREA NO. 1

TASK A

MEASUREMENT NUMBER	*LOCATION OF MEASUREMENT* *See Figure B26806*	*RESISTANCE*				
		Expected	*Initial*			
1	*Ground to GTP-3*	*<25 ohms*				

TASK B ***Net resistance shall be less than 1 ohm***

MEASUREMENT NUMBER	*LOCATION OF MEASUREMENT* *See Figure B26806*	*RESISTANCE*	
		Measured	*NET Minus line*
2	*GTP-3 to GTP-4*		
3	*GTP-3 to GTP-2*		
4	*GTP -3 to No. 3*		
5	*GTP-3 to No. 1*		
6	*GTP-3 to No. 2*		
7	*GTP-3 to GTP-1*		

Soil Condition: _____

*Lead Resistance*_____

*Calibration Date:*_____

Remarks: _____

List Measurement Number(s) of failed tests:

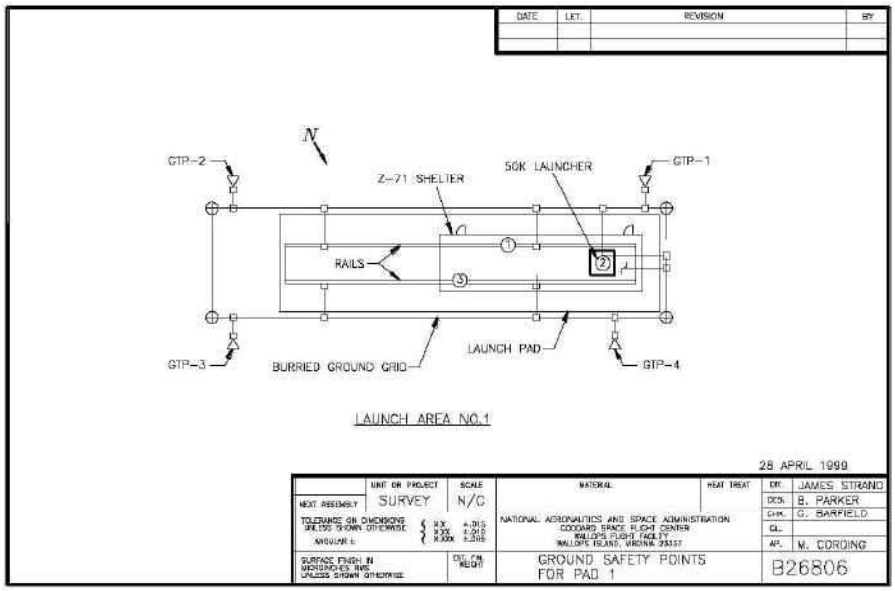
_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN **DATE** **TASK LEADER** **DATE**

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

GSFC 3-19 (11/09)


DATE
LET.
REVISION
BY
N
GTP-2
Z-71 SHELTER
50K LAUNCHER
GTP-1
RAILS
GTP-3
BURRIED GROUND GRID
LAUNCH PAD
GTP-4
LAUNCH AREA NO.1
28 APRIL 1999
UNIT OR PROJECT
SCALE
MATERIAL
HEAT TREAT
NEXT ASSEMBLY
SURVEY
N/C
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE
ANGULAR ±
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE
DIST. FM. WEIGHT
GROUND SAFETY POINTS
FOR PAD 1
DR. JAMES STRANO
DES. B. PARKER
CHK. G. BARFIELD
GL.
AP. M. CORDING
B26806

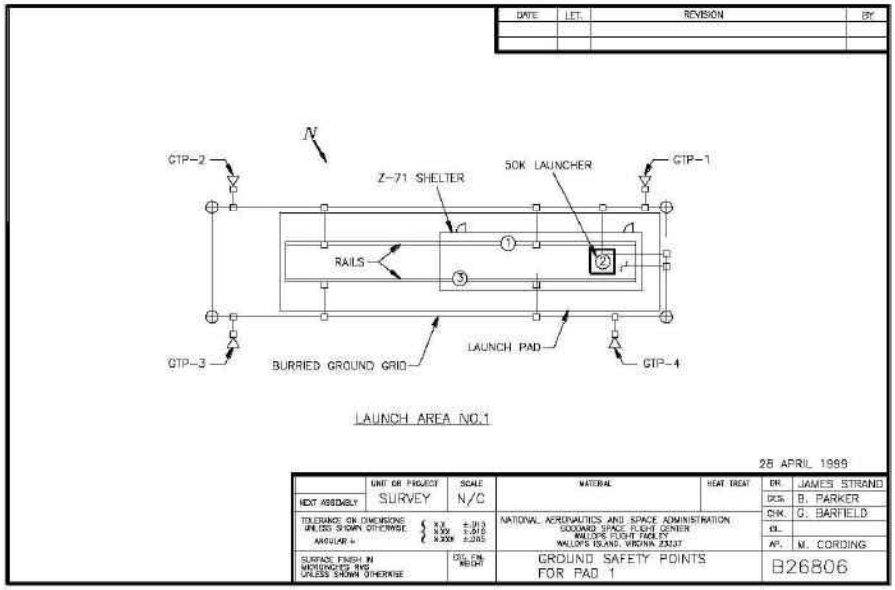
DIRECTIVE NO.	548-WI-8072.1.63A	Page 10 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Area No. 1

Ground Point	Pass	Fail	Remarks
GTP-1			
GTP-2			
GTP-3			
GTP-4			
No. 1			
No. 2			
No. 3			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
Y-15 ASSEMBLY SHOP

TASK A **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	Ground to No. 2 (Bay 1)	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE NET Measured Minus line	
2	Bay 1- No. 2 to Bay 1 No. 1		
3	Bay 1- No. 2 to Bay 2- No. 3		
4	Bay 1- No. 2 to Bay 2- No. 4		
5	Bay 1- No. 2 to Bay 3 No. 5		
6	Bay 1- No. 2 to Bay 3- No. 6		
7	Bay 1- No.2 to Bay 4 No. 4		
8	Bay 1- No. 2 to Bay 4- No. 8		
9	Bay 1- No. 2 to Bay 5 No. 9		
10	Bay 1- No. 2 to Bay 5- No. 10		
11	Bay 1- No. 2 to Bay 6 No. 11		
12	Bay 1- No. 2 to Bay 6- No. 12		
13	Bay 1- No. 2 to Bay 7 No. 13		
14	Bay 1- No. 2 to Bay 7- No. 14		
15	Bay 1- No. 2 to Bay 8 No. 15		
16	Bay 1- No. 2 to Bay 8- No. 16		

Soil Condition: _____

Lead Resistance_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

DATE	LET.	REVISION	BY
7/14/99	A	GENERAL REVISION	MLC

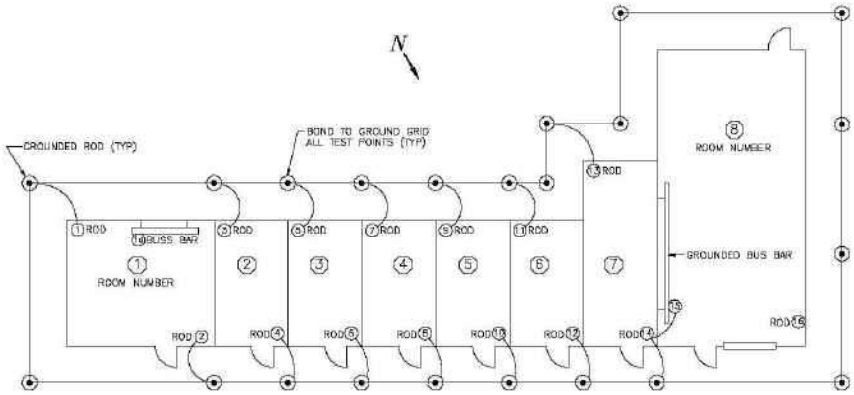


FIG. Y-15 ASSEMBLY SHOP NO.1

14 JULY 1999

NEXT ASSEMBLY	UNIT OR PROJECT: SURVEY	SCALE: N/C	MATERIAL	HEAT TREAT	DR. JAMES STRAND
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA 23337		DES. B. PARKER; CHK. G. BARFIELD; GL.; AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR Y15		B26804

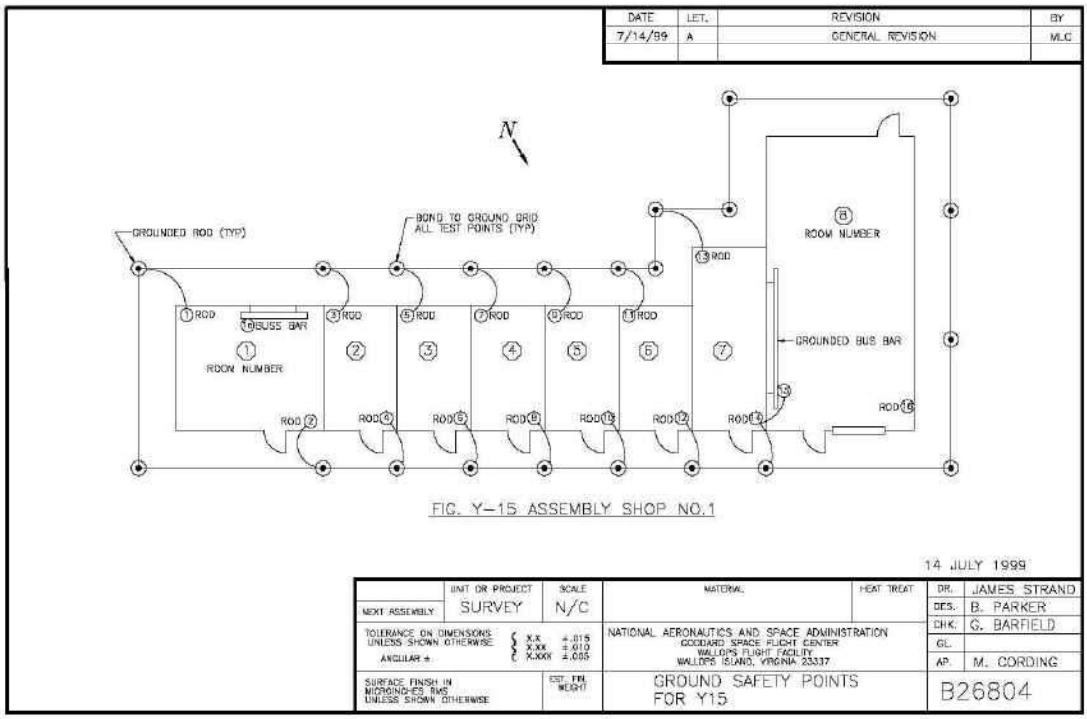
6-Month Visual Inspection of Pyrotechnic Grounding Points
Assembly Shop No. 1 (Building Y-15)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

6-Month Visual Inspection of Pyrotechnic Grounding Points
Assembly Shop No. 1 (Building Y-15)



GROUND MEASUREMENT DATA
LAUNCH AREA, NO. 2, SOUTH

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26671	RESISTANCE Expected	Initial			
1	Ground to GTP-2 SOUTH	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26671	RESISTANCE NET Measured Minus line	
2	GTP-2 to No. 3		
3	GTP-2 to No. 1		
4	GTP-2 to No. 2		
5	GTP-2 to GTP-1	<	

Soil Condition: _____

Lead Resistance_____

Calibration Date _____

Remarks: _____

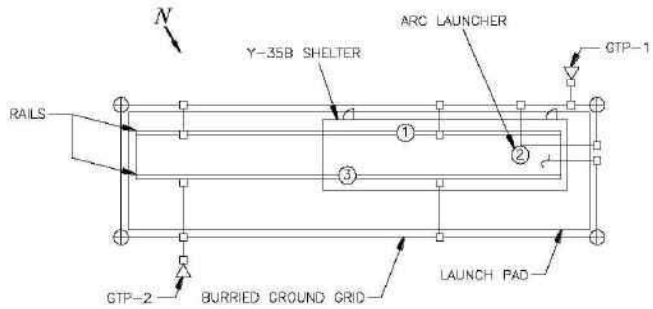
List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

DATE	LET.	REVISION	BY



LAUNCH AREA NO.2 SOUTH

27 APRIL 1999

	UNIT OR PROJECT	SCALE	MATERIAL	HEAT TREAT	DR.	JAMES STRAND
NEXT ASSEMBLY	SURVEY	N/C			DES.	B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK.	G. BARFIELD
					GL.	
					AP.	M.CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FN. WEIGHT	LAUNCH AREA PAD 2 SOUTH GROUNDING POINTS			B26671

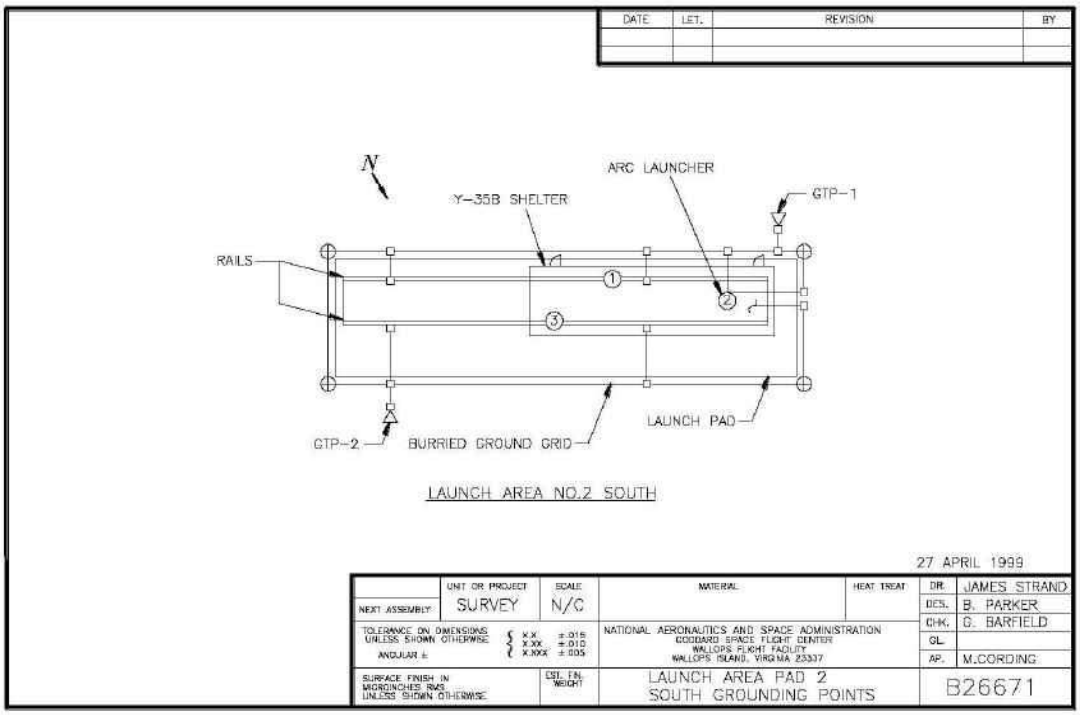
DIRECTIVE NO.	548-WI-8072.1.63A	Page 18 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Pad No. 2, South

Ground Point	Pass	Fail	Remarks
GTP-1			
GTP-2			
No. 1			
No. 2			
No. 3			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
LAUNCH AREA, NO. 2, EAST

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26888	RESISTANCE Expected	Initial			
1	Ground to GPT-1 EAST	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26888	RESISTANCE Measured	NET Minus Line
2	GTP-1 EAST to No, 2-4		
3	GTP-1 EAST to No. 2-5		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

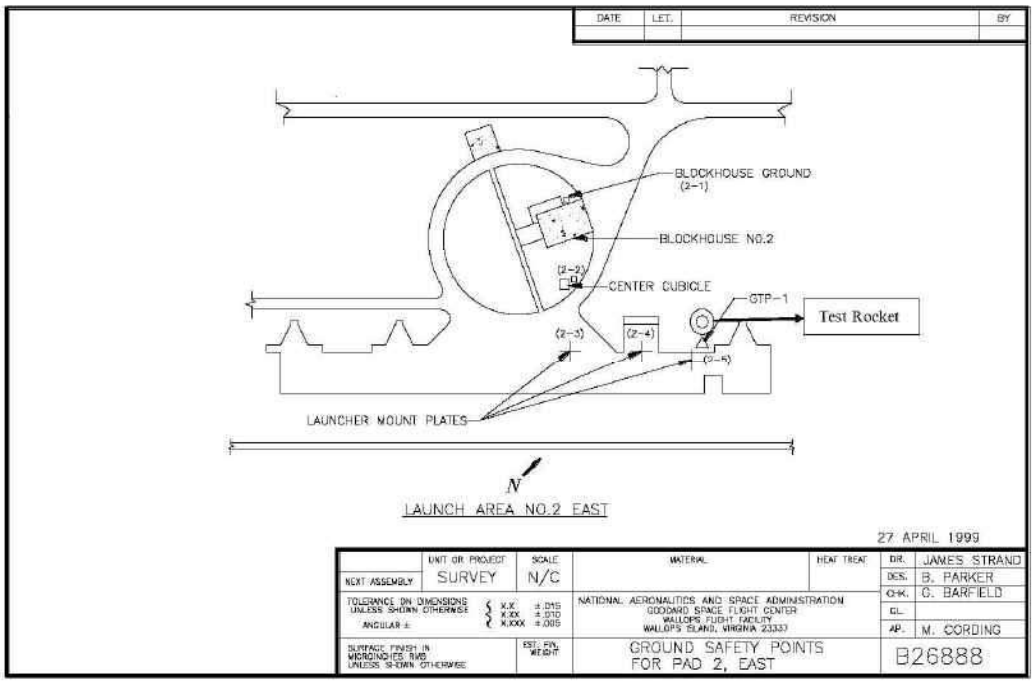
Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**


DATE
LET.
REVISION
BY
BLOCKHOUSE GROUND
(2-1)
BLOCKHOUSE NO.2
(2-2)
CENTER CUBICLE
GTP-1
Test Rocket
(2-3)
(2-4)
(2-5)
LAUNCHER MOUNT PLATES
N
LAUNCH AREA NO.2 EAST
27 APRIL 1999
UNIT OR PROJECT
SCALE
MATERIAL
HEAT TREAT
NEXT ASSEMBLY
SURVEY
N/C
DR. JAMES STRAND
DES. B. PARKER
CHK. C. BARFIELD
CL.
AP. M. CORDING
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE
X.X ±.015
X.XX ±.010
X.XXX ±.005
ANGULAR ±
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE
EST. FIN. WEIGHT
GROUND SAFETY POINTS
FOR PAD 2, EAST
B26888

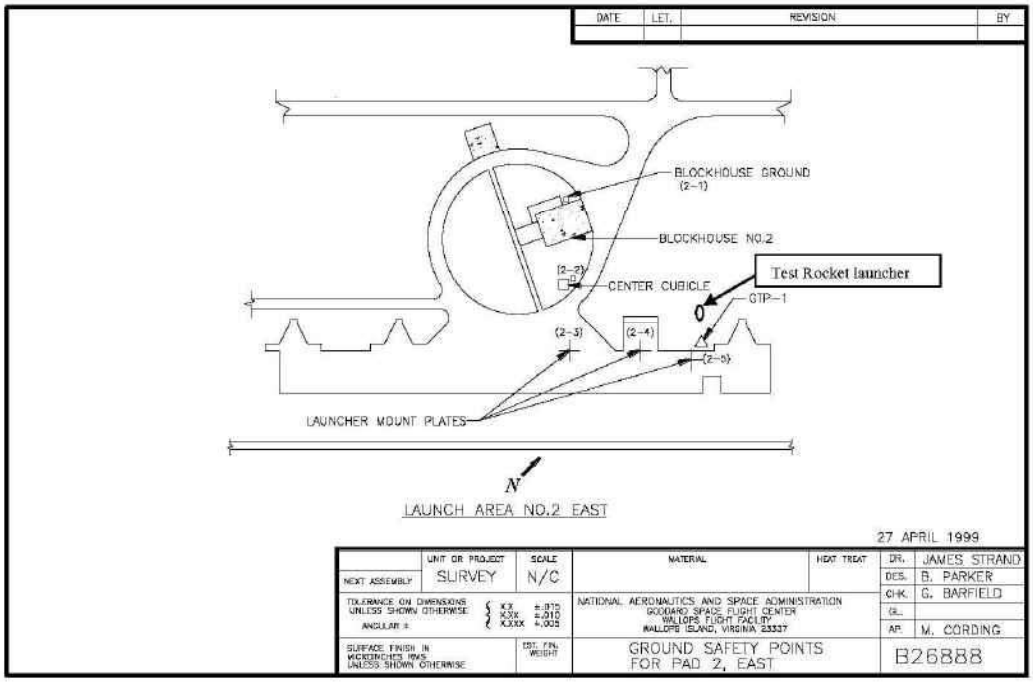
DIRECTIVE NO.	548-WI-8072.1.63A	Page 21 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Pad No. 2, East

Ground Point	Pass	Fail	Remarks
GTP-1			
No. 2-4			
No. 2-5			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
W-65 ASSEMBLY SHOP

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26985	RESISTANCE Expected	Initial			
1	Ground to no. 3	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26985	RESISTANCE Measured	NET Minus Line
2	Bay 1- No. 3 to no. 2		
3	Bay 1- No. 3 to No. 1		
4	Bay 1- No. 3 to No. 4		
5	Bay 1- No. 3 to No. 5		
6	Bay 1- No. 3 to No.6		
7	Bay 1- No. 3 to No. 7		
8	Bay 1- No. 3 to No.8		
9	Bay 1- No.3 to No. 9		
10	Bay 1- No. 3 to No. 10		
11	Bay 1- No. 1 to Bay 2 No. 11		
12	Bay 1- No. 1 to No. 12		
13	Bay 1- No. 1 to No. 13		
14	Bay 1- No. 1 to No. 14		
15	Bay 1- No. 1 to No. 15		
16	Bay 1- No. 1 to No. 16		
17	Bay 1- No. 1 to No. 17		

18	Bay 1- No. 1 to Bay 3 No. 18		
19	Bay 1- No. 1 to Bay 3- No. 19		
20	Bay 1- No. 1 to No. 20		
21	Bay 1- No. 1 to No. 21		
22	Bay 3- No. 21 to Bay 4 No. 22		
23	Bay 3- No. 21 to No. 23		
24	Bay 3- No. 21 to No. 24		
25	Bay 3- No. 21 to No. 25		
26	Bay 3- No. 21 to Bay 5 No. 26		
27	Bay 3- No. 21 to No. 27		
28	Bay 3- No. 21 to No. 28		
29	Bay 3- No. 21 to No. 29		
30	Bay 3- No. 21 to Bay 6 No. 30		
31	Bay 3- No. 21 to No. 31		
32	Bay 3- No. 21 to No. 32		
33	Bay 3- No. 21 to No. 33		
34	Bay 3- No. 21 to No. 34		
35	Bay 3- No. 21 to No. 35		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

DATE	LET.	REVISION	BY
7/14/99	A	GENERAL REVISION	MLC

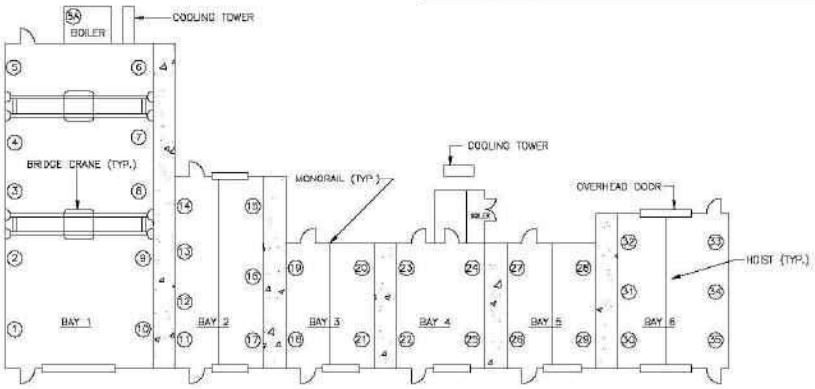


FIG. W-65 ASSEMBLY SHOP NO. 3

7 JULY 1999

NEXT ASSEMBLY	UNIT OR PROJECT: SURVEY	SCALE: N/S	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					CL.
					AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		CST. PRL WEIGHT	GROUND SAFETY POINTS FIG. NO.W-65 ASSEMBLY SHOP NO.3		B26985

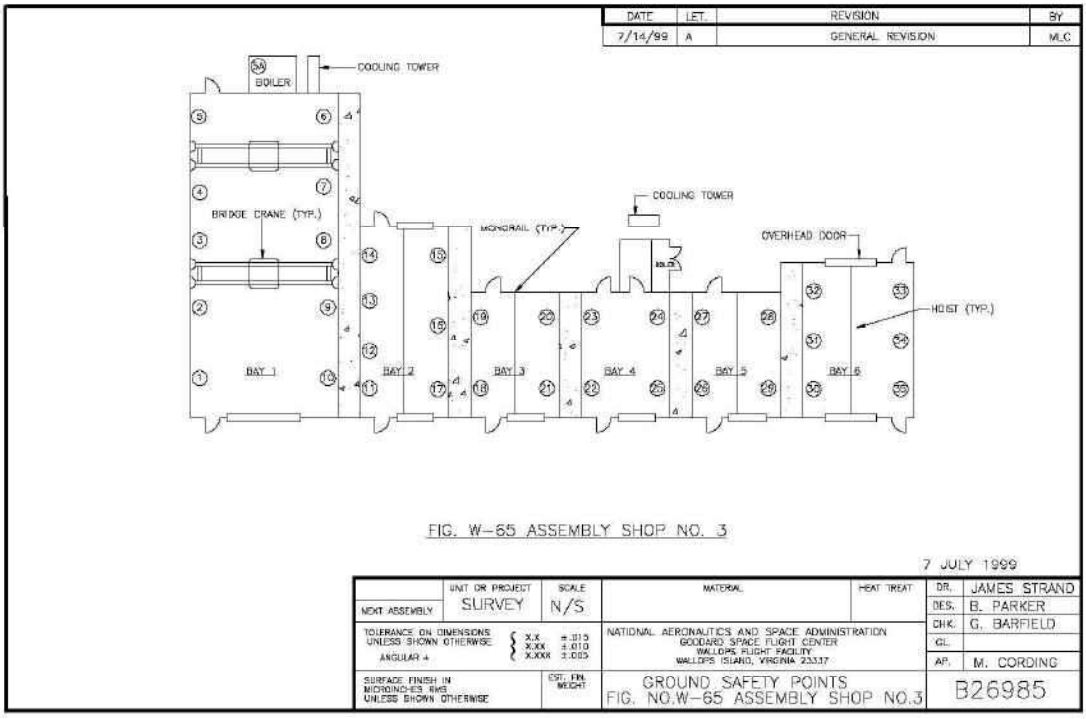
6-Month Visual Inspection of Pyrotechnic Grounding Points
Assembly Shop No. 3 (Building W-65)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			
No. 17			
No. 18			
No. 19			
No. 20			
No. 21			
No. 22			
No. 23			
No. 24			
No. 25			
No. 26			
No. 27			
No. 28			
No. 29			
No. 30			
No. 31			
No. 33			
No. 34			
No. 35			

6-Month Visual Inspection of Pyrotechnic Grounding Points
Assembly Shop No. 3 (Building W-65)

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
LAUNCH PAD 4

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26843	RESISTANCE Expected	Initial			
1	Ground to GTP-1	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26843	RESISTANCE Measured	NET Minus line
2	GTP-1 to No. 2		
3	To No. 3		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

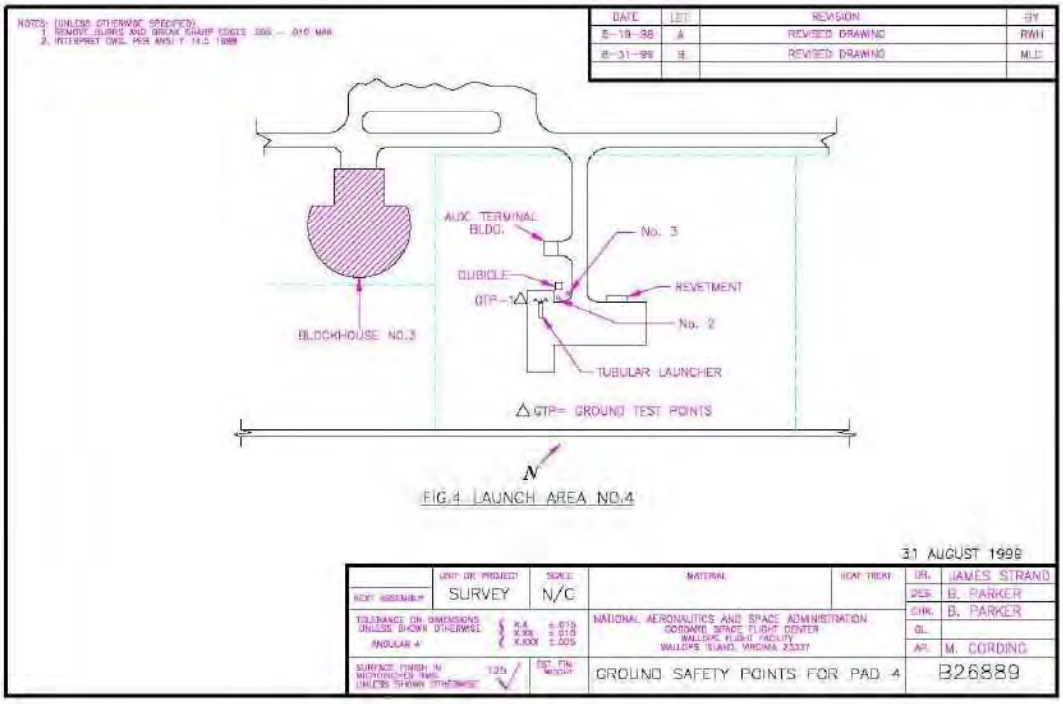
Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**


NOTES: (UNLESS OTHERWISE SPECIFIED)
1. REMOVE BURRS AND BREAK SHARP EDGES .005 – .010 MAX
2. INTERPRET DWG. PER ANSI Y 14.5 1988
DATE
LET
REVISION
BY
5-19-98
A
REVISED DRAWING
RWH
8-31-99
B
REVISED DRAWING
MLC
AUX. TERMINAL BLDG.
No. 3
CUBICLE
REVETMENT
GTP-1
No. 2
BLOCKHOUSE NO.3
TUBULAR LAUNCHER
△GTP= GROUND TEST POINTS
N
FIG.4 LAUNCH AREA NO.4
31 AUGUST 1999
UNIT OR PROJECT
SCALE
MATERIAL
HEAT TREAT
NEXT ASSEMBLY
SURVEY
N/C
DR. JAMES STRAND
DES. B. PARKER
CHK. B. PARKER
GL.
AP. M. CORDING
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE
ANGULAR ±
X.X ±.015
X.XX ±.010
X.XXX ±.005
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE
125
DO. FIN. MACHINE
GROUND SAFETY POINTS FOR PAD 4
B26889

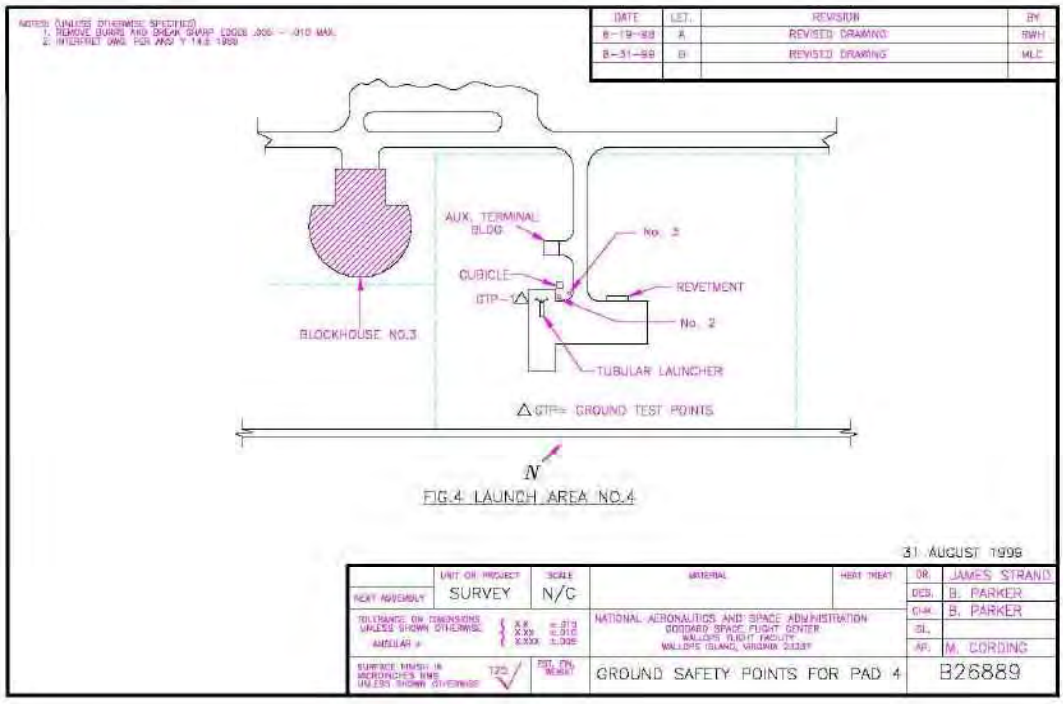
DIRECTIVE NO.	548-WI-8072.1.63A	Page 29 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Pad No. 4

Ground Point	Pass	Fail	Remarks
GTP-1			
No. 2			
No. 3			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
W40 ASSEMBLY SHOP NO. 5

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26987	RESISTANCE Expected	Initial			
1	Ground to Building Frame 1	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26987	RESISTANCE Measured	NET Minus Line
2	Building Frame 1 to Building Frame 2		
3	Building Frame 1 to Building Frame 3		
4	Building Frame 1 to Building Frame 4		
5	Building Frame 1 to Building Frame 5		
6	Building Frame 1 to Building Frame 6		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

DATE	LET.	REVISION	BY
8-19-99	A	REVISED DRAWING	RWH
7-14-99	B	DELETED HOISTS	MLC

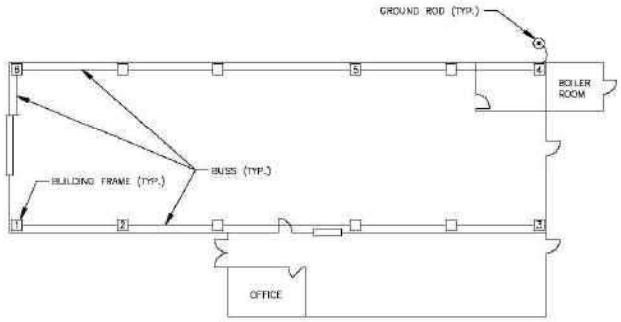


FIG. W-40 ASSEMBLY SHOP NO. 5

14 JULY 1999

NEXT ASSEMBLY	UNIT OR PROJECT SURVEY	SCALE N/S	MATERIAL	HEAT TREAT	DR. JAMES STRAND DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE ANGULAR ±	X.X ±.015 X.XX ±.010 X.XXX ±.005		NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD CL. AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE	DET. DIM. WEIGHT	GROUND SAFETY POINTS FIG. NO. W-40 ASSEMBLY SHOP NO.5			B26987

DIRECTIVE NO.	548-WI-8072.1.63A	Page 32 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Assembly Shop No. 5 (Building W-40)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

DATE	LET.	REVISION	BY
6-19-98	A	REVISED DRAWING	RWH
7-14-98	B	DELETED HOISTS	MLC

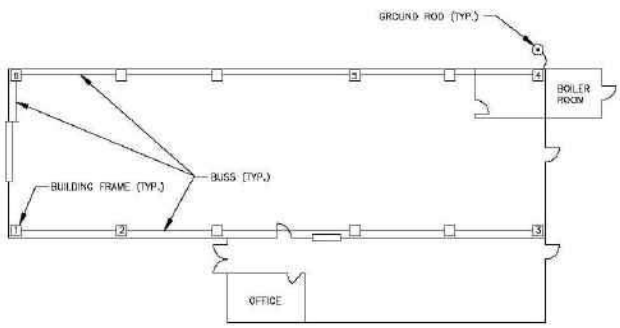


FIG. W-40 ASSEMBLY SHOP NO. 5

14 JULY 1999

NEXT ASSEMBLY	UNIT OR PROJECT SURVEY	SCALE N/S	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE ANGULAR ±	X.X ±.015 X.XX ±.010 X.XXX ±.005		NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					GL.
					AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. TIN. WEIGHT	GROUND SAFETY POINTS FIG. NO. W-40 ASSEMBLY SHOP NO.5		B26987

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.
GSFC 3-19 (11/09)

GROUND MEASUREMENT DATA
LAUNCH AREA NO. 5

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26843	RESISTANCE				
		Expected	Initial	-10 feet	+10 feet	Avg.
1	Ground to GTP-1	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26843	RESISTANCE	
		Measured	NET Minus Line
2	5-1 to GTP-1		
3	5-2 to GTP-1		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

DATE	LET.	REVISION	BY

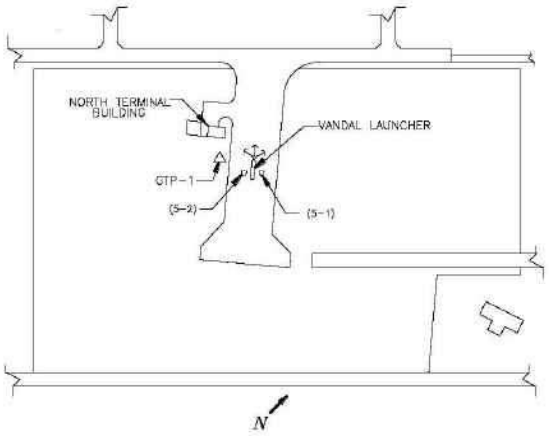


FIG.5 LAUNCH AREA NO.5

6 MAY 1999

NEXT ASSEMBLY	UNIT OR PROJECT SURVEY	SCALE N/C	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: XX ±.015, XXX ±.010, XXXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					CL.
					AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR PAD 5		B26843

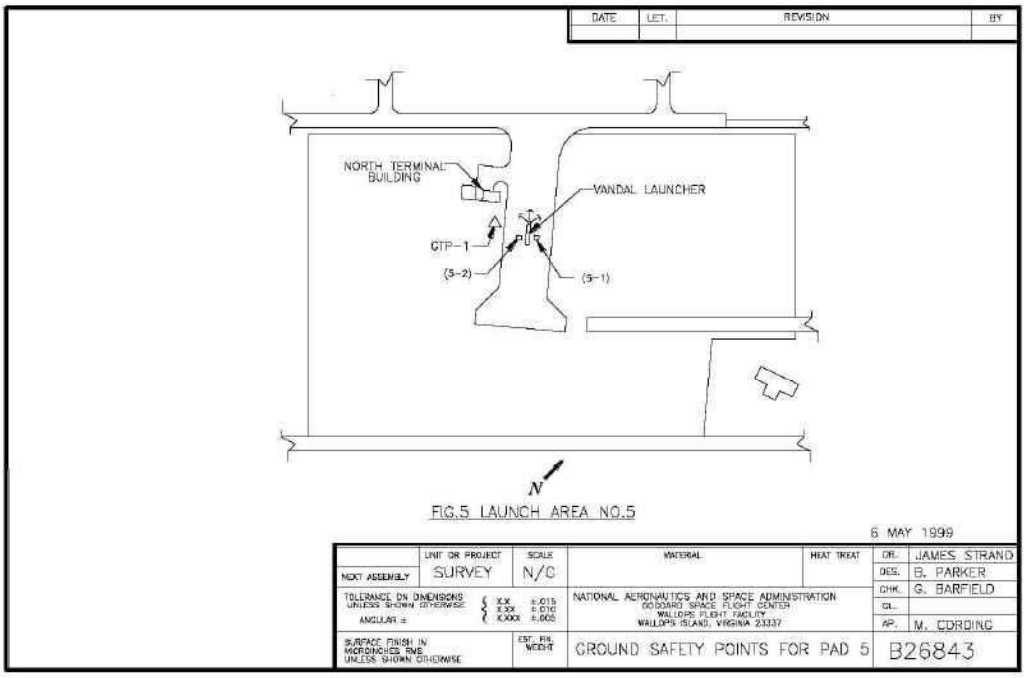
DIRECTIVE NO.	548-WI-8072.1.63A	Page 35 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Pad No. 5

Ground Point	Pass	Fail	Remarks
GTP-1			
5-1			
5-2			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



DIRECTIVE NO.	548-WI-8072.1.63A	Page 36 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

GROUND MEASUREMENT DATA
V-55 ENVIRONMENTAL TEST FACILITY

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26786	RESISTANCE Expected	Initial			
1	Ground to Building Frame No. 8	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26786	RESISTANCE Measured	NET Minus line
2	Building Frame 8 to Vertical Machine 10		
3	Building Frame 8 to Building Frame 9		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN **DATE** **TASK LEADER** **DATE**

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.
GSFC 3-19 (11/09)

DATE	LET.	REVISION	BY

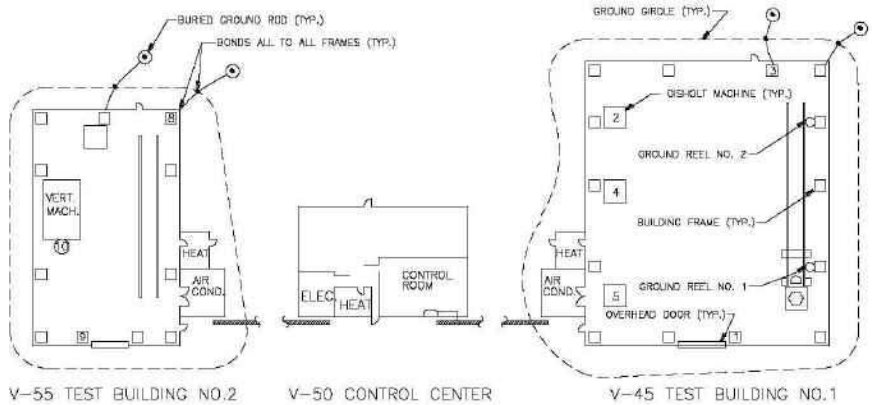


FIG. V-50 ENVIRONMENTAL TEST FACILITY

21 JUNE 1999

	UNIT OR PROJECT	SCALE	MATERIAL	HEAT TREAT	DR.	JAMES STRAND
NEXT ASSEMBLY	SURVEY	N/C			DES.	B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK.	G. BARFIELD
					DL.	
					AP.	M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR BUILDINGS V-45, V-50 AND V-55		B26786	

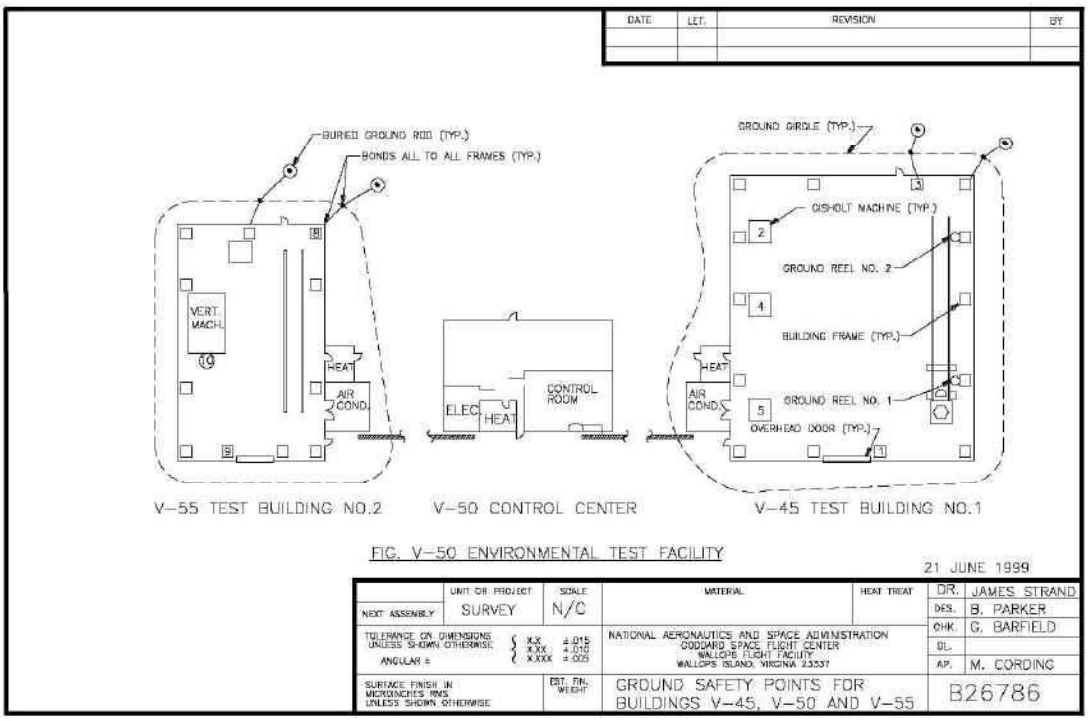
DIRECTIVE NO.	548-WI-8072.1.63A	Page 38 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Environmental Test Facility (Building V-55)

Ground Point	Pass	Fail	Remarks
No. 8			
No. 9			
No. 10			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



DIRECTIVE NO.	548-WI-8072.1.63A	Page 39 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

GROUND MEASUREMENT DATA
V-45 ENVIRONMENTAL TESTING FACILITY

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26786	RESISTANCE Expected	Initial			
1	Ground to Building Frame No. 3	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26786	RESISTANCE Measured	NET Minus line
2	Building Frame 3 to Gisholt Machine 2		
3	Building Frame 3 to Gisholt Machine 4		
4	Building Frame 3 to Gisholt Machine 5		
5	Building Frame 3 to Building Frame No. 1		
6	Building Frame 3 to Ground Reel 1		
7	Building Frame 3 to Ground Reel 2		

Soil Condition: _____

Lead Resistance:_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

GSFC 3-19 (11/09)

DATE	LTR.	REVISION	BY

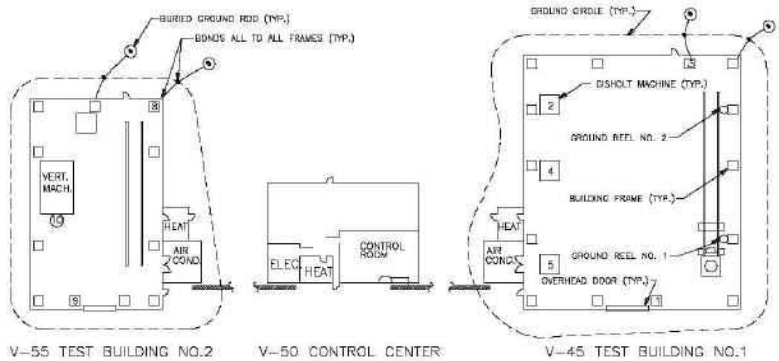


FIG. V-50 ENVIRONMENTAL TEST FACILITY

21 JUNE 1999

NEXT ASSEMBLY	UNIT OR PROJECT: SURVEY	SCALE: N/C	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE ANGULAR ±	X.X ±.010 X.XX ±.010 X.XXX ±.005		NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					CL.
					AP. M. CORDING
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR BUILDINGS V-45, V-50 AND V-55		B26786

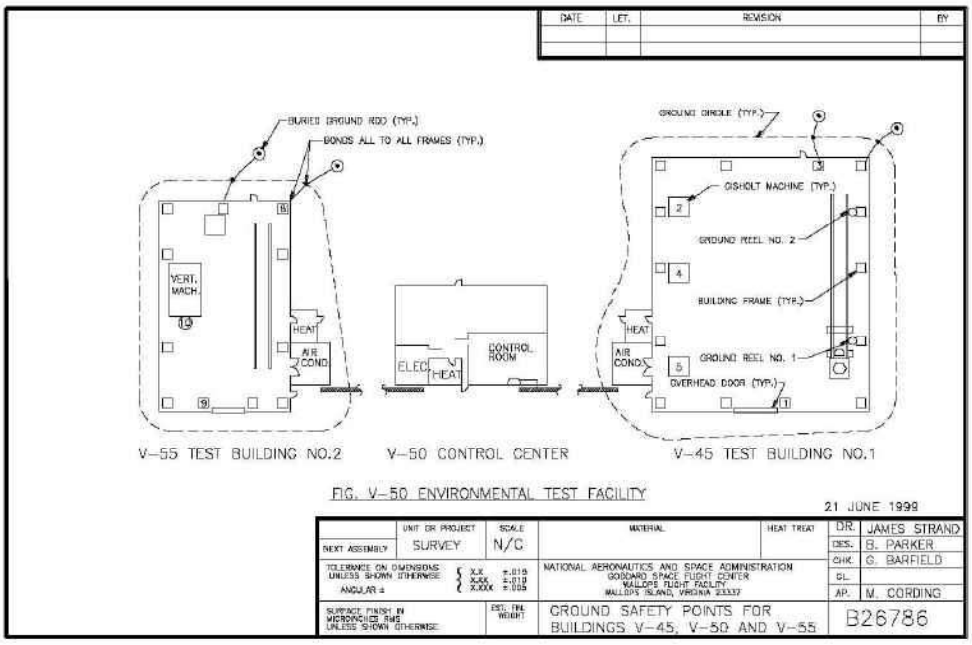
DIRECTIVE NO.	548-WI-8072.1.63A	Page 41 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Environmental Test Facility (Building V-45)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
Ground Reel No. 1			
Ground Reel No. 2			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
V67 PYROTECHNIC STORAGE FACILITY

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26797	RESISTANCE Expected	Initial			
1	Ground to GTP-4	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26797	RESISTANCE Measured	NET Minus Line
2	GTP-4 TO GTP 3		
3	To GTP 2		
4	To GTP 1		
5	To GTP 5		
6	To GTP 6		
7	GTP 4 To buss bar 4		
8	GTP 4 To buss bar 3		
9	GTP 4 To buss bar 2		
10	GTP 4 To buss bar 1		
11	GTP 4 To buss bar 5		
12	GTP 4 To buss bar 6		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

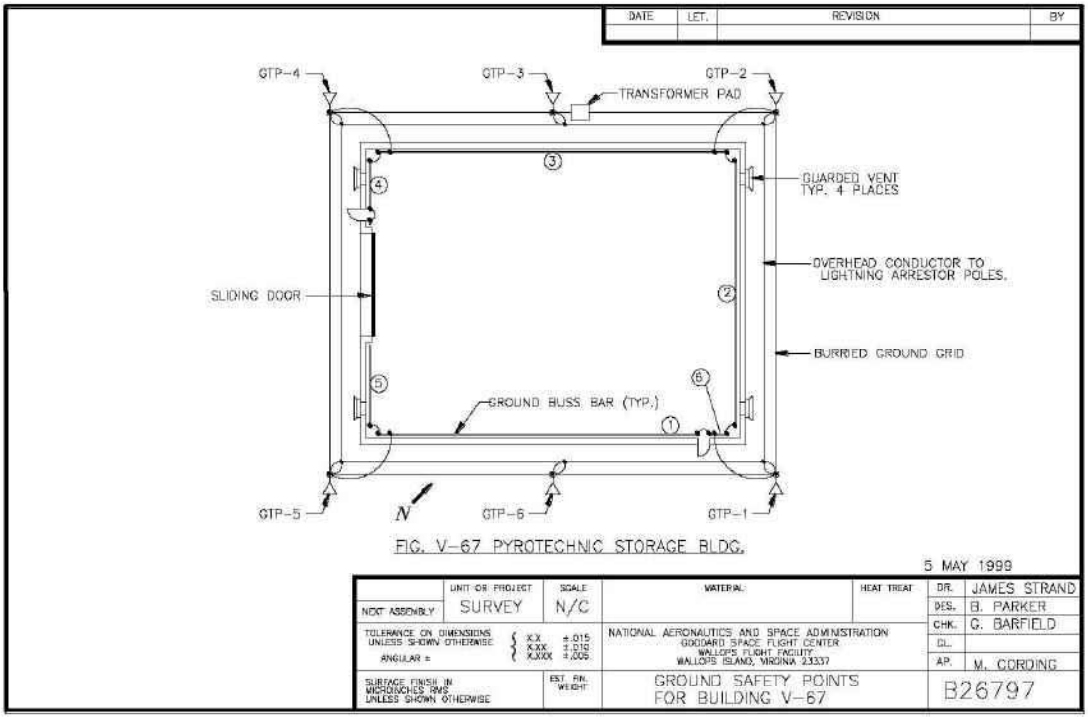


FIG. V-67 PYROTECHNIC STORAGE BLDG.

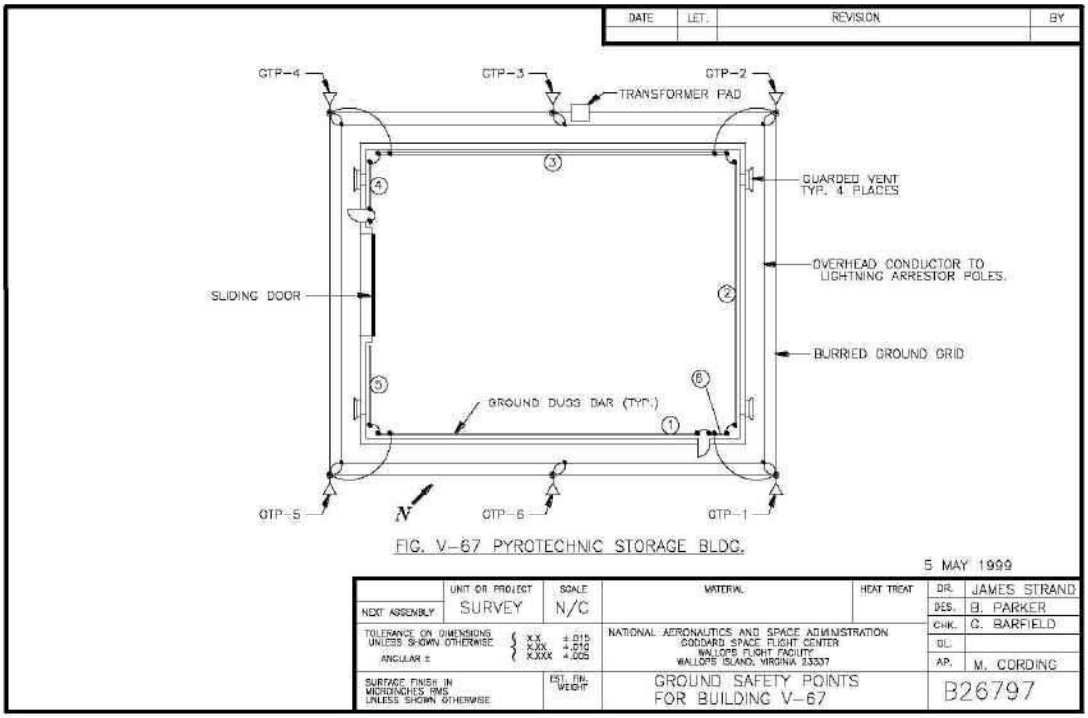
6-Month Visual Inspection of Pyrotechnic Grounding Points
Pyrotechnic Storage Facility (Building V-67)

Ground Point	Pass	Fail	Remarks
GTP-1			
GTP-2			
GTP-3			
GTP-4			
GTP-5			
GTP-6			
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

6-Month Visual Inspection of Pyrotechnic Grounding Points
Pyrotechnic Storage Facility (Building V-67)



GROUND MEASUREMENT DATA
W-15 ROCKET MOTOR STORAGE

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure W15_1SU	RESISTANCE Expected	Initial			
1	Ground to GP-1	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure W15_1SU	RESISTANCE Measured	NET Minus Line
2	GP-1 to GP-2		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

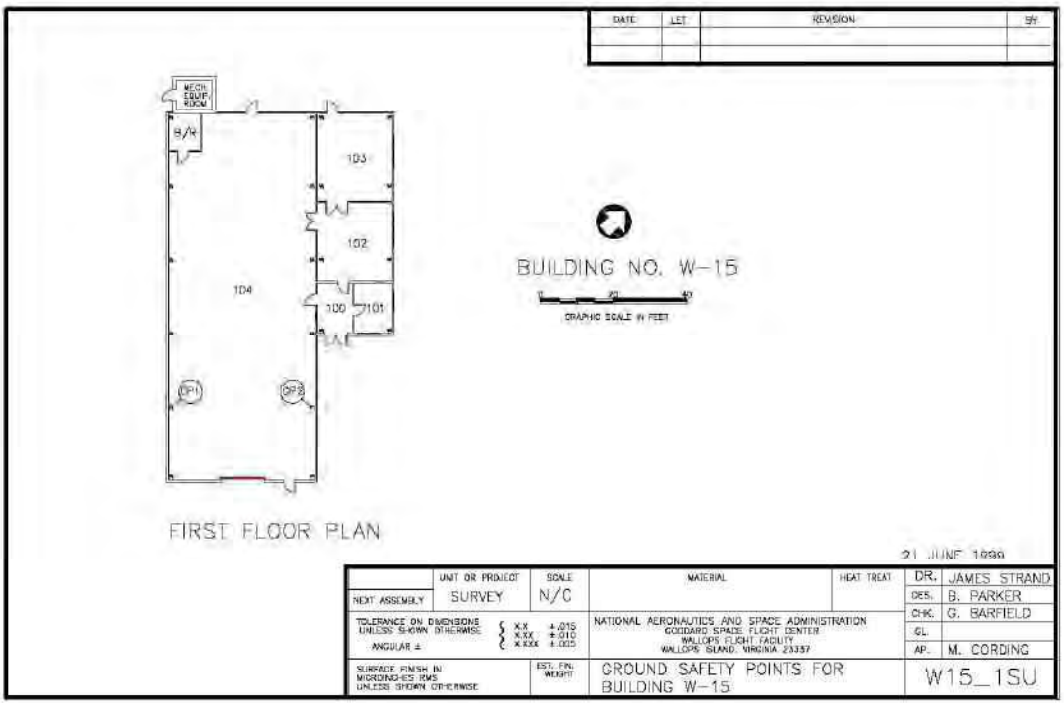
List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

DIRECTIVE NO.	548-WI-8072.1.63A	Page 48 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	



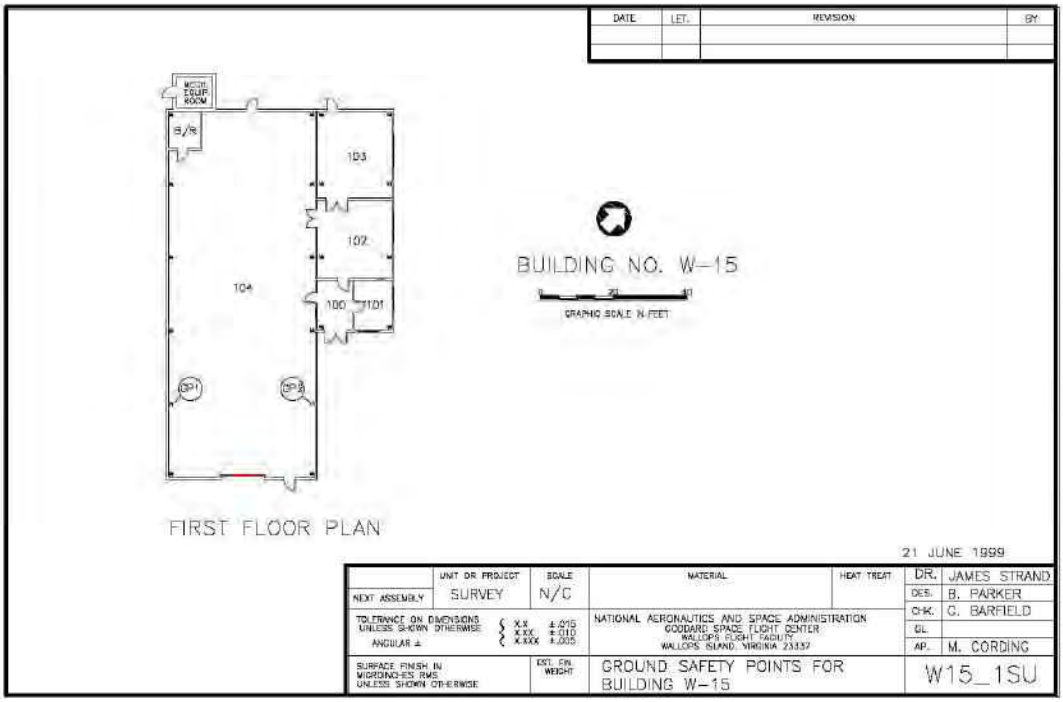
DIRECTIVE NO.	548-WI-8072.1.63A	Page 49 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Rocket Motor Storage Facility (Building W-15)

Ground Point	Pass	Fail	Remarks
GP-1			
GP-2			

NCR filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
M-15 ROCKET MOTOR STORAGE

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26891	RESISTANCE Expected	Initial	-10 feet	+10 feet	Avg.
1	Earth to Ground Rod No. 9	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26891	RESISTANCE Measured	NET Minus Line
2	Ground Rod 9 to Buss Bar 8		
3	Ground Rod 9 to Buss Bar 10		
4	Ground Rod 9 to Buss Bar 11		
5	Ground Rod 9 to Ground Rod 12		
6	Ground Rod 9 to Rod Ground 7		
8	Ground Rod 9 to Buss Bar 5		
9	Ground Rod 9 to Ground Rod 6		
10	Ground Rod 9 to Buss Bar 1		
11	Ground Rod 9 to Ground Rod 2		
12	Ground Rod 9 to Ground Rod 3		

Soil Condition: _____

Lead Resistance: _____

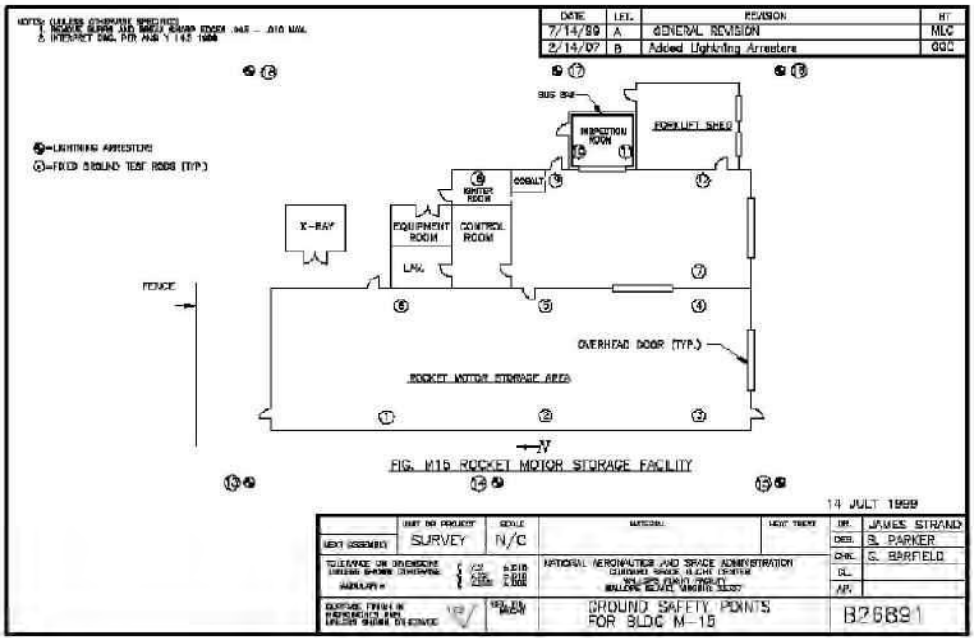
Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests: _____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN **DATE** **TASK LEADER** **DATE**

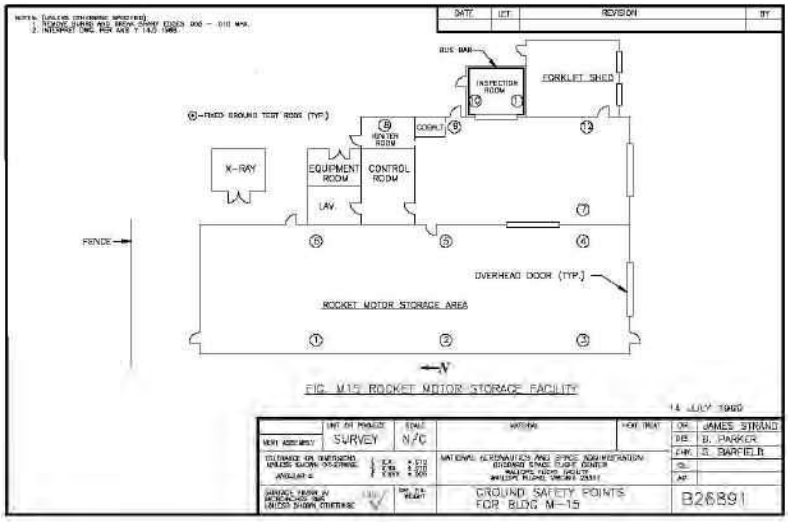

DATE
LET.
REVISION
7/14/99
A
GENERAL REVISION
2/14/97
B
Added Lightning Arresters
INSPECTION ROOM
FORKLIFT SHED
X-RAY
EQUIPMENT ROOM
CONTROL ROOM
FENCE
OVERHEAD DOOR (TYP.)
ROCKET MOTOR STORAGE AREA
FIG. M15 ROCKET MOTOR STORAGE FACILITY
14 JULY 1999
SURVEY
N/C
JAMES STRAND
S. PARKER
S. BARFIELD
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GROUND SAFETY POINTS FOR SLDC M-15
B26891

6-Month Visual Inspection of Pyrotechnic Grounding Points
Rocket Motor Storage Facility (Building M-15)

No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
M-16 ROCKET MOTOR STORAGE

TASK A **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	Ground to Ground point 4	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE NET Measured Minus line	
2	Ground point 4 to Ground point 1		
3	Ground point 4 to Ground point 2		
4	Ground point 4 to Ground point 5		
5	Ground point 4 to Ground point 3		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

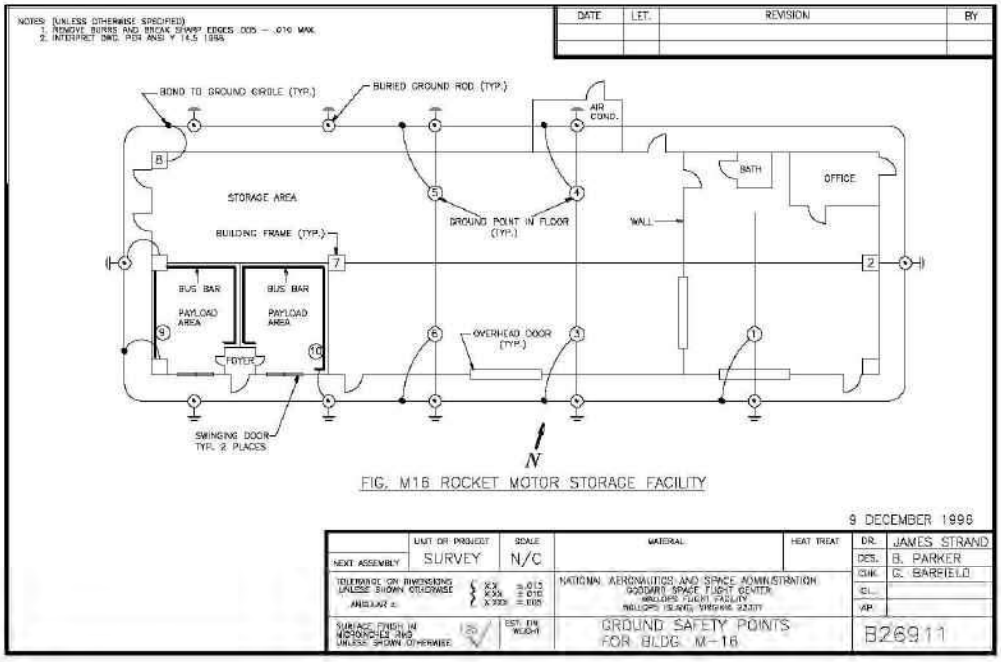
Remarks: _____

List Measurement Number(s) of failed tests: _____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.
GSFC 3-19 (11/09)


NOTES: (UNLESS OTHERWISE SPECIFIED)
1. REMOVE BURRS AND BREAK SHARP EDGES .005 – .010 MAX.
2. INTERPRET DWG. PER ANSI Y 14.5 1994.
DATE
LET.
REVISION
BY
BOND TO GROUND CIRCLE (TYP.)
BURIED GROUND ROD (TYP.)
AIR COND.
STORAGE AREA
BATH
OFFICE
GROUND POINT IN FLOOR (TYP.)
WALL
BUILDING FRAME (TYP.)
BUS BAR
PAYLOAD AREA
BUS BAR
PAYLOAD AREA
FOYER
OVERHEAD DOOR (TYP.)
SWINGING DOOR TYP. 2 PLACES
N
FIG. M16 ROCKET MOTOR STORAGE FACILITY
9 DECEMBER 1996
NEXT ASSEMBLY
UNIT OR PROJECT
SURVEY
SCALE
N/C
MATERIAL
HEAT TREAT
DR. JAMES STRAND
DES. B. PARKER
CHK. G. BARFIELD
CL.
AP.
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE
ANGULAR ±
X.XX ±.015
X.XX ±.010
X.XXX ±.005
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE
EST. DN WLGHT
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
GROUND SAFETY POINTS FOR BLDG. M-16
B26911

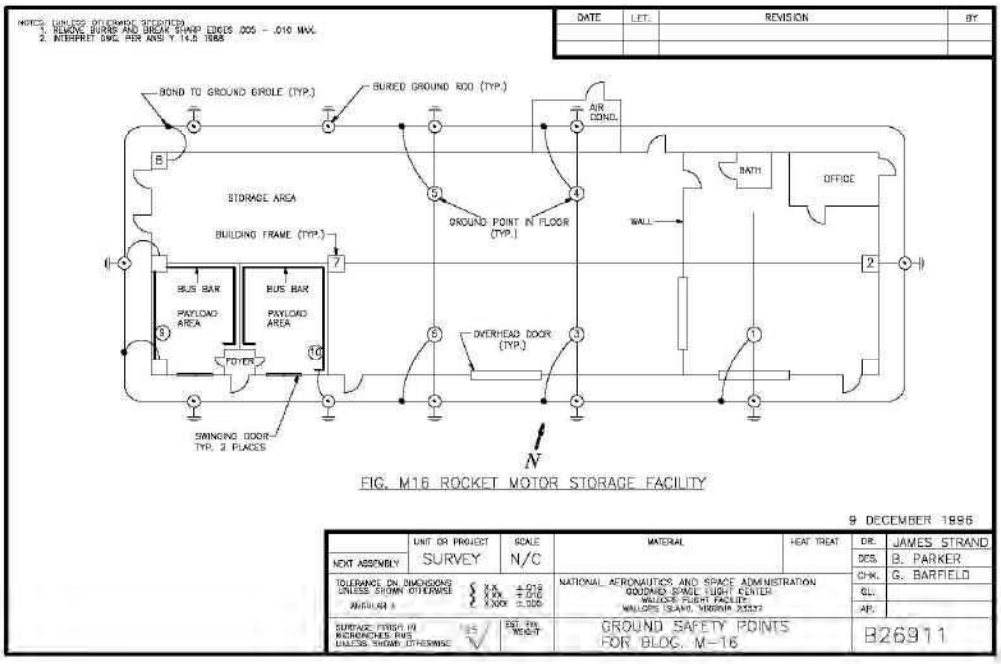
DIRECTIVE NO.	548-WI-8072.1.63A	Page 57 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Rocket Motor Storage Facility (Building M-16)

No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp **TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.**

GSFC 3-19 (11/09)

GROUND MEASUREMENT DATA
M-20 ROCKET MOTOR STORAGE

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26911	RESISTANCE Expected	Initial			
1	Ground to Point No. 6	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26911	RESISTANCE Measured	NET Minus Line
2	Ground Point No. 6 to No. 1		
3	Ground Point No. 6 to No. 2		
4	Ground Point No. 6 to No. 3		
5	Ground Point No. 6 to Buss Bar 7		
6	Ground Point No. 6 to Buss Bar 8		
7	Ground Point No. 6 to Buss Bar 9		

DIRECTIVE NO.	548-WI-8072.1.63A	Page 59 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

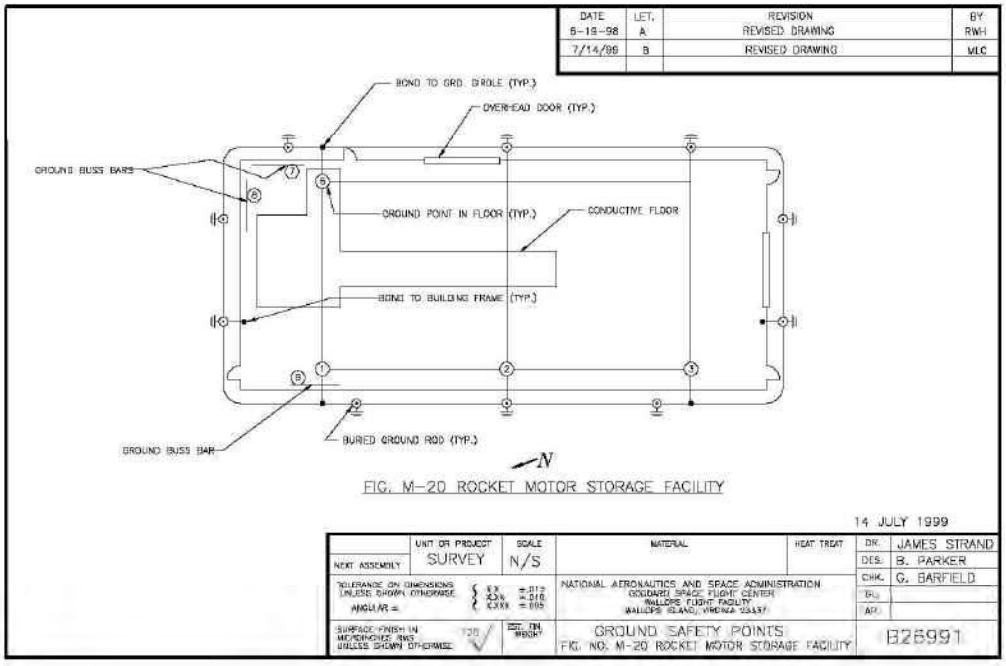
Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE



CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

GSFC 3-19 (11/09)

6-Month Visual Inspection of Pyrotechnic Grounding Points
Rocket Motor Storage Facility (Building M-20)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 6			
No. 7			
No. 8			
No. 9			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

DATE	LET.	REVISION	BY
6-19-98	A	REVISED DRAWING	RWH
7/14/99	B	REVISED DRAWING	MLC

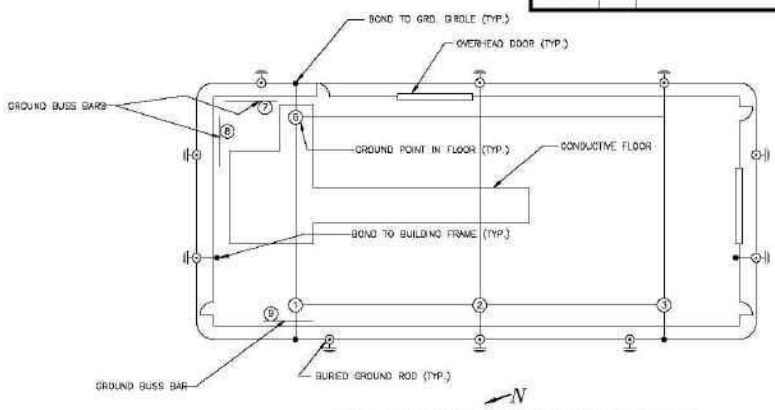


FIG. M-20 ROCKET MOTOR STORAGE FACILITY

14 JULY 1999

NEXT ASSEMBLY	UNIT OR PROJECT: SURVEY	SCALE: N/S	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					GL.
					AP.
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE: 125		EST. DR. WEIGHT	GROUND SAFETY POINTS FIG. NO. M-20 ROCKET MOTOR STORAGE FACILITY		B26991

GROUND MEASUREMENT DATA
M-22 ROCKET MOTOR STORAGE

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26890	RESISTANCE Expected	Initial			
1	Ground to Floor Ground Receptacle No. 1	<25 ohms				

TASK B **Net resistance shall not be more than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26890	RESISTANCE Measured Line	Net Minus
2	Floor Ground 1 to 60' Mast No. 11		
4	Floor Ground 1 to Floor Ground 3		
5	Floor Ground 1 to Floor Ground 4		
6	Floor Ground 1 to Floor Ground 6		
7	Floor Ground 1 to Floor Ground 5		
8	Floor Ground 1 to Buss Bar 7		
9	Floor Ground 1 to Buss Bar 8		
10	Floor Ground 1 to Buss Bar 9		
11	Floor Grid No. 1 to 60' Mast No. 11		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

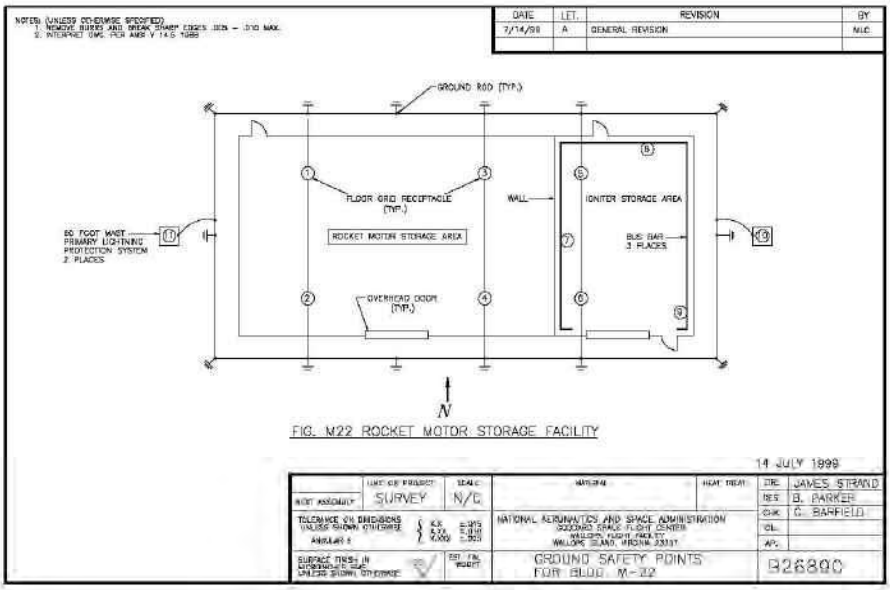


FIG. M22 ROCKET MOTOR STORAGE FACILITY

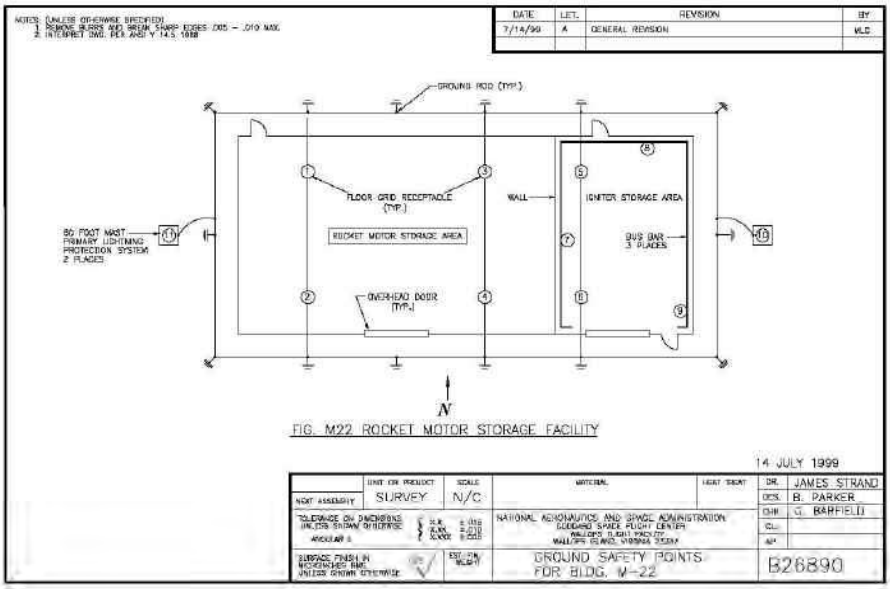
DIRECTIVE NO.	548-WI-8072.1.63A	Page 65 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Rocket Motor Storage Facility (Building M-22)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

GSFC 3-19 (11/09)

GROUND MEASUREMENT DATA
D-1 AIRCRAFT HANGAR

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26965	RESISTANCE Expected	Initial			
1	Ground to Point No. 1	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26965	RESISTANCE Measured	NET Minus Line
2	GTP No. 1 to No. 2		
3	GTP No. 1 to No. 3		
4	GTP No. 1 to No. 4		
5	GTP No. 1 to No. 5		
6	GTP No. 1 to No. 6		
7	GTP No. 1 to No. 7		
8	GTP No. 1 to No. 8		
9	GTP No. 1 to No. 9		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

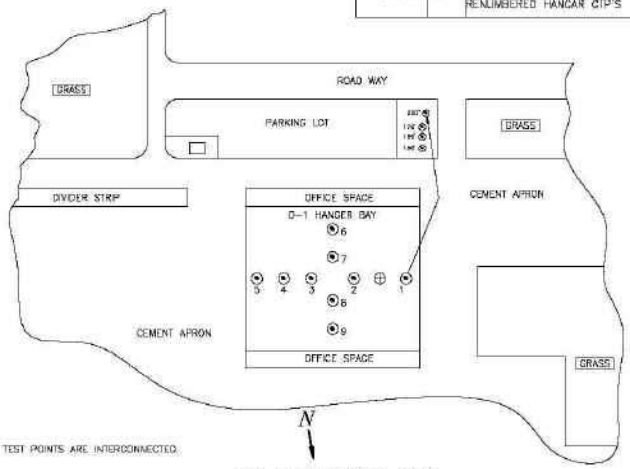
List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

DATE	LET.	REVISION	BY
9/27/02	A	DELETED GTP 11 AND GTPS OUTSIDE HANGAR, RENUMBERED HANGAR GTP'S	MLC



NOTES:
1. D-1 HANGER BAY GRD TEST POINTS ARE INTERCONNECTED.
⊙ = GROUND TEST POINT
⊕ = DEFECTIVE TEST POINT

FIG. D-1 HANGER AREA
AIRCRAFT GROUND TEST POINTS

27 SEPTEMBER 2002

NEXT ASSEMBLY	UNIT OR PROJECT: SURVEY	SCALE: N/C	MATERIAL	HEAT TREAT	DR: JAMES STRAND
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: XX ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA 23337		DES. B. PARKER; CHK. G. BARFIELD; GL.; AP.
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. DN. WEIGHT	GROUND SAFETY POINTS FOR D-1 HANGER		B26965

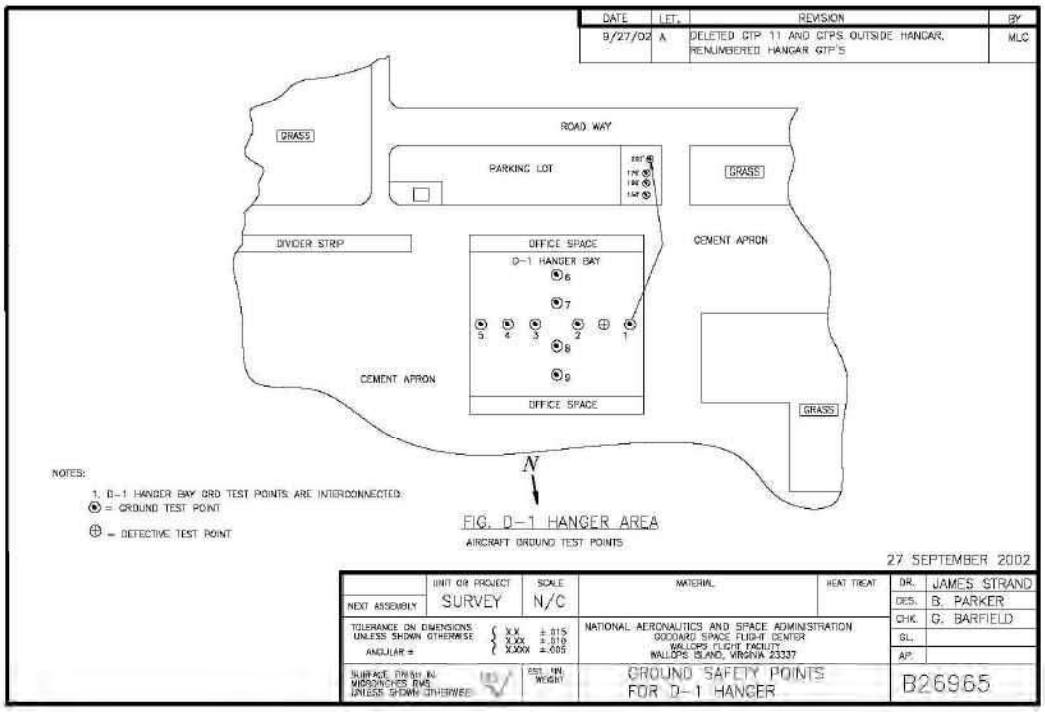
6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Hangar (Building D-1)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Hangar (Building D-1)



GROUND MEASUREMENT DATA
RUNWAY 17-35

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26964, sht. 1&2	RESISTANCE Expected	Initial			
1	Ground to Point 18	<25 ohms				

TASK B **Net resistance shall not be more than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26964, sht. 1&2	RESISTANCE Measured	NET Minus Line
2	Ground Point 18 to Ground Point 17		
3	Ground Point 18 to Ground Point 16		
4	Ground Point 18 to Ground Point 15		
5	Ground Point 18 to Ground Point 14		
6	Ground Point 18 to Ground Point 13		
7	Ground Point 18 to Ground Point 7		
8	Ground Point 18 to Ground Point 8		
9	Ground Point 18 to Ground Point 9		
10	Ground Point 18 to Ground Point 10		
11	Ground Point 18 to Ground Point 11		
12	Ground Point 18 to Ground Point 12		
13	Ground Point 18 to Ground Point 6		
14	Ground Point 18 to Ground Point 5		
15	Ground Point 18 to Ground Point 4		
16	Ground Point 18 to Ground Point 3		
17	Ground Point 18 to Ground Point 2		
18	Ground point 18 to Ground point 1		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

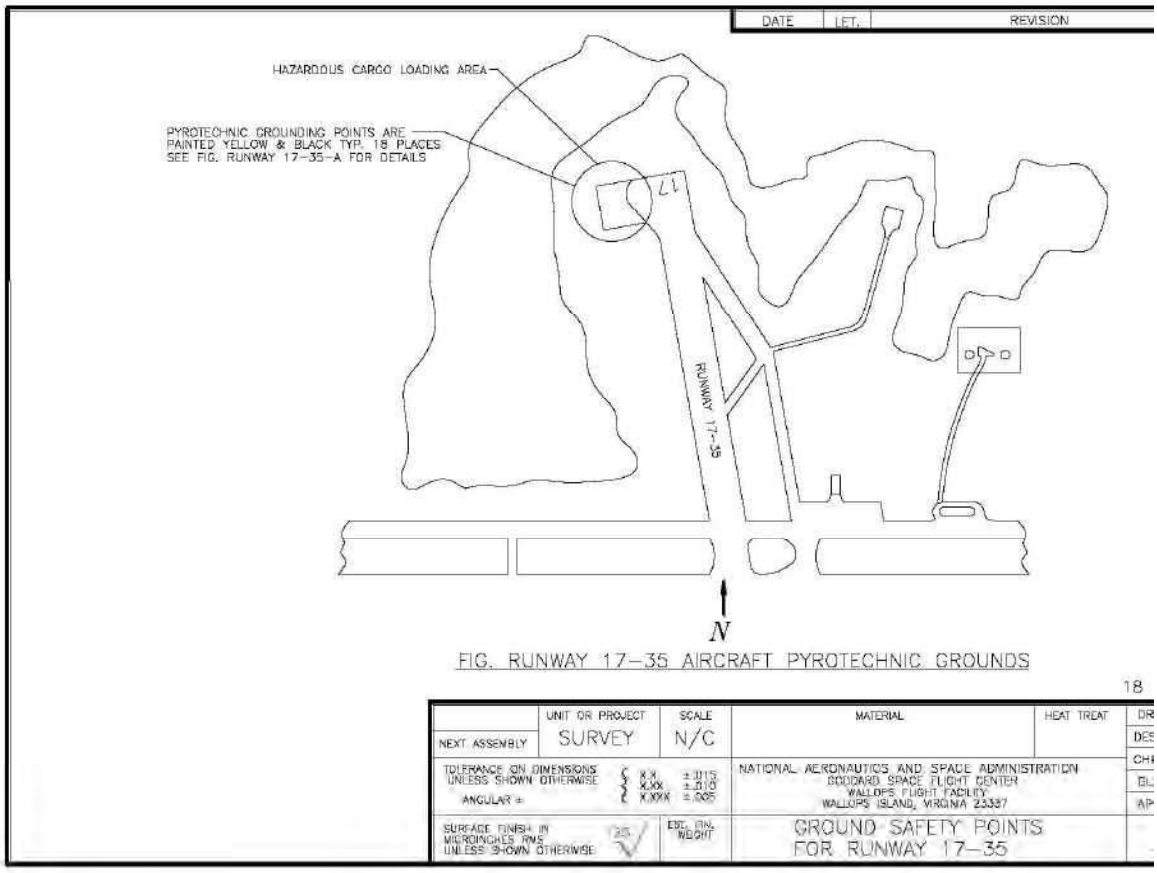
List Measurement Number(s) of failed tests:

_____

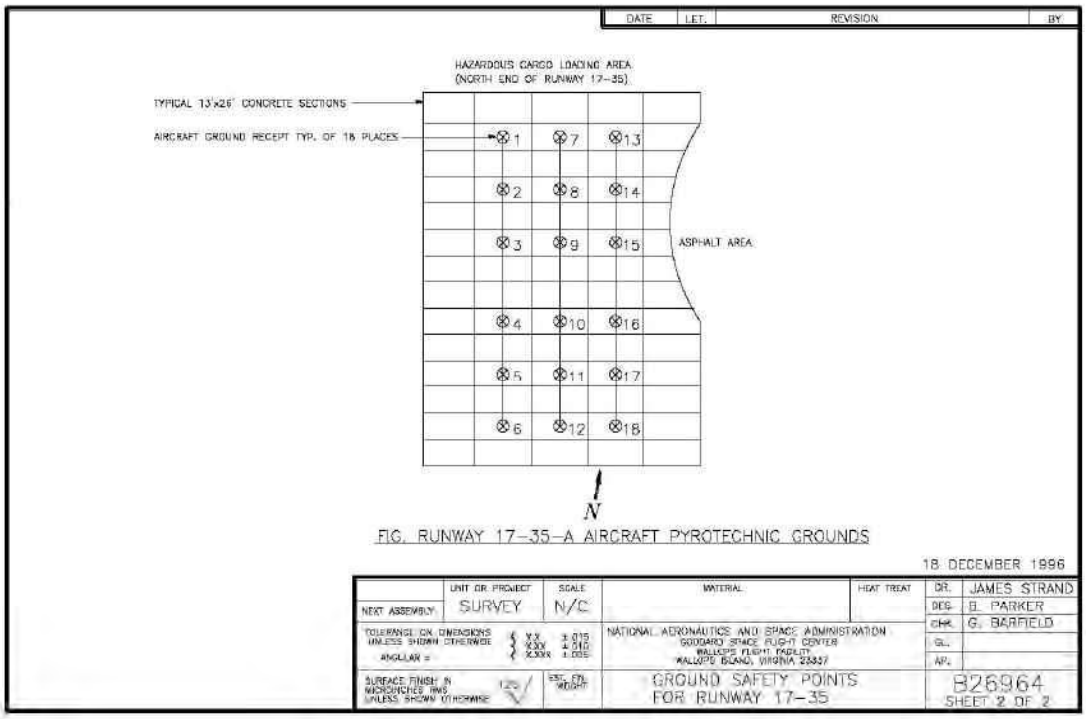
NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN **DATE** **TASK LEADER** **DATE**

DIRECTIVE NO.	548-WI-8072.1.63A	Page 72 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	



DIRECTIVE NO.	548-WI-8072.1.63A	Page 73 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	



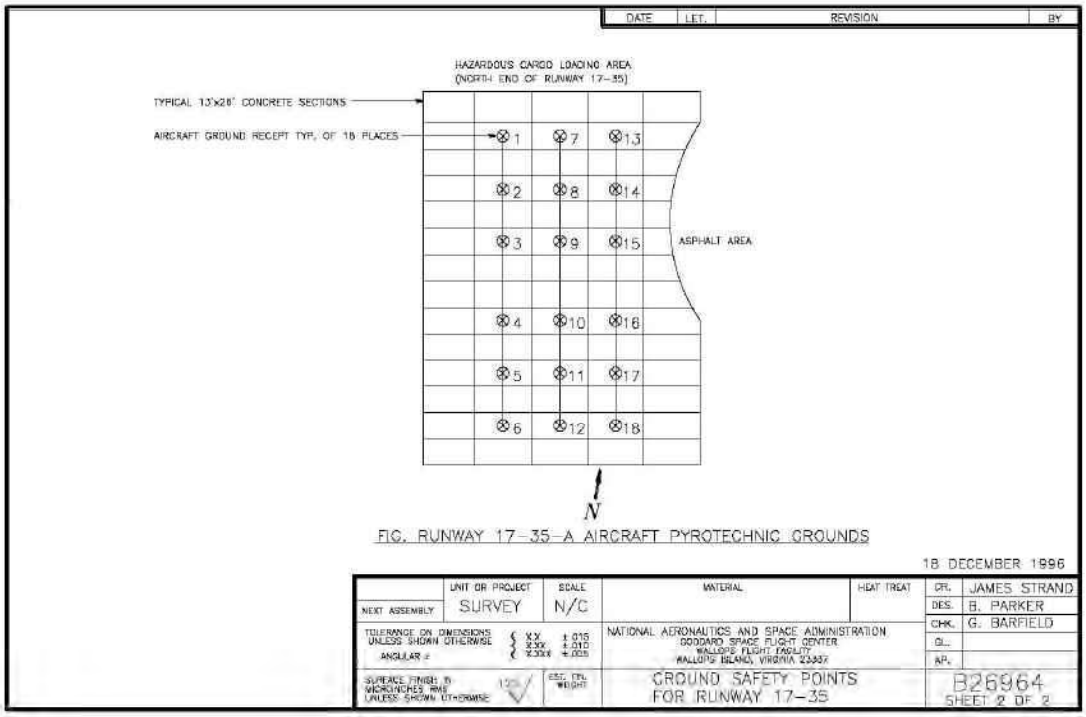
6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Pyrotechnic Grounds (Runway 17-35)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			
No. 17			
No. 18			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Pyrotechnic Grounds (Runway 17-35)



GROUND MEASUREMENT DATA
N-159 AIRCRAFT HANGAR AND APRON GROUNDS

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26964, sht. 2	RESISTANCE Expected	Initial			
1	Ground to Point 1	<25 ohms				

TASK B **Net resistance shall not be more than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26964, sht. 2	RESISTANCE Measured	NET Minus Line
2	Point 1 to Point 2		
3	Point 1 to Point 3		
4	Point 1 to Point 4		
5	Point 1 to Point 5		
6	Point 1 to Point 6		
7	Point 1 to Point 7		
8	Point 1 to Point 8		
9	Point 1 to Point 9		
10	Point 1 to Point 10		
11	Point 1 to Point 11		
12	Point 1 to Point 12		
13	Point 1 to Point 13		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

DATE	LET.	REVISION	BY

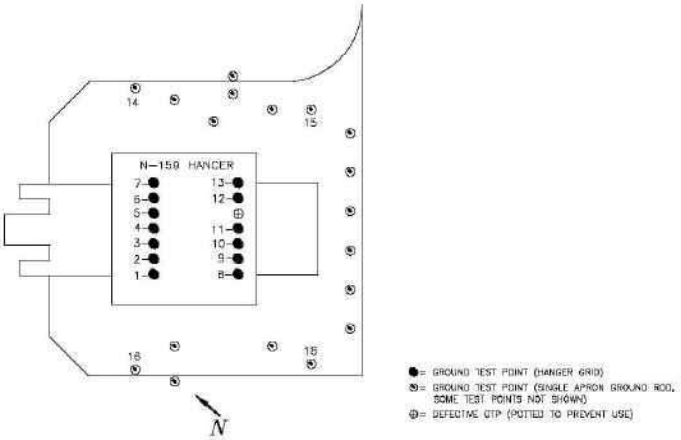


FIGURE NO. N-159 AIRCRAFT HANGER
SHEET NO. 2

30 DECEMBER 1996

NEXT ASSEMBLY	UNIT OF PROJECT: SURVEY	SCALE: N/S	MATERIAL	HEAT TREAT	DR. JAMES STRAND
					DES. B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: X.X ±.015, X.XX ±.010, X.XXX ±.005; ANGULAR ±			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, GODDARD SPACE FLIGHT CENTER, WALLOPS FLIGHT FACILITY, WALLOPS ISLAND, VIRGINIA 23337		CHK. G. BARFIELD
					CL.
					AP.
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR N-159 HANGER		B26977 SHEET 2 OF 2

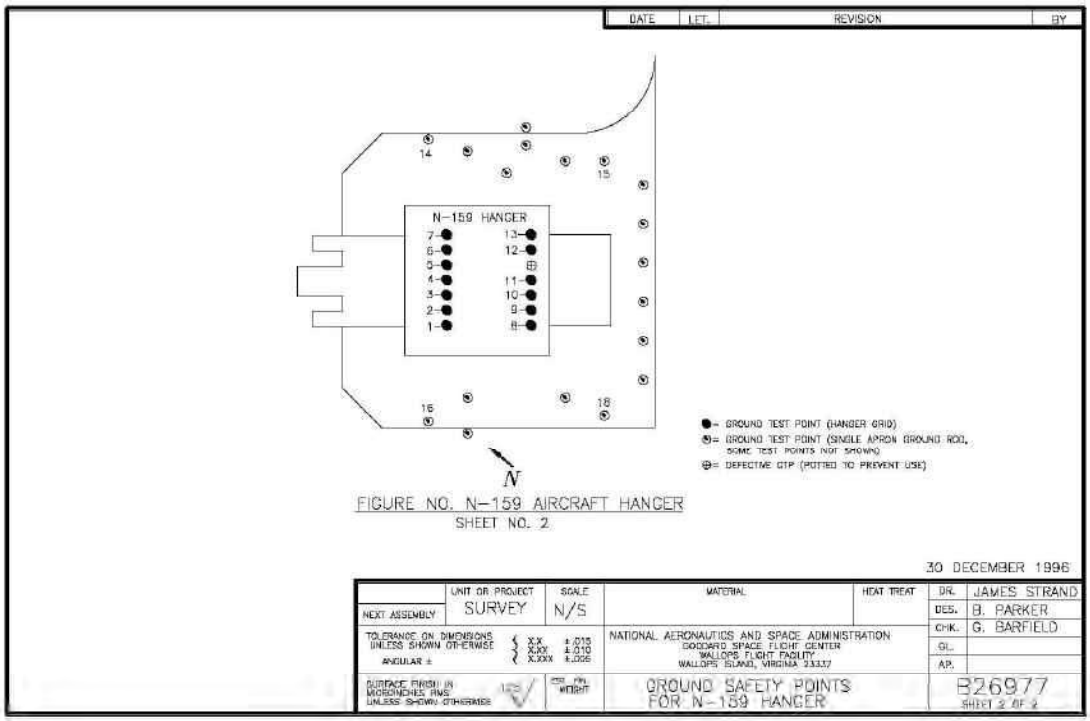
6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Hangar (Building N-159)

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

6-Month Visual Inspection of Pyrotechnic Grounding Points
Aircraft Hangar (Building N-159)



GROUND MEASUREMENT DATA
OBOD Facility
South End Wallops Island, near Z100

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B33477	RESISTANCE Expected	Initial			
1	Ground Rod	<25 ohms				

Soil Condition: _____

Calibration Date: _____

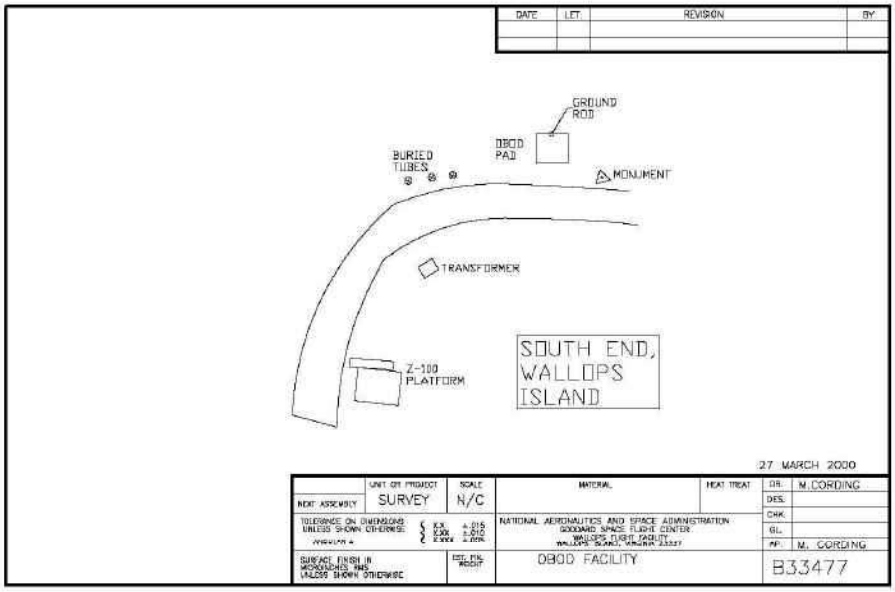
Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE


DATE
LET.
REVISION
BY
GROUND ROD
DBOD PAD
BURIED TUBES
MONUMENT
TRANSFORMER
Z-100 PLATFORM
SOUTH END, WALLOPS ISLAND
27 MARCH 2000
UNIT OR PROJECT
SCALE
MATERIAL
HEAT TREAT
NEXT ASSEMBLY
SURVEY
N/C
DR.
M.CORDING
DES.
CHK.
GL.
APP.
M. CORDING
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE
EST. PIS. WGHT
DBOD FACILITY
B33477

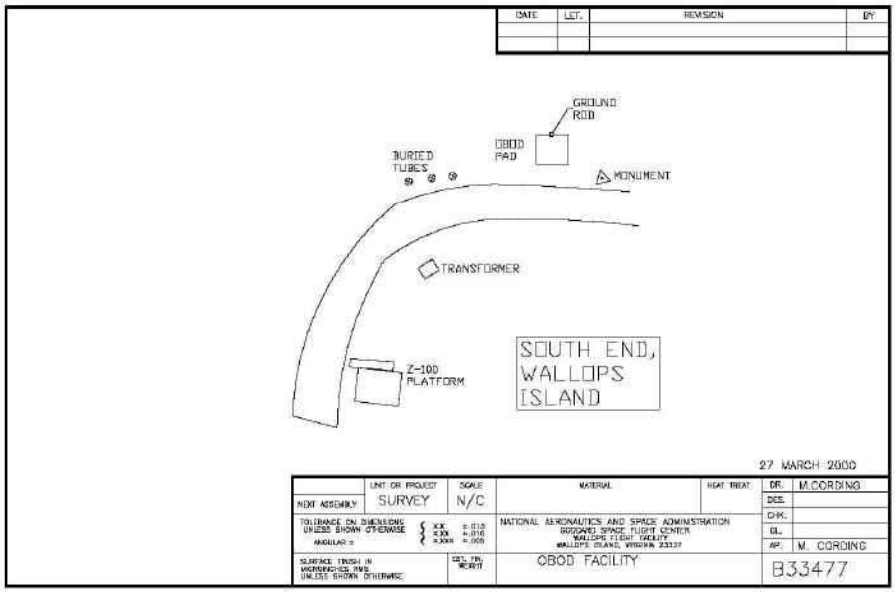
DIRECTIVE NO.	548-WI-8072.1.63A	Page 83 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
GROUND MEASUREMENT DATA
OBOD Facility
South End Wallops Island, near Z100

Ground Point	Pass	Fail	Remarks
No. 1			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
LAUNCH PAD 2-NORTH

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26806	RESISTANCE Expected	Initial			
1	GROUND TO GTP- 1 East	<25 ohms				

TASK B **Net resistance shall not be more than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26806	RESISTANCE Measured	NET Minus Line
2	GTP 1 EAST TO GTP-2 NORTH		
3	GTP 2 NORTH To GTP 3		
4	GTP 2 NORTH To GTP-1		
5	GTP 2 NORTH To No. 4		
6	GTP 2 NORTH To No. 3		
7	GTP 2 NORTH To No. 1		
8	GTP 2 NORTH To No. 2		
9	GTP-2 NORTH To GTP -4		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. REMOVE BURRS AND BREAK SHARP EDGES .005 – .010 MAX.
2. INTERPRET DWG. PER ANSI Y 14.5 1988

DATE	LET.	REVISION	BY

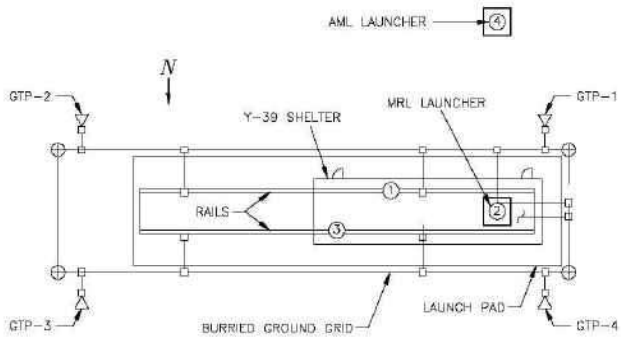


FIG.2B LAUNCH AREA NO.2 NORTH

19 NOVEMBER 1996

	UNIT OR PROJECT	SCALE	MATERIAL	HEAT TREAT	DR.	JAMES STRAND
NEXT ASSEMBLY	SURVEY	N/C			DES.	B. PARKER
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE: ANGULAR =			NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA 23337		CHK.	G. BARFIELD
					Q.	
					AP.	
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN. WEIGHT	GROUND SAFETY POINTS FOR PAD 2 NORTH		B26805	

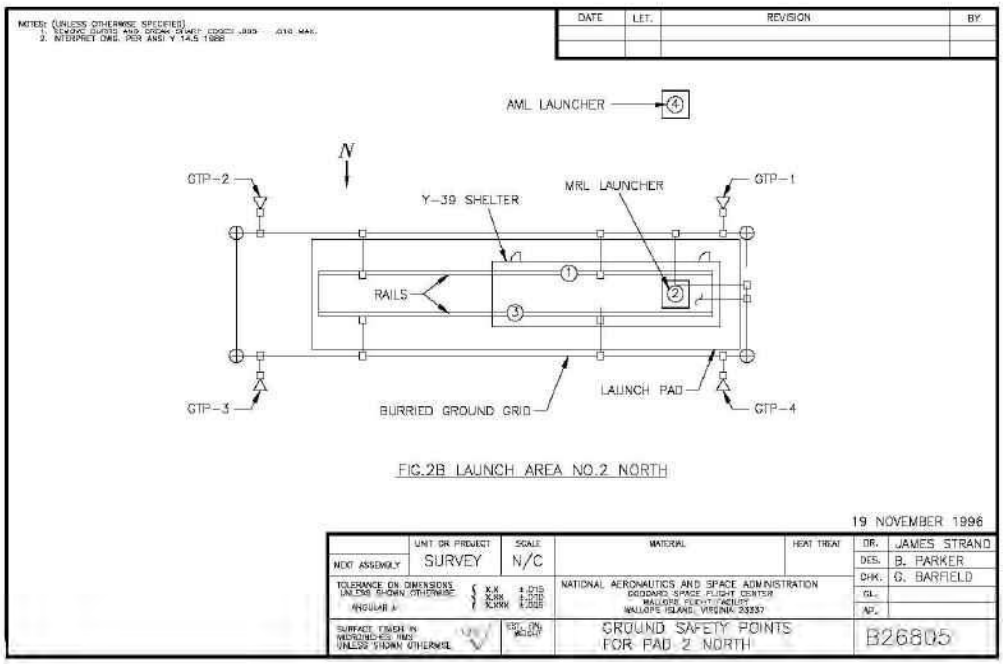
DIRECTIVE NO.	548-WI-8072.1.63A	Page 87 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

6-Month Visual Inspection of Pyrotechnic Grounding Points
Launch Pad 2 – North

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
GTP-1			
GTP-2			
GTP-3			
GTP-4			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
Building F-10

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26797	RESISTANCE Expected	Initial			
1	Ground to Buss Bar No 1	<25 ohms				

TASK B **Net resistance shall not be more than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26797	RESISTANCE Measured	NET Minus Line
2	Buss Bar No. 1 to Buss Bar No. 2		
3	Buss Bar No. 1 to Buss Bar No. 3		
4	Buss Bar No.1 to Buss Bar No. 4		
5	Buss Bar No. 4 to Buss Bar No. 5		
6	Buss Bar No. 4 to Buss Bar No. 6		
7	Buss Bar No. 4 to Buss Bar No. 7		
8	Buss Bar No .4 to Buss Bar No. 8		
9	Buss Bar No. 4 to Buss Bar No. 9		
10	Buss Bar No. 4 to Buss Bar No. 14		
11	Buss Bar No .4 to Buss Bar No. 10		
12	Buss Bar No .4 to Buss Bar No. 11		
13	Buss Bar No .4 to Buss Bar No. 12		

14	Buss Bar No .10 to Buss Bar No. 13		
15	Buss Bar No .10 to Buss Bar No. 15		
16	Buss Bar No .10 to Buss Bar No. 16		
17	Buss Bar No .10 to Buss Bar No. 17		
18	Buss Bar No .10 to Buss Bar No. 18		
19	Buss Bar No .10 to Buss Bar No. 19		
20	Buss Bar No .19 to Buss Bar No. 20		
21	Buss Bar No .19 to Buss Bar No. 21		
22	Buss Bar No .19 to Buss Bar No. 22		
23	Buss Bar No .19 to Buss Bar No. 23		
24	Buss Bar No .19 to Buss Bar No. 24		
25	Buss Bar No .19 to Buss Bar No. 25		
26	Buss Bar No .19 to Buss Bar No. 26		
27	Buss Bar No .19 to Buss Bar No. 27		
28	Buss Bar No .19 to Buss Bar No. 28		
29	Buss Bar No. 20 to Buss Bar No. 31		
30	Buss Bar No. 3 to Buss Bar No. 33 2nd floor		
31	Buss Bar No. 33 to Buss Bar No. 34 2nd floor		

32	Buss Bar No. 33 to Buss Bar No. 32 2nd floor		
33	Buss Bar No. 33 to Buss Bar No. 35 2nd floor		
34	Buss Bar No. 33 to Buss Bar No. 36 2nd floor		
35	Buss Bar No. 33 to Buss Bar No. 37 2nd floor		
36	Buss Bar No. 33 to Buss Bar No. 38 2nd floor		
37	Buss Bar No. 33 to Buss Bar No. 39 2nd floor		
38	Buss Bar No. 1 to Buss Bar No. 29 3rd Floor		
39	Buss Bar No. 1 to Buss Bar No. 30 3rd Floor		

Soil Condition: _____

Lead Resistance: _____

Calibration Date: _____

Remarks: _____

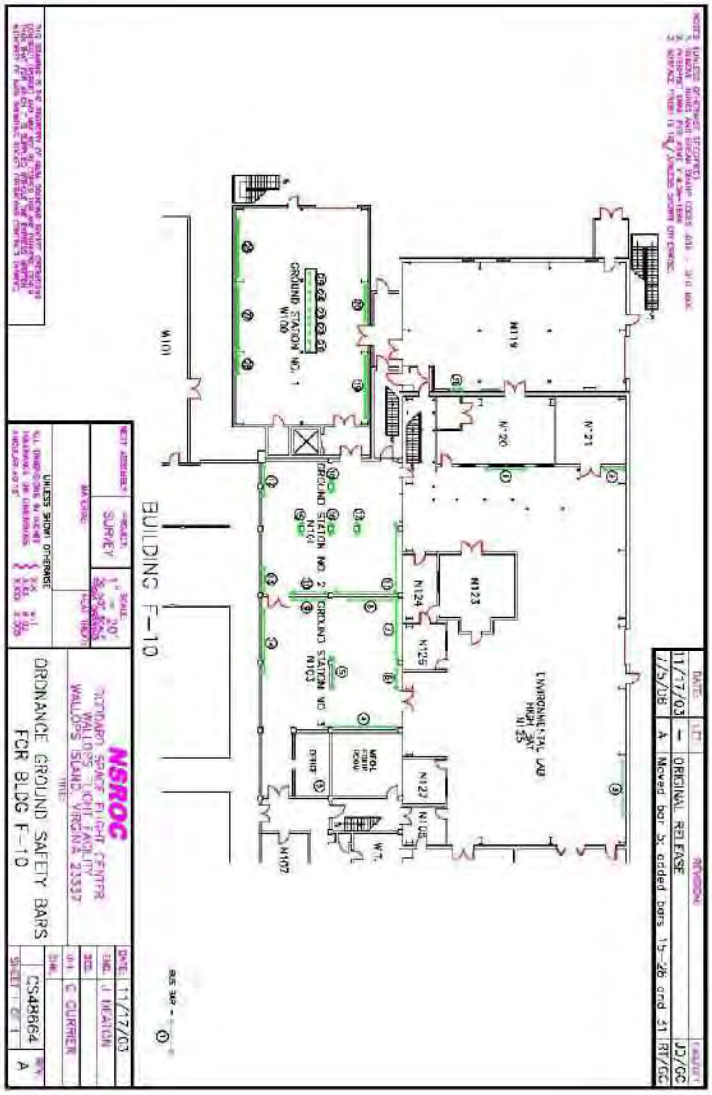
List Measurement Number(s) of failed tests:

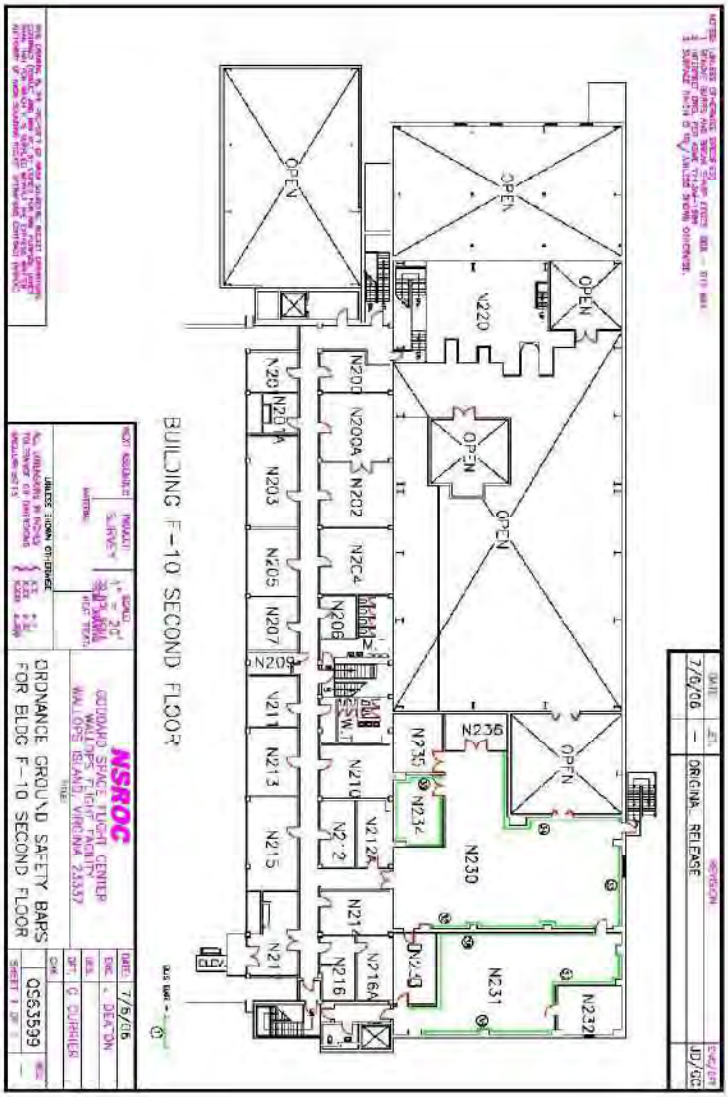
_____

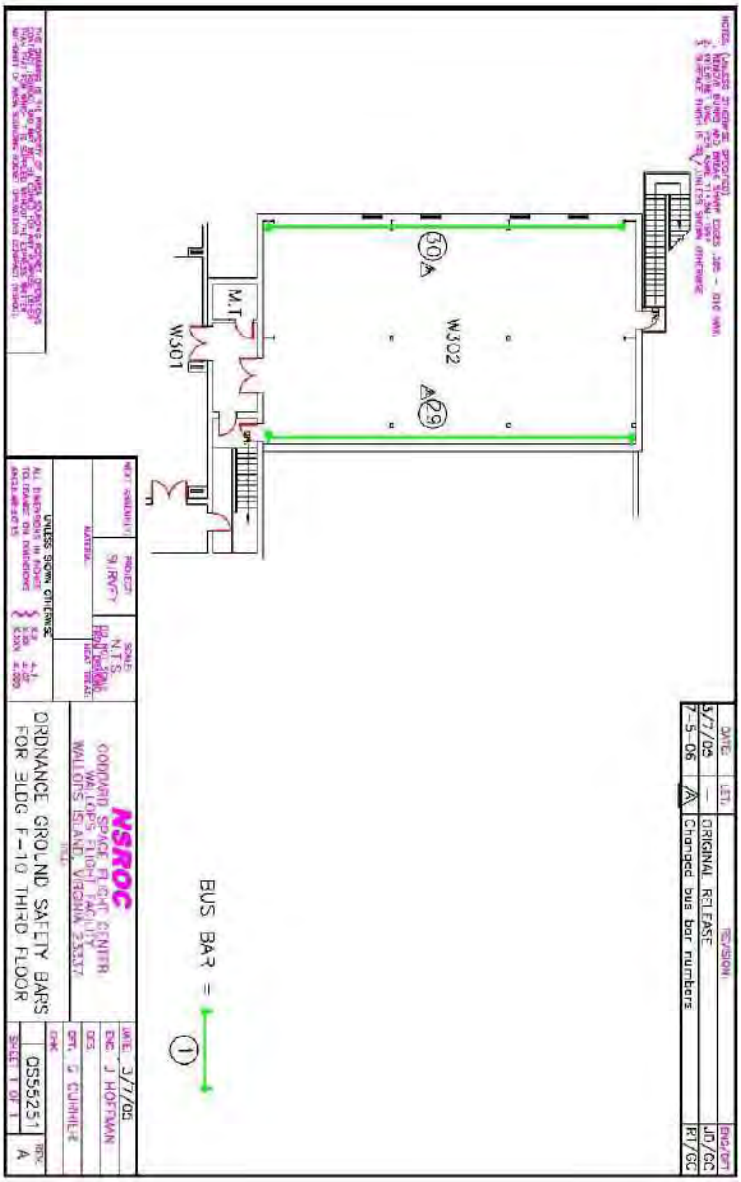
NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____

TECHNICIAN DATE TASK LEADER DATE


DATE
11/17/03
7/5/06
REVISION
ORIGINAL RELEASE
Moved bar 3x, added bars 1b-2b and 21
JD/GC
N119
N120
N121
N123
N124
N125
N122
N108
N107
N101
N103
N104
N100
GROUND STATION NO. 1
GROUND STATION NO. 2
GROUND STATION NO. 3
ENVIRONMENTAL LAB
BUILDING F-10
NSROC
DRONANCE GROUND SAFETY BARS
FOR BLDG F-10
11/17/03
J MEATON
C CURRIER
CS48664
A
SHEET 1 OF 1


BUILDING F-10 SECOND FLOOR
OPEN
N220
N200
N200A
N202
N204
N206
N203
N205
N207
N209
N211
N213
N215
N230
N231
N232
N234
N235
N236
N216
N216A
N210
N212
N212A
NSROC
GOUDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
ORDNANCE GROUND SAFETY BARS
FOR BLDG F-10 SECOND FLOOR
7/6/06
ORIGINAL RELEASE
JD/GC
DEA DN
G. CURRIER
0563599


W302
W301
M.T.
30A
29
BUS BAR = 1
DATE
REVISION
5/7/05
ORIGINAL RELEASE
7-5-06
Changed bus bar numbers
JD/GC
RT/GC
NSROC
COMMAND SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337
ORDNANCE GROUND SAFETY BARS
FOR BLDG F-10 THIRD FLOOR
SCALE
N.T.S.
PROJECT
SURVEY
DATE 3/7/05
ENG. J HOFFMAN
DRT. J GUNNELL
055251
SHEET 1 OF 1
REV. A

6-Month Visual Inspection of Pyrotechnic Grounding Points
Ground Measurement Data Building F-10

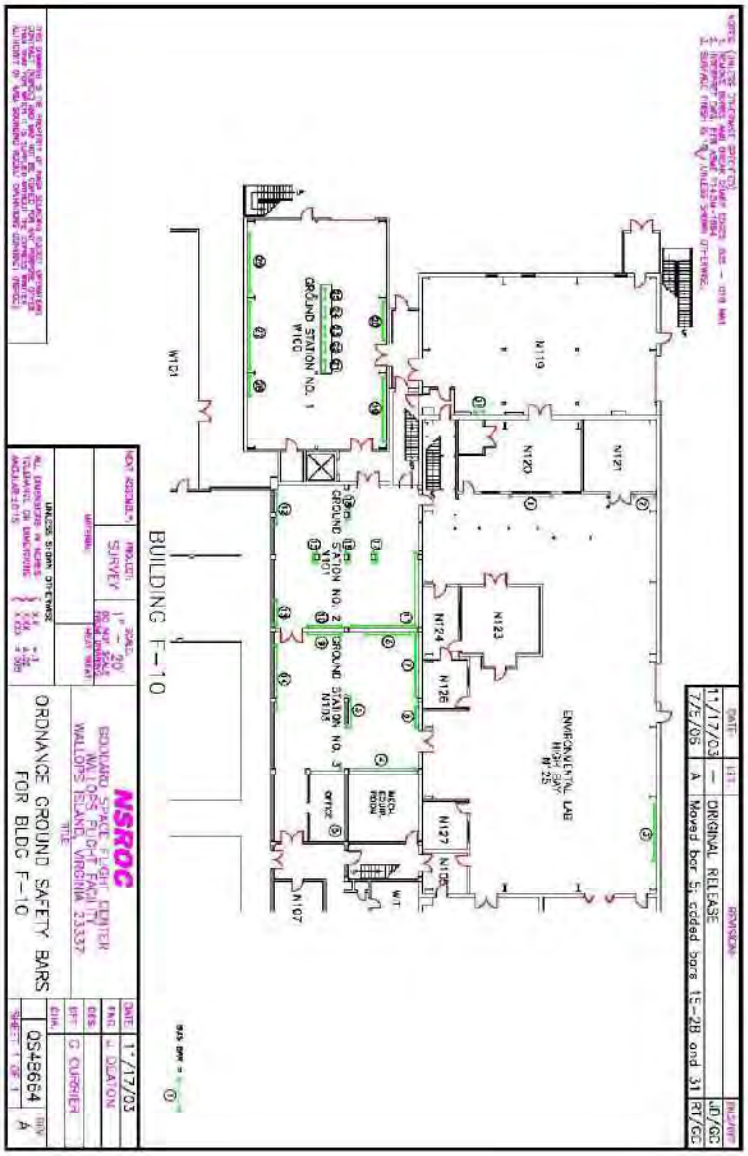
Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			
No. 17			
No. 18			
No. 19			
No. 20			
No. 21			
No. 22			
No. 23			
No. 24			
No. 25			
No. 26			
No. 27			
No. 28			
No. 29			
No. 30			
No. 31			
No. 32			
No. 33			

DATE CASE No.

Ground Point	Pass	Fail	Remarks
No. 34			
No. 35			
No. 36			
No. 37			
No. 38			

COMPLETED: _____
TECHNICIAN DATE

NCR for failed Ground Points filed on: _____


DATE
REVISION
11/17/03
ORIGINAL RELEASE
7/5/05
A
Moved bar 5, added bars 15-28 and 31
BUILDING F-10
GROUND STATION NO. 1
GROUND STATION NO. 2
GROUND STATION NO. 3
ENVIRONMENTAL LAB
N119
N120
N121
N123
N124
N125
N126
N127
N107
W101
NSROC
EDWARD SPACE FLIGHT CENTER
WALLOPS ISLAND, VIRGINIA 23337
SURVEY
ORDNANCE GROUND SAFETY BARS
FOR BLDG F-10
11/17/03
G. CURRIER
QS48664
A

GROUND MEASUREMENT DATA
LAUNCH AREA, NO. 2, GUN MOUNT

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26671	RESISTANCE Expected	Initial			
1	Ground to GTP-2 NORTH	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26671	RESISTANCE	NET Measured Minus line
2	GTP-2 NORTH to GPT-1 GUN		
3	GTP-2 NORTH to GPT-2 GUN		
4	GTP-2 NORTH to GPT-3 GUN		
5	GTP-2 NORTH to GTP-4 GUN		
6	GPT-2 NORTH to No. 1 GUN		

Soil Condition: _____

Lead Resistance_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

DIRECTIVE NO.	548-WI-8072.1.63A	Page 99 of 120
EFFECTIVE DATE:	03/12/2013	
EXPIRATION DATE:	03/12/2018	

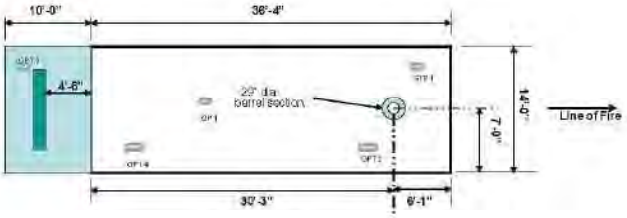
6-Month Visual Inspection of Pyrotechnic Grounding Points
GROUND MEASUREMENT DATA
PAD 2 GUN MOUNT

Ground Point	Pass	Fail	Remarks
GPT -1 GUN			
GPT -2 GUN			
GPT -3 GUN			
GPT -4 GUN			
NO. -1 GUN			

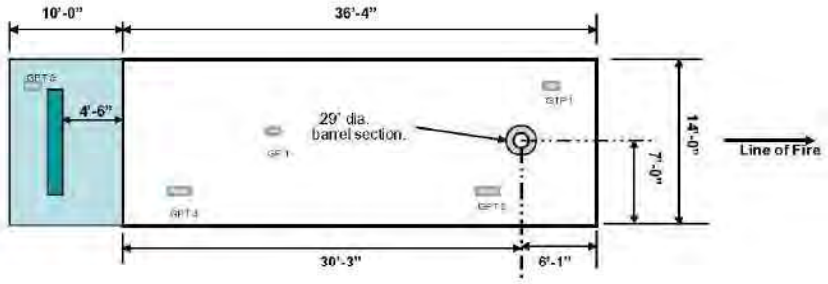
NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

Pad 2 Gun Mount Ground Points



Pad 2 Gun Mount Ground Points



GROUND MEASUREMENT DATA
BLDG. H-100 PAYLOAD PREPARATION FACILITY

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	Ground to Buss Bar 1	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE NET Measured Minus Line	
2	Buss Bar 1 to Buss Bar 2		
3	Buss Bar 1 to Buss Bar 3		
4	Buss Bar 1 to Buss Bar 4		
5	Buss Bar 1 to Buss Bar 5		
6	Buss Bar 1 to Buss Bar 6		
7	Buss Bar 1 to Buss Bar 7		
8	Buss Bar 1 to Buss Bar 8		
9	Buss Bar 1 to Buss Bar 9		
10	Buss Bar 1 to Buss Bar 10		
11	Buss Bar 1 to Buss Bar 11		
12	Buss Bar 1 to Buss Bar 12		
13	Buss Bar 1 to Buss Bar 13		
14	Buss Bar 1 to Buss Bar 14		
15	Buss Bar 1 to Buss Bar 15		
16	Buss Bar 1 to Buss Bar 16		

17	Buss Bar 1 to Buss Bar 17		
18	Buss Bar 1 to Buss Bar 18		
19	Buss Bar 1 to Buss Bar 19		
20	Buss Bar 1 to Buss Bar 20		
21	Buss Bar 1 to buss bar 21		
22	Buss Bar 1 to buss bar 22		
23	Buss Bar 1 to buss bar 23		
24	Buss Bar 1 to buss bar 24		
25	Buss Bar 1 to buss bar 25		

Soil Condition: _____

Lead Resistance_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

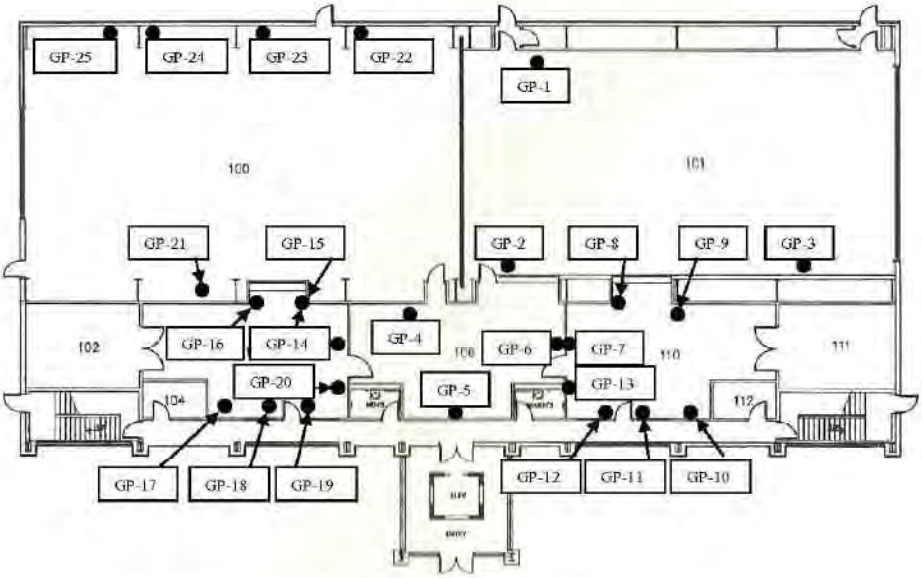
COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

6-Month Visual Inspection of Pyrotechnic Grounding Points
BLDG H-100 PAYLOAD PROCESSING FACILITY

Ground Point	Pass	Fail	Remarks
No. 1			
No. 2			
No. 3			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			
No. 17			
No. 18			
No. 19			
No. 20			
No. 21			
No. 22			
No.23			
No.24			
No. 25			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



FIRST FLOOR PLAN

F-7 Clean Room

TASK A

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	Bus Bar 1 to Earth Ground	<25 ohms				

TASK B **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE NET Measured Minus line	
2	Bus Bar 1 To Bus Bar 2		
3	Bus Bar 1 To Bus Bar 3		
4	Bus Bar 1 To Bus Bar 4		
5	Bus Bar 1 To Bus Bar 5		

Soil Condition: _____

Lead Resistance_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE **TASK LEADER DATE**

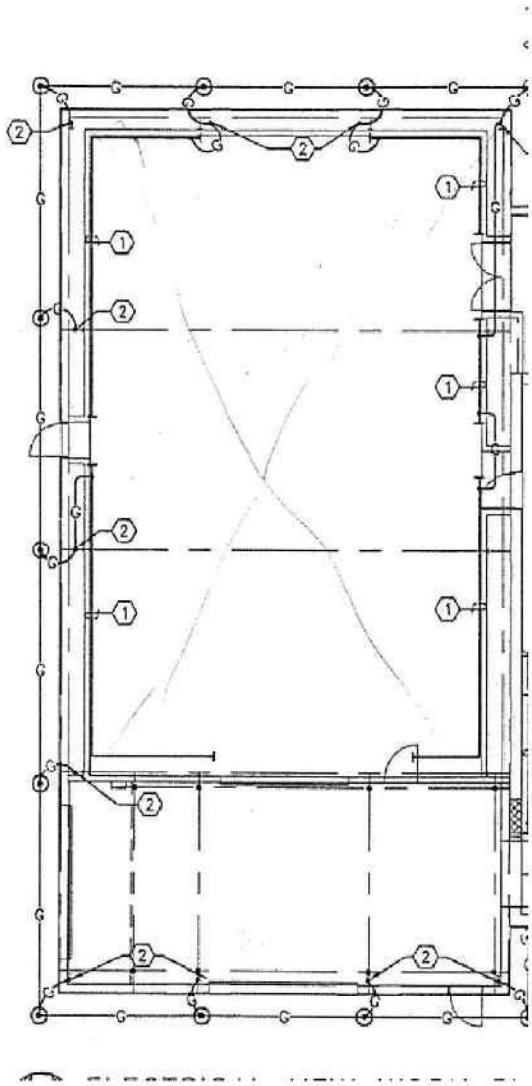
6-Month Visual Inspection of Pyrotechnic Grounding Points

GROUND MEASUREMENT DATA
BLDG F-7 CLEAN ROOM

Ground Point	Pass	Fail	Remarks
BUS BAR 1			
BUS BAR 2			
BUS BAR 3			
BUS BAR 4			
BUS BAR 5			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE



GROUND MEASUREMENT DATA
X-79 ASSEMBLY SHOP

TASK A **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	GTP 01 TO GROUND	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE NET Measured Minus line	
2	GTP 01 TO GTP 02		
3	GTP 01 TO GTP 03		
4	GTP 01 TO GTP 04		
5	GTP 04 TO GTP 05		
6	GTP 04 TO GTP 06		
7	GTP 04 TO GP 01		
8	GP 01 TO GP 01A		
9	GP 01 TO GP 02A		
10	GP 01 TO GP 02		
11	GP 01 TO GP 03		
12	GP 01 TO GP 03A		
13	GP 01 TO GP 04		
14	GP 01 TO GP 05		
15	GP 01 TO GP 06		
16	GP 01 TO GP 07		

17	GP 01 TO GP 08		
18	GP 01 TO GP 09		
19	GP 01 TO GP 10		
20	GP 01 TO GP 11		
21	GP 01 TO GP 12		
22	GP 01 TO GP 13		
23	GP 01 TO GP 14		
24	GP 01 TO GP 15		
25	GP 01 TO GP 16		
26	GP 01 TO GP 17		
27	GP 01 TO GP 18		
28	GP 01 TO GP 19		
29	GP 01 TO GP 20		
30	GP 01 TO GP 21		
31	GP 01 TO GP 22		
32	GP 01 TO GP 23		
33	GP 01 TO GP 24		
34	GP 01 TO GP 24A		
35	GP 01 TO GP 25A		
36	GP 01 TO GP 25		
37	GP 01 TO GP 26		
38	GP 01 TO GP 27		
39	GP 01 TO GP 27A		
40	GP 01 TO GP 28		
41	GP 01 TO GP 29		
42	GP 01 TO GP 30		

43	GP 01 TO GP 31		
44	GP 01 TO GP 32		
45	GP 01 TO GP 33		
46	GP 01 TO GP 34		
47	GP 01 TO GP 35		
48	GP 01 TO GP 36		
49	GP 01 TO GP 37		
50	GP 01 TO GP 38		
51	GP 01 TO GP 38A		
52	GP 01 TO GP 39		
53	GP 01 TO GP 40		
54	GP 01 TO GP 41		
55	GP 01 TO GP 42		
56	GP 01 TO GP 43		
57	GP 01 TO GP 44		
58	GP 01 TO GP 45		
59	GP 01 TO GP 46		
60	GP 01 TO GP 47		
61	GP 01 TO GP 48		
62	GP 01 TO GP 49		
63	GP 01 TO GP 50		
64	GP 01 TO GP 51A		
65	GP 01 TO GP 51		
66	GP 01 TO GP 52		
67	GP 01 TO GP 53		
68	GP 37 TO GP 61		
69	GP 37 TO GP 54		
70	GP 37 TO GP 55		

71	GP 37 TO GP 56		
72	GP 37 TO GP 57		
73	GP 37 TO GP 58		
74	GP 37 TO GP 59		
75	GP 37 TO GP 60		
76	GP 37 TO GP 62		

Soil Condition_____

Line Resistance_____

Calibration Date_____

Remarks_____

List Measurements of Failed Test_____

NCR Filed on _____ _____
DATE **CASE NO.**

Completed _____ _____ _____ _____
TECHNICIAN **DATE** **TASK LEADER** **DATE**

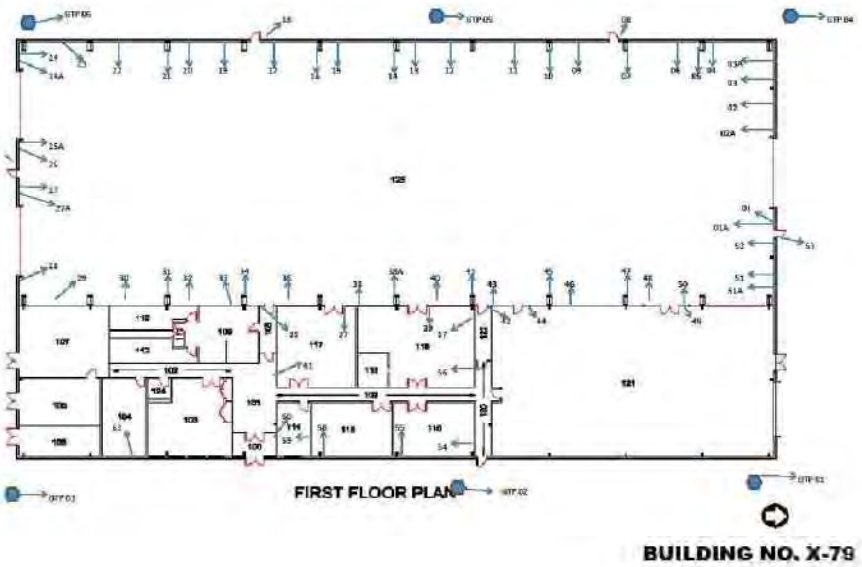
6-Month Visual Inspection of Pyrotechnic Grounding Points
Ground Measurement Data Building X-79

Ground Point	Pass	Fail	Remarks
No. 1			
No. 1A			
No. 2			
No. 2A			
No. 3			
No. 3A			
No. 4			
No. 5			
No. 6			
No. 7			
No. 8			
No. 9			
No. 10			
No. 11			
No. 12			
No. 13			
No. 14			
No. 15			
No. 16			
No. 17			
No. 18			
No. 19			
No. 20			
No. 21			
No. 22			
No. 24			
No. 24A			
No. 25A			
No. 25			
No. 26			
No. 27			
No. 27A			
No. 28			
No. 29			
No. 30			
No. 31			
No. 32			

No. 33			
No. 34			
No. 35			
No. 36			
No. 37			
No. 38			
No. 38A			
No. 39			
No. 40			
No. 41			
No. 42			
No. 43			
No. 44			
No. 45			
No. 46			
No. 47			
No. 48			
No. 49			
No. 50 No. 51A			
No. 51			
No. 52			
No. 54			
No. 55			
No. 56			
No. 57			
No. 58			
No. 59			
No. 60			
No. 61			
No. 62			
GTP 1			
GTP 2			
GTP 3			
GTP 4			
GTP 5			
GTP 6			

NCR Filed on _____ _____
DATE **CASE NO.**

Completed _____ _____
TECHNICIAN **DATE**


FIRST FLOOR PLAN
BUILDING NO. X-79

GROUND MEASUREMENT DATA
Y-45 Explosive Storage Bunker

TASK A **Net resistance shall be less than 1 ohm**

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	RESISTANCE Expected	Initial			
1	GTP 01 TO GROUND	<25 ohms				

TASK B

MEASUREMENT NUMBER	LOCATION OF MEASUREMENT See Figure B26804	NET RESISTANCE MEASURED_ MINUS LINE	
2	GTP 01 TO GTP02		
3	GTP 01 TO GP 01		
4	GTP 01 TO GP 02		
5	GTP 01 TO GP 03		

Soil Condition: _____

Line Resistance_____

Calibration Date:_____

Remarks: _____

List Measurement Number(s) of failed tests:

_____

NCR filed on: _____
DATE CASE No.

COMPLETED: _____ _____
TECHNICIAN DATE TASK LEADER DATE

CHANGE HISTORY LOG

CHECK THE GSFC DIRECTIVES MANAGEMENT SYSTEM AT
http://gdms.gsfc.nasa.gov/gdmsnew/home.jsp TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

GSFC 3-19 (11/09)

6-Month Visual Inspection of Pyrotechnic Grounding Points
Y-45 Explosive Storage Bunker

Ground Point	Pass	Fail	Remarks
GTP 1			
GTP 2			
GP 1			
GP 2			
GP 3			

NCR for failed Ground Points filed on: _____
DATE CASE No.

COMPLETED: _____
TECHNICIAN DATE

Appendix A – Definitions

A.1 Soil Condition – Wet, dry, and damp

Appendix B – Acronyms

NSS	NASA Safety Standard
NCR	Non-Conformance Report
GP	Ground Point
GTP	Ground Test Point
OBOD	Open Burn Open Detonation

Revision	Effective Date	Description of Changes
Baseline	05/18/2009	Initial Release
A	03/12/2013	Document formatted to new template and minor edits.

EXHIBIT II.C-2: SOIL MONITORING PLAN

Virginia Department of Environmental Quality
Division of Land Protection and Revitalization
Office of Financial Responsibility and Waste Programs

Permit No. VA7800020888
Expiration Date: April 13, 2028

OPEN BURNING AREA
SOIL MONITORING PLAN

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

May 2016

EXHIBIT II.C-2: SOIL MONITORING PLAN

1. INTRODUCTION II.C-1
   1.1. Site History II.C-1
   1.2. Geology and Soils II.C-1
   1.3. Hydrogeology II.C-2
   1.4. Open Burning Area II.C-3
   1.5. Past Releases II.C-4
2. PRE AND POST OB EVENT SAMPLING II.C-5
3. SOIL MONITORING PLAN II.C-5
   3.1. Sample Locations II.C-5
   3.2. Hazardous Consituents of Concern II.C-8
   3.3. Sampling Frequency II.C-9
   3.4. Laboratory Selection II.C-9
   3.5. Instrument Calibration II.C-9
   3.6. Sample Containers and Preservation Techniques II.C-9
   3.7. Sample Labeling II.C-9
   3.8. Field Logbook II.C-10
   3.9. Health and Safety Considerations II.C-10
   3.10. Sample Collection II.C-11
   3.11. Chain-of Custody Control II.C-12
   3.12. Equipment Decontamination II.C-12
   3.13. Management of Investigation Derived Wastes II.C-13
4. FIELD AND LABORATORY QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES II.C-13
   4.1. Field Quality Assurance/Quality Control (QA/QC) Procedures II.C-13
   4.2. Laboratory Quality Assurance/Quality Control (QA/QC) Procedures II.C-14
5. DATA EVALUATION II.C-14
   5.1. Data Validation II.C-14
   5.2. Statistical Evaluation II.C-15
   5.3. Empircal Comparisons II.C-16
   5.4. Treatment of Outliers II.C-16
6. REPORTING II.C-16

1. INTRODUCTION

This Soil Monitoring Plan (SMP) has been developed to monitor the potential impacts to surface soils resulting from the operation of the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center's Wallops Flight Facility (WFF), Open Burning (OB) Area, Environmental Protection Agency Identification Number VA7800020888, located at Wallops Island, Virginia. This SMP is required as part of the OB Area permit renewal submittal on May 20, 2015. The SMP outlines the procedures that will be followed for the duration of the OB permit.

1.1. Site History

The WFF is located in Accomack County, Virginia, on the Atlantic Coast of the Delmarva Peninsula (Refer to figures in OB Permit Attachment II.A Facility Description). It is located approximately 145 kilometers (90 miles) north of Norfolk, Virginia, and is comprised of three separate landmasses: Wallops Main Base, Wallops Mainland, and Wallops Island. The OB Area is located on the south end of Wallops Island.

Since 1945, the WFF has been responsible for planning and launching scientific payloads, sounding rockets, and various other test vehicles. NASA also operates an airfield with three active runways, and has host-tenant agreements with the U. S. Navy, U. S. Coast Guard, Mid-Atlantic Regional Spaceport, and the National Oceanic and Atmospheric Administration (NOAA).

NASA uses open burning as the preferred method of treatment for waste rocket motors and igniters. This method is considered the safest treatment of these materials. The rocket motors and igniters are considered hazardous waste because they meet the characteristic of reactivity (D003) and some have secondary toxicity characteristics for chromium (D007) or lead (D008). NASA has been using the OB Area since 1972. In 1988, NASA submitted a RCRA Part B Permit Application and operated under interim status until the final Permit for Open Burning Treatment of Hazardous Waste was issued on September 20, 2005.

1.2. Geology and Soils

Located within the Atlantic Coastal Plain physiographic province, WFF is underlain by approximately 2,135 meters (7,000 feet) of sediment that lies atop crystalline basement rock. The sedimentary section, ranging in age from Cretaceous to Quaternary period, consists of a thick sequence of nonmarine deposits overlain by a much thinner sequence of marine sediments. The two uppermost stratigraphic units at WFF are the Yorktown Formation and the overlying Columbia Group sediments, which are not subdivided into formations.

The southern end of Wallops Island consists of nearly level to steep, very deep, moderately well to excessively drained, Fisherman and Assateague Fine Sand complex. The area relies on natural drainage patterns to intercept and divert flow. The maximum elevation of the southern end of Wallops Island is 4.3 meters (14 feet) above mean sea level.

1.3. Hydrogeology

The VDEQ has identified four major aquifers on the Eastern Shore of Virginia: the Columbia aquifer and the three aquifers comprising the Yorktown-Eastover multiaquifer system.

The water table aquifer, known as the Columbia aquifer, primarily consists of Pleistocene sediments of the Columbia Group. It is unconfined and typically overlain by wind-deposited beach sands, silts, and gravel. The aquifer occurs between depths of 1.5 to 18.3 meters (5 and 60 feet) below the ground surface. The water table ranges from depths of 0 to 9.1 meters (0 to 30 feet) below the ground surface. Groundwater flow is generally east and north toward nearby creeks and the marsh area that separates Chincoteague Island from the mainland.

The Yorktown-Eastover aquifer system is a multiaquifer unit consisting of late Miocene and Pliocene deposits and is composed of the sandy facies of the Yorktown and Eastover Formations. The top of the shallowest confined Yorktown-Eastover aquifer at WFF is found at depths of approximately 30.5 meters (100 feet) below the ground surface. It is separated from the overlying Columbia aquifer by a 6.1 to 9.1-meter (20 to 30-foot) confining layer (aquitard) of clay and silt. The Yorktown-Eastover aquifers are classified as the upper, the middle, and the lower Yorktown-Eastover aquifers. Correspondingly, each Yorktown-Eastover aquifer is overlain by the upper, middle, and lower Yorktown-Eastover aquitards. In the Wallops area, the lower Yorktown-Eastover aquifer contains the freshwater/saltwater interface, which occurs at a depth of approximately 91 meters (300 feet) below mean sea level.

Wallops Island's unconfined surface aquifer, comprised of Holocene beach sands, drains groundwater vertically from 1 to 2 meters (3 to 6 feet) until meeting the water table, then flows down-gradient to either interior marshes or the ocean. Recharge to the water table aquifer is through direct infiltration of rainwater, and through gains from Hog Creek and the adjoining marshes. Recharge to the Miocene Aquifer is from the central portions of the Eastern Shore in Maryland. Flow gradients on Wallops Island vary in direction relative to seasonal and tidal influences on head pressure.

Monitoring wells (MW) were installed in September 1998. Data used to characterize the water table aquifer was collected from slug tests conducted on OB MW1. The test results indicated a hydraulic conductivity (K) of 0.00115 feet per second and a transmissivity (T) of 4.5 square feet per second.

Groundwater flow direction was established most recently using field data collected during the June 16, 2014, and December 15, 2014, sampling events. Seepage velocity was calculated to be 1.81 feet per day for the June 16, 2014, and 2.06 feet per day for the December 15, 2015, sampling events.

1.4. Open Burning Area

The OB Area (refer to figures in OB permit Attachment II.A Facility Description), located on the shoulder of the dike road at the southwestern corner of Wallops Island, consists of four subunits (ground embedded cylinders) and one open burn pad assembly. Subunits 1 and 3 are vertical steel cylinders made from Taurus rocket motor casings (refer to figures found in OB permit Attachment II.H Plans and Specifications for Open Burn Units). Subunits 1 and 3 are 0.6 meters (1.9 feet) in diameter, stand 0.8 meters (2.6 feet) above the ground surface, and are embedded 2.3 meters (7.5 feet) below the ground and filled with concrete. Subunit 2 is a vertical steel cylinder made from a Nike rocket motor casing. Subunit 2 is 0.4 meters (1.4 feet) in diameter, stands 1.1 meters (3.5 feet) above the ground surface, and is embedded 2.2 meters (7.1 feet) below the ground surface. Subunit 2 also is filled with concrete. Subunit 4 (refer to figures found in OB permit Attachment II.H Plans and Specifications for Open Burn Units) is 0.7 meters (2.4 feet) in diameter, stands 1.10 meters (3.6 feet) above the ground surface, and is embedded 3.1 meters (10.2 feet) below the ground surface. The subunits 1, 2, and 3 were constructed around 1989. Subunit 4 was installed in 2012.

The OB pad assembly is a 4.6 meters (15 feet) square by 46 centimeters (18 inches) thick concrete pad with a steel plate in the center for motor head attachment. The unit is equipped with a burn pad cover and is surrounded by a berm. Four cable tie downs are used to stabilize the motors. The pad was constructed around 1996.

The OB Area is within the 100-year floodplain. The subunits are covered when not in use to prevent entry and accumulation of precipitation. The subunits also have concrete bases to prevent contact between constituents, subsurface soils, and groundwater. A berm and cover for the pad has been designed and will be in use prior to the permit approval. Runoff, which should not come in contact with contaminated media, is directed across the access road to the east and north and across vegetation to the south and west. Runoff is not collected and does not impact other drainage structures on the Island. Runoff from the OB Area infiltrates into the sandy soil surrounding the units. Since the OB Area will not have a point source or a storm water collection system, a Virginia Pollutant Discharge Elimination System (VPDES) Permit is not required.

Any rocket motor treated at the OB Area, follows guidelines and measures, which have been approved by the WFF Safety Office. The rocket motor and igniter are placed inverted into a cylinder or attached to the pad motor head assembly. The

igniter is set off by a battery hook-up behind a protective barrier. The distance between the barrier and burning area is specified in a ground safety plan prepared for each rocket motor type. Burned motors and igniters are inspected for visible signs of untreated material. If untreated material is present in the motor, then the motor is reignited or the material removed and reignited on the burn pad.
Occasionally, propellant is removed from a motor(s) when modifications are required. Propellant (not in a motor casing), ash, residue, or ejected material are placed on the burn pad in a burn pan. A squib igniter is fabricated, and the material is ignited. Any unburnable material is containerized, sampled for characterization, if necessary, and any hazardous waste is disposed of through WFF's hazardous waste disposal contractor.

1.5. Past Releases

On July 30, 2013, several fires developed in the immediate vicinity of the OB Area and one fire in the State of Virginia marsh, northwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. During the inspection process of the motor, inconsistencies were found in the Taurus rocket motor, which were similar to those found in the motor which caused the fire on July 17, 2013. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, positioned additional equipment and manpower at the site to respond to the fire, should one occur. As a result, all fires on WFF property were immediately extinguished. The fire on Virginia state property was extinguished within 45 minutes.

On July 17, 2013, several fires developed in the State of Virginia marsh, northwest, west, and southwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, responded to the fire. Additional water tankers were supplied by the Atlantic Virginia Volunteer Fire Department. All permit procedures were followed during treatment. A Ground Safety representative was also present during operations. The fire self-extinguished at approximately 9:16 p.m.

On October 25, 2010, two small fires, each scarring approximately patches of grass and brush covering an area of approximately 10 feet by 10 feet. One fire extinguished itself and the other fire was extinguished with water by the on-scene Wallops Fire Department. The fire, which extinguished itself, was approximately 30 feet northeast of the burn pad, on the road. The second fire was approximately 20 feet southwest of the burn pad in the brush. The ejected material was from Arcas motor grain.

On March 25, 2009, during routine OB Area operations, the on-scene fire department personnel responded to two small brush fires at the facility. The fire did not occur outside the facility, did not result from a release of hazardous waste, and did not threaten human health or the environment.

On March 10, 1992, six Nike rocket motors were prepared for OB at the rocket motor disposal site on the south end of the island. These motors, which were manufactured in 1959, had been contaminated with sea water during the January storm which hit Wallops Island. Two of the six motors were prepared for open burning and at approximately 1430, the first motor was ignited without incident. Upon ignition of the second motor an anomaly occurred which resulted in the motor being ejected from the subunit. This motor hit the pavement in the vicinity of the tube from which it had been ejected and came to rest approximately 50 meters south of the tube in the marsh/beach area. There were no personnel injuries nor significant property damage as a result of this anomaly. It should be noted that all necessary safety precautions were followed and all environmental restrictions adhered to during these disposal operations. The technicians also indicated several small brush fires were started by this motor. One fire was unique in that it was started approximately 150 meters west of and behind the barricade. All fires were extinguished by Damage Control, which, according to standard operating procedure, was stationed behind the barricade. These fires were most likely the result of burning propellant being ejected from the motor. Procedures were modified to prevent reoccurrence of this anomaly.

2. PRE AND POST OB EVENT SAMPLING

Prior to and following each OB operation, surface soil and water within a 1.2 meters (4 foot) diameter of the subunit or pad are sampled to validate the lack of contamination from OB operations. Surface soil sampling consists of six discrete points, which lie between the OB subunit or pad and a 1.2 meters (4 foot diameter) boundary line. The six discrete points are sampled before and after the OB operation. The six discrete before samples and the six discrete after samples are each composited into one sample (two samples total). One grab surface water sample is taken from the same source both before and after each OB operation. Surface water samples are field tested for pH, conductivity, and temperature. Surface soil samples are analyzed for total lead (SW-846 6010B) and energetics (SW-846 8330 modified or 8321). Results are reported semiannually in the OB Area Groundwater monitoring report.

3. SOIL MONITORING PLAN

The SMP will be used to monitor for the presence of hazardous constituents from the operation of the OB Area. Soils will be monitored from the layer 0-15 centimeter (0-6 inch) below ground surface at selected locations located within the OB Area. Samples will be collected and compared to the greater of specific regulatory limits and background values which will function as action levels. If these levels are exceeded, interim measures will be implemented.

3.1. Sample Locations

The soil sampling area is defined as the area affected by a historical or potential release at the site. Though recent and historical release information will be evaluated prior to each sampling event, from historical information thus far a conservative 15-meter (50-foot) radius around the cylinders and pad will be used. Motors placed in the cylinders are approximately 2 meter (6 feet) above the soil surface. The tallest motor attached to the burn pad historically is approximately 6 meters (17 feet) above ground surface. The additional height and its effect on the trajectory of ejected material have been calculated and the potential impact area determined to be a 13-meter (42-foot) radius area around the burn pad.

The location of the background sample location will be approved by VDEQ prior to sampling. Initially, a hand augered core from the 0-15 centimeter (0-6 inch) layer will be collected from the background soil sample location and one sample location within the OB Area. The two samples will be compared to confirm that the soil type of the background location is representative of the soil within the OB Area. The location is planned to be south of background groundwater monitoring well 4. Once the background location is established, it will be marked and located. All future background soil samples will be collected within a 4.6 meter (15 feet) radius of the initial background sample. One background sample will be collected during each sampling event.

The sample locations will be chosen based upon simple random sampling using a statistical sampling strategy, and biased sampling (for known release spots). A grid will be established, over the OB Area (See Figure 1). The size and number of grid locations will be determined based on approximate surface area and in accordance with sampling procedure outlined in SW-846. Figure 1 shows each grid to be approximately 30 feet by 35 feet. One sample will be collected from each of the grid locations within the 50 foot radius of the OB units. Soil samples shall be obtained from the 0-15 centimeter (0-6 inch) layer. All sampling equipment will be decontaminated between samples to avoid cross-contamination.

Figure 1
Approximate Soil Sample Locations
0
50
100
Feet
N
W
E
S
WFF Environmental Office
5/15/2015
2013 Imagery

3.2. Hazardous Constituents of Concern

Each type of rocket motor and igniter varies in the type and quantity of reactive constituents. The percent composition of the chemicals is proprietary/classified information and not provided in most cases by the manufacturer. Material Safety Data Sheets or Safety Data Sheets are included in OB Permit Exhibit II.B-1 OB Area Waste Analysis Plan. The Hazardous Constituents of Concern (HCOCs) are those hazardous constituents historically managed at the OB Area which are identified in RCRA under 40 CFR § Part 261, Appendix VII, Basis for Listing Hazardous Wastes, and Appendix VIII, Hazardous Constituents or have been groundwater parameters. The HCOCs are listed in Table 1 along with the respective analytical test method. All analytical methods are in accordance with SW-846, Test Methods for Evaluating Solid Waste, Third Edition, 1986, EPA as updated by Updates I, II, IIB, III, IIIA, IVA, and IVB (SW-846) or as proposed below. After the initial two year period, NASA may petition to reduce or modify the HCOC based on analysis of results.

Table 1
Hazardous Constituents of Concern Analytical Test Methods Table

Hazardous Constituent	SW-846 Method	PQL/EQL (ug/Kg)	MDL (ug/Kg)
Ammonia	SM4500-NH3-BG	2500	1000
Chromium, total	6010C low	500	100
Cyanide, total	9014R/9010B/9012B	750	125
Diethyl phthalate (DEP)	8270	333	83.3
Dibutylphthalate	8270	333	83.3
Dioxins and Furans	1311 and 8830 or 8270		
Lead, total	6020/6010C low	250	75
Maleic Anhydride	8270		
Nitrates	9056	2500	330
Nitrites	9056	2500	330
Nitroglycerin	8332/8330/8330A	1000	250
Perchlorate	6850	20	5
Phenols	9065/EPA420.4	1	0.2
Resorcinol	8270	660	660
Toluene di-isocyanate (TDI)	8270	660	660

*In accordance with SW-846, the definitions of a PQL/EQL and MDL are as follows: EQL - The estimated quantitation limit (EQL) is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data

reporting. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve. Sample EQLs are highly matrix-dependent. The EQLs in SW-846 are provided for guidance and may not always be achievable.

MDL – The method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

3.3. Sampling Frequency

Samples will be collected semi-annually. After the initial two year period, NASA may petition VDEQ to change the sampling frequency based on analysis of results.

3.4. Laboratory Selection

Each laboratory used to conduct analysis of the collected samples will be accredited through the Virginia Environmental Laboratory Accreditation Program and be able to perform analyses to meet the PQL and MDL in Table 1.

3.5. Instrument Calibration

All field analytical instruments shall be calibrated before each event and on each day of the event according to the manufacturer's specifications. The standards used for calibration shall be documented in the field logbook. Instruments shall also be thoroughly cleaned with deionized water between calibration standards and samples.

3.6. Sample Containers and Preservation Techniques

All samples will be collected in glass jars with a teflon lined cap provided by the laboratory. All samples will be kept in a cooler and maintained at 4°C during shipment to the laboratory and until analyses are performed.

3.7. Sample Labeling

Each sample container will be labeled with the following information:

- Site name
- Sample identification number
- Date and time of collection
- Type of preservation

- Analysis required
- Sample type (grab, composite)
- Sample matrix (soil, water, other)
- Any other information pertinent to the sample

3.8. Field Logbook

A field logbook shall be utilized which contains the following information at a minimum:

- Project for which the sample is being collected
- Date and time
- Sample Location to include GPS coordinates and grid location
- Name and signature of sampler(s)
- Source of sample (including name, location, and sample type)
- Deviations from Sampling Plan or Standard Operating Procedures
- Pertinent field data (pH, temperature, conductance, depth of sample, weather conditions, etc.)
- Unique sample or log number
- Sampling techniques

3.9. Health and Safety Considerations

A WFF Dig Permit will be requested and obtained prior to each sampling event to ensure that underground utilities will not be reached during the sampling process.

Due to the nature of past and current operations on NASA Wallops Flight Facility, all sampling personnel will be training to identify munitions and explosives of concern (MEC). Should an item of concern be encountered, personnel will Recognize the hazard, Retreat from the area, and Report the item to the Wallops Fire Department, by dialing 911.

Prior to each sampling event, a tailgate safety briefing will be held to discuss the weather, physical, biological, and chemical hazards which may be encountered during the sampling event.

3.10. Sample Collection

Soil samples will be collected using stainless hand augers, trowels, and bowls. Disposable one-time use EnCore samplers will be used for the collection of volatile organic compounds. Samples will be collected from the 0-15 centimeter (0-6 inch) layer. For VOC analysis use an EnCore disposable sampler to collect the sample directly from the soil. Soil for other samples will be thoroughly mixed. Sample containers will be filled by scooping a portion of the soil into each container until all containers are filled. The procedure for collecting samples will be:

- Obtain sample containers from laboratory
- Label sample containers.
- Layout the sampling grid at the OB Area.
- Record the location of the sample using Global Position System (GPS).
- Place plastic sheeting on the ground around the sampling location to prevent cross contamination.
- Sampling personnel will wear a fresh pair of nitrile gloves at each sampling location.
- Decontaminate sampling equipment.
- Remove surface gravel or loose vegetation from the sampling site using a decontaminated spade.
- For VOC analysis use an EnCore disposable sampler to collect the sample directly from the soil.
- For all other analysis, use a decontaminated stainless steel hand auger or trowel, collect the sample from the 0-15 centimeter (0-6 inch) interval and then homogenize soil in a stainless steel bowl.
- Transfer the soil sample into the appropriate laboratory-supplied bottle with a stainless steel spoon or equivalent.
- Secure the sample container lid tightly.

- Note the time of sample collection on the sample label.
- Place filled containers on ice immediately.
- Complete chain-of-custody documents and record in the field logbook.
- Place excess soil back into the hole.
- Decontaminate sampling equipment after use and between sample locations.

3.11. Chain-of Custody Control

Strict chain-of-custody procedures will maintained for all samples. A chain-of-custody form will be completed for each set of samples collected. The form is maintained as a record of sample collection, transfer, and receipt by the laboratory and will be kept with the samples. Custody of samples will be maintained and documented from the time of sample collection to the completion of analysis. The laboratory conducting the sample analysis will provide chain-of-custody documentation. A copy of the chain-of-custody will be included with certificates of analysis provided by the laboratory.

3.12. Equipment Decontamination

Sampling equipment will be thoroughly decontaminated by washing with (non-phosphate) detergent, thoroughly rinsed with de-ionized water, and air dried. All equipment coming in contact with media suspected of being contaminated will be decontaminated before it contacts a media which is likely to be less contaminated or uncontaminated.

- All non-dedicated sampling equipment will be cleaned over a decontamination pad after each use in the following manner:
- Rinse with tap water.
- Wash with a non-phosphate laboratory detergent and tap water.
- Rinse with distilled water
- Wash with laboratory-grade methanol or isopropanol
- Triple rinse with de-ionized, distilled water
- Allow to air dry.

If the equipment is not to be used again immediately, it should be packaged and properly stored to protect it from dust and dirt. Equipment may be wrapped in aluminum foil (shiny side on the outside) and placed in a plastic bag. A label should be affixed to the outside wrapping summarizing the decontamination procedure and stating the date of decontamination. Decontaminated sampling equipment should not be placed on the ground or on other contaminated surfaces prior to use.

The decontamination pad will be lined with polyethylene sheeting and sloped to promote drainage towards one corner into an in-ground container. This will facilitate removal of any potentially contaminated decontamination fluids.

3.13. Management of Investigation Derived Wastes

Investigation derived waste will be collected, contained, labeled, and stored in U.S. Department of Transportation (DOT)-approved 55 gal drums. All decontamination fluids will be managed and disposed of in accordance with the DEQ Investigation-Derived Waste Policy. Disposable items will be disposed of as solid waste in an approved, permitted landfill.

4. FIELD AND LABORATORY QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

4.1. Field Quality Assurance/Quality Control (QA/QC) Procedures

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of blanks to verify that the sample collection and handling process has not affected the quality of the samples. Both field and laboratory QC samples should be prepared during the sampling event. It is recommended that the following samples be analyzed with each batch of samples (a batch may not exceed 20 samples):

- One equipment rinsate (required only when non-disposable equipment is being used)
- One duplicate sample (either a matrix duplicate or a matrix spike duplicate which should be accounted for in sample volume supplied to the laboratory)
- One field duplicate

A trip blank should be prepared and analyzed when samples are being analyzed for volatile organic analytes. A trip blank should be submitted with samples each day that samples are collected.

All samples will be packed in coolers sealed with a custody seal prevent tampering while in route to the laboratory.

4.2. Laboratory Quality Assurance/Quality Control (QA/QC) Procedures

The laboratory shall perform internal quality control checks regularly to assess the precision and accuracy of analytical procedures. Internal quality control checks shall include use of calibration standards, standard references, duplicates and spiked/fortified samples.

The laboratory shall verify calibration standards against standard reference from an outside source. Calibration curves shall be comprised of a minimum of one blank and three standards. Samples shall be diluted if necessary to ensure analytical measurements fall on the linear portion of the calibration curve.

The laboratory shall process duplicate samples at an average frequency of ten percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked/fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of analysis. During the course of analysis, quality control data and sample data shall be reviewed to identify questionable data.

5. DATA EVALUATION

5.1. Data Validation

Laboratory analytical data will be validated based on guidelines outlined in:

- Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, April 1993, and

- Region III Modifications to National Functional Guidelines for Organic Data Review Multi-Media, Multi-Concentration, September 1994.

Additionally, the analytical laboratory QA/QC will be evaluated for conformance with and adherence to prescribed data quality objectives.

The evaluation of the analytical laboratory's compliance with the analytical methods and validation of the results will be based on a limited review of the following items: QC deliverables package, QC history documentation, technical holding times, preservation requirements, instrument performance (tune) check, instrument calibrations, blank sample analyses, surrogate spike recoveries, laboratory control samples, matrix spike, matrix spike duplicate, or sample duplicate analyses, interference check sample results, and internal standard requirements where appropriate. The review will be limited mainly to summary sheets provided by the laboratory, unless a notable discrepancy in the data package requires review of the raw data.

5.2. Statistical Evaluation

After the initial 2 year period, the background 95 percent upper tolerance limit will be calculated from the four results collected at the background soil sampling location and inserted in Table 2. Statistical analysis of the background data will include the following:

- Outliers
- Testing of normality
- Missing data
- Evaluation of data below detection limits or quantitation limits
- Selection of statistical method

Table 2
Soil Levels

Hazardous Constituent	Background Concentration	Region III Risk Based Concentrations for Industrial Worker mg/Kg	Limit for Comparison
Ammonia		NA	
Chromium, total		6.30E+01	
Cyanide, total		1.30E+01	
Diethyl phthalate (DEP)		6.60E+04	
Dibutylphthalate		8.20E+03	
Dioxins and Furans		7.30E-05	
Lead, total		8.00E+02	
Maleic Anhydride		8.1E+03	
Nitrates		1.9E+05	
Nitrites		1.2E+04	
Nitroglycerin		8.2E+00	
Perchlorate		8.2E+01	
Phenols		3.10E+05	
Resorcinol		NA	
Toluene diisocyanate (TDI)		NA	
NA: Soil screening levels not provided in Region III risk-based screening tables.			

5.3. Empirical Comparisons

In general, the evaluation of the analytical data for this program involves the direct comparison of validated results to the greater of specific regulatory limits and background values to be compiled in Table 2. If a result is in excess of the greater limit, NASA may choose to verify the result in accordance with the procedure outlined in this section.

5.4. Treatment of Outliers

All data will be investigated to verify outliers. An outlier refers to a data point which is an inconsistently large or small value. An outlier may occur due to sampling, laboratory, transportation, or transcription errors. To remove the possibility of including data with this type of error, the historical data will be screened for each sample and constituent for the existence of outliers using the method described by Dixon. Any elimination of an outlier must have prior approval from the VDEQ.

6. REPORTING

The analytical results for each semi-annual sampling event will be compiled, evaluated, and interpreted upon receipt from the analyzing laboratory to determine whether any soil contamination exists at the OB Area above the levels in Table 2. The results of the data evaluation will be summarized annually and kept in the operating record. The data will be submitted to the VDEQ semiannually and annually.

If it is determined during the course of the SMP that there is evidence of soil contamination in excess of the designated levels at any sampling point, NASA may demonstrate that a source other than the OB Area is the cause of the contamination, or that the detection is caused by error in sampling, analysis, or evaluation. To make such a demonstration, NASA shall:

- Notify the VDEQ in writing within seven days that they intend to make a demonstration.
- Within 90 days, submit a report to the VDEQ demonstrating that a source other than the OB Area caused the contamination or that the contamination resulted from error in sampling, analysis, or evaluation.
- Within 90 days, submit a permit modification application to the VDEQ to make any appropriate changes to the SMP.
- Continue to monitor in accordance with SMP.

If contamination in excess of the levels in Table 2 is detected at any sampling point, and NASA does not make a demonstration that a source other than the OB Area is the cause of the contamination, NASA shall:

- Notify the VDEQ in writing within seven days. The notification must indicate which chemical or hazardous constituents have shown evidence of contamination.

- At the discretion of NASA, immediately sample at those sampling points for the constituents detected and confirm which constituents are present and at what concentration. Sampling will also include a determination of horizontal extent by trending out in all four compass directions (north, south, east and west) at a distance as close as practicable to 20 feet in each direction from the point of original detection.

- Within 90 days, if the contamination is confirmed, NASA will submit a proposed interim measure corrective action work plan.

ATTACHMENT II.D

SECURITY PROVISION AND PROCEDURES TO PREVENT HAZARDS

ATTACHMENT II.D -SECURITY PROVISION AND PROCEDURES TO PREVENT HAZARDS

II.D.1. Security

Security is provided at the entrance to the Main Base and the Mainland. To enter Wallops Island, security access must be granted at the Main Base. Entrance to Wallops Island operations is through the security gate located at the Mainland, approximately 13 kilometers (8 miles) south of the Main Base, and over the causeway crossing Cat Creek and coastal marshes. Security personnel are under contract to NASA and are trained by a NASA Security Office approved law enforcement program.

II.D.1.1. Security Procedures and Equipment

Upon entering Wallops Island, NASA has established security systems for rocket motor handlers. These security systems are applicable to the Open Burn (OB) Area. Security systems are outlined in NPR 1600.1 NASA Protective Services Program Requirements and GPR 1600.1 GSFC Protective Services Program Requirements. Security procedures include employee and visitor identification procedures, measures for receiving and control, and general security police orders. Physical security includes fencing along land access routes, security patrols, a badge identification system, and employee training certification for rocket motors.

II.D.1.1.1. 24 Hour Surveillance System

NASA provides 24-hour security for the Wallops Island and Mainland facilities. The security gate is manned with a 24-hour standing and roving patrol, who conduct a visual check on buildings and structures.

II.D.1.1.2. Barrier and Means to Control Entry

Entry to Wallops Island is by way of a two-lane causeway from the Mainland. The location of the security gate on the Mainland and causeway is shown in Figure II.AA-7. The Atlantic Ocean and several creeks and marshes serve as natural water barriers. Badges are required for all personnel and visitors for admission to the Island. Badges of different types designate the necessity of an employee's presence in a building. Buildings/areas are placarded with applicable entry procedures. Regardless of the badge type, all employees who work with rocket motors are under the supervision of the Range Safety Officer, who has complete control of the Range. These employees have passed a range safety training course requiring certification as outlined in Attachment II.E - Personnel Training.

Warning lights are located on Wallops Island along the access road and at the end of the causeway to control vehicular traffic. A red light requires all vehicles to stop at

the designated point. Roadblocks are used to control access to areas within the Island. Unmanned roadblocks are not to be violated under any circumstances and serve as danger warnings.

Warning signs are located on structures to indicate limited access by certified personnel. The signs are in accordance with the procedures outlined in the United Nations document "Transport of Dangerous Goods, " Department of Defense (DoD) 6055.9 "Ammunition and Explosive Safety Standards, " and NASA-STD-8719.12 "Safety Standard for Explosives, Propellants, and Pyrotechnics." The warning signs are located on all visible angles of approach and are classified as follows:

- "Class 1, Division 1" on an international orange, octagonal-shaped sign, denotes the presence of DoD hazard class/division 1.1 explosives, which present a blast hazard primarily and can be expected to mass detonate when involved with fire.

- "Class 1, Division 2" on an international orange, X-shaped sign, denotes the presence of DoD hazard class/division 1.2 explosives, which present both a blast and fragment hazard.

- "Class 1, Division 3" on an international orange, triangular sign, denotes the presence on DoD hazard class/division 1.3 explosives, which present primarily a mass fire hazard.

- "Class 1, Division 4" on an international orange, rectangular sign, denotes the presence of DoD hazard class/division 1.4 explosives, which present primarily a moderate fire hazard.

"Dangerous - Unauthorized Personnel Keep Out" signs are displayed in addition to the explosives warning signs. A "Danger - Unauthorized Personnel Keep Out" sign is also posted at the OB Area.

II.D.1.2. Waiver

A waiver from the security requirements is not applicable to Permit.

II.D.2. Inspection Schedule

General inspections are routinely performed on buildings and structures located on Wallops Island. These inspections include the OB Area and related facilities. Roving security patrol on the Island check for unauthorized entry onto the facility and report obvious building damage when it is encountered. The fire department performs fire drills and water supply systems inspections on a semi-annual schedule. Unplanned fire drills are also used to ensure proper preparation of fire-fighting capabilities on the Island. Prior to each semiannual OB groundwater monitoring event, the condition of monitoring wells and OB structures are noted in the site field book. In addition, OB

subunits and pad assembly are inspected prior to each burn. A Post Burn Inspection is also conducted; refer to Attachment II.C Inspection Schedule.

II.D.2.1. Types of Problems

The OB Area is located on a remote part of the Island. An inspection of the area is performed prior to OB operations to determine if the subunits are in a vertical position and in sound shape to support the rocket motor with waste propellant. A visual inspection of the pad is also performed. Four subunits and one burn pad are available for OB operation. In the event a subunit is determined unfit for OB, one of the other subunits is used to support the rocket motor. In the event the burn pad is determined unfit for OB, the pad is not used until necessary repairs are made.

Rocket motors are inspected prior to, and after shipping to OB. This ensures that the rocket motor's integrity is not compromised in any way that could lead to an unplanned explosion or other release of waste constituents. The inspection also includes a survey of personal protective equipment, calibration of equipment, malfunctions, and weather conditions.

Groundwater monitoring equipment will be inspected prior to well purging for each groundwater monitoring sampling event.

II.D.2.2. Frequency of Inspections

An equipment/site inspection log has been incorporated into the work instructions developed for the static firing of rocket motors. The work instruction identifies equipment associated with the OB process. Prior to any operation involving ordnance disposal at WFF, the site designated for hazardous waste disposal shall be inspected to detect any possible deterioration of equipment. The following will also be inspected (a) rocket motors, (b) monitoring equipment's calibration, (c) safety and emergency equipment, and (d) other devices to be utilized during the operation. The inspection includes date, weather conditions, notations of any observations, and nature of corrective actions, if any. OB personnel shall maintain the log for a minimum of 3 years, from the date of inspection. A copy of all inspections will be kept at Building X-55 General Services in the OB record storage area.

The frequency of inspections is based upon the number of OB operations. Inspections are made prior to any thermal treatment of rocket motors. Any deterioration or malfunction is corrected prior to thermal treatment.

II.D.3. Preparedness and Prevention Documentation

A waiver from the requirements of 40 CFR § 270.14(b)(6) is not part of this Permit. Documentation of NASA's preparedness and prevention requirements for open burning are described in the following sections.

II.D.3.1. Equipment Requirements

II.D.3.1.1. Internal Communications

The communication equipment at the OB Area consists of hand-held, two-way FM radios, which are on a radio net monitored by the Security Office, the Range Safety Office, the Fire Department, and the Health Unit. A telephone is located at Building Z-40, approximately 1.6 kilometers (1.0 miles) from the OB barricade.

II.D.3.1.2. External Communications

A telephone at Building Z-40 serves as the external communication equipment to summon emergency personnel other than the fire department. Access to outside lines is available through this telephone. Hand held radios used at the site have access to the Emergency Console. In addition OB personnel have cell phones available for use. The Emergency Console will summon emergency personnel from WFF Main Base or off facility emergency units if needed.

II.D.3.1.3. Emergency Equipment

During open burn operations, the fire department is on stand-by status. As described in Attachment II.F - Contingency Plan, the fire department for WFF is available for emergency operations. Portable fire extinguishers are located on vehicles used to transfer rocket motors for open burning. WFF also maintains agreements with local police, fire, emergency response, and hospitals. Documentation of arrangements can be found in Attachment II.F – Contingency Plan.

II.D.3.1.4. Water for Fire Control

The Fire Department on Wallops Island consists of 1 Structural Pumper fire truck with a total capacity of 2,839 liters (750 gallons) of water and 227 liters (60 gallons) of foam. On the Island, three water storage towers 56,781, 189,270, and 189,279 liters (150,000, 50,000 and 50,000 gallons) provide water to a water hydrant system maintained at 5300 liters per minute at 19 kilograms per square centimeter (1,400 gallons per minute at 42 pounds per square inch). In addition, a 378,541 liter (100,000 gallon) storage tank located on the mainland provides water to the Island. The closest water hydrant to the OB Area is located approximately 609 meters (2,000 feet) away at the Virginia Commercial Spaceport. Hydrant flow tests are performed annually by the fire department to ensure the water supply system is functioning properly. Structural Pumper fire trucks are used at the open burning area that can pump 1250 gallons per minute. In the event additional capacity is needed, 3 fire trucks are available from the Main Base which can provide 34,068 liters (9,000 gallons) of water and 4,542 liters (1200 gallons) of AFFF foam pumping at a rate of 2000 gallons per minute.

II.D.3.2. Aisle Space Requirement

Aisle space requirements are more than adequate for the outdoor thermal treatment at the OB Area. Sufficient space is available between the subunits and burn pad for inspection and maintenance purposes. Emergency equipment may reach the OB Area from the access roadway.

II.D.4. Preventative Procedures, Structures, and Equipment

The following subsections describe the procedures, structures, or equipment used at the OB Area to comply with the requirements of 40 CFR § 270.14(b)(8).

II.D.4.1. Unloading Operations

NASA vehicles transport rocket motors to the OB Area, in original packing containers. Vehicles are required to meet the requirements of DoD Form 626, and Wallops Institutional Consolidated Contract (WICC) work instruction WWI-15-00.2 Local Transportation of Class 1 Explosive Material which require emergency equipment, suitable transport, and certified drivers. All drivers transporting rocket motors must hold a Commercial Driver's license with Hazardous Materials endorsement. All NASA motor vehicles used for transporting rocket motors to Wallops Island are inspected prior to loading to check for safe mechanical condition. Vehicles are equipped with spark arrestors, have wooden-lined back carriages to prevent accidental ignition, and are properly placarded with their explosive designations.

Large rocket motors (greater than 100 pounds) are transported in crated containers and are handled with a forklift. The motors are unpacked in reverse order of packing in preparation for open burning. Smaller rocket motors are containerized and placed in the wood-lined pickup truck. These are unpacked at the OB Area and prepared for OB.

II.D.4.2. Flood Proofing and Flood Protection Measures

The OB Area is located within the 100-year and 500-year floodplain; however, OB operations are not conducted during inclement weather conditions nor is waste stored at the OB Area. WFF OB personnel monitor weather conditions prior to each burn and have the flexibility to reschedule burning operations. In addition, hazardous waste is not taken to the OB Area unless weather conditions are favorable. Normal operations require the removal of ash, residue, and unburnable material and the covering of the subunits and pad at the conclusion of the burn, eliminating the possibility that waste is stored at the OB Area.

In the event of unforecasted rising water, OB operation will cease. Wastes will be removed, to a location where the wastes will not be vulnerable to flood waters.

Motors will be returned to the rocket motor storage building on Wallops Island, Building V-67, and stored with compatible materials. Residue and ash will be containerized and taken to Building U-81, less-than-90-day accumulation area and stored for less than 90 days. Rocket motors will be returned to their shipping containers prior to transport while residue or ash will be placed in closed labeled containers. There will be little to no chance of accidental discharge during movement. WFF personnel will be utilized to move hazardous waste to its storage location. Hazardous waste will be relocated in less than one hour from the start of the process. The Hurricane/Nor'easter Preparedness Plan for WFF, dated August 30, 2015, describes the timetable and procedures implemented to remove hazardous wastes prior to forecasted hurricane or severe nor'easter flood waters reaching the OB Area as:

CONDITION IV -- 72 HOURS TO TROPICAL STORM FORCE WINDS (>39 MPH)
Code 200 and SCSC FMD:

- Move hazardous waste to Mainland (250)

CONDITION III -- 48 HOURS TO TROPICAL STORM FORCE WINDS (>39 mph)
Code 200 and SCSC FMD:

- Inspect all hazardous waste storage sites for cleanup and secure storage (250)
- Inspect all hazardous material and waste containment areas for possible overspill/overflow during heavy rain periods (250)

The elevated terrain, in addition to the design of the subunits, 0.8 meters (2.6 feet) above the ground surface and 1.1 meters (3.5 feet) above the ground surface, provide protection from rising floodwaters. The pad has a 20 centimeters (8 inches) tall berm. Both the subunits and the pad are covered. No other flood proofing or flood protection measures are used or would be effective at the OB Area.

Potential scour or deposition of existing surface soils from floodwater movement may occur during high water flood events. Therefore, prior to resuming OB, a field inspection is performed to determine if the facility needs repairs. Necessary repairs to the units are made prior to use of the OB Area. Any loss of soil from around the units is replaced with a similar sandy soil from the island.

II.D.4.3. Run off

Migration of contaminants, from the OB Area during a rain event, is prevented by covered subunits and pad at the site. The subunits are covered and the pad is protected by a berm and cover.

Following each OB operation, the OB Area is inspected for ejected material. Ejected material and residue is reignited on the burn pad.

Runoff, which should not come in contact with contaminated media, is directed across the access road to the east and north and across vegetation to the south and west. Runoff is not collected and does not impact other drainage structures on the Island. Runoff from the OB Area infiltrates into the sandy soil surrounding the units.

Since the OB Area will not have a point source or a storm water collection system, a Virginia Pollutant Discharge Elimination System (VPDES) Permit is not required.

The OB Area lies west of the Atlantic Ocean at an elevation of +10.0 MSL, limiting high water from reaching the OB Area.

II.D.4.4. Water Supplies

The nearest water supply well is located on the Mainland approximately 4.3 kilometers (2.7 miles) from the OB Area. Runoff and infiltration from the site enter the Atlantic Ocean or brackish creeks and marshes surrounding the OB Area. This water is not a source of potable water for humans or animals.

II.D.4.5. Equipment and Power Failure

The OB operations have no permanent power requirements. Electric power failure will have no impact on OB at Wallops Island. OB activities are not performed in the event of electrical storms. OB activities in progress are immediately terminated whenever lightening is within 16 kilometers (10 miles) of the OB Area. In addition, buildings and areas containing rocket motors are vacated when the 16 kilometers (10 miles) distance is determined. The NASA weather station on the Main Base continuously tracks weather conditions at Wallops Island and notifies the Range Safety Officer when electrical storms are observed on radar.

II.D.4.6. Personal Protection Equipment

To prevent exposure of personnel to propellant contained in rocket motors, NASA provides personal protective clothing and equipment (PPE) to certified employees. Items available to employees include the following:

- Safety goggles and safety spectacles;
- Safety shoes;
- Non-static producing, fire resistant shop coat, coveralls, and gloves;
- Protective head gear;

- Face shields; and
- Wrist-stats.

Additional protection of employees is provided by the fiberglass barricade located 381 meters (1250 feet) from the OB Area. The barricade serves as a shield to protect personnel from any potential escaping debris and gases. Ignition of the propellant does not occur until all personnel are located behind the barricade.

II.D.5. Prevention of Reaction of Ignitable, Reactive, or Incompatible Wastes

The waste propellants have been identified by EPA's hazardous waste identification criteria as reactive wastes. Propellants are reactive and are capable of an explosive reaction if subject to a strong initiating source or if heated under confinement (40 CFR § 261.23(a)(6)). As required by 40 CFR § 264.17(c), a source of published documentation that cites the reactivity of these wastes is provided in Dangerous Properties of Industrial Materials and Material Safety Data Sheets.

The WFF takes precautions to prevent the ignition or reaction of ignitable and reactive waste. For example, all storage and support activities for propellants are included in limited access areas at WFF. Information signs warning against smoking, the introduction of matches, and other flame-producing devices are displayed at all normally used limited area entrances. A "No Smoking" sign has been posted.

NASA has several operating procedures aimed at preventing ignition or reaction of the propellants. Sparks are avoided at rocket motor handling facilities by requiring all of the operating personnel to wear non-conductive shoes and wrist-stats when involved with propellant operations. Heat or spark producing, electrically powered, or impact tools required for OB preparation are permitted only with written permission.

These procedures ensure that the waste is separated and protected from sources of ignition or reaction from open flames, static, etc.

II.D.5.1. No-Fire Operation

In the event of No-Fire, all personnel will remain behind the barricade for 30 minutes. Further instructions are found in the Open Burning Procedure Work Instruction found in Attachment II.C.

ATTACHMENT II.E

PERSONNEL TRAINING

ATTACHMENT II.E - PERSONNEL TRAINING

II.E.1. Outline of Training Program

Personnel training programs for OB operations include rocket motor handling, contingency plan implementation, emergency response, and hazardous waste management. A major component of the training program is *Procedure and Guideline 8715.11 Training and Certification Procedures for Ordnance Handlers at GSFC/WFF* (Exhibit II.E.1). This procedure is intended to provide and assist managers and employees in safe OB operation practices and is administered by the Ordnance Training and Certification Committee (OTCC). The procedures set forth the policy for personnel who are assigned duties in handling rocket motors and complies with the requirements of:

- Executive Order 12196, "Safety and Health Programs";
- Subpart H of the "*Basic Program Elements for Federal Employees Occupational Safety and Health Programs*" under 29 CFR 1960.59; and

Employees that are certified in ordnance handling are the only individuals permitted to perform work on ordnance and rocket motor devices.

Initial HAZWOPER training is a federally required comprehensive 24 or 40-hour course, which instructs students in emergency response safety procedures and protocol during hazardous material releases. HAZWOPER training prepares the individual in emergency response and common work practice situations, which could result in accidental releases or could potentially affect human health and the environment. Personnel who are not 40 hour trained will not respond to emergencies at the OB Area and will not be required to wear level A personal protective equipment. In conjunction with initial 24 or 40-Hour HAZWOPER training, a federally required annual 8-hour HAZWOPER Refresher training is attended every year thereafter. The purpose of the 8-hour refresher training is to maintain a current and thorough knowledge of emergency response and safety procedures. Training also updates the individual's awareness in new technologies and/or response procedures to be used during hazardous material releases.

II.E.1.1. Job Titles and Duties

Personnel certified in the handling of ordnance and rocket motors are the principal individuals involved in the operation of the OB units. Three categories of ordnance training and 8 ordnance task codes are available and are as follows:

Categories:

- TL – Team Lead
- TM- Team Member
- IT – In Training

Ordnance task codes:

1. Hazard class 1.1 ordnance handler
2. Hazard class 1.2 ordnance handler
3. Hazard class 1.3 ordnance handler
4. Hazard class 1.4 ordnance handler
5. Shipping, logistics, transportation ordnance handler
6. Ordnance training instructor
7. Firing console ordnance handler
8. K-9 ordnance handler

Operators and technicians handling rocket motors will possess a minimum Category TM certification.

A request for ordnance certification training is initiated by submittal of completed Form GSFC 17-1, Request for Ordnance Training/Certification. The OTCC assures appropriate course content and delegates individual's certification instruction. The OTCC Chairman with recommendations from the OTCC, approves ordnance certification training programs, provides technical direction of the OTCC, and recommends certification of applicants to the Chief, Safety Office. The Chief, Safety Office shall certify applicants based on OTCC recommendations. Ordnance Certification cards are issued to operators and technicians upon successful completion of the certification program. The OTCC Secretary in Building E-107 is responsible for maintaining records for each individual certified to handle ordnance devices.

II.E.1.2. Training Content, Frequency and Technique

All current and future operators and technicians performing duties for rocket motor handling at the OB Area will complete the Ordnance Certification Training.

Recertification of ordnance and rocket motor handlers will be required every 3 years. New operators and/or technicians assigned to the facility will be required to complete all training requirements prior to performing work duties in the OB Area. Supervisors of OB operators, as well as the OTCC will participate in reviews of the initial and continuing training.

Training will be conducted in three phases: classroom lectures, hands-on training, and field experience. The ordnance training manual is included in Exhibit II.E-1. The field experience will involve the refurbishment of rocket motors, instruction on contingency planning, and residual material management.

This course will be taught by a Category TM certified individual or equivalent with ordnance task code of 6.

A comprehensive physical and medical health surveillance examinations will also be a part of the certification process conducted in accordance with 29 CFR 1910.120 [f]. Annual physical medical health surveillance examinations will be required each year thereafter. These physical examinations are also intended to determine an employee's fitness for using a respirator in accordance with 29 CFR 1910.134.

The Environmental Office representatives, who support the OB operation and designated OB personnel, are required to complete the initial 24-hour HAZWOPER training program. Eight-hour HAZWOPER Refresher training is required annually every year thereafter. Personnel who are not 40 hour trained will not respond to emergencies at the OB Area and will not be required to wear Level A personal protective equipment.

The initial and annual HAZWOPER course includes:

- Site safety planning – levels of protection
- Hazard recognition
- Toxic effects
- Safe work practices
- Anticipated hazards
- Handling emergencies and self rescue
- Rules and regulations for vehicle use

- Employee rights and responsibilities
- Containerizing and transporting hazardous materials
- Respiratory protection and levels of personal protective equipment
- Use, care and limitations of personal protective equipment
- Personal and equipment decontamination
- Contingency planning and implementation
- Proper sampling techniques and documentation

Certified instructors will teach Hazwoper initial and refresher training.

Resource Conservation and Recovery Act (RCRA) Hazardous Waste classes and Integrated Contingency Plan classes are required to be taken annually by all hazardous waste generators and Treatment, Storage, or Disposal Facility operators at WFF. Environmental Office representatives, who have a minimum of 3 years' experience in their field, and who have taken advanced classes in their subject area, give these classes.

The RCRA Hazardous Waste class includes:

- Hazardous waste management procedures
- Emergency procedures
- Contingency plan implementation
- Waste minimization/pollution prevention

All training requirements for personnel associated with the OB Area will be completed within six months of their employment date and before working at the OB Area.

II.E.1.3. Program Director

An environmental coordinator will be responsible for oversight and review of environmental activities, training, hazardous waste management, emergency technical assistance, and compliance. The environmental coordinator is required to be an engineer, with 2 years of environmental management experience or equivalent.

II.E.1.4. Relevance of Training to Job Position

Employees will receive training within the scope of their specific job positions that will include: site orientation; hazardous waste management; and contingency plan training. Employees responsible for OB activities, including supervisors, will be trained in ordnance and rocket motor handling and in recognizing safety and health hazards in the workplace. Training will include all aspects of handling, transport, ignition or detonation, propellants, igniters, and residuals. Training will be reviewed annually.

II.E.1.5. Training for Emergency Response

The applicable requirements of this section are the procedures for using, inspecting, repairing and replacing facility emergency and monitoring equipment, response to fires, explosions, sudden and non-sudden releases associated with residuals. The general requirements for these are outlined in OB (Integrated) Contingency Plan training, HAZWOPER training, and the NASA Basic Explosive Safety training. OB personnel will initially and in conjunction with the course refresher cycle be trained on these elements. In addition, the Ground Safety Group prior to any potentially hazardous operation or launch conducted at WFF prepares a Ground Safety Plan. The WFF training programs are designed to promote effective staff response to emergencies through awareness of correct operating procedures, appropriate equipment, emergency systems, communication, and alarm systems. Training on procedures is received during the employee's site orientation. Response to fires, explosions and releases will be provided by the WFF fire department, with additional support available from local community volunteer fire departments within the proximity or region of WFF. The WFF fire department personnel are trained as first level emergency responders and are on-site during actual OB activity. The Fire Chief and all captains attend WFF annual OB (Integrated) Contingency Plan training offered by the WFF Environmental Office and annually review the WFF OB Area Contingency Plan. This training includes training on identifying potential sources of groundwater contamination, and how to respond to potential groundwater contamination incidents. A copy of these sign-in sheets will be placed in the OB Area Operating Record

II.E.2. Implementation of Training Program

New employees receive training through lectures and handout materials during orientation. The orientation information is available through the employee's supervisor. Newsletters and other information are distributed to employees on a regular basis. Personnel assigned to OB operations will successfully complete Ordnance Certification and training on contingency planning prior to working in the OB Area. Rocket motor handlers cannot work without direct supervision from ordnance trained and certified employees until they are certified. Designated

personnel will obtain HAZWOPER certification prior to assignment. All drivers must have commercial driver's licenses with Hazardous materials endorsement before they are allowed to transport rocket motors. All training requirements for personnel associated with the OB Area will be completed within six months of their employment date and before working at the OB Area.

Records and certifications for OB personnel regarding health, safety, and security are maintained in the following locations: Health Office, Building F-160; Safety Office, Building E-107; and Security Office, Building F-160.

EXHIBIT II.E-1: TRAINING AND CERTIFICATION PROCEDURES FOR ORDINANCE HANDLERS

Goddard Procedural Requirements (GPR)

DIRECTIVE NO.	GPR 8715.11	**APPROVED BY Signature:**	*Original Signed by*
EFFECTIVE DATE:	November 10, 2015	**NAME:**	William A. Wrobel
EXPIRATION DATE:	November 10, 2020	**TITLE:**	Director of Wallops Flight Facility

COMPLIANCE IS MANDATORY

Responsible Office: 803/Safety Office

Title: Training and Certification Procedures for Ordnance Handlers

PREFACE

P.1 PURPOSE

Operations involving handling of explosive (ordnance) devices are conducted at the Goddard Space Flight Center (GSFC), including the component facilities, as well as, other sites designated for GSFC approved programs and projects. These ordnance devices are potentially hazardous if not handled properly.

NASA requires all personnel handling explosive devices to be trained and certified. This directive identifies the training and certification process and requirements by which personnel become certified ordnance handlers.

P.2 APPLICABILITY

This procedure is applicable to all GSFC personnel including contractors who are required to handle explosive devices in execution of their work duties at GSFC, including other sites designated for GSFC approved programs and projects.

Personnel visiting GSFC and other sites designated for GSFC approved programs and projects to conduct operations shall either submit satisfactory evidence of the required skills and knowledge to the Ordnance Training and Certification Committee (OTCC) or become certified by the OTCC. Ordnance handling certifications from other ranges or facilities will normally qualify as an acceptable demonstration (i.e., military certifications, NAVSEA certifications etc.) of the required skills and knowledge, but need to be approved by the OTCC prior to the handling of ordnance (See Section 2d, Certification-by-Equivalency). Explosive ordnance disposal personnel and law enforcement personnel handling ammunition are exempt when qualified by formal training or certifications acceptable (certifications by equivalency) to the OTCC.

P.3 AUTHORITIES

NPR 8715.3, NASA General Safety Program Requirements
NASA-STD-8719.12 Safety Standards for Explosives, Propellants, and Pyrotechnics

P.4 APPLICABLE DOCUMENTS

NPR 1800.1, NASA Occupational Health Program Procedures
GPD 8715.1, Goddard Space Flight Center Safety Policy
GSFC 17-1, Request for Ordnance Training/Certification

P.5 CANCELLATION

800-PG-8715.0.2D, Training and Certification Procedures for Ordnance Handlers at GSFC/WFF

P.6 SAFETY

N/A

P.7 TRAINING

See Section 4 Certification Requirements

P.8 RECORDS

Record Title	Record Custodian	Retention
Request for Ordnance Training/Certification form, GSFC 17-1 (completed by applicant)	OTCC Secretary	*NRRS 3/33C. Destroy or Delete 5 years after separation of employee or when no longer needed, whichever comes first.
Applicant's resume of ordnance handling experience	OTCC Secretary	NRRS 3/33C
Applicant's ordnance handling course data and test results	OTCC Secretary	NRRS 3/33C
Ordnance Handler Violations w/Actions	OTCC Secretary	NRRS 3/33C

**NRRS 1441.1 – NASA Records Retention Schedules*

P.9 MEASUREMENT/VERIFICATION

N/A

PROCEDURES

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

1. AUTHORITIES AND RESPONSIBILITIES

The Ordnance Training and Certification Committee (OTCC) consists of individuals from various organizations who have direct interaction with explosive handlers and a firm understanding of safety precautions involved with handling explosives.

The OTCC's membership is appointed by the GSFC Explosive Safety Officer (ESO) and concurred by the WFF Director and the GSFC Director. There are no term limits. The OTCC's function is to evaluate and approve/reject applicants applying for ordnance handler certification, as well as developing or approving training programs for ordnance handlers.

a. Chairman, OTCC - Responsible for the technical direction of the OTCC. The Chairman, with recommendations from the OTCC, shall review and approve ordnance certification training programs that meet the requirements of this GPR. The Chairman has the authority to authorize an extension up to three months if needed for individuals who have not had any recent refresher training.

b. Secretary, OTCC - Responsible for maintaining records for each individual certified to handle ordnance devices. The Secretary is also responsible for advising the ordnance handler's immediate supervisor or contract program manager when certification is about to expire (90-day certification renewal notice).

c. Immediate Supervisor - The applicant's immediate supervisor or contractor program manager is responsible for initiating the request for ordnance training/certification and for certifying the accuracy of all data or medical information provided in support of the application. This documentation will be submitted to the applicant's approving official.

d. Approving Official - The applicant's approving official (Branch Head/Office Chief equivalent, or Contracting Officer's Representative (COR)) is responsible for approving the submittal of the Request for Ordnance Training/Certification (GSFC 17-1), to the OTCC.

e. GSFC Health Units and/or Medical Organizations –
(1) At GSFC/WFF, all ordnance handlers can obtain physical examinations from the WFF Health Unit.

(2) At GSFC/Greenbelt, civil servants can obtain physical examinations from the Center Medical Director. Contractor personnel will obtain exams from external medical sources.

(3) At other GSFC component facilities, civil servants will obtain physical examinations from the Code 250 designated medical provider and contractors from an external medical source.

2. ORDNANCE CERTIFICATION CLASSIFICATIONS

Ordnance certification consists of the following classifications:

a. Team Member (TM) - Personnel shall have knowledge of the basic ordnance safety precautions pertaining to the ordnance task and associated explosive devices as defined by the ordnance task codes. (See Section 3 for description of task codes).

b. Team Leader (TL) - Personnel shall possess all the qualifications identified for a TM, as well as the capability to direct Team Members in the performance of safe and reliable operations.

   Additionally, the TL shall have a minimum of three years of experience, within their given task code, and demonstrate proficiency with ordnance configurations within their assigned discipline.

c. In-Training (IT) – Personnel that have completed classroom instruction and the hands-on portion of ordnance training. The IT classification also applies to personnel that have no adequate explosive handling experience concerning the explosive operations and risk involved and/or newly certified personnel who require supervision during ordnance handling operations. IT personnel shall have mandatory direct supervision and can only perform the function for which he/she is being certified to do while under the supervision of an individual who is certified. IT classified personnel typically retain an IT classification for a period of one year prior to applying for a certification upgrade.

d. Certification-by-Equivalency (CBE) – Personnel have provided adequate information in order to receive ordnance certification similar to their current certification outside of GSFC:
   1) Description of relevant training (with dates)
   2) Description of experience relevant to operations to be performed (with dates)
   3) A statement from a physician stating that the applicant's health is adequate (with date)

   The restrictions implemented by the external certifying organization will be applicable. CBE classified personnel retain a CBE classification for a period of one year due to the annual physical examination requirements.

3. ORDNANCE TASK CODES

Ordnance task codes define the responsibility of the certified individual including the type of ordnance which can be worked on. Ordnance task codes consist of the following per NASA-STD-8719.12:

a. Code 1, Ordnance Hazard Classification 1.1 - Responsibilities included handling, assembly/disassembly, installation/removal, arming/de-arming, inspection and storage.

b. Code 2, Ordnance Hazard Classification 1.2 - Responsibilities include handling, assembly/disassembly, installation/removal, arming/de-arming, inspection and storage.

c. Code 3, Ordnance Hazard Classification 1.3 - Responsibilities include handling, assembly/disassembly, installation/removal, arming/de-arming, inspection and storage.

d. Code 4, Ordnance Hazard Classification 1.4 - Responsibilities include handling, electrical testing, installation/removal, arming/de-arming, inspection and storage.

e. Code 5 - Responsibilities include logistics, transportation, loading/unloading, inventory and storage of all hazardous classifications of ordnance.

f. Code 6 - Responsibilities include instruction of both classroom and hands-on training for all ordnance handlers.

g. Code 7 - Responsibilities include knowledge of firing circuits, safeguards, launch sequencing, launch vehicle hardware, and requirements/procedures involving hang-fires and misfires.

h. Code 8 - Ordnance Hazard Raw Explosives - Responsibilities included handling, inspection and storage of raw explosives in support of K-9 training, protective services training or other requirements as needed. At a minimum, training should include knowledge and procedures for handling raw explosives.

4. CERTIFICATION REQUIREMENTS

The Ordnance Certification Program includes as a minimum an OTCC approved formal training program and a demonstration of applicant's proficiency in handling ordnance devices in a safe and reliable manner. The OTCC establishes various limitations via the ordnance card which will be strictly adhered to by all programs and organizations.

To obtain ordnance handler certification through the OTCC, all applicants shall:

4.1 Provide justification for the need to handle ordnance in the execution of their job duties or responsibilities.

4.2 Complete the Request for Ordnance Training Certification form (GSFC 17-1). The data contained on this form shall be used by the OTCC to determine whether or not the candidate has satisfied the certification requirements.

4.3 Provide current documentation showing that the applicant has been properly trained in standard ordnance handling safety practices. The OTCC shall approve the contents of the pyrotechnics safety training courses or conduct (lead) the training courses associated with the NASA Basic Explosive Class including:

a. Basic Principles of Explosives Safety
b. Transportation and Storage Requirements
c. Radio Frequency Hazards
d. Electro-Static Discharge Hazards
e. Basic Initiator Circuits

The supervisor or contractor program manager shall request training from the OTCC for new ordnance handlers and recertification candidates.

The OTCC shall ensure that a written/oral exam covering the course items (a through e above) is achieved by the applicant. Seventy-five percent (75%) correct is considered passing.

4.4 Have knowledge of the systems and procedures they are required to use and shall ensure that only NASA approved procedures are being followed.

The supervisor, contractor program manager or system engineer's statement of training and knowledge shall be used to evaluate this element.

4.5 Have demonstrated through on-the-job training, direct experience, or by "classroom demonstration" that they are proficient in ordnance handling techniques. For personnel requesting recertification, documentation showing adequate explosive handling experience concerning the explosive operations and risk involved or refresher training within the most recent certification period shall be provided.

Before the OTCC will recertify an "In Training" certification, a certified ordnance handler specifically a Team Leader (TL) or Team Member (TM) with a minimum of three years' experience in the same discipline shall sign-off on satisfactory demonstrations of hands-on experience.

4.6 Demonstrate through a certification provided by a licensed medical provider that they possess no disqualifying health problems by undergoing an annual physical exam. All ordnance handlers shall obtain physical exams in accordance with the requirements of Appendix C of NPR 1800.1, NASA Occupational Health Program Procedures. The OTCC should not be provided any specific medical documentation or information. Any medical information inadvertently provided to the OTCC will be transmitted to the WFF Health Unit, or the Center's Medical Director.

For personnel who have demonstrated a need to handle ordnance devices in execution of their normal duties and who cannot satisfy all of the requirements (Section 4.3 through 4.5) an In-Training (IT) Certification may be issued after completion of Section 4.3 (a through e). IT Certifications shall restrict the applicant to only handling specific ordnance devices under the direct supervision of a certified ordnance handler either a TL or a TM.

For personnel who have demonstrated a need to handle ordnance devices in execution of specific project duties and are certified via another entity, a Certification-by-Equivalency (CBE) may be issued and approved by the OTCC. The restrictions implemented by the original certifying organization will be applicable when certified as CBE. For CBEs, the following information needs to be provided and the certification is valid for one year:

a. Description of relevant training (with dates)
b. Description of experience relevant to operations to be performed at GSFC (with dates). The ordnance handling experience shall have occurred within the last 12 months.
c. A statement from a physician stating that the applicant has undergone a physical within the last year and the applicant's health is adequate such that the applicant can perform the ordnance work as described in NPR 1800.1.

Personnel desiring to upgrade or remove restrictions from their certification may do so at any time during their certification period by completing and submitting the Request for Ordnance Training/Certification Form (GSFC 17-1) to the OTCC with appropriate justification.

5. CERTIFICATION PERIOD

Ordnance handler certifications are valid for a period of 3-years from the date of certification with the exception of IT or CBE as mentioned in Section 2.

6. VIOLATIONS

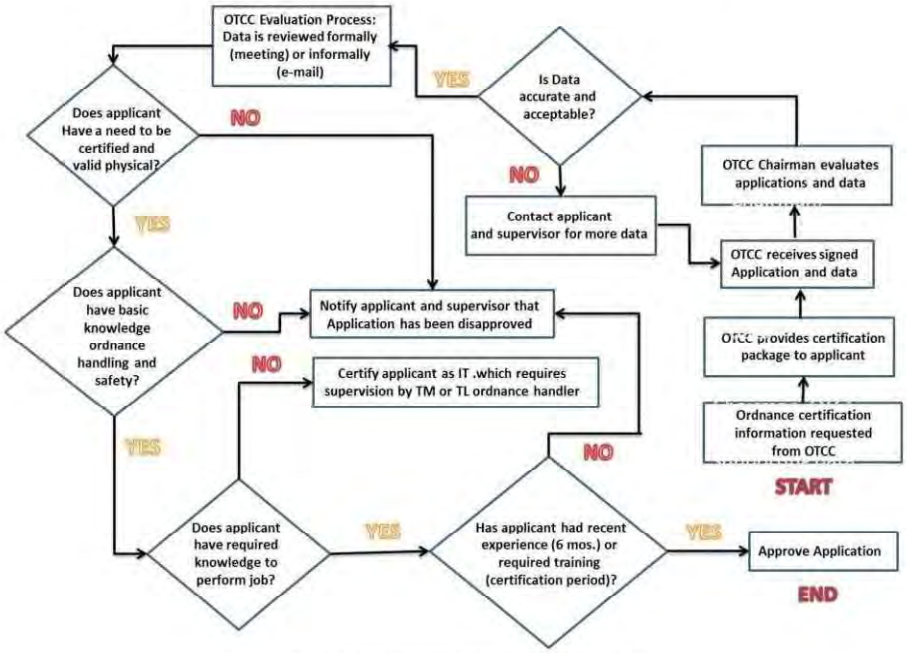
All violations of the requirements for maintaining or obtaining an ordnance certification for a certified ordnance handler shall be reported to the OTCC and will require immediate corrective action by the OTCC. The action will be determined by the severity of the violation. Listed below are examples of possible violations and the resulting corrective actions.

❖ Violation of procedures:	- 30-60 day suspension of certification, will attend refresher training. - Civil servant - an ordnance statement of violation is sent to the offender's Supervisor. - Contractor - an ordnance statement of violation is sent to the offender's Contracting Officer's Representative (COR).
❖ Misconduct (horseplay, pranks):	Civil Servant – an ordnance statement of violation is sent to the offender's Supervisor; suspension of certification until a comprehensive evaluation of incident is completed. Contractor – an ordnance statement of violation is sent to the offender's COR; suspension of certification until a comprehensive evaluation of incident is completed.
❖ Errors and Omissions:	Corrective action determined by majority of OTCC members. Could result in no action required **or** a written warning.
❖ Repeated violations or under the influence of alcohol or drugs:	Permanent suspension of ordnance handling privileges.

All violations and actions will be documented in the records of the OTCC.

7. FLOW DIAGRAM OF CERTIFICATION PROCESS

The following flow diagram depicts the process employed by the OTCC to evaluate and certify personnel to handle ordnance devices:


OTCC Evaluation Process: Data is reviewed formally (meeting) or informally (e-mail)
YES
Is Data accurate and acceptable?
NO
Contact applicant and supervisor for more data
OTCC receives signed Application and data
OTCC Chairman evaluates applications and data
OTCC provides certification package to applicant
Ordnance certification information requested from OTCC
START
Does applicant Have a need to be certified and valid physical?
NO
YES
Does applicant have basic knowledge ordnance handling and safety?
NO
Notify applicant and supervisor that Application has been disapproved
NO
Certify applicant as IT .which requires supervision by TM or TL ordnance handler
YES
NO
Does applicant have required knowledge to perform job?
YES
Has applicant had recent experience (6 mos.) or required training (certification period)?
YES
Approve Application
END

Appendix A – Definitions

N/A

Appendix B – Acronyms

CBE	Certification by Equivalency
COR	Contracting Officer's Representative
ESO	Explosive Safety Officer
GSFC	Goddard Space Flight Center
IT	In-Training
OTCC	Ordnance Training and Certification Committee
TL	Team Leader
TM	Team Member
WFF	Wallops Flight Facility

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	November 10, 2015	Initial Release. This GPR cancels the 800-PG-8715.0.2D; same title, and widens the applicability to all of GSFC, as well as, the component facilities and GSFC responsible areas of operation.

EXHIBIT II.E-2: BASIC EXPLOSIVE SAFETY TRAINING

BASIC EXPLOSIVES SAFETY TRAINING

March 2015 (Updated)

COURSE INTRODUCTION

This course was developed and is maintained by the National Aeronautics Space Administration, NASA, Explosive Safety Officers, ESOs.

The course provides basic explosive safety training for personnel throughout NASA who are involved in handling, storage, transportation, and processing of explosives. This includes technicians, engineers, scientists, supervisors, and managers that will work, in some form, with or be in the presence of explosive/pyrotechnic systems, components, or explosive materials.

This instruction emphasizes the safety aspect of these operations, and is not intended to teach specific operations.

The principle of explosive safety is to expose the minimum number of people to the minimum quantity of explosives for the minimum period consistent with the operation being conducted.

TRAINING OBJECTIVES

- To familiarize each individual with the hazards and risks involved with explosive handling, storage, transportation, and processing.
- To iterate the precautions involved with explosive handling, storage, transportation, and processing.
- To provide an overview of the basic principles of explosive safety.
- To provide an overview of the fundamental requirements governing explosives.
- Review basic safety principles with emphasis on practical applications and adhere to NASA-STD 8719.12, NASA Standard for Explosives, Propellants and Pyrotechnics.
- Describe the characteristics, effects, and hazards of explosives, explosive devices and components.
- Understand various federal hazard classification systems for explosive and flammable materials.
- Understand the explosive hazard classification markings and fire symbols used in the explosive industry.
- Identify explosive compatibility groups including storage principles.
- Understand the nature of extraneous electrical energy and be able to apply protective measures.

Table of Contents

CHAPTER 1: CHARACTERISTICS OF EXPLOSIVES **8**

FIGURE 1: CLASSIFICATIONS OF EXPLOSIVES 8
FIGURE 2: VELOCITY OF COMBUSTION OF EXPLOSIVES 9
A. Low Explosives *9*
FIGURE 3: EXAMPLE OF LOW EXPLOSIVE TRAIN 9
FIGURE 4: TYPICAL DESIGN OF A SOLID ROCKET 11
FIGURE 5: LIQUID ROCKET MOTOR DESIGNS 12
FIGURE 6: SPACE SHIP ONE (HYBRID VEHICLE) 14
FIGURE 7: AIRCRAFT FLARE (LIGHT PRODUCING PYROTECHNIC) 15
FIGURE 8: BURNING THERMITE (HEAT PRODUCING PYROTECHNIC) 16
FIGURE 9: COLOR SMOKE GRENADES (SMOKE PRODUCING PYROTECHNIC) 16
FIGURE 10: 0.2 SECOND DELAY CARTRIDGE FOR EJECTION SEAT 17
FIGURE 11: IN-LINE DELAY ASSEMBLY 17
B. High Explosives *18*
FIGURE 12: EXAMPLE OF HIGH EXPLOSIVE TRAIN 18
C. Sensitivity *20*
D. Stability *20*
E. Reactivity *20*
F. Toxicity *21*
TABLE 1: TOXICITY OF SOME COMMON EXPLOSIVE MATERIALS 21

CHAPTER 2: EXPLOSIVE EFFECTS **22**

A. Blast Effects *22*
FIGURE 13: BLAST EFFECTS 23
B. Thermal Effects *23*
FIGURE 14: THERMAL EFFECTS (DETONATION) 24
FIGURE 15: THERMAL EFFECTS (DEFLAGRATION) 24
C. Fragmentation Effects *24*
D. Subsidiary Explosive Effects *25*
E. Ground and Water Shock *25*

CHAPTER 3: CLASSIFICATION SYSTEMS AND HAZARD DIVISIONS **26**

A. Hazard Classification *26*
FIGURE 16: HAZARDOUS MATERIALS CLASSIFICATION 26
I. Hazard Division (H/D) 1.1 / Mass Explosion *26*
FIGURE 17: HAZARD DIVISION 1.1 CLASSIFICATION SYMBOL 27
II. Hazard Division (H/D) 1.2 / Non-Mass Explosion, Fragment Producing *27*
FIGURE 18: HAZARD DIVISION 1.2 CLASSIFICATION SYMBOL 27
III. Hazard Division (H/D) 1.3 / Mass Fire *27*
FIGURE 19: HAZARD DIVISION 1.3 CLASSIFICATION SYMBOL 28
IV. Hazard Division (H/D) 1.4 / Moderate Fire – No Blast *28*
FIGURE 20: HAZARD DIVISION 1.4 CLASSIFICATION SYMBOL 29
V. Hazard Division (H/D) 1.5 / Very Insensitive Explosives *29*
FIGURE 21: HAZARD DIVISION 1.5 CLASSIFICATION SYMBOL 29
VI. Hazard Division (H/D) 1.6 / Extremely Insensitive Explosives *29*
FIGURE 22: HAZARD DIVISION 1.6 CLASSIFICATION SYMBOL 30
B. Compatibility Groups *30*
C. Inert Devices *32*

CHAPTER 4: STORAGE PRINCIPLES **33**

A. Compliance Requirements *33*
B. Storage Principles *33*
C. Mixed Storage *34*
TABLE 2: STORAGE COMPATIBILITY MIXING CHART 34

CHAPTER 5: FIRE AND CHEMICAL HAZARD SYMBOLS 37

A. Fire Protection *37*
FIGURE 23: NO SMOKING SIGN FOR EXPLOSIVE SITES 37
B. Fire Division Symbols *38*
FIGURE 24: FIRE DIVISION 1 SYMBOL 38
FIGURE 25: FIRE DIVISION 2 SYMBOL 39
FIGURE 26: FIRE DIVISION 3 SYMBOL 39
FIGURE 27: FIRE DIVISION 4 SYMBOL 40
C. Chemical Symbols *40*
FIGURE 28: CHEMICAL SYMBOL 40
D. Display of Fire, Chemical Symbols *41*
E. Firefighting Procedures *41*

CHAPTER 6: TRANSPORTATION OF EXPLOSIVES 43

A. General Transportation Requirements *43*
I. Training *43*
II. Vehicle Requirements *43*
B. Explosive and Pyrotechnics Shipment *44*
I. Packaging *44*
II. Documentation Requirements *45*

CHAPTER 7: PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT 46

A. General *46*
B. Clothing *46*
FIGURE 29: COVERALLS 47
C. Eye Protection *47*
FIGURE 30: SAFETY GLASSES 48
D. Hearing Protection *48*
FIGURE 31: HEARING PROTECTION 48
E. Static Dissipation *49*
FIGURE 32: WRIST STRAPS 49
FIGURE 33: CALIBRATED WRIST STRAPS TESTERS 49

CHAPTER 8: ORDNANCE EQUIPMENT 50

A. Igniter Circuit Testers *50*
I. Alinco *50*
FIGURE 34: ALINCO IGNITER CIRCUIT TESTER 50
II. Valhalla *51*
FIGURE 35: VALHALLA IGNITER CIRCUIT TESTER 52
III. Amptec-601ES *53*
FIGURE 36: VALHALLA IGNITER CIRCUIT TESTER 53
IV. Initiator Resistance Measurement Unit (IRMU) *53*
FIGURE 37: IRMU 54
B. Other Equipment *55*
I. Blasting Galvanometer *55*
FIGURE 38: BLASTING GALVANOMETER 55
II. Teledyne RISI FS-43 Exploding Bridge Wire (EBW) Firing System *55*
FIGURE 39: TELEDYNE RISI FS-43 EBW FIRING SYSTEM 56

III. Initiator Firing Unit (IFU) *56*
FIGURE 40: IFU 57

CHAPTER 9: STATIC ELECTRICITY, ELECTROSTATIC DISCHARGE, ELECTRICAL, EMR AND LIGHTNING PROTECTION 58

A. Static Electricity *58*
FIGURE 41: ESD EXAMPLE 58
TABLE 3: TYPICAL ELECTROSTATIC VOLTAGES FOR PRODUCTS AND ACTIVITIES 59
I. ESD Sensitivity *60*
II. Control Program Requirements *61*
III. Types of ESD Controls *62*
IV. Associated Hazards *63*
V. Prevention *64*
B. Relative Humidity *65*
C. Electromagnetic Radiation *65*
FIGURE 42: "NO RF ALLOWED" SIGN 65
D. Lightning Protection *66*
E. Electrical Storms *66*
FIGURE 43: ELECTRICAL STORM 67
F. Bonding and Grounding *68*

CHAPTER 10: SAFETY CONSIDERATIONS 69

A. Concurrent Hazardous Operations *70*
B. Emergency Procedures *70*
C. Personnel Limits *71*
FIGURE 44: EXPLOSIVE PLACARDING 71
D. Briefings *71*
E. Housekeeping *72*

CHAPTER 11: TYPES OF EXPLOSIVE SYSTEMS, COMPONENTS, AND DEVICES 74

A. Typical Explosives *74*
I. Electrical Initiators *74*
FIGURE 45: NSI 75
II. Mechanical Initiators *75*
FIGURE 46: MECHANICAL INITIATOR 76
III. Laser Initiators *76*
FIGURE 47: FLASH LAMP ROD LASER FIRING UNIT 77
FIGURE 48: DIODE LASER FIRING UNIT 78
FIGURE 49: LASER INITIATOR FIRING LINES 79
FIGURE 50: LASER INITIATOR DESIGN 80
B. Deflagrating Explosives *80*
I. Cartridges *80*
FIGURE 51: PRESSURE CARTRIDGE 81
II. Thrusters and Actuators *81*
FIGURE 52: BELLOWS ACTUATOR BA31K47 81
III. Cutters *81*
FIGURE 53: GUILLOTINE CUTTER 82
IV. Mortars *82*
FIGURE 54: MORTAR ASSEMBLY FOR APOLLO DROGUE CHUTE 83
V. Retractors and Pin Pullers *83*
FIGURE 55: PIN PULLER ATLAS 228-50000 / 1MT18CC 84
VI. Pyrotechnic Valves *84*
FIGURE 56: PYROTECHNIC OPERATED VALVES 84
VII. Separation Nuts *84*

FIGURE 57: SEPARATION NUT 85
VIII. Deflagrating Cords *85*
FIGURE 58: M700 SAFETY FUSE 86
C. Detonating Explosives *87*
I. Detonators *87*
FIGURE 59: NASA STANDARD DETONATOR 87
FIGURE 60: FRANGIBLE JOINT 88
FIGURE 61: EXPLOSIVE BOLT 89
II. Linear Explosives *89*
FIGURE 62: FCDC 90
FIGURE 63: MDC AND MDF 91
FIGURE 64: VARIOUS USES OF DETONATING CORDS 91
FIGURE 65: DETACORD 93
FIGURE 66: SHOCK TUBE 94
FIGURE 67: LSC / LSC WITH INITIATOR BLOCK 95
FIGURE 68: CSC 96

CHAPTER 12: DEFINITIONS, TERMS, AND ACRONYMS 97

Chapter 1: CHARACTERISTICS OF EXPLOSIVES

The term "explosive" or "explosives" includes any chemical compound of mechanical mixture which, when subjected to heat, impact, shock, friction, electrical energy, or other suitable stimulus, undergoes a very rapid chemical change with the evolution of a large volume of highly heated gases that exert pressure in the surrounding medium. Explosive materials contain their own oxygen and do not require atmospheric oxygen for combustion. Explosive materials can either detonate or deflagrate. During a detonation, the original volume of the explosive material increases approximately 10,000 times in about 30 microseconds with temperatures as high as 5,000 °C. Byproducts of the detonation are water, nitrogen, nitrogen oxides, carbon dioxide, carbon monoxide, and other complex gases. Some explosives can produce toxic vapors of metal or metal compounds, such as lead, antimony, and selenium. Smoke from a detonation should be considered a respiratory hazard. During deflagration, the explosive material burns evenly and at a uniform rate on all ignited surfaces. Additionally, gases and other combustion products flow away from the burning surfaces.

For this training, explosives can be classified into two basic categories: Low Explosives and High Explosives.

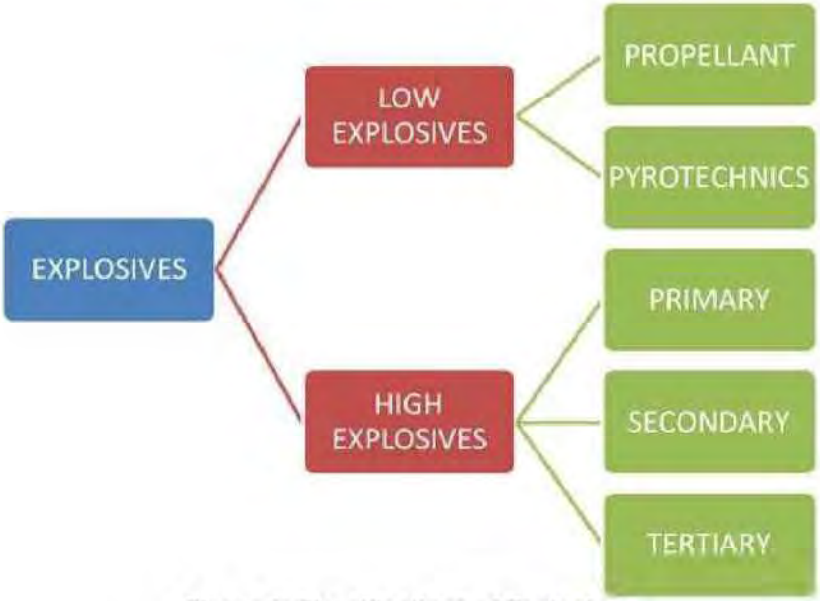


Figure 1: Classifications of Explosives

The difference between Low and High Explosives is the speed at which it burns. Both the Low and High Explosives burn; however, the High Explosive train also produces a shock wave.

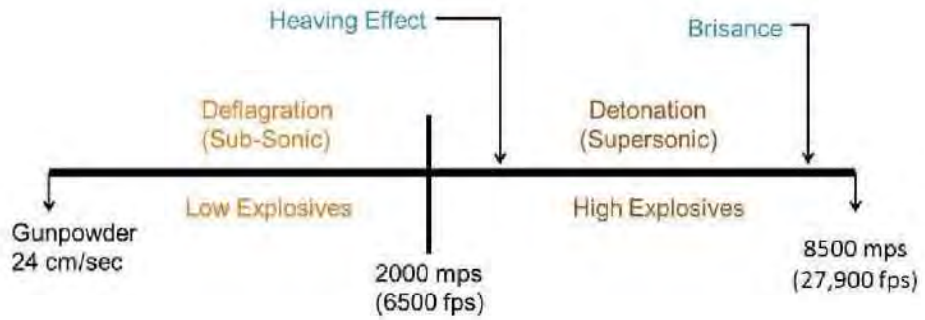


Figure 2: Velocity of Combustion of Explosives

A. Low Explosives

Low Explosives deflagrate, burn, under normal conditions which is basically unconfined. The burning action, while self-sustaining after initiation, proceeds at a slow rate. This burning rate is sub-sonic. Lower pressures are produced over a longer period of time. The burning rate is a function of pressure. Burn rate can be quite low, such as black powder time fuse burning at a few mm/sec at 1 atmosphere of pressure, or quite high, such as black powder confined at high pressure burning at 600 meters/sec.

Low Explosives are very sensitive to heat, shock, friction and electric spark.

Low Explosives are subdivided into two groups:

- Propellants – gun and rocket motors
- Pyrotechnics

The Low Explosive train is comprised of a highly sensitive explosive material called a primer and a second element that is less sensitive and is called a propellant. The output of a Low Explosive train is flame, gas, and particles.

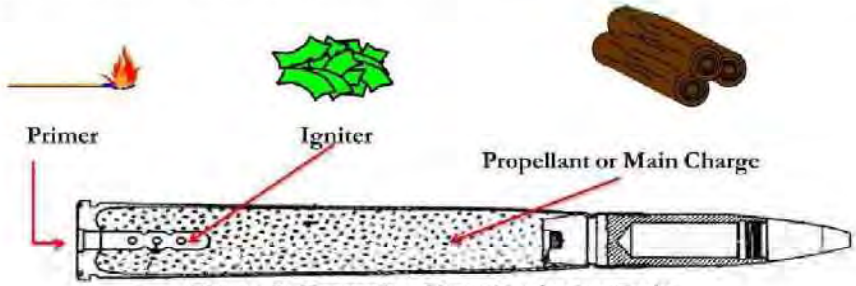


Figure 3: Example of Low Explosive Train

A basic low explosive train burns throughout its life, and is usually composed of three elements. These components are progressively larger and less sensitive. The primer may contain primary high explosives similar to those used in high explosive trains. They may contain a primer composition consisting of mixture of fuels and oxidants that are sensitive to stimuli such as impact, heat or spark. The stimulus causes the ignition. The igniter receives the initial fire from the primer and in turn ignites the propellant charge. The igniter contains a pyrotechnic mixture. The propellant (main charge) provides the final effect and may serve to propel a projectile from a cannon, power a rocket or missile, or perform some other function that requires a low explosive rather than a high explosive.

I. Propellants

Propellants are good gas producers and deflagrate (burn) rather than detonate. They are generally more stable and difficult to ignite. Black powder is the oldest known and most dangerous and sensitive propellant mixture. It was used to propel bullets and projectiles from guns, and as filler for other projectiles. It is still used today in igniters and as a pyrotechnic mixture in many explosive devices.

a. Gun Propellant

Beside black powder, gun propellants include, Single Based, Double Based, and Triple Based Propellants.

Single Based Propellants include Nitrocellulose as the primary ingredient. Nitrocellulose (also: cellulose nitrate, flash paper, flash cotton, guncotton, flash string) is a highly flammable compound formed by nitrating cellulose through exposure to nitric acid or another powerful nitrating agent. In addition to a stabilizer, such as Ethyl Centralite, single based propellants may contain inorganic nitrates, nitro-compounds, and non-explosive materials, such as metals, metallic salts, and dyes. IMR is considered a single-base propellant even though the formulation contains a small amount of nitroglycerin.

Double Base Propellants contain nitrocellulose and gelatinizer such as nitroglycerine. They also contain additives and a stabilizer.

Triple Base Propellants include Nitroguanidine as the major ingredient. The other two components are nitrocellulose and nitroglycerine. They also contain additives and a stabilizer. Nitroguanidine is a colorless, crystalline solid it is not flammable and is a low sensitivity explosive; however, its detonation velocity is high. It is used as a propellant (air bags), fertilizer, and as an explosive propellant. Nitroguanidine reduces the propellant's flash and flame temperature without sacrificing chamber pressure. These are typically used in large bore guns where barrel erosion and flash are particularly important to avoid. It also produces a lower flame temperature and a greater amount of gases.

b. Rocket Propellant

Rocket Propellant is chemical mixtures burned to produce thrust in rockets and consists of a fuel and an oxidizer. A fuel is a substance which burns when combined with oxygen producing gas for propulsion. An oxidizer is an agent that releases oxygen for combination with a fuel. The ratio of oxidizer to fuel is called the mixture ratio. Rocket propellants are classified according to their state. Solid rocket propellants are covered below and liquid and hybrid propellants are covered in additional sections.

Solid propellant motors are the simplest of all rocket designs. They consist of a casing, usually steel, filled with a mixture of solid compounds (fuel and oxidizer) which burn at a rapid rate, expelling hot gases from a nozzle to produce thrust. The fuel and oxidizer are usually mixed together during manufacture to form the propellant. When ignited, a solid propellant burns from the center out towards the sides of the casing. The shape of the center channel determines the rate and pattern of the burn, thus providing a means to control thrust. Once ignited, they will burn until all the propellant is exhausted. They are ideal for space propulsion because they utilize propellant that contains its own oxygen and can operate in and out of the atmosphere.

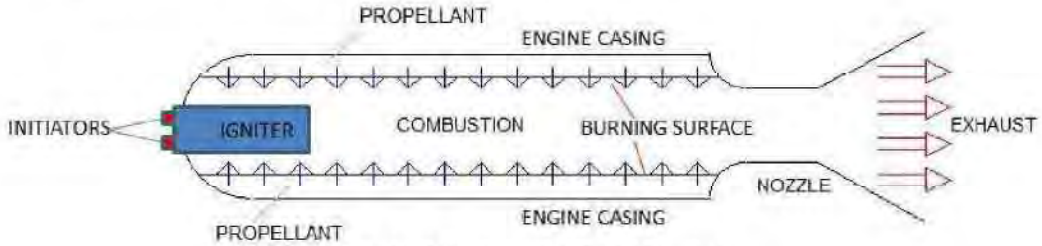


Figure 4: Typical Design of a Solid Rocket

c. Liquid Propellant

In a liquid propellant rocket, the fuel and oxidizer are stored sometimes in liquid form in separate tanks, and are fed through a system of pipes, valves, and pumps to a combustion chamber where they are combined and burned to produce thrust. The major components of liquid propellant engines are the propellants, flow controls, combustion chamber and nozzle, supporting structure and guidance mechanisms. Liquid propellant engines are more complex than their solid propellant counterparts; however, they offer several advantages. By controlling the flow of propellant to the combustion chamber, the engine can be throttled, stopped, or restarted.

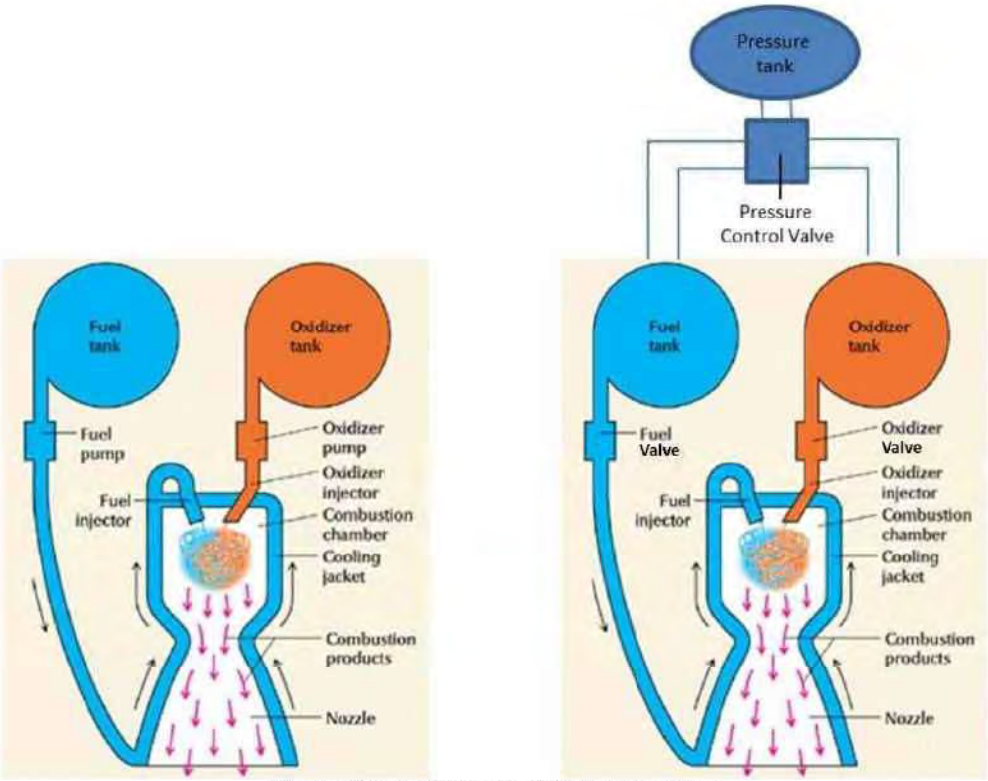


Figure 5: Liquid Rocket Motor Designs

Liquid propellants used in rocketry are classified into three types: petroleum, cryogens, and hypergols.

Petroleum fuels are those refined from crude oil and are a mixture of complex hydrocarbons, i.e. organic compounds containing only carbon and hydrogen. The petroleum used as rocket fuel is a type of highly refined kerosene, called RP-1 in the United States. Petroleum fuels are usually used in combination with liquid oxygen (LO_2 or LOX) as the oxidizer. RP-1 delivers a specific impulse considerably less than cryogenic fuels, but it is generally better than hypergolic propellants. LOX and RP-1 are used as the propellant in the first-stage boosters of the Atlas, Antares and Delta II launch vehicles. It also powered the first-stages of the Saturn 1B and Saturn V rockets.

Cryogenic propellants are liquefied gases stored at very low temperatures, most frequently liquid hydrogen (LH_2) as the fuel and LOX as the oxidizer. Hydrogen remains liquid at temperatures of -253°C (-423°F) and oxygen remains in a liquid state at temperatures of -183°C (-297°F). LOX and LH_2 were used as the

propellant in the high efficiency main engines of the Space Shuttle. Another cryogenic fuel with desirable properties for space propulsion systems is liquid methane (CH_4). When burned with LOX, methane is higher performing than state-of-the-art storable propellants but without the volume increase common with LOX/LH_2 systems, which results in an overall lower vehicle mass as compared to common hypergolic propellants. LOX/CH_4, like LOX/LH_2 is clean burning and non-toxic.

Hypergolic propellants are fuels and oxidizers that ignite spontaneously on contact with each other and require no ignition source. The easy start and restart capability of hypergols make them ideal for spacecraft maneuvering systems. Also, since hypergols remain liquid at normal temperatures, they do not pose the storage problems of cryogenic propellants. Hypergols are highly toxic and must be handled with extreme care. Hypergolic fuels commonly include hydrazine (N_2H_4), monomethyl hydrazine (MMH) and unsymmetrical dimethyl hydrazine (UDMH). Hydrazine gives the best performance as a rocket fuel, but it has a high freezing point and is too unstable for use as a coolant.

d. Hybrid Propellant

A hybrid propellant rocket represents an intermediate group between solid and liquid propellant rockets. One of the substances is solid, usually the fuel, while the other, usually the oxidizer, is liquid either LOX or sometimes nitric acid. The liquid is injected into the solid, whose fuel reservoir also serves as the combustion chamber. The main advantage of such engines is that they have high performance, similar to that of solid propellants, but the combustion can be moderated, stopped, or even restarted. It is difficult to make use of this concept for vary large thrusts, and thus, hybrid propellant rockets are rarely built. The below figure shows a hybrid engine that burns nitrous oxide as the oxidizer and HTPB as the fuel.

13

Figure 6: Space Ship One (Hybrid Vehicle)

II. Pyrotechnics

Pyrotechnic mixtures evolve large amounts of heat but much less gas than propellants or high explosives, the exothermic chemical reaction can be described as non-detonating, relatively slow, and self-sustaining. As with propellants, if confined, an explosion or detonation can occur. All pyrotechnic mixtures contain oxidizers and fuels. They may also contain binding agents, retardants, waterproofing agents and dyes. The oxidizer liberates oxygen or fluorine at high temperatures, thus sustaining the chemical reaction. Examples of oxidizers found in pyrotechnic mixtures are: Barium Nitrate, Potassium Perchlorate, and Strontium Peroxide. Finely powdered aluminum and magnesium are the most frequently used fuels in pyrotechnic mixtures. Red phosphorus, sulfur, boron, and silicon are also used. The ingredients are determined by the desired effect. Pyrotechnic devices are designed to create: heat, flame, light, smoke, signals, delays, noise, pressure, etc.

Pyrotechnics are divided into five major categories:

- Sound Producers
- Light Producers
- Heat Producers
- Smoke Producers
- Delay Producers

Sound Producers are primarily used in the fireworks industry and in military simulators. There are two types of sound producer pyrotechnics: a composition that produces a loud, short-duration sound and a composition that produces a shrill whistle of long duration.

Light Producers are divided into two subdivisions: flash powers and flares. Flash powders burn very rapidly, some almost bordering on detonation velocities. Flares, burn very slowly, and are used to produce sustained lighting for a variety of purposes, including signaling, and illuminating battlefields at night.

Figure 7: Aircraft Flare (Light Producing Pyrotechnic)

Heat Producers are pyrotechnics used for ignition mixes, thermites, sparks and incendiaries and heat pellets for thermally activated batteries.

Figure 8: Burning Thermite (Heat Producing Pyrotechnic)

Smoke Producers are subdivided into organic and inorganic type of pyrotechnics. Both forms of smoke producing pyrotechnics are used as markers, signals, and obscurants (tactically).

Figure 9: Color Smoke Grenades (Smoke Producing Pyrotechnic)

Delay Producers are pyrotechnic devices that use the controlled burning rate of a mix to create a predetermined time delay between the ignition event and the output.

Figure 10: 0.2 Second Delay Cartridge for Ejection Seat

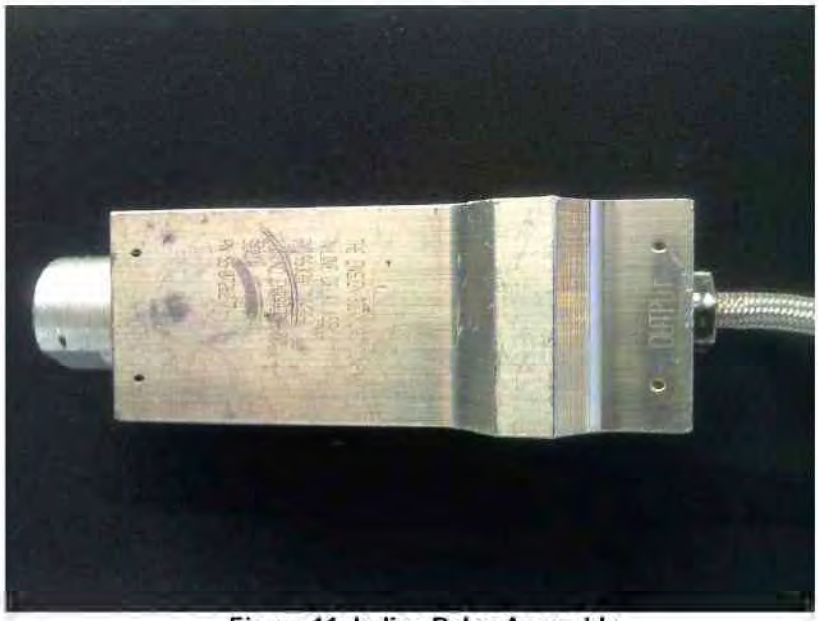


Figure 11: In-line Delay Assembly

B. High Explosives

High explosives are explosive materials that once initiated, normally produces a detonation. They are chemical compounds or mixtures that are capable of supporting or sustaining a detonation wave. Their main source of power is due to shock or shattering force instead of pressure. They cannot be initiated by spark or flame. However, they do burn when set on fire as this is a means of disposal.

High explosives are divided into three classes.

- Primary – Detonation very easily
- Secondary – Detonation more difficult
- Tertiary – Detonation most difficult

An example of a High Explosive train is shown below. The components are the primer, the detonator, the booster and the main charge.

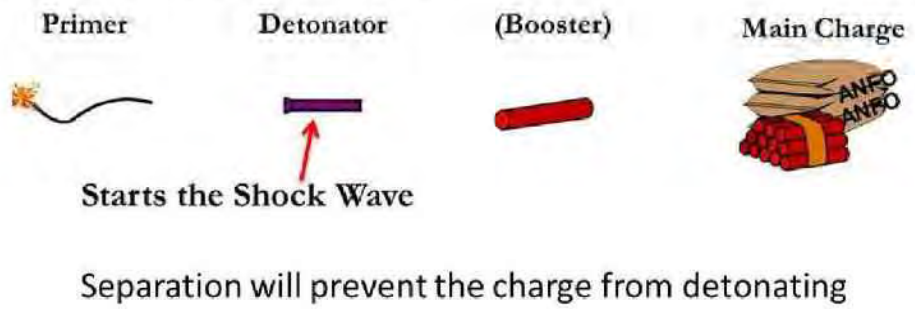


Figure 12: Example of High Explosive Train

Each element in the high explosive train is larger than the last. The primer also known as an initiator is a primary charge contained in a suitable housing capable of being activated by either a relatively small stimulus (electrical or mechanical) or a self-propagating reaction. The output of the primer consists of low velocity hot gases and particles. Percussion primers are initiated by impact. Electrical primers are initiated by applying electrical energy. The detonator is an intermediate charge of primary high explosives in which transition from burning to detonation occurs. A detonation (shock) wave is transferred to the next element. The booster is a secondary high explosive that intensifies the shock output from the detonator. This causes the main charge to be initiated. The main charge is another high explosive that has a high enough output to produce the desired effect.

III. Primary High Explosives

Primary high explosives when initiated can transform the deflagration process into a true detonation. They are very sensitive, thus can be easily initiated when subjected to

impact, shock, heat, friction or electrical energy. They are often used in small quantities as a primer to initiate secondary high explosives and other explosive material. Primary high explosives are much more sensitive than secondary high explosives.

Examples of Primary High Explosives:

- Lead Azide
- Lead Styphnate
- Mercury Fulminate
- Tetracene

IV. Secondary High Explosives

Secondary high explosives are more powerful than primary high explosives, but less sensitive. They are normally initiated by the explosive wave produced by a primary high explosive, or by some other high energy source. Secondary high explosives, under the right conditions, can be initiated by heat, friction, or impact, and may detonate while burning. They may be a pure chemical compound that has explosive characteristics or mixtures of explosive materials.

Examples of Pure Secondary High Explosive Compounds

- Trinitrotoluene (TNT)
- Cyclotrimethylene Trinitramine (RDX)
- Hexanitrostilbene (HNS)
- Nitroglycerine
- Pentaerythrite Tetranitrate (PETN)
- Trinitrophenylmethylnitramine (TETRYL)

Examples of Secondary High Explosive Mixtures

- Amatol –TNT (various %) and Ammonium Nitrate
- PBX 9604 –RDX (96%) and Kel-F (4%) with 800 Binder
- Pentolite –TNT (90%) and PETN (10%)
- Composition C4 – RDC (91%) and Plasticizer (9%)
- Composition B – RDX (63%), TNT (36%) and Wax (1%)

V. Tertiary High Explosives

Tertiary high explosives are explosive substances that are so insensitive to impact, friction, heat, and electrical energy, there is negligible probability of accidental initiation or transition from burning to detonation. These explosive materials require a powerful shock wave to initiate them. Once initiated, they will mass detonate.

Examples of Tertiary High Explosives

- Ammonium Nitrate
- Triaminotrinitrobenzene (TATB)

C. Sensitivity

Many tests have been devised to assess the sensitivity of explosives. These tests attempt to duplicate parts of the complex accident environment to which explosive materials / devices may be exposed. Sensitivity of explosives includes:

Impact Sensitivity: Sensitivity measurement of response to a physical blow or a drop from a particular height to determine sensitivity to impact.

Shock Sensitivity: Sensitivity measurement of the effect of a shock wave from a donor explosive.

Friction Sensitivity: Sensitivity measurement of the degree to which an explosive is susceptible to friction when working with explosive material and during explosives processing.

Thermal Sensitivity: Sensitivity measurement of the effect of external heat on explosive materials when the threshold initiation temperature is reached.

Electrostatic Sensitivity: Sensitivity measurement of when initiation of an explosive material by an electrostatic pulse is achieved when sufficient energy is delivered to the material.

Primary explosives and most pyrotechnics are susceptible to electrical stimulus. . In general, secondary explosives are not particularly susceptible to this mode of ignition. Most explosive materials are not good electrical conductors; the electrostatic pulse must have sufficient potential to overcome the explosive material's low electrical conductivity

Reliability and safety are important requirements for any explosive device. When installed in a well-designed system, the explosive device should be sensitive enough to fire reliably but insensitive enough to not be initiated by any other external or internal source. Reliability and safety of the explosive systems can only be achieved if the explosive sensitivity is well known.

D. Stability

Stability is the ability of an explosive material to retain its explosive properties, such as sensitivity, after long periods under adverse conditions. All explosive materials are unstable to some extent. Their physical and chemical properties will change over time. Assume that an explosive item is capable of functioning even after long periods of time.

E. Reactivity

Explosives should be as non-reactive as possible with materials and metals used in the construction of the component and / or device. Undesirable reactions can liberate gaseous

products, cause loss of explosive power, and reduce the sensitivity of the material and / or device. In some situations, sensitivity can increase.

Example: Lead azide is allowed to remain in contact with copper, copper azide salt forms, which is 10 times as sensitive as lead azide alone.

The explosive components, additives, and binders in explosive mixtures should not chemically react or separate. Moisture can also be considered a contributing problem. If propellants and pyrotechnic materials absorb moisture, the burn rate will decrease.

F. Toxicity

Many explosives, because of their chemical structure, are toxic. Symptoms may vary from mild dermatitis or a headache to serious damage to internal organs. Depending on the explosive material, symptoms may be immediately apparent or appear year's later due to cumulative effects. Treat all explosive materials as if they are toxic and avoid:

- Inhalation of particles, fumes, smoke, and dust
- Ingestion of solid or liquid material or byproducts.
- Contact with and absorption through the skin

Table 1: Toxicity of Some Common Explosive Materials

Explosive	Toxic Hazards/Symptoms
Lead Azide	Inhalation of Lead Azide dust and smoke / Headaches and distention of blood vessels
TNT	Inhalation, ingestion, and skin absorption / Decreased red blood cells and hemoglobin count. Prolonged exposure leads to more serious blood disorders, toxic hepatitis, and kidney problems.
RDX	Inhalation of fine particles, or fumes and ingestion can cause RDX intoxication / Weakness, dizziness, nausea, convulsions, muscle soreness and amnesia. Periods of recovery varies from a few days to about three months.

Chapter 2: EXPLOSIVE EFFECTS

Explosives have several effects. When an explosion occurs, very hot (between 3,000 ^{0}F and 7000 ^{0}F) expanding gases are formed in a period of approximately 1/10,000 of a second. These gases exert pressures of about 700 tons per square inch on the atmosphere surrounding the point of detonation. These expanding gases roll out from the point of detonation like ripples in water, at velocities up to 13,000 mph or 29,900 fps. These effects include blast, thermal, fragmentation, subsidiary explosive, and ground and water shock.

A. Blast Effects

Blast is the most powerful of all explosive effects. When an explosive charge is detonated, a shock wave is created in the surrounding air. This shock wave moves outward with an initial velocity much greater than the speed of sound. The speed decreases rapidly after a short distance. A shock wave created by a blast effect has two distinct phases positive and negative.

Positive wave; is when the blast effect pressure wave moves outward from the point of detonation and delivers violent force to everything in its path. It lasts a relatively short period of time and delivers the highest pressures and velocity.

Negative wave; more descriptively known as the suction phase. It is three times longer in time duration but of less intensity than the positive wave. It is formed as the out rushing air is compressed and forms a vacuum at the point of detonation. The vacuum causes the displaced air to reverse its movements and return to the point of detonation. This accounts for much of the debris that is found at the seat of the explosion and nearby.

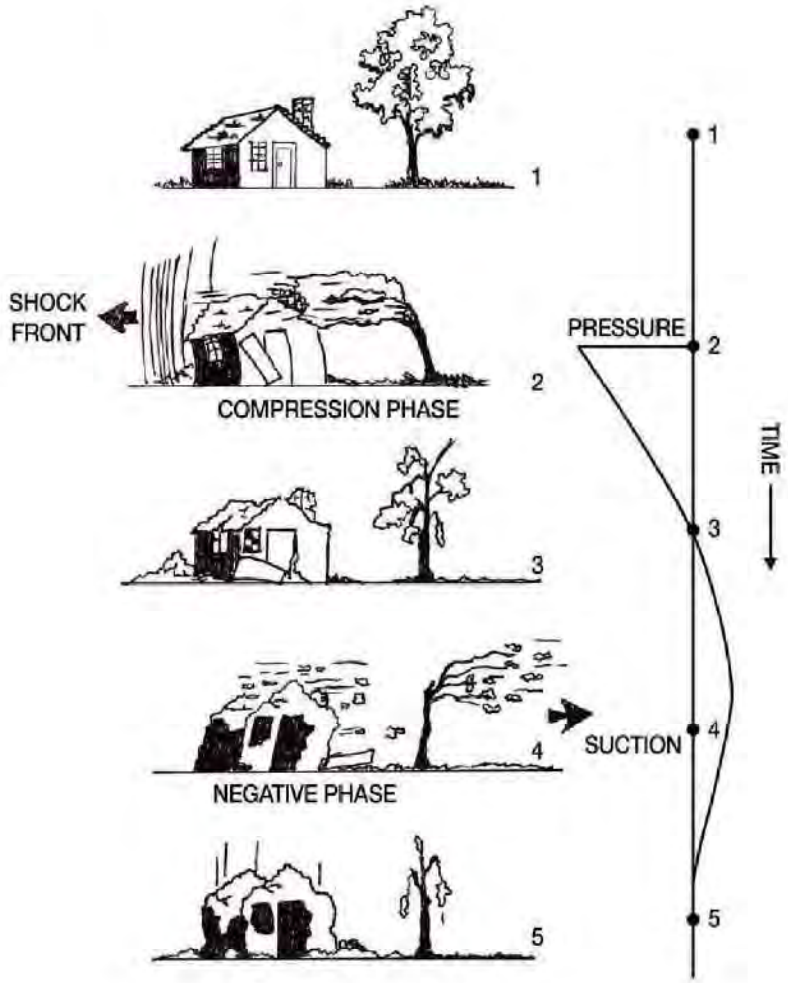


Figure 13: Blast Effects

B. Thermal Effects

Thermal effect can vary greatly from one explosive to another. In general, low explosives will produce longer thermal effects than high explosives. A high explosive will produce higher temperatures but for a shorter time. The effect is seen usually as a bright flash or

fireball at the moment of detonation. The low explosive fireball is more likely to cause a secondary fire than a high explosive fireball. Personnel who may be exposed to the thermal effects must be protected by a thermal shield or thermal protective clothing. Thermal protective clothing must be capable of limiting bodily injury to first degree burns.

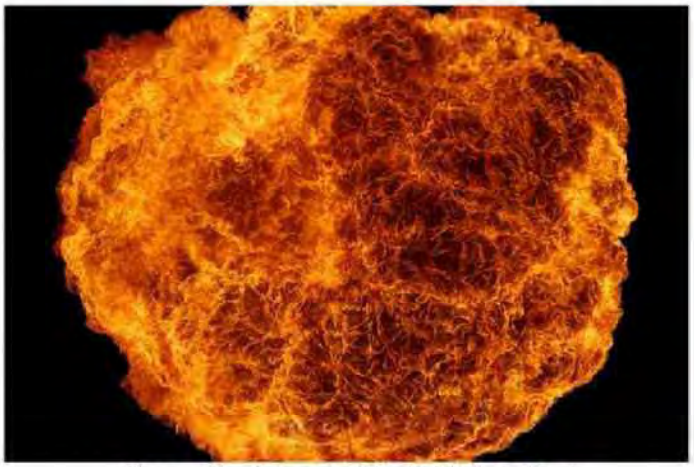


Figure 14: Thermal Effects (Detonation)

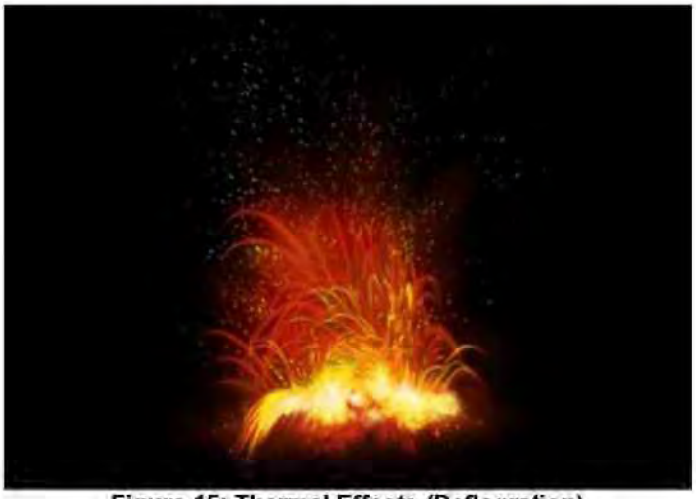


Figure 15: Thermal Effects (Deflagration)

C. Fragmentation Effects

Fragmentation effect involves fragments that are produced by the explosive container, objects around the detonation point and the intended target. Fragmentation adds to the

destructive force of the explosive device. Fragments can travel at velocities up to 2,700 fps. Fragments generated by an explosion are classified as either primary or secondary fragmentation.

Primary fragments are created from the explosive container when it breaks into small pieces. This may be the casing of the explosive, process equipment used in the manufacturing of the explosive or other devices in which the explosives are confined.

Secondary fragments are formed when high blast pressure acts on structure and other items in close proximity to the explosion. Fragments may include pieces of bricks, concrete, or metal from buildings or other structures, parts of equipment, or other material near the explosion. Secondary fragments are usually larger than primary fragments and travel at initial velocities in the order of hundreds of ft. /sec.

Personnel must be protected from high trajectory fragments as well as direct line of sight fragments. Blockhouses, barricades, and overhead cover offer protection from secondary fragments.

D. Subsidiary Explosive Effects

Subsidiary explosive effects are secondary blast effects (reflected); created by blast waves that are shattered, reflected or shielded by reflective surfaces. The blast wave reflects off of surfaces surrounding it, and may actually reinforce the original wave by overlapping it in some places (i.e. corners of a room).

E. Ground and Water Shock

Ground and Water shock occur when an explosive is initiated while buried in the earth or submerged under water. Both earth and water are less compressible than air and tend to propagate a shock wave further and with more force than air. Structural damage may be substantially greater under those circumstances where earth and water are involved. Water cannot be compressed at all and will transmit energy much faster and farther than any other medium.

Chapter 3: CLASSIFICATION SYSTEMS AND HAZARD DIVISIONS

A. Hazard Classification

Figure 16: Hazardous Materials Classification

A hazard classification is assigned for each explosive item depending on the form and packaging in which it is normally stored and offered for transportation. This classification eases identification of hazard characteristics and promotes safe storage and transport of explosives. NASA uses the DOT system of explosives classification, which is an implementation of the international system of classification devised by the United Nations Organization (UNO) for transport of dangerous goods. Some items that contain a small amount of explosives, and also one or more other hazardous materials (liquid propellants) might be assigned by DOT to a different class, based on the predominant hazard.

When explosive items are not in the form and packaging in which they are normally stored and shipped, different hazard classifications may apply due to changes in spacing, orientation, confinement, and other factors.

Hazard class 1 is divided into six Divisions that indicate the character and predominance of associated hazards.

I. Hazard Division (H/D) 1.1 / Mass Explosion

Mass-Explosion (H/D 1.1): Items in this division are primarily a blast hazard and may be expected to mass detonate when a small portion is initiated by any means. A mass detonation is one which affects almost the entire load instantaneously. Items in H/D 1.1 include bulk explosives, some propellants, demolition charges, some missile components, and some rockets.

Figure 17: Hazard Division 1.1 Classification Symbol

II. Hazard Division (H/D) 1.2 / Non-Mass Explosion, Fragment Producing

Non-mass explosion, fragment producing (H/D 1.2): Items in this division are explosives that have a projection hazard, but not a mass detonation hazard. The explosion can throw fragments, firebrands, and non-functioned items from the point of initiation. Blast effects are limited to the immediate vicinity and are not the primary hazard.

Figure 18: Hazard Division 1.2 Classification Symbol

III. Hazard Division (H/D) 1.3 / Mass Fire

Mass fire (H/D 1.3): Items in this division have a fire hazard. They burn vigorously and are difficult to put out. Explosions are usually pressure ruptures of containers, which may produce fragments, but do not produce propagating shock waves or damaging blast overpressure.

Figure 19: Hazard Division 1.3 Classification Symbol

IV. Hazard Division (H/D) 1.4 / Moderate Fire – No Blast

Moderate fire - no blast (H/D 1.4): These are explosives that present a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. This division includes items such as small arms ammunition without explosive projectiles, fuse lighters and squibs, colored smoke grenades, guillotine cutters, pressure cartridges and explosive valves or switches.

Figure 20: Hazard Division 1.4 Classification Symbol

V. Hazard Division (H/D) 1.5 / Very Insensitive Explosives

Very insensitive explosives (H/D 1.5): This division comprises substances that have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport or storage.

Figure 21: Hazard Division 1.5 Classification Symbol

VI. Hazard Division (H/D) 1.6 / Extremely Insensitive Explosives

Extremely insensitive explosives (H/D 1.6): This division comprises articles that contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental ignition or propagation.

Figure 22: Hazard Division 1.6 Classification Symbol

B. Compatibility Groups

Explosives are assigned to one of thirteen Compatibility Groups, CG, with respect to storage principles and the considerations for mixed storage. The CG allows explosives to be stored together without increasing significantly either the probability of an accident or the magnitude of the effects of any accident for a given quantity. Considerations such as chemical and physical properties, design characteristics, inner and outer packing considerations, Quantity Distance (QD) division, Net Explosive Weight (NEW), rate of deterioration, sensitivity to initiation, and explosive effects are used in developing the below CGs.

Group A
This group includes initiating explosives. They are bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, dry RDX, and dry PETN.

Group B
This group includes detonators and similar initiating devices not containing two or more independent safety features. They are items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms, primers, and fuses.

Group C

This group includes bulk propellants, propelling charges, and devices containing propellant with or without their means of ignition. They are items that upon initiation will deflagrate, explode, or detonate. Examples are single-, double-, triple-base, and composite propellants and rocket motors (solid propellant).

Group D
This group includes black powder, high explosives, and devices containing high explosives without their own means of initiation and without propelling charge, or a device containing an initiating explosive and containing two or more independent safety features. They are explosives that can be expected to explode or detonate when any given item or component thereof is initiated except for devices containing initiating explosives with independent safety features. Examples are bulk trinitrotoluene (TNT), Composition B, black powder, wet RDX, or PETN.

Group E
This group includes ammunition containing HE without its own means of initiation and or with propelling charge (other than one containing a flammable or hypergolic liquid). Examples are rockets or guided missiles.

Group F
This group includes ammunition containing HE with its own means of initiation and with propelling charge (other than one containing a flammable or hypergolic liquid) or without a propelling charge.

Group G
This group includes fireworks, illuminating, incendiary, and smoke, including hexachlorethane (HC) or tear-producing devices other than those that are water activated or which contain white phosphorus (WP) or flammable liquid or gel. They are devices that, upon functioning, result in an incendiary, illumination, lachrymatory, smoke, or sound effect. Examples are flares, signals, incendiary or illuminating, and other smoke or tear-producing devices.

Group H
This group includes devices containing both explosives and WP or other pyrophoric material. They contain fillers, which are spontaneously flammable when exposed to the atmosphere. Examples are WP, plasticized white phosphorus (PWP), or other devices containing pyrophoric material.

Group J
This group includes devices containing both explosives and flammable liquids or gels. They contain flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid- or gel-filled incendiary devices, fuel-air explosive (FAE) devices, and flammable liquid-fueled missiles.

Group K

This group includes devices containing both explosives and toxic chemical agents. They contain chemicals specifically designed for incapacitating effects more severe than lachrymation.

Group L
This group includes explosives not included in other compatibility groups. They are devices having characteristics that do not permit storage with other types or kinds of explosives, or dissimilar explosives of this group. Examples are water-activated devices, prepackaged hypergolic liquid-fueled rocket engines, certain FAE devices, triethyl aluminum (TEA), TEB, and TEA/TEB, damaged or suspect items of any group, and explosives in substandard or damaged packaging in a suspect condition or with characteristics that increase the risk in storage. Types presenting similar hazards may be stored together but not mixed with other groups.

Group N
This group includes Hazard Division 1.6 devices containing only extremely insensitive detonating substance (EIDS). If dissimilar Group N explosives are mixed together and have not been tested to assure non-propagation, the mixed explosives are considered to be Hazard Division 1.2, Compatibility Group D, for purposes of transportation and storage.

Group S
This group includes explosives presenting no significant hazard. They are explosives so packaged or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not hinder firefighting significantly. Examples are thermal batteries, explosive switches or valves, and other items packaged to meet the criteria of this group.

C. Inert Devices

Inert explosives are those devices that contain no explosives or chemical agents. The material shows no exothermic decomposition when tested. They also show no compatibility with energetic material. All inert material shall be clearly identified as inert. A stencil or otherwise clear marking on the device accomplishes this. All inert material must remain segregated from active (live) material. The inert items shall be cleaned to the greatest extent possible to remove reactive residue.

All inert material must be clearly de-milled to avoid possible re-filling with reactive material. All material identified as inert must be recorded and logged. This record will indicate location of the device, and at least three unique pieces (nomenclature, lot number, serial number) of information to positively identify the particular inert item. It will also indicate the date inerted, and the authorized inerting authority. Only personnel designated can certify devices inert. If the device is shipped, a copy of the inert log will accompany the inert item.

Chapter 4: STORAGE PRINCIPLES

A. Compliance Requirements

There are three primary sources for determination of requirements for storage and compatibility of explosive materials. The three sources are:

1. 29 CFR 1910, Subpart H, 1910.109 "Explosives and Blasting Agents"
2. Department of Defense 6055.09-STD, "Ammunitions and Explosives Safety Standard"
3. NASA-STD-8719.12, "Safety Standard for Explosives, Propellants and Pyrotechnics".

The NASA Standard is comprehensive having adopted 25 CFR 1910.109 and DoD 6055.09 storage principles.

Adhering to the storage principles includes knowledge about the quantity, capacity and surveillance of the explosives material to be stored. Explosives materials range from raw explosives to an end item device. A best practice would include review of explosives material pre-shipping document prior to delivery. The pre-shipping document should provide the material nomenclature, hazard classification, part number and quantity. As a condition of shipping, Department of Transportation (DOT) requires a Safety Data Sheet (SDS) to accompany explosives shipments. Review of the explosives material's SDS provides hazard division, storage compatibility group code, NEW along with temperature and humidity parameters for storage. In addition, the SDS provides environmental disposal codes which are costly for unserviceable or suspect explosives material. Thus it is important for the explosives materials custodian / owner to be knowledgably of the disposal requirements should the project require disposal.

Being knowledgeable of an explosives material's storage requirements provides the information required to ensure there is facility capacity for explosive material storage. Facility capacity includes footprint, and environmental controls (temperature and humidity requirements).

Often the surveillance of the explosive material stored is overlooked. The explosives materials custodian / owner must be responsible to provide the surveillance plan. The surveillance plan provides instruction, methods, and parameters to periodically evaluate explosives material in storage. This provides oversight and lead time before an explosives material physical properties change state. Discovering an explosives material physical properties have changed after the fact significantly effects safe handling and is often costly. A challenge to executing a surveillance plan for an explosives material is also having a facility to carry out the method of surveillance. For example, raw explosives material where a sample is necessary to inspect by means of a microscope shall not be performed in the storage facility.

B. Storage Principles

There are several principles that need to be followed when storing explosives. Good housekeeping should be practiced in all storage locations. Structures should be in good condition and suitable for explosive storage. Some explosive require environmental control for storage. Precautions need to be maintained to ensure proper environmental controls. Outer container used for storage need to be in good condition, securely closed and properly maintained (grounding, etc.). In magazines, stacks of containers must be stable and arranged appropriately. There should be no empty containers, dunnage or loosely unpackaged rounds or components stored in the magazine. Flammable materials including paint or oily rags cannot be present in magazines containing explosives. Liquid propellants, flammable liquids, and gases, corrosives, and oxidizers will not be stored with explosives. Magazines shall be locked at all times except during permissible operations and access to the magazine should be limited to only individuals who have a required need.

The highest degree of safety with explosives storage can be assured if each item or division were stored separately. Such ideal storage is generally not feasible. A proper balance of safety and other factors frequently requires mixing of several types of explosives in storage. Sometimes this requires approval from the Explosive Safety Officer, ESO.

Explosives shall not be stored together with dissimilar materials or items that present positive hazards to the explosives. Examples are mixed storage of explosives with flammable or combustible materials, acids, or corrosives.

C. Mixed Storage

Explosives of different compatibility groups may only be mixed in storage as indicated in the below table.

Table 2: Storage Compatibility Mixing Chart

Groups	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z					X	X
C		Z	X	X	X	Z	Z					X	X
D		Z	X	X	X	Z	Z					X	X
E		Z	X	X	X	Z	Z					X	X
F		Z	Z	Z	Z	X	Z					Z	X
G		Z	Z	Z	Z	Z	X					Z	X
H								X					X
J									X				X
K										Z			
L													
N		X	X	X	X	Z	Z					X	X
S		X	X	X	X	X	X	X	X			X	X

NOTES

(1) The marking "X" at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted according to Note 2, below.

(2) The marking "Z" at an intersection of the above chart indicates that when warranted by operational considerations or magazine non-availability, and when safety is not sacrificed, logically mixed storage of limited quantities of some items of different groups may be approved (See Note 7). These relaxations involving mixed storage shall be approved in writing by the ESO and are not considered waivers. These items shall be kept packaged according to DOT shipping container specifications of Special Packaging Instructions, or equivalent. Also these items shall not be opened in the magazine for the purpose of issuing unpacked explosives or components. Outer containers shall not be opened except for the following actions:

(a) Opening outer containers for removal of inner packages. Complete any further processing of these items in an approved operating location.
(b) Opening "lite" boxes for inventory purposes. Use of pneumatic nail guns is prohibited in the explosives storage location.
(c) Opening containers of H/D 1.4 explosives to allow inspection. Unpack, inspect, and repack in the storage location if storage is limited to H/D 1.4 items.

(3) Equal numbers of separately packaged components of complete items of any single type of device may be stored together. When so stored, compatibility is that of the assembled item, that is, WP filler in Group H, HE filler in Groups D, E, or F, as appropriate.

(4) Group K shall be stored separately from other groups, and also may require separate storage within the group. NASA Headquarters, SARD, shall determine which items under Group K may be stored together and those which must be stored separately.

(5) Items without explosives that contain substances properly belonging to another U.N. hazard class may be assigned to the same compatibility group as items containing explosives and the same substance, and be stored with them.

(6) The ESO may authorize devices designated "Practice" by National Stock Number (NSN) and nomenclature to be stored with the fully loaded device it simulates.

(7) The ESO may authorize the mixing of compatibility groups, except items in Groups A, K, and L in limited quantities (generally 1000 lbs. or less).

(8) For purposes of mixing, all items shall be packaged in approved storage/shipping containers. Items shall not be opened for purposes of issuing unpackaged items in storage locations. Outer containers may be opened in storage locations for purposes of inventorying; for removing items still inside an approved inner package in limited amounts; and, for magazines storing only Hazard Division 1.4 items, unpacking, inspecting, and repacking the Hazard Division 1.4 devices.

(9) When using the "Z" mixing authorized by Note 2, articles of either compatibility Group B or F, each shall be segregated in storage from articles of other compatibility groups by means that prevent the propagation of Group B or F articles to articles of other compatibility groups.

(10) If dissimilar H/D 1.6 N items are mixed together and have not been tested to ensure non-propagation, the mixed items shall be individually considered to be H/D 1.2.1 D or H/D 1.2.2 D based on their NEWQD or overriding fragmentation characteristics for purposes of transportation and storage. When mixing CG N items with CG B through CG G or with CG S, see paragraphs 5.50.7.2.1, 5.50.7.2.4, 5.50.7.2.9, and 5.50.7.2.10 of NASA-STD-8719.12 to determine the H/D for the mixture.

Chapter 5: FIRE AND CHEMICAL HAZARD SYMBOLS

Standard firefighting hazard identification measures for NASA field Installations and explosive storage locations ensure a minimum practicable risk in fighting fires of explosives, pyrotechnics, propellants, and similar hazardous materials.

A. Fire Protection

Fire and excessive heat are two of the greatest hazards to explosives. Many explosive items and materials are extremely sensitive to heat and react to temperatures substantially lower than those required to ignite ordinary wood, paper, or fabrics. Even indirect heat generated by a fire could initiate a reaction and result in an explosion.

Fires that may occur in buildings or magazines containing explosives will vary in intensity and effect, depending on the explosive material involved in the fire. Certain explosives will ignite immediately on contact with a spark or flame or when subjected to frictional heat or concussion. Some explosive substances may burn freely while others will be subject to explosion while burning or will develop such intense heat that firefighting efforts will be practically impossible.

Personnel in charge of explosive operations will notify the Fire Department when there is a change in the type of explosives being worked which would require a change of fire or chemical hazard symbols. Matches or other flame or spark producing devices will not be permitted in any magazine or explosives area. Carrying and using "strike anywhere" (kitchen) matches are prohibited in/around explosives facilities. Smoking, matches, open flames and spark-producing devices shall be prohibited inside or within 50 feet of explosives storage, operating area or other explosive location. This also includes all areas where liquid oxygen, liquid hydrogen, and other energetic liquid propellants and chemicals are present. A "No Smoking" sign shall be posted at each entrance to an explosives storage area.

Figure 23: No Smoking Sign for Explosive Sites

Designated smoking areas beyond the 50 foot limit are subject to the following minimum precautionary measures:

(1) Proper receptacles for cigarette, cigar butts and pipe heels shall be provided.
(2) Permanently installed electrical lighters of the push-button type that cut off when pressure is released shall be provided.
(3) Smoking shall be prohibited for personnel dressed in clothing/coveralls contaminated with explosives or flammable materials.
(4) Persons who work with toxic chemicals, toxic containers or other toxic materials shall wash their hands before smoking.
(5) A "No Smoking" sign shall be posted at each entrance to an explosives facility or storage area. Where applicable, a notice shall be posted that flame-producing devices must be turned over to the entry controller or placed in the container provided.
(6) Smoking shall be prohibited in, on, or within 25 feet of any motor vehicle, trailer, rail car, or material handling equipment loaded with explosives or similar hazardous material items.

B. Fire Division Symbols

Fire Division Symbols are numbered 1 through 4 which are synonymous with the Hazard Divisions 1.1 through 1.4 for explosives. The hazard decreases with ascending fire division numbers. These symbols, signs are used to identify the hazards for firefighters from long range, as they approach a fire scene.

Fire Division 1
This fire symbol is used for Hazard Division 1.1 explosives which represents Mass-Explosion. As mentioned earlier, this includes items such as bulk explosives, some propellants, demolition charges, some missile components, and some rockets.

Figure 24: Fire Division 1 Symbol

Fire Division 2
This fire symbol is used for Hazard Division 1.2 explosives which represents Explosion with Fragmentation Hazard. This includes items such as hand grenades, mines and some rockets.

Figure 25: Fire Division 2 Symbol

Fire Division 3
This fire symbol is used for Hazard Division 1.3 explosives which represents Mass Fire. This includes items such as some propellants and rockets.

Figure 26: Fire Division 3 Symbol

Fire Division 4
This fire symbol is used for Hazard Division 1.4 explosives which represents Moderate Fire. As mentioned earlier, this includes items such as small arms ammunition without explosive projectiles, fuse lighters and squibs, colored smoke grenades, guillotine cutters, pressure cartridges and explosive valves or switches.

Figure 27: Fire Division 4 Symbol

C. Chemical Symbols

Chemical symbols need to be displayed in conjunction with standard fire symbols at explosive storage locations, depending upon the type of items stored. The below figure shows appropriate chemical symbols.

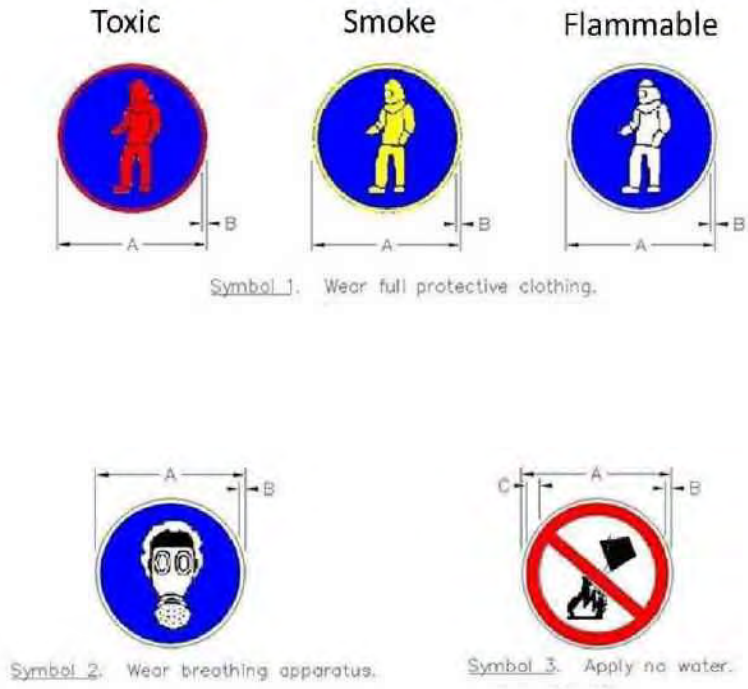


Figure 28: Chemical Symbol

D. Display of Fire, Chemical Symbols

Appropriate fire and chemical symbols shall be displayed on the exterior of all facility buildings and storage sites containing explosives, pyrotechnics, and similar hazardous materials. Additionally a master list of explosive storage sites and their locations, fire symbols, and available empty storage sites shall be kept current and maintained by the local fire departments and protective services. This master list should be available to emergency response personnel, fire department and protective services.

Fire symbols shall be displayed to make them easily visible for the greatest distance from each approach route of responding firefighter forces. They may be placed directly on the exterior of a building; however, removable placards or boards displaying the symbols may be preferred for facilities in which the explosive content is subject to frequent change. For long dimensional buildings with access from several directions, more than one symbol on a side may be necessary. The Fire symbol displayed shall reflect the most hazardous material stored in the building or site.

Facility warehouses and storage facilities used for storage of containers from which explosives have been removed, but which have not been decontaminated to remove explosive residue, shall be placarded with Fire symbols consistent with the degree of hazard.

All railroad cars and motor vehicles containing explosives, propellants, or pyrotechnics, while on NASA facilities, shall be provided with Fire symbols or DOT labels/placards for identification of fire hazards. Field Installation or facility railroad cars and motor vehicles that are not destined for off-site movement but are temporarily stored shall display at least two appropriate Fire symbols. Field Installation transport vehicles destined for off-site shipment and commercial railroad cars and motor vehicles shall have DOT placards displayed in accordance with DOT regulations when containing explosives and propellants or similar hazardous materials.

E. Firefighting Procedures

All fires starting in the vicinity of explosives or pyrotechnics shall be reported and an alarm sounded. If the fire involves explosive materials or is supplying heat to explosive materials, all personnel shall evacuate and seek safety immediately.

Operational personnel shall be instructed and retrained on the specific characteristics of the explosive materials and their reactions to heat/fire. The firefighting forces and other essential personnel shall be briefed before approaching the scene of the fire. The briefing should include the following:

(1) Known hazards and conditions existing at the scene of the fire before proceeding to the location of the fire
(2) Location of all personnel, nonessential and essential, in reference to safe adequate distance from the fire

(3) Exact head count of all employees that are safe and out of harm's way

Chapter 6: TRANSPORTATION OF EXPLOSIVES

There are safety requirements for the transportation of explosives and for the safe operation of vehicles. These requirements comply with Department of Transportation (DOT) regulations.

A. General Transportation Requirements

No person should smoke or carry matches, flame-producing devices, or unauthorized firearms or cartridges while transporting explosive materials. Vehicles transporting explosive materials should avoid congested areas and heavy traffic. Delivery should be made only to authorized persons and into authorized magazines or approved temporary storage or handling areas.

I. Training

All persons who transport explosives shall be trained to have working knowledge of the explosive transport vehicle inspection, equipment and operation requirements. This includes federal, state and local requirements. These requirements must be complied with for inspection and operation.

Training is also required for operators of explosive transport vehicles. The individuals must possess a valid state driver's license and any other required certifications. If the operators are involved in ordnance handling operations, they are required to complete an explosive handler's physical and explosive handler's training.

The operator should also be familiar with proper explosive item packaging for transport/shipping.

II. Vehicle Requirements

All motor vehicle shipments are governed by DOT and shall comply with DOT, State, and municipal regulations. Special precautions shall be taken to avoid ignition of the material by the exhausts of vehicles. The lighting system shall be electric, with batteries and wiring so located that they will not come into contact with containers of explosives. Vehicles shall not be left unattended unless they are parked in a properly designated area. When an operator leaves an explosive laden vehicle, the brakes shall be set and wheels chocked. When transporting electro-explosive devices (EEDs), full consideration shall be given to the inherent hazards where vehicles are equipped with transmitters or other electromagnetic radiation sources. EEDs shall always be transported in their packaged configuration. Explosives shall not be grounded to the transport vehicle.

a. Placarding

Motor vehicles used for transporting any quantity of explosive materials on public highways should display all placards, lettering or numbering required by the DOT with the exception of explosives less than 1000 lbs. of hazard class 1.4. Requirements for placarding of vehicles transporting explosives are to include Fire, Chemical, and/or Apply No Water symbols. DOT placards should also be incorporated as required.

b. Fire Extinguishers

All vehicles, with the exception of those directly supporting ejection seat operations, shall be equipped with two (2) each Class 4A: 60BC rated portable fire extinguishers when transporting DOT Class 1 explosives. Vehicles used for the transport of ejection seats shall have 2 each 2A:10BC extinguishers, one mounted externally by the driver's door.

c. Vehicle Inspection

Before any motor vehicle may be loaded with explosives or ammunition (DOT Class 1, all Divisions) or other dangerous similar articles, the vehicle shall be inspected by a qualified explosive vehicle inspector.

d. Securing Cargo

Explosive materials transported on a vehicle with an open body; a portable magazine securely fastened to the vehicle body should be used to store the explosive materials. Vehicles (including flat-bed type), partly or completely loaded, shall have the lading blocked, braced, chocked, tied down, or otherwise secured to prevent shifting during transit.

e. Personnel Transport

No personnel are allowed to be transported in the same compartment with explosives.

B. Explosive and Pyrotechnics Shipment

I. Packaging

In accordance with 49 CFR Part 172 and 173, DOT has very clear requirements for the receiving and shipping of hazardous materials. Contact the transportation office for guidance and support when receiving or shipping hazardous materials. Hazardous material may be stored in the as received packaging. Be aware of and follow DOT and manufactures SDS requirements for repacking for issue and / or storage. Consider retaining received packaging and dunnage materials for potential reuse.

ESD precautions need to be labeled on the packages or shipping containers to prevent an inadvertent event causing a static discharge and perhaps injury to personnel or damage to equipment. An approved list of all explosive devices needs to prepared and constantly maintained as explosive quantities are received and shipped. All explosive devices and shipping or storage containers will be identified with the proper explosive symbol and stamped ESD sensitive.

Note: Explosives can change hazard class once removed from a shipping package or when the volume changes. They should be stored based on their correct hazard class depending on their state. Examples include propellants which are hazard class 1.4 for shipping but are hazard class 1.3 during processing and removal from shipping container or MDF which is hazard class 1,1 greater than 26 ft. and hazard class 1.4 less than 26 ft.

II. Documentation Requirements

When dealing with shipping explosives, there is usually a logistics / transportation office that handles the documentation requirements. In accordance with 49 CFR Part 172, DOT requires the following minimum documentation for shipping explosives.

- Shipper
- Competent Authority Approval (each item)
- SDS (each item)
- Shipping Bill

Chapter 7: PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

A. General

Personal Protective Equipment, PPE, consists of garments and devices to protect individuals from specific hazards that may be encountered in the performance of their jobs. Requirements for protective items are determined by a thorough assessment of the potential hazards and usually incorporated within the procedures governing the particular hazardous operation.

PPE shall be issued to NASA employees at government expense in those situations where engineering controls, management controls, or other corrective actions have not reduced the hazard to an acceptable level or where use of engineering controls, management controls, or other techniques are not feasible.

Pre-employment and pre-placement physical examinations shall include determination of the individual's ability to wear PPE that is required for the job.

Operations shall be analyzed by qualified personnel to determine the need for any specific kinds of PPE. Once the requirement for PPE is established, it is the responsibility of the employee to abide by the standards.

For special operations where employees are required to wear special clothing (e.g., explosive plant clothing, anti-contamination clothing, and impervious clothing) a designated location for changing of clothes with suitable clothing lockers shall be provided.

B. Clothing

Explosive handlers require special clothing. The following specifications should be considered: Fasteners shall be nonmetallic. Coveralls shall be easily removable. Pockets shall be of the lattice type. Trouser legs, slacks, and sleeves should be tapered. There shall be no cuffs on legs or sleeves. Coveralls shall extend over shoes or boots. The waist and neck should be fitted snugly to prevent ingress of powder dust, but not so tight as to cause skin irritation or dermatitis. Cotton undergarments should be worn in any operation where the generation of static electricity would create a hazard. Garments shall be made from cotton fabric (not wool, rayon, nylon, polyester, etc.), be static dissipative, flame retardant or flame resistant.

Appropriate footwear shall be worn in explosive operating facilities. Examples include closed toed, ESD, or conductive shoes.

Figure 29: Coveralls

C. Eye Protection

Appropriate eye and face protection is required when employees are exposed to hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases, vapors or potentially damaging light radiation.

Suitable devices shall be worn by all personnel when working in or visiting an eye hazard areas including aisles and hallways. Industrial safety eyeglasses shall meet all the requirements of ANSI Standard Z87.1.

Contact lenses cannot be considered as substitutes for appropriate eye protection. They shall not be worn in work environments where there are chemicals, burners, smoke, dusts, particles, or molten metals.

Figure 30: Safety Glasses

D. Hearing Protection

All personnel exposed to noise hazards, either intermittently or when assigned to a noise hazard area, shall wear hearing protection.

Figure 31: Hearing Protection

E. Static Dissipation

Static dissipation devices such as leg straps, wrist straps, or conductive shoes shall be worn when handling, installing, connecting or disconnecting solid propellant, solid rocket motors, electro-explosive devices (EEDs), and pyrotechnics. Wrist straps shall be tested prior to use to ensure contact with the skin and that the resistance measurement is between one and ten mega ohms.

Note: Wrist straps are tested prior to ordnance operations and every time they are removed and reinstalled from an individual's wrist.

Figure 32: Wrist Straps

Wrist straps are tested using either calibrated ohmmeters or wrist strap testers to ensure adequate resistance for static dissipation. Examples of calibrated wrist strap testers are shown below.

Figure 33: Calibrated Wrist Straps Testers

Chapter 8: ORDNANCE EQUIPMENT

A. Igniter Circuit Testers

I. Alinco

The Alinco Igniter Circuit Tester was developed by the Allegany Company in 1956, and since 1965 has been manufactured by MB Electronics. The models that are currently being used are a stable, precision instrument designed primarily for the testing of bridge-wires for open or short-circuit conditions.

This Alinco is mounted in a weatherproof case, which provides complete portability. The years of successful service by this device have been proven its safety and reliability in testing all explosive systems. Accidents involving the use of Alinco Igniter Circuit Testers have occurred. These accidents caused death and injury to the individual in close-proximity. The accidents involved faulty Igniter Circuit Testers that had been "assumed" safe because they had just recently been returned from the manufacturer who had repaired and "recertified" those units. The output current of the Alinco was in excess of 1 Ampere and should have been limited to 5 milliamperes. The below figure shows the Alinco Igniter Circuit Tester.

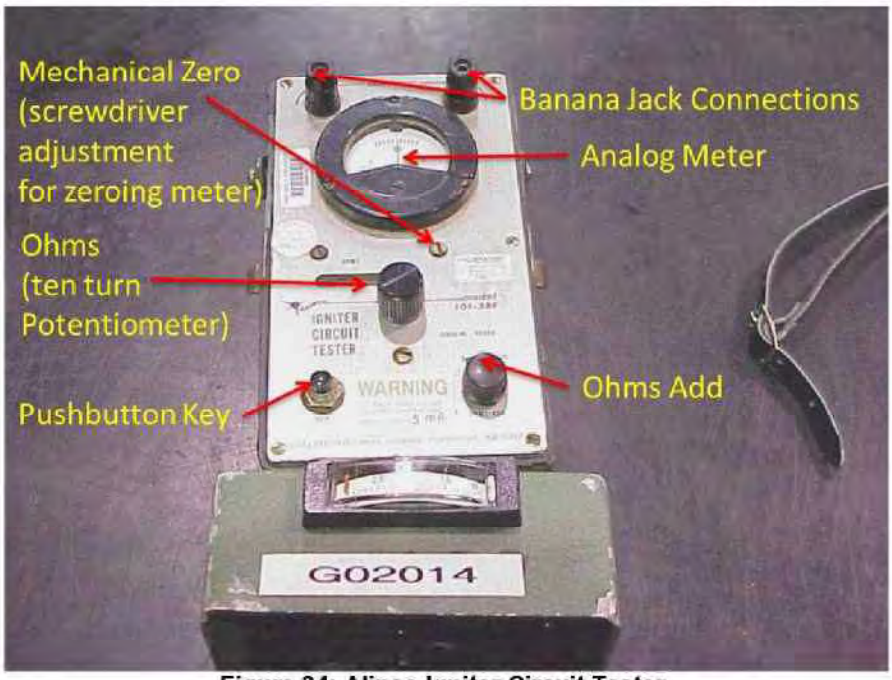


Figure 34: Alinco Igniter Circuit Tester

All Alinco Igniter Circuit Testers used by personnel to measure bridgewire or firing line resistance must be tested to verify that a maximum available output current does not exceed 5 milliamperes. A verification test must be performed immediately prior to using the Alinco Igniter Circuit Tester.

II. Valhalla

The Valhalla Igniter Circuit Tester is designed specifically to test the igniters used to detonate charges in explosive devices. The manufacture designed this tester with one objective: to make it absolutely fail-safe. This design of igniter circuit tester incorporates internal protective circuits, which render it incapable of delivering excessive voltage or current to the igniter under test. The meters are pre-tested at the factory where component failure is simulated to duplicate a failed mode. The resulting fail-safe current levels are recorded and supplied as part of the original calibration information. As a further precaution, operating the tester from an internal battery pack eliminates the possibility of an external common-mode voltage delivering unwanted power to the igniter. An external line-powered charger is available for charging the Nickel-Cadmium, NI CAD, batteries.

The Valhalla has the following accuracy:

- Reading: +/- 0.02% (20Ωs, 200Ωs, 2KΩs and 200KΩs)
- Range: +/- 0.02% (20Ωs, 200Ωs, 2KΩs and 200KΩs)
- Reading: +/- 1.0% (2MΩs)
- Range: +/- 1.0% (2MΩs)
- Reading: +/- 2.0% (20MΩs)
- Range: +/- 2.0% (20MΩs)

The Valhalla has a maximum input of 250 VDC and average power of 115VAC for charging. The operating temperature is 0° to 50 ° C. Its power consist of rechargeable 5V NI-CAD batteries. The Valhalla weighs 1.6 lbs. The below figure shows the Valhalla Igniter Circuit Tester.

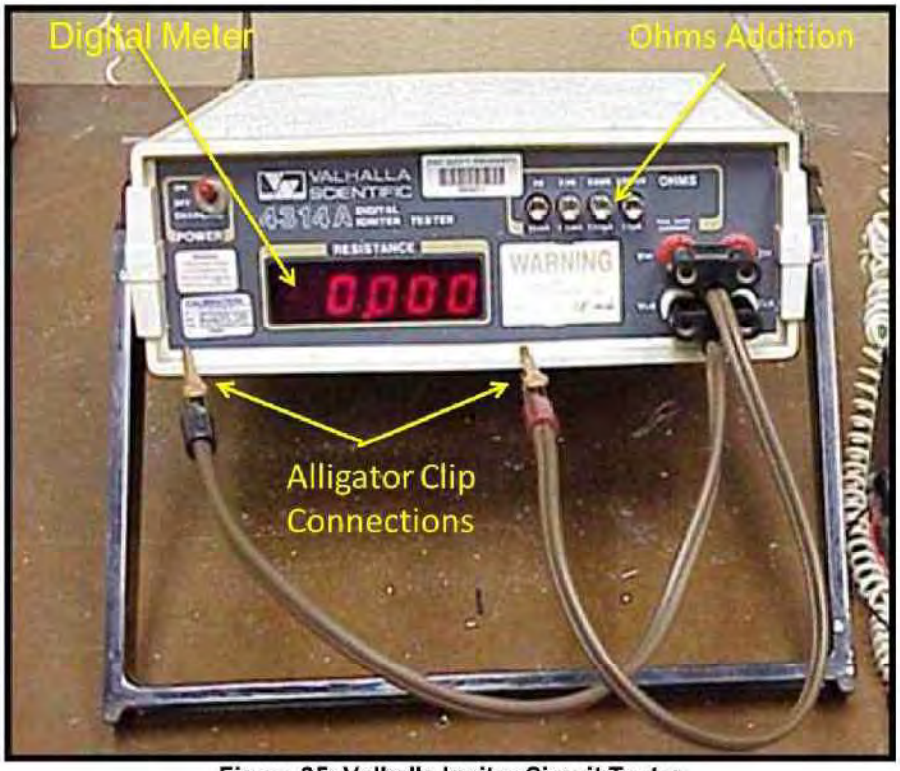


Figure 35: Valhalla Igniter Circuit Tester

III. Amptec-601ES

Figure 36: Valhalla Igniter Circuit Tester

IV. Initiator Resistance Measurement Unit (IRMU)

The IRMU is a resistance measurement device designed to operate with an IBM compatible personal computer (PC). It uses an internal microcontroller to accept commands, make measurements, and return results. When used with the included laptop and printer, the IRMU measures bridge-wire resistance values with 1 milliohm accuracy. The IRMU can also monitor single bridge-wire resistance values at time intervals, store the measurements/monitored data on a user-determined drive, display the measurements/monitored data on the laptop PC, and interface with a printer to

print measurements/monitored data in a column orientated format. The below figure shows the IRMU.

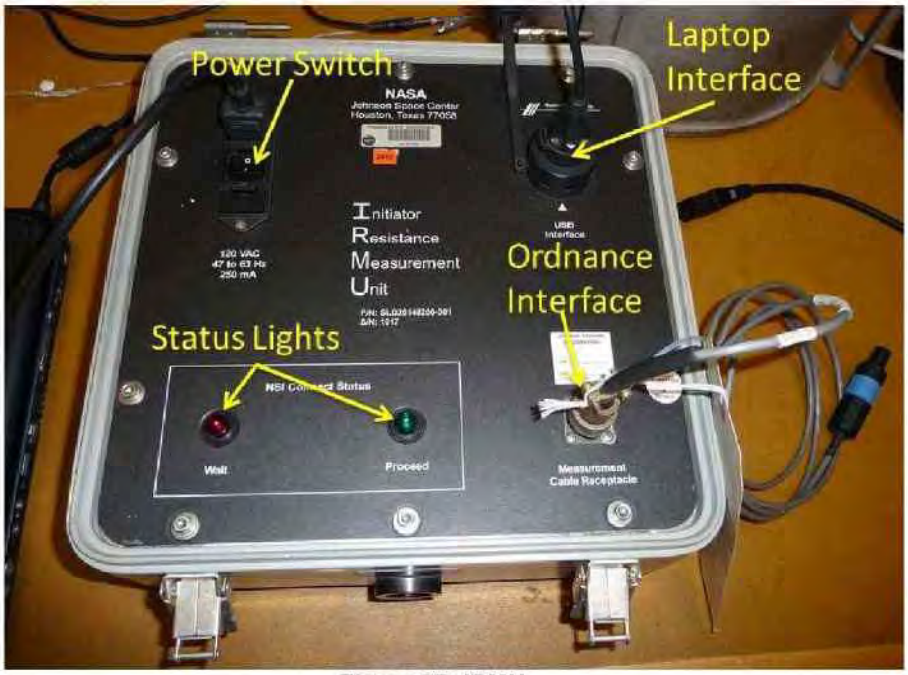


Figure 37: IRMU

B. Other Equipment

I. Blasting Galvanometer

The blasting galvanometer is used to measure continuity. It is normally used to measure the short back through ordnance circuitry. This short enables the ordnance to remain in a safe configuration by keeping the explosive shorted. A drawing of the galvanometer is shown below.

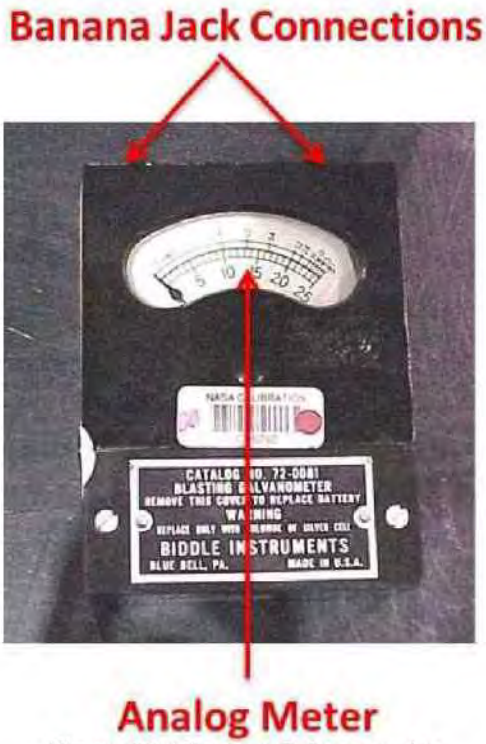


Figure 38: Blasting Galvanometer

II. Teledyne RISI FS-43 Exploding Bridge Wire (EBW) Firing System

The Teledyne RISI FS-43 EBW Firing System is designed for field firings where the actual module voltage must be monitored and instantaneous firing is required. Alternating Current, AC, power is available. The separate module allows long distance and remote firings to be performed. The below figure shows the Teledyne RISI FS-43 EBW Firing System.

Figure 39: Teledyne RISI FS-43 EBW Firing System

III. Initiator Firing Unit (IFU)

The IFU is designed to provide pyrotechnic device manufacturer and test personnel with a reliable piece of equipment to evaluate single bridge-wire for NSIs and similar electrically actuated initiators in a laboratory or field environment. There are two types of IFU presently being built: A basic unit and a full-featured unit. The basic unit has a fixed energy capacity discharging a 680 μF capacitor bank charged to 40 volts, whereas, in the full featured unit the capacitor values (680 μF or 1000 μF) and the output voltage can be stepwise varied from 5 volts to 45 volts in steps of 5 volts. Both units can supply up to four discharge output channels. All four channels can be fired simultaneously, and the full-featured unit can divide the channels into pairs and vary the time between pairs from 1 millisecond to 99.9 seconds. These features allow the operator to test initiators through a wide range of discharge energy. The below figure shows the IFU.

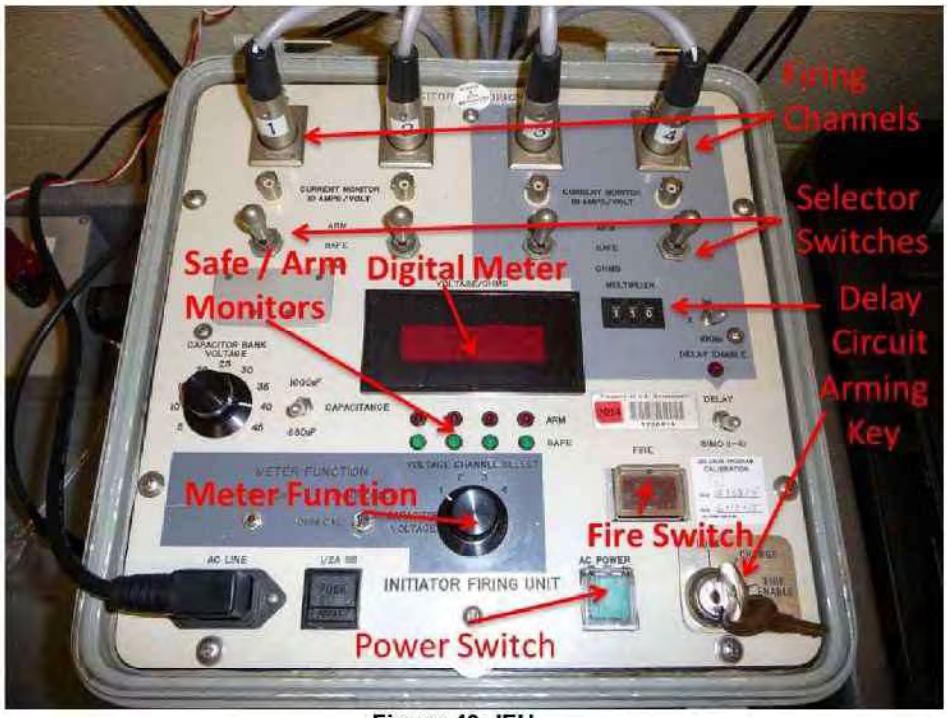


Figure 40: IFU

Chapter 9: STATIC ELECTRICITY, ELECTROSTATIC DISCHARGE, ELECTRICAL, EMR AND LIGHTNING PROTECTION

A. Static Electricity

Static Electricity is an electrical charge at rest. More specifically, static electricity is the imbalance of positive and negative charges. The movement of static electricity is the transfer of electrons from one object to another at different potentials caused by direct contact or induced by a charged field. The magnitude of the charge is dependent on the size, shape, composition, and electrical properties that make up the object. This charge can transfer electrons within an object (polarization) or from one object to another (conductive charging). When this occurs the static electricity is quickly released known as an Electrostatic Discharge (ESD) resulting in the form of a spark. Electro-explosive devices (EED's), ordnance systems, flammable vapor mixtures, explosive materials, and other explosive components can be ignited by ESD. The generation of static electricity is not in itself a hazard. The hazard arises when static is allowed to accumulate, subsequently discharging as a spark across an air gap in the presence of highly flammable materials or energetic materials such as explosives, ordnance or propellants.

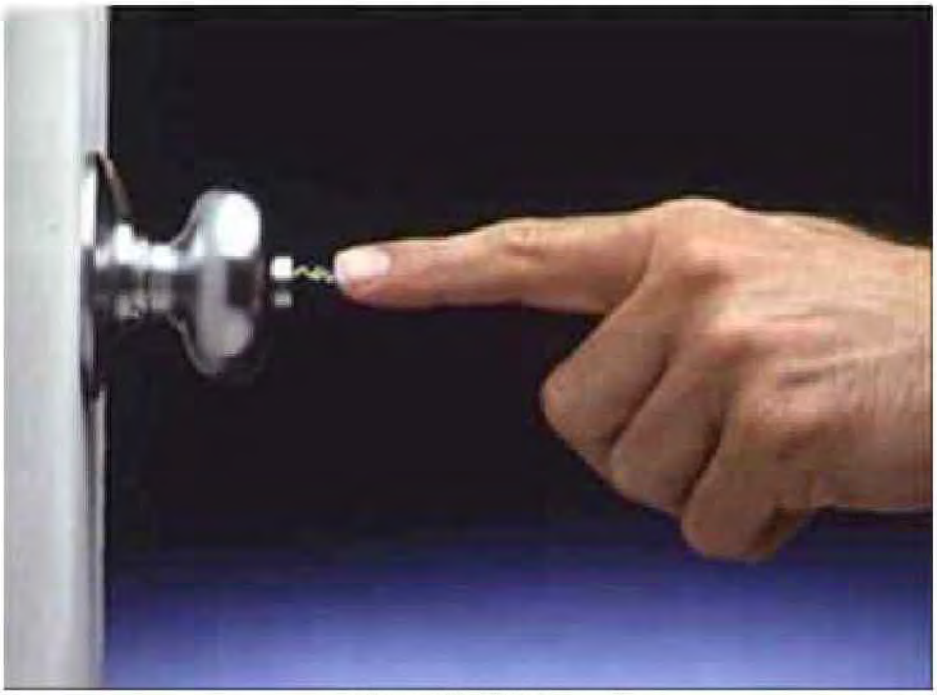


Figure 41: ESD Example

Static buildup or generation can be developed in many ways. Two of the most common are friction charging and induction charging. The prime method of generating static electricity is by rubbing or separating materials, commonly known as the triboelectric method. A triboelectric charge is defined as an electrical charge generated by frictional movement, or a separation of two surfaces. Triboelectrification of materials occurs anytime two dissimilar materials are in contact with each other. The outer atoms of one material will strip some of the electrons from the other. The additional energy of rubbing will cause a larger exchange of electrons, creating a greater charge

Triboelectric generation is not limited to personnel movement. Machinery moving parts, equipment operating the flow of fluids or gases can also generate substantial electrostatic voltages. Table below shows some typical electrostatic voltages for various types of products and activities. The table shows a comparison between high and low relative humidity levels. The more moisture content in the air, the easier it is for electrons to dissipate through it. Relative humidity levels between 30% and 70% decrease the potential for static buildup.

Thunderstorms create electrostatic charges. When warm air rises above the cold air and the upward and downward movement of air causes a charge of electricity to build-up on clouds that are formed. When the charge on the clouds gets large enough, discharge takes place and we see "lightning". The same process takes place anytime we move. If conditions are right, a simple act of people moving can generate a static charge of up to **35,000 volts**. Simple, movement of a worker at a workbench can generate up to a **6,000 volts** static charge on their clothing and body. When the workers body is fully charged any contact with an object with a difference in potential or a grounded item the static electricity is discharged causing a spark to jump. The "first touch rule" should be applied as ESD control when a component is grounded to a certified ordnance ground.

Table 3: Typical Electrostatic Voltages for Products and Activities

Means of Static Dissipation	Voltages 10-30 % Relative Humidity	Voltages 30-70 % Relative Humidity	Voltages 70-90 % Relative Humidity
Walking across carpet	35,000	7,500	1,500
Walking across vinyl floor	12,000	3,000	250
Worker at bench	6,000	400	100
Vinyl envelops for work instructions	7,000	1,500	600
Common plastic bag picked up from bench	20,000	6,500	1,200
Work chair padded with polyurethane foam	18,000	5,000	1,500

Materials are considered either conductive, static dissipative or insulating. Conductive materials redistribute the electrical charge rapidly, thus preventing a buildup of charges.

Static dissipative materials distribute the charges at a slower rate. Insulating materials hold static charge and prevent the charge from flowing. When we charge something with static electricity, no electrons are made or destroyed. Electrons are just moved from one place to another. The net, or total electric charge stays the same. This principle is called the **Conservation of Charge**.

Another method of charging is called the **Induction Method**. Unlike the Triboelectric method, the induction method of charging does not require actual contact between two objects. Anytime an object becomes charged, or anytime a current flows, invisible electromagnetic fields of force develop around the charged object or around the current-carrying conductor. These electromagnetic fields are similar to the field or lines of flux of a magnet. As the charge on an object increases, or as the current flow increases, the electromagnetic fields increase in strength and dimension. When a conductor is moved through the field, or the field is moved through a conductor, a voltage is induced in the conductor. Anytime an object is charged, even if an insulator, it emits an electromagnetic field. When a conductor is exposed to an electrostatic field, some of its electrons will become mobile and either moves toward or away from the field, depending on the polarity. The movement of electrons constitutes an electrical current. A phenomenon known as polarization occurs on the conductor if the field and the conductor are both stationary.

In the case of ESD, the actuation phenomena usually consist of an arc which occurs between the bridge-wire and the outer case of the explosive. It is a basic characteristic of the majority of explosive compounds that they will initiate when an electric arc is passed through them, even though the current in such an arc may be very small. Regardless of the reasons, it is safe to say that when a condition occurs which results in an electric arc through an explosive prime that an explosion will result. The problem of protection against static electricity is the most critical in the field of EEDs. Static charges can and are present in every environment, and when not present, they can be readily induced. It appears to be an established fact that there have been hundreds of so called "incidents" which can be directly attributed to premature actuation of an EED by ESD. There is not only the problem of bridge-wire to case arcing; there is the problem of an arc occurring between bridge-wire circuits in dual bridge-wire circuit parts.

Manufacturers are striving to produce the standard 1-ohm, 1-watt, 1-ampere NO FIRE capability for ordnance, but also one that will withstand very high potential differences between the case and the bridge-wires. This reduces the chance of inducing an arc. Explosive industries are primarily concerned with the sparks associated with ESD. These sparks can trigger a fire or explosion during certain stages of the process. Current flow through bridge-wires or sensitive electrical components is of equal concern.

I. ESD Sensitivity

Clothing is one of the greatest producers of static electricity. Polyester, nylon, rayon, wool and silk can produce high levels of static electricity. Also undergarments made of these materials present less of a hazard but still should be avoided. Loose clothing should also be avoided. The movement of the clothing on a person's body, donning or

removing, can produce static electricity and cause charge separation between the layers of clothing. Explosive handler's clothing should be made from 100% cotton, a cotton-synthetic blend, or a polystat blend, which contains 1% stainless steel for static dissipation.

Some electronic parts have been known to fail at charges of 15 volts. Many electronic parts are damaged below levels of 2000 volts. Personnel do not typically feel these low voltages when discharged. Human sensitivity levels usually occurs around 3500 volts. It is very important for individuals to remember when handling sensitive explosive devices that even though you may not feel a static discharge the device still could be initiated depending on the sensitivity of the explosive device. Below is the Human Body Model device sensitivity to ESD:

(1) **ESD Class 0-1c (0 to 1,999 volts):** Damage caused that one will not feel.
(2) **ESD Class 2 (2000 to 3,999 volts):** Damage caused that one might feel.
(3) **ESD Class 3A-3B: (4,000 to 15,999 volts):** Damage you will detect as a spark with your own body.

II. Control Program Requirements

Explosive devices that are designed to function when an electric current is applied can be initiated by ESD. Electric primers, squibs, blasting caps, detonators and igniters are devices that are susceptible to ESD. Maintaining proper controls of procedures as well as maintaining proper protection levels of materials is essential to an ESD control program. A control program should focus on proactive prevention rather than reactive detection and damage control. The following elements are required to provide proper controls.

(1) Verify conformance of protected areas to NASA requirements. An initial survey is required of the area to determine types of explosive devices used, types of testing performed, expiration dates, maintenance, reliability of test equipment and if the proper PPE and other safety equipment to safely perform the hazardous test is available.
(2) Proper clothing for employees has been issued to prevent static charge generation.
(3) Purchasing the proper handling and test equipment with the required training and technical assistance for the correct uses of that equipment is essential.
(4) Training shall be provided to all employees involved with handling of ordnance devices are essential. All personnel shall be given proper training involving associated with their duties, on the PPE that is issued, and certified on the most recent requirements of and techniques of ESD.
(5) Safety and performance audits should be periodically performed in all work areas where hazardous activities are performed. If a deficiency is detected the findings will be documented and reported for corrective and preventative disposition.

III. Types of ESD Controls

Personnel, pyrotechnics, explosive devises, motors, Ground Support Equipment (GSE), and other equipment present during explosive operations must be handled with each individual and / or component at the same electrical potential to eliminate discharge of electrical energy that could cause an explosion. Several types of controls include grounding and bonding, shielding, neutralization, ESD packing symbols.

Grounding and Bonding. The most effective method of dissipating static electricity is to provide a continuous path to a common ground. In the case of the explosives an independent certified ordnance ground is required and periodically tested to assure adequate protection. To ensure static discharge protection, a continuous wire or braided ground straps are used to bridge potential breaks. Be aware that paint, rust, and/or other surface conditions may cause a break in the continuity resulting in an inadequate ground. Equipment that is merely touching the conductive table or floor is not considered sufficiently grounded without an independent ground strap attached resulting in the equipment and the conductive surface both being at the same electrical potential. Examples of grounding devices are removable clip type ground connectors, bonded straps between explosive components that will eventually be mated, conductive coats and cotton clothing, wrist straps / associated tester, foot grounders / associated testers, conductive work surfaces, and / or conductive floors connected to a certified ordnance ground.

Wiring Shielding and Faraday Shielding. Explosives and their components shall be designed to prevent inadvertent arming, actuation, or initiation due to operator error, short circuits, radio frequency transients, or other unexpected failure modes. Two designs are using faraday cage shielded wiring and Electro-Explosive Device (EED) faraday cap shields. Firing circuit shielding shall provide a minimum of 20db safety margin below the rated function current of the system initiator (max NO-FIRE current for EED's) and provide a minimum of 85% coverage. A solid shield rather than a mesh would provide 100% coverage. Shielding shall be continuous and terminated to the shell of connectors and / or components. The shield shall be electrically joined to the shell of the connector / component around the full 360 degrees of the shield. The shell of connectors/components shall provide attenuation at least equal to that of the shield. The EED should have a faraday cap that will short the leads, shield the connector from RF or static electricity, and also be grounded to the ordnance ground.

First Touch Rule. If you consider that you are a charged object at all times and ready to discharge, "contamination of charge rule", one must consider where the discharge is going to take place by considering the handler's **first touch**. Always avoid making the "**first touch**" or connection to the explosive device first. Try to always seek the same potential by touching other grounded devices at the same potential that are not directly in contact with the explosive device.

Other controls. Other controls include monitoring static buildup with electrostatic meters and static alarms. Special conductive coatings and antistatic wax for floors, glass, acrylic, etc. can be used. Establishing constraints for temperature, wind, and humidity for internal and external operations is also good ESD controls. Design considerations and prohibition of introduction of static generators (tape, adhesives, foam devices, food bags, etc.) and Electromagnetic field generators (radios, transmitters, radars, electronic devices, etc.). Training, lighting detection system, and test equipment calibration.

IV. Associated Hazards

Hazards associated with ESD during handling of explosives are not always easily identifiable or understood. Some are very obvious and others are not so obvious. In many cases, the actual planning and implementation of the operations can be a first step in a potentially hazardous situation. The below items identify and offer an explanation on how the risk associated with ESD can be minimized. Some of these will be discussed in more detail within this training.

Electrostatic Buildup: The simple task of walking across a carpeted surface in a dry environment can produce 30-40 thousand volts of static and when one touches a doorknob a spark is produce. Individuals do not feel a static discharge until it reaches about 3,500 volts. It takes approximately 4,000 volts to see a spark in a dark room and approximately 5,000 to hear it crackle. An ESD that is not perceived can initiate a pyrotechnic device. A standard blasting cap is ignited at around .036 to .064 joules. An individual can easily store approximately .156 joules of energy, enough to ignite sensitive explosives.

Inadequate Wrist Straps: All wrist straps shall contain a current limiting safety resistor of 1 Meg ohm minimum. The resistor protects from a rapid discharge of electrons that could cause increased current levels and also a spark. The wrist strap should be tested each time the strap is installed. To ensure correct readings, a tester or ohmmeter should be used for testing the wrist strap. Additionally, proper procedures for installing, testing and using the wrist strap shall be followed.

Not Using Calibrated Explosive Test Equipment: Explosive handlers are required to use only test equipment that has been calibrated, certified along with a proper calibration sticker with expiration dates included. The explosive handlers are required to perform an operational test before use. If this procedure is not followed the program and employee safety is placed in a high risks and dangerous situation.

Not Using Authorized Standard Operating Procedures: During operations that involve handling, testing, and processing explosive devices and systems, it is imperative that all operations will use authorized and approved procedures to accomplish these tasks. No operation will be performed on explosive systems without an approved and signed procedure. Any deviation to the procedure

required to complete the operation will be documented and approved before authorization to proceed is granted.

Grounding for Transporting Explosives: In order to transport explosives, the ground must be disconnected from the certified ordnance ground. Do not disconnect the ground from the explosive. Leave the ground attached to the explosive. The explosive will be subjected to a substantial amount of static electric buildup during transport depending on the RH. It is very important to remember that the first operation that you perform after transport is to connect the explosive ground to the certified ordnance ground first. Any other connection could result in ESD.

Other hazards: Checking for stray voltage is required when using an overhead crane, ungrounded ordnance components, propellant removal operations, low humidity, igniter or initiator removal/installation, handling and storage of pyrotechnic devices, storage surveillance and periodic inspection, etc.

V. Prevention

There are additional safety tips for preventing static induced hazards in an explosive area. Explosive handlers should utilize their training and judgment when determining a facility, operation, or situation is unsafe and be prepared to cease an operation until such time as the operation is deemed safe. When entering a facility make sure you take proper precautions and observe the types and quantity of explosives, number of hazardous operations being performed at one time, and the number of people in the area. Make sure you are aware of the emergency exit routes and if the routes are clear. Always keep the explosive handler and the explosive device at the same potential. When removing a explosive device from storage or shipping container, if possible, place device on a static dissipative surface and connect a ground lead to the packing material before you take the explosive device out of the packing. Verify that the "buddy system", working with another individual, is being followed. Check the humidity levels. Find out about the transmission of different radio frequencies being transmitted from radars, radios, etc.

Make sure that proper explosive grounds are installed and have been previously tested and records are kept. Verify the proper shielding is being used. Check how the grounding has been implemented for the various types of explosive devices. Verify the explosives are properly stored. Verify the wrist straps, and other PPE is operating properly and is tested at a minimum on a daily basis. Make sure that all test equipment has a current calibration certification decal or label. If not red tag the device until such time as the unit is calibrated. Find out if a lighting detection system is being used and if so find out how the lines of communication are established in order for everyone to be notified. Ask questions if there are any other concerns.

B. Relative Humidity

Except as specifically approved by the ESO, relative humidity (RH) in the operational area shall be determined and recorded prior to the start and every 4 hours during operations involving open rocket propellant grains, rocket motors with nonconductive cases, open flammable/combustible fluid systems, and EEDs. At or below 50 percent RH, bonding, grounding, nonconductive materials, and personnel grounding devices shall be verified at less than 350 volts potential. Electrostatic scanning of personnel, materials, and hardware within ten feet of the operation, not to exceed 1-hour intervals, shall be performed during the operation and at any time additional personnel, equipment, or hardware are introduced into the immediate area. If the RH falls to or below, 50%, continuous RH monitoring shall be performed. When operations are permitted at 30 % RH or below, electrostatic scanning shall be accomplished at 10-minute intervals if the explosive material is exposed and 30-minute intervals if the explosive material is covered.

C. Electromagnetic Radiation

Figure 42: "No RF Allowed" Sign

Premature ignition of EEDs can occur from electro-magnetic induction induced by radar and communications equipment and/or basic AC power lines. Radio waves, micro waves, visible light and x-rays are all examples of electromagnetic waves. These waves are produced by the motion of electrically charged particles, also known as Electromagnetic Radiation (EMR). EMR shall not be introduced to or near EEDs. Cell phones, radios or key fods shall not be permitted in any area where EEDs are present.

The personnel hazard EMR level has been set at .01 watt/cm2. For a 10-Watt transmitter, the dangerous area around an antenna extends to approximately 2.5 inches from the antenna. Maintaining a safe separation distance between the emitter (transmitter) and the EED provides protection. This distance is a factor of the effective radiated power (ERP) and frequency of the emitter (transmitter).

D. Lightning Protection

For the design of LPS, the requirements of NFPA Standard 780 and 70 are used as minimum criteria. **Note:** NASA facilities containing explosives shall require these references as basic criteria for lightning protection. Approved Systems shall be used in NASA facilities to provide protection from lightning to all explosives facilities. Lightning protection especially is needed in explosives operating facilities where operations cannot be shut down during electrical storms and personnel evacuated. No LPS is required for explosives facilities when the following conditions are met:

- A lightning detection system (LDS) is available to permit termination of operations and evacuation of all personnel prior to the incidence of an electrical storm.
- Earth-covered magazines (ECM) are used for the storage of explosives and propellants in closed containers or in their approved shipping configuration, provided metallic ventilators, doors, and reinforcing steel are electrically bonded together and grounded.
- Bonding and surge protection of referenced standards also apply for such magazines.
- Facilities containing explosives, pyrotechnics, and propellants or items or systems incorporating explosive components that cannot be initiated by lightning as determined by the responsible organizations. These facilities shall meet bonding and surge suppression requirements and not be subject to fire in the event of a lightning strike.

E. Electrical Storms

A visible lightning strike can produce as much as 20 to 50 million volts. This is enough to certainly kill an individual. Also during an electrical storm small electrical discharges are prevalent and can initiate an explosive device. Explosive devices that are ESD sensitive have a rated electrostatic sensitivity of .1 joule or less. These explosive are mostly primers, igniters, tracers, explosive bolts, explosive cutters, and other pyrotechnic devices. Whenever an electrical storm approaches an explosive facility, the facility should be secure by a shutdown and evacuation procedure as quickly as possible.

Figure 43: Electrical Storm

Upon notification of an approaching electrical storm, personnel shall be evacuated from facilities where there is an explosives hazard that could be initiated by lightning. Distances and processes vary per center. Personnel shall be evacuated to an area that will provide protection commensurate with the hazard level. Explosive operations requiring attention at all times shall continue to be performed by the minimum number of personnel consistent with safety requirements if approved by the local safety authorities. Any process involving explosives shall not be started unless absolutely necessary or unless the process can be completed prior to an anticipated storm. There is no guarantee that LPS will provide the same degree of safety as a lightning-free environment.

The following locations require evacuation during electrical storms:

(1) Explosives operating facilities without approved LPS and other locations within Public Transport Route (PTR) distance of such facilities.
(2) Test stands and launch pads.
(3) Facilities located within ILD and containing exposed explosives, explosives dust or vapors, or unpackaged electrically initiated explosive devices, whether or not equipped with approved LPS (evacuate to nearest control room, building, or other safe haven type structure).
(4) Magazines, open storage sites, loading docks, explosive loaded vehicle holding pads or explosive loaded railroad cars on ungrounded tracks, that are not equipped with approved LPS and allocations within PTR distance of such structures, sites, vehicles, or cars.

F. Bonding and Grounding

The use of appropriate bonding and grounding practices is the first line of defense against ignition of an energetic material by static electricity. The generation of static electricity cannot be totally prevented, because its intrinsic origins are present at every interface. The effectiveness of a bond or ground whether provided through the use of an "added on" path or through the inherent charge dissipation properties of the equipment under consideration depends on the ability of the path to dissipate charge at a rate commensurate with the rate at which it is generated. Bonding provides protection of equipment and personnel from the hazards of lightning discharges and shock hazards arising from accidental power grounds. It creates an establishment of fault current return paths. It prevents static charge accumulation. When grounding equipment, the following practices shall be followed:

(1) Static grounds shall not be made to gas, steam, air lines, dry pipe sprinkler systems or air terminals of lightning protection systems (LPS).
(2) When grounding explosives/propellants, ground cable shall be attached to explosive/propellant container (e.g., rocket motor case) first and then to building/facility ground.
(3) Static grounds can be made to conductive water pipes that have been tested and verified to be permanent and continuous, ground cones, buried copper plates, driven ground rods, or to down conductors of LPS as close to the ground rod or counterpoise as possible.
(4) Bonding wires/cables and ground wire shall have adequate capacity to carry the largest currents that are anticipated.
(5) Flexible conductors shall be utilized for bonds that are frequently connected and disconnected.

The primary purpose of bonding and grounding is to ensure requirements are met and thereby prevent the generation of an incendiary spark. It is not to drain all charges to ground or to bring all objects in question to zero potential relative to ground.

Chapter 10: SAFETY CONSIDERATIONS

Concerning explosive safety, the following principles apply and are required to be followed:

(1) Minimize personnel exposure; only use the number of personnel needed to accomplish the job. Personnel not needed for the operations shall not be allowed in the location. These individuals are considered nonessential.
(2) Minimize quantities of explosives; use the minimum amount of material necessary to accomplish the desired operation.
(3) Minimize personnel exposure time; the minimum amount of time that personnel are exposed to the hazards. Unnecessary tasks shall not be performed.

The primary concern is to prevent accidental or inadvertent detonations. When preventive efforts fail, the above principles, the cardinal rule, minimizes the negative impact.

Safety considerations apply in general to all Explosives, Energetic Liquids, and Pyrotechnics, EELP, and should be considered in preparations for operations involving possibly hazardous EELP. Thinking safety and working safely must become a firmly established habit when working with or in the vicinity of items that are potentially dangerous by reason or their explosive, flammable, or toxic characteristics. EELP will be handled under the direct supervision of an experienced, certified and competent individual who knows and understands the hazards and risks involved. Personnel engaged either directly or indirectly in operations in which EELP is involved shall be thoroughly trained in safety and must be alert at all times to be in observance of safety precautions. Personnel must be capable of recognizing hazardous situations and taking prompt and effective action.

Prompt action will be taken to control any hazard. Supplemental instructions will be issued as necessary. If an immediately dangerous situation is encountered, all operations in the vicinity will be shut down and personnel evacuated to a safe location. Properly qualified personnel will then proceed with the elimination of the hazard. Operations in the area will not be resumed until the hazard has been eliminated.

EELP will not be subject to rough handling or shock or in any manner which will damage them or cause their activation. The material will be protected from extreme heat including direct sunlight. High temperatures increase sensitivity. EELP will not be submitted to open flames, heating and electrical equipment. Always carry EELP in proper containers. Small pyrotechnics will not be carried in pockets, tool boxes or similar unprotected places.

Additional safety precautions include a "Buddy System". This shall be used for all EELP operations. The person acting as the second person will be actively involved in the operation if the operation requires two ordnance handlers. The safety supervisor will remain out of the danger area, but will be prepared to go to the aid of a person if an accident should occur. Operations will not be conducted by one person alone.

Do not leave EELP unattended. Treat all EELP as toxic avoiding inhalation, ingestion and contact through skin. Always wash your hands after handling. Wear appropriate PPE, eye

protection, non-static producing clothing, gloves, etc. No Smoking, matches or other flame producing devices within 50 feet. No EELP will be transported in Personally Owned Vehicles (POV).

Remember your ESD. Remember the First Touch rule. If you consider that you are a charged object at all times and ready to discharge one must consider where the discharge is going to take place by considering the handler's **first touch**. Always avoid making the "**first touch**" or connection to the explosive device first. Try to always seek the same potential by touching other grounded devices at the same potential that are not directly in contact with the explosive device.

Respect the power of these materials. If the work makes you nervous, find a different job.

A. Concurrent Hazardous Operations

NASA's policy is that consistent with operational requirements, to provide limited exposure of the minimum number of people to the minimum quantity of explosives for the minimum amount of time. Permissible concurrent hazardous operations should be conducted in separate buildings located at the appropriate intraline distance, ILD, from other operating buildings. When it becomes necessary to conduct concurrent operations in the same building, the operational layout shall be planned to segregate the primary hazards by substantial dividing walls, barricades, or other means to ensure maximum personnel protection. Concurrent hazardous operations should only occur with approval from the ESO or the local safety authorities. Multiple hazardous operations are not recommended within the same facility involving high energetic materials with significant loss potentials, such as solid rocket booster motors. If operational necessity arises, however, special considerations to address the effects of noise levels, personnel stands, and personal air breathing or other equipment shall be evaluated to ensure the safety of operations and personnel emergency egress. Proposed multiple operations should only occur with approval from the ESO or the local safety authorities

B. Emergency Procedures

NASA's policy is that there are approved emergency (contingency) procedures when performing operations with explosives. These procedures should cover the following topics to some degree:

- Evacuation routes
- Marshalling areas if needed
- Hang-fire or Misfire
- Communication during mishap or accident
- Alarm sounding
- PPE

There are many more topics that can be covered depending on the type of explosive operation.

C. Personnel Limits

The Net Explosive Weight (NEW), the maximum explosive limit, and personnel limits for buildings, rooms and service magazine areas shall be posted within the existing facilities. A placard stating the NEW, the maximum number of operators, ordnance handlers or safety observers and the number of casuals permitted in the control area at any one time shall be posted in a conspicuous place in all areas containing explosives. The placard containing personnel limit and NEW shall be kept current and maintained for legibility. Operators, ordnance handlers and safety observers are responsible for the protection of the casuals. Individuals in training, tour groups or bystanders are considered casuals. Below is an example of placarding in an explosive facility.

Figure 44: Explosive Placarding

1. NEW is the total quantity of explosive material or pyrotechnics in an item. Inventory is controlled by the maximum NEW allowed in a unit / facility. The inventory is to be updated real-time as explosives are entered and removed from a unit / facility.

2. Personnel Limits (Operators) shall not be no less than 2 trained ordnance handlers. In addition, it shall not be greater than the operational procedure requires to safely perform the task(s).

3. Personnel Limits (Casuals) shall not be any greater than the operational procedure requires to safety perform the task(s). Casuals are transient personnel who are authorized to perform specific actions within a task (e.g., safety observers, quality assurance specialist, customer pyrotechnic (ordinance) handlers and other nonessential personnel.

D. Briefings

Prior to explosive operations, explosive tests or tour of explosive facilities, a safety briefing shall be given to all affected personnel. Because the types of hazards in explosive

operations and tests vary widely, it is not practical to list all the items required in a safety briefing. In general, topics in an explosive safety briefing should include but are not limited to:

- ✓ Description of the explosive operation
- ✓ Description of the explosive device(s)
- ✓ Description of hazards
- ✓ Description of PPE required
- ✓ Number of personnel allowed in the operation's area
- ✓ Inclement weather procedures
- ✓ Evacuation plans and routes
- ✓ Description of location of emergency equipment

E. Housekeeping

Structures containing explosives shall be kept clean and orderly. A regular program of cleaning shall be carried out as frequently as local conditions require for maintaining safe conditions. General cleaning shall not be conducted while hazardous operations are being performed. Explosives should be removed from the area prior to general cleaning operations.

During explosive cleaning operations, hazardous waste materials such as oily rags, combustible and explosive scrap, wood, paper, and flammable packing materials shall not be mixed but shall be kept separately in carefully controlled, approved, and properly marked containers. Containers shall be kept outside explosives facilities, except for containers that are required at workstations, and shall be emptied at least once each workday or shift. Containers for hazardous waste shall have covers, preferably self-closing. Hazardous waste materials also include scrap powders, initiating or sensitive explosives or propellants, sweepings from explosive areas, and rags contaminated with these explosives or propellants. If plastic bags are used as inserts, they shall be static dissipative and/or conductive and properly grounded. Static-producing plastic bags shall not be allowed in any sensitive explosive operations. Explosives, explosive dust, and other hazardous materials shall not be allowed to accumulate on structural members, radiators, heating coils, steam, gas, air, water supply lines, or electrical fixtures and equipment.

All loose explosives recovered from sweeping floors of operating facilities shall be destroyed. Explosives that are recovered from breakdown and cleanup operations shall be thoroughly inspected by operating supervisors and reused, screened, reprocessed, or destroyed as the situation warrants.

Sweeping compounds containing wax or oil shall not be used on conductive floors. Cleaning agents that include caustic alkalis shall not be used in locations containing "exposed explosives" because sensitive explosives compounds may be formed. Hot water or steam is the preferred method of cleaning if "exposed explosives" are located on the floor. When sweeping compounds are used, they shall be nonabrasive. Sweeping compounds may be combustible but shall not be volatile. The building or facility

supervisor, foreman, or worker-in-charge shall prevent accumulations of excess explosives on materials and equipment.

Vegetation should be controlled outside magazines, test areas, test stands, and explosive storage and operating facilities to minimize potential damage to the magazine or facility from grass, brush, forest fires, or erosion. A firebreak at least 50 feet wide and free from combustible material should be maintained around each aboveground magazine, explosive processing area or explosive storage facility. If the explosive's facility exterior is fire resistant, the firebreak need not be devoid of vegetation, but growth shall be controlled by mowing to prevent rapid transmission of fire to the magazine or facility. Maintenance of firebreaks around earth-covered magazines and cutting of grass covering these structures are not normally required, except around ventilators to prevent transmission of a fire into a structure.

Chapter 11: TYPES OF EXPLOSIVE SYSTEMS, COMPONENTS, AND DEVICES

A. Typical Explosives

I. Electrical Initiators

The NASA Standard Initiator, NSI, Type 1, is a 2-pin eclectically activated, hot-wire, EED designed and qualified initially as a single bridge wire Apollo standard initiator (SBASI) to meet the requirement of the Apollo Lunar Mission. It was adopted and standardized for use on the NASA Space Shuttle System, payloads, and other NASA-sponsored programs. Its function is to translate an electrical stimulus, producing a flame and hot particles to ignite or initiate an explosive train of action. It can also be used alone or incorporated into a higher level device. The NSI uses a fine-particle, zirconium fuel mixed with a fine-particle zirconium potassium perchlorate oxidizer, ZPP, bound together with a Viton rubber binder, Its features include high electrostatic sensitivity protection, internal construction designed for severe vibration protection, a high-pressure ceramic header, flush-mounted single stainless-steel bridge wire, 1 amp-1 watt, 5-minute no-fire protection, and high-and-low cryogenic temperature performance

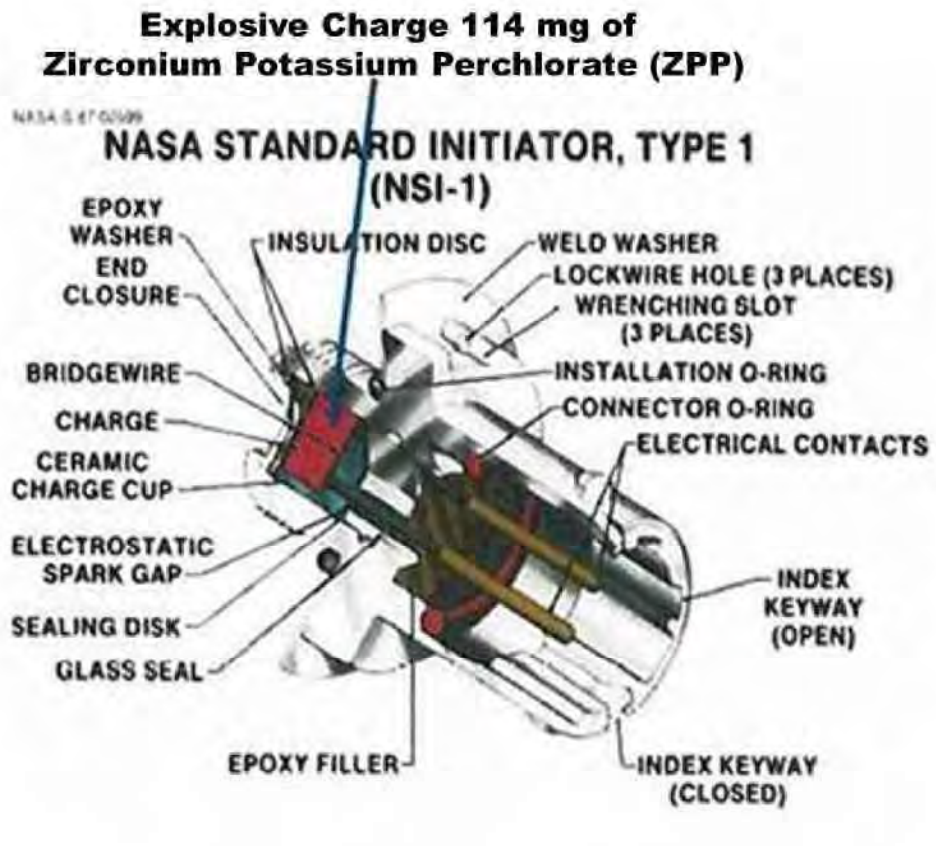


Figure 45: NSI

II. Mechanical Initiators

Mechanical initiators consist of simple mechanical construction, but not necessarily in terms of their mechanism of initiation, design, or performance analysis. There are various mechanical initiators.

Friction initiators are the most common igniter in the world and called a "safety match". It is initiated by bringing two chemicals into contact that react instantly with one another. Potassium chlorate is mixed with a number of other ingredients, including glue and red phosphorus mixed with glue, in the match head. When rubbed on the sticker, the glue coating is broken, resulting in immediate response between the two reactants.

Stab initiators are the most mechanically sensitive of all the nonelectric types. They are generally similar in size and sensitivity. A firing pin pierces the closure disc and penetrates the priming mix during activation, causing heating of the mix by both compression of the mix in front of the pin and friction on the mix by the conical sides of the pin.

Percussion initiators require only compression of the ignition mix. The firing pin does not penetrate the case of the primer. Percussion primer mixes usually contain a lead styphnate, tetracene, an antimony sulfide-type mixture, which acts as grit to sensitize the mix to crushing and compression.

Figure 46: Mechanical Initiator

III. Laser Initiators

Pyrotechnic laser firing systems can be split into three parts: Firing Unit, Fiber optic lines, and Initiators. Pyrotechnic laser firing systems were on the NASA X-38 program the late 1990's and early 2000's. To date, no laser initiation system has been standardized.

The two types of firing units that have been used are the rod laser and diode laser. The rod laser is typically a Nd: YAG laser rod. High intensity light comes from a flash lamp. Typical flash lamps are Xenon. Some rod laser firing systems use mechanically

initiated flash bulbs in place of the Xenon flash lamps. Since flash bulbs are one time use item, they would typically be used in one time use systems such as emergency jettison systems.

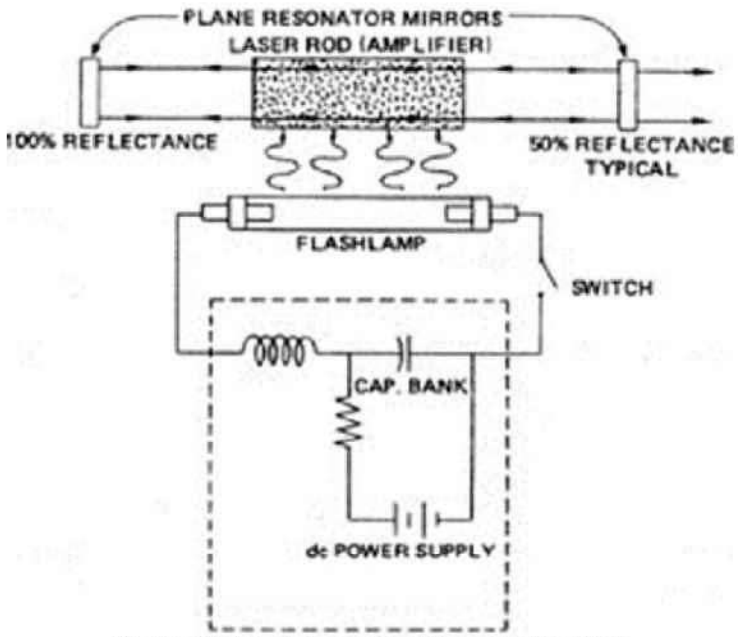


Figure 47: Flash Lamp Rod Laser Firing Unit

The advantages of a rod laser system are that they can produce a high energy output and one rod can energize several optical fibers at a time. Some of the disadvantages are that they have low power efficiency, are difficult to obtain reliable optical alignment, and they have a somewhat inconsistent output.

The diode laser firing unit is a solid state device that imparts a high energy beam of light directly from the diode into a single optical fiber. Diode lasers don't put out as much energy as a rod laser, and a diode can only energize one optical fiber. But it doesn't have the optical alignment problems of a rod laser.

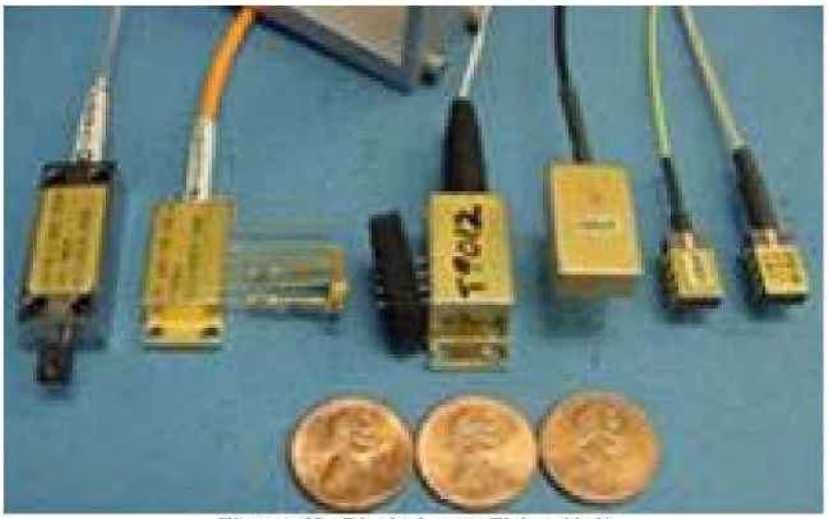


Figure 48: Diode Laser Firing Unit

Fiber Optic Lines transfer the laser energy from the firing unit to the initiator and are considered the weakest link in the system. Testing and experience during the X-38 program gave rise to a series of recommendations for optical firing lines that include: use a minimum of 6 fiber strands per initiator with half of the strands coming from one power source and the other half of the bundle coming from a redundant source, the fiber material should be radiation hardened, low OH for best wavelength transmission, bend radius should be two inch minimum and no splicing or connectors between firing unit and initiator.

Fiber Lines

Figure 49: Laser Initiator Firing Lines

The output of a laser initiator can be identical to other initiators such as a Zirconium Potassium Perchlorate (ZPP) used in a NSI. Instead of an electrical bridgewire being used to deliver the initiating energy, the optical fiber butts up next to the back end of the initiator and delivers a high intensity light beam with enough energy and temperature to ignite the ZPP mix.

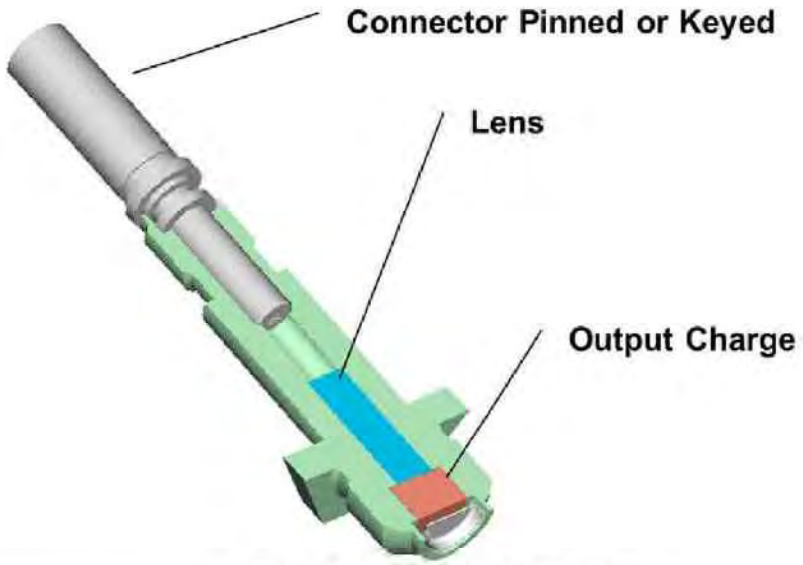


Figure 50: Laser Initiator Design

B. Deflagrating Explosives

I. Cartridges

Cartridges are also known as pressure cartridges. Pressure cartridges, in general, consist of an ignition primer and a main charge encased in a single cartridge. The primer ignites the main propellant charge, which then produces gas in the required quantity and temperature. The gas thus produced may be used for any number of useful work-producing applications, such as, pushing pistons, breaking diaphragms, filling flotation devices, and air bags. The applications and components of the pressure cartridge belong to the category of Low Explosive Train.

Figure 51: Pressure Cartridge

II. Thrusters and Actuators

Thrusters and actuators are similar in design and manufacture. In general, a thruster is considered a slower, less shock-inducing mechanism used to accomplish work, i.e., moving a latch or ejecting another device. The actuator is a faster moving piston generally used to penetrate another device, such as a pressure bottle burst disk.

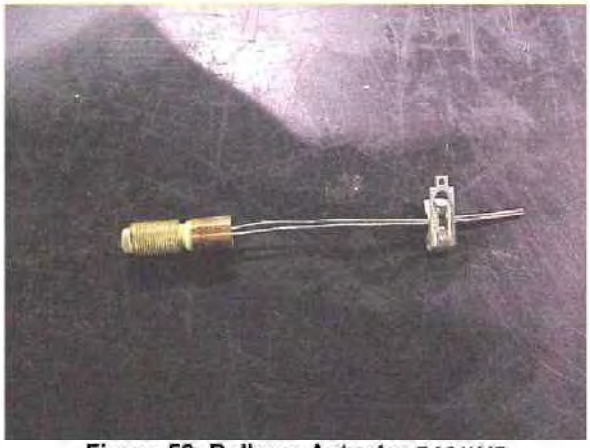


Figure 52: Bellows Actuator BA31K47

III. Cutters

A cutter is considered a cartridge-actuated device (CAD). It is used to cut cables or bolts and provides a fast and reliable separation of mechanical parts. The devices are also referred to as guillotines due to their physical description. Below is a picture of a Holex 2800 guillotine cutter,

Figure 53: Guillotine Cutter

IV. Mortars

Mortars are typically used to eject a packed parachute from the payload as one mass to begin the deployment process of larger parachutes. The smallest mortars are commonly called Pilot Mortars. Larger Mortars are called Drogue Mortars. Mortars are the most common method of parachute deployment for spacecraft planetary entry. Many mortars are comprised of what is known as a high-low system. The mortar cartridge fires into a breech assembly at very high pressure. The pressure then bleeds out through an orifice at a lower pressure and pushes the parachute pack out of the mortar tube. This provides thrust to the parachute pack throughout the entire deployment of the parachute out of the mortar tube. A sabot inside the mortar tube protects the parachute and pack from being burned by the hot gases during deployment.

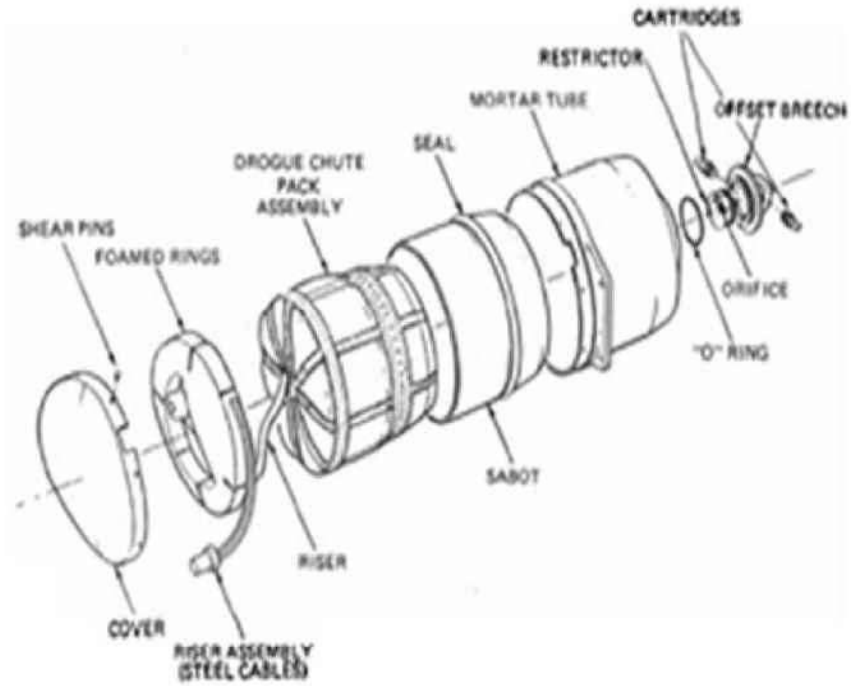


Figure 54: Mortar Assembly for Apollo Drogue Chute

V. Retractors and Pin Pullers

Pin pullers are usually employed where relatively little shock is desired. A pin puller is used in conjunction with a spring separation, or perhaps where gravity will supply the energy of separation.

Figure 55: Pin Puller Atlas 228-50000 / 1MT18CC

VI. Pyrotechnic Valves

Pyrotechnic valves are initially in one particular state (open or closed). An important disadvantage of a pyro valve (with respect to a typical electrically activated on-off valve) is that a pyro valve can switch states only once. The advantage of using a pyro valve is that it is extremely reliable. It will stay in its initial state until fired. When the valve is fired, it is guaranteed to switch to its opposite state, where the valve remains.

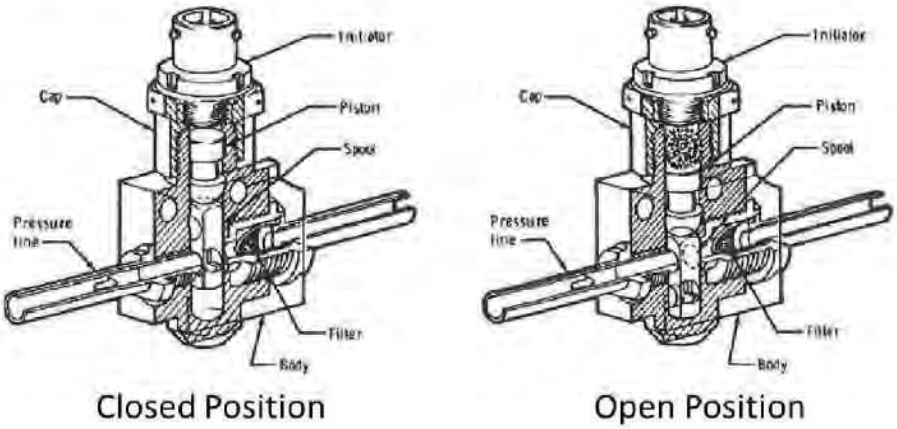


Figure 56: Pyrotechnic Operated Valves

VII. Separation Nuts

A frangible nut assembly is reliable and is designed to accommodate two explosively loaded booster assemblies. The nut assembly is comprised of a combination of an inert item (usually the nut) and a pyrotechnic source (booster assemblies) that when combined will provide controlled nut fracture at a predetermined separation plane. The separation event is initiated with detonation. The output of the initiating device provides the energetic stimulus for initiation of the explosive powder inside the booster assemblies. The powder detonates causing rapid expansion of the steel booster housing and transmission of shock waves through the booster housing into the frangible nut.

Figure 57: Separation Nut

VIII. Deflagrating Cords

Deflagration cords burn rather than detonate. They are used for delays, ignition sources and deflagrating distribution systems.

a. Safety Fuse

The safety fuse is a type of fuse invented and patented by William Bickford in 1831. Originally it consisted of a "tube" of gunpowder surrounded by a waterproofed varnished jute "rope". It replaced earlier and less reliable methods of igniting gunpowder blasting charges which had caused many injuries and deaths in the mining industry. The safety fuse burnt at a rate of typically about 30 seconds per foot (1 second per cm).

Today, safety fuse, also known as 'time fuse,' has saved countless lives since its introduction in the 1830's. Safety Fuse is manufactured with a black powder core, textile yarns and a waterproof outer jacket. It is a linear textile and pyrotechnic cord used to create a time delay. Due to confinement of a center core of black powder, time fuse burns at a nominal rate of 40 seconds per foot (130 seconds per meter).

The output of time fuse is a notable spit of flame and burning particles. This spit is what initiates the sensitive ignition powders found in fuse caps.

Figure 58: M700 Safety Fuse

b. Igniter Cord

A Plastic Igniter Cord (PIC) is a type of fuse used to initiate an explosive device or charge. In appearance, igniter cord is similar to safety fuse and when ignited, an intense flame spits perpendicular to the cord at a uniform rate as it burns along its length. Igniter cord in construction is similar to safety fuse, consisting of a pyrotechnic composition at the core, wrapped with a nylon sheath to provide shape and finally wrapped again in an outer plastic shell to provide water resistance. Normally, igniter cord also consists of a metal wire at the very center of the pyrotechnic core which also runs the entire length of the cord; the pyrotechnic composition will react with the metal wire (typically aluminum, iron or copper) to increase the energetics of the fuse. There are two types of PICs: the fast type which has nominal burning speed of 30 cm per second, a diameter of about 3 mm, and is brownish in color; and the slow type, which has a diameter of 2 mm, is greenish in color, and has a nominal burning speed of 3 cm per second.

c. PYROFUZE

PYROFUZE consists of two metallic elements in intimate contact with each other. When these two elements are brought to the initiating temperature, they alloy (mix) rapidly resulting in instant deflagration without support of oxygen. Initiation is by heat and heat alone. All that is required is the exposure of the composite to the proper minimum temperature. The trigger reaction will reach temperatures in excess of the boiling point of the constituents. Once started, the reaction will not stop until alloying is completed or the unalloyed composite is subjected to some form of massive cooling that overwhelms the composite so that it cannot reach minimum operating temperature. The reaction end products consist normally of tiny discreet particles of the alloy of the participating materials. The present

PYROFUZE composition was chosen for a number of desirable characteristics; it is a composite of alloys of Palladium and Aluminum. It is available in the following physical forms: Wire; and Ribbon rolled from wire. It cannot be overemphasized that the PYROFUZE reaction is not of an explosive or pyrotechnic nature. The only energy released is thermal (approximate minimum reaction temperature 2800°C/5000°F, 325 calories per gram, 2890 calories per cubic centimeter). The minimum initiation temperature is 650°C/1200° F.

C. Detonating Explosives

I. Detonators

A detonator is most commonly used for the detonation of high explosives. It uses a filament wire, which is covered with a sensitive ignition mix or prime. The prime will not detonate but ignites a booster charge, which will transfer the deflagration to a detonation which then detonates the main charge or load. The load is sized according to the type of work it needs to perform. This can vary from a simple pressed cylindrical form to a shape charge, which will direct the shock front. Detonators can be chemically, electrically or mechanically initiated.

The NASA Standard Detonator, NSD, consists of an NSI mated to the NSD cartridge. Propellant in the NSD consists of a primary explosive charge, intermediate charge lead azide and a output charge RDX.

Figure 59: NASA Standard Detonator

d. Frangible Joints

The Frangible Joint is uniquely designed to completely confine explosive debris. Key components include Mild Detonating Fuse (MDF), an explosive confinement tube, a separable structural element, and association initiation manifolds and

attachment hardware. It is used extensively to accomplish launch vehicle payload fairing removal. Frangible Joints are also used for stage separation to prevent collateral damage to other sensitive hardware.

Figure 60: Frangible Joint

e. Pyrotechnic Fasteners

A pyrotechnic fastener is a fastener, usually a nut or bolt that incorporates a pyrotechnic charge that is initiated electrically.

Explosive bolts also known as frangible or pyrotechnic bolts incorporate one or more explosive charges embedded within the bolt. They are typically activated by an electric current, and the charge breaks the bolt into two or more pieces. The bolt is typically scored around its circumference at the point(s) where the severance should occur. Such bolts are often used in space applications to ensure separation between rocket stages, because they are lighter and much more reliable than mechanical latches.

Figure 61: Explosive Bolt

The frangible nut, commonly confused with an explosive bolt, is a component used in many industries, but most commonly by NASA to sever mechanical connections. It is, by definition, an explosively-splittable nut. The bolt remains intact while the nut itself is split into two or more parts.

II. Linear Explosives

Linear explosive products are available for a number of aerospace, defense and commercial solutions. Some of those include but not limited to: Emergency Egress Systems (EES), Canopy Fracturing or Canopy Fracturing Initiation Systems (CFS/CFIS), Transparency Removal Systems (TRS), Missile/Drone/UAV Flight Termination Systems (FTS), Payload Deployment or Placement, Stage Separation Events, Thrust Termination Systems (TTS), Skin Severance, Thermally Activated Safety Systems (TASS), Engine Start Event Sequencing and Oil & Gas Industry Applications.

Common linear explosives use high explosives such as HNS, PBXN-5, HMX, and PETN and deflagration materials (rapid deflagration material, time delay mixes, and auto-ignition powders). They are divided into three categories: (1) deflagrating cords, (2) detonating cords, and (3) linear shaped charges.

a. Detonating Cord (CDC, FCDC, FDC, MDC and SMDC)

Detonating cord has a core of PETN or RDX in a reinforced plastic and fabric-coated covering. It will transmit a detonating wave from one point to another at a rate between 20,000 and 24,000 feet per second. It is used to prime or detonate other explosive charges. It can also be used as an explosive item by itself; several wraps around a tree will cut a tree on a line as clean as a whistle. Although it does

not lose its explosive properties by exposure to low temperatures, the covering becomes stiff and cracks when bent. Great care is required in using detonating cord primers in arctic conditions.

Flexible Confined Detonating Cord (FCDC)/ Confined Detonating Cord (CDC) are flexible lines designed with layers such as polyethylene, fiberglass, Kevlar and stainless steel braiding to ensure confinement of detonating byproducts when functioned.

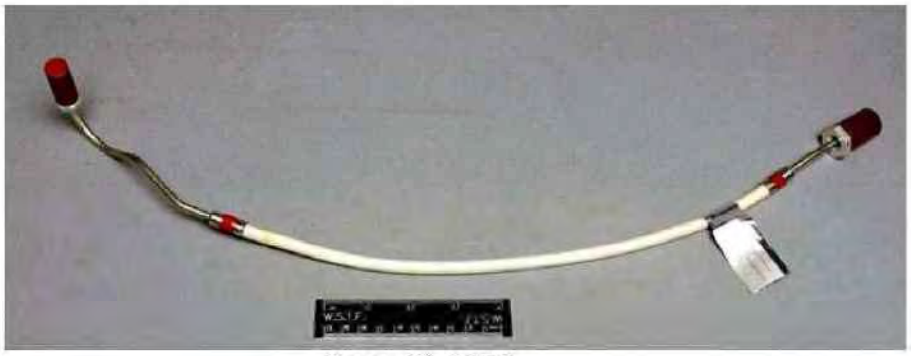


Figure 62: FCDC

Flexible Detonating Cord (FDC) is designed as a cost effective and robust. Explosive Transfer Line (ETL) for primary use in missile, munitions and target vehicle FTS applications where byproducts of combustion containment is not a requirement.

Mild Detonating Cord (MDC) is metal-clad linear explosive typically drawn or extruded in a round, elliptical or flat ribbon configuration by extruding through sets of wire drawn dies. The metal-clad linear can supplied in aluminum, tin, lead or silver sheath. The product derives its "mild" name because it can be produces with a core explosives as low as 0.5 grains per foot (0.1 grams per meter). The core explosives are usually PETN. However, MDC can be produced with core explosives of lead azide, RDX, HMX, HNS, and NHAB. Detonation velocities vary between 6.5 and 8.0 km/s depending upon the core explosives, the core explosives density and wall thickness of the sheath.

MDC is used in detonation distribution and manifolds in complex systems. It may also be produces with a heavy yarn sheath around the metal which makes if self-contained for use in aircraft escapes systems. CFS's create a safe escape path in the canopy using cast acrylic canopies shattered with a Mild Detonating Fuse (MDF)

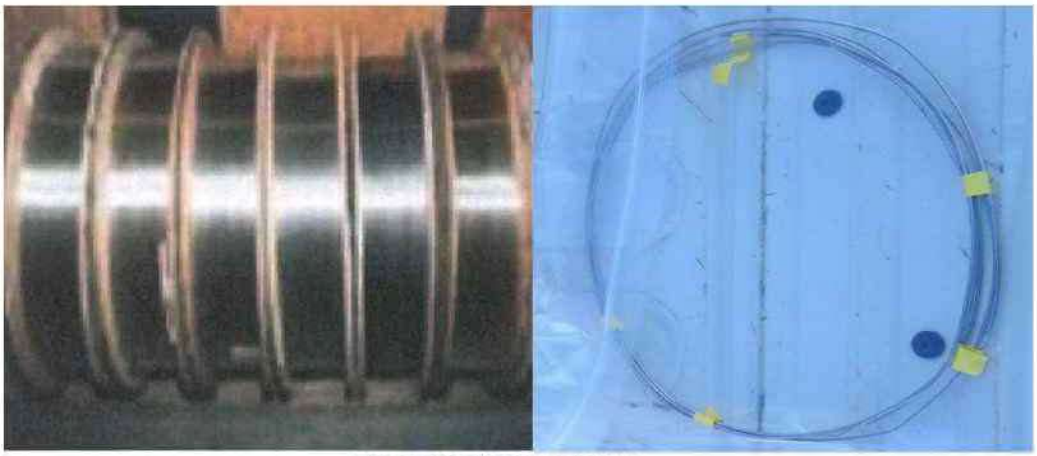


Figure 63: MDC and MDF

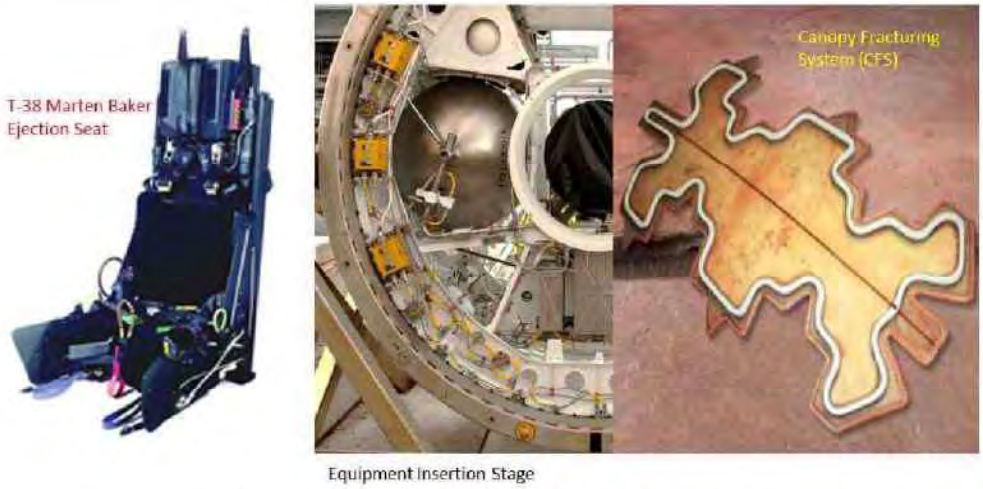


Figure 64: Various Uses of Detonating Cords

Shielded Mild Detonating Cord (SMDC) consists of ridged lines, bent to required configurations and designed for rugged environments (high traffic, heat, etc.). SMDC lines are hermetically sealed within a stainless steel tube and end fittings. When functioned, SMDC contain all byproducts of combustion.

b. Detonating Cord (Primacord)

The most familiar as well as highest production volume among the detonating cords is Primacord. Primacord detonating cord is simple in design and use. The high

explosive core is encased in various protective coverings developed to withstand the many conditions encountered in the field. The difference between the standard types of Primacord detonating cord is essentially the core load coupled with a difference in the degree of protection afforded by the encasements. Various combinations of materials such as textiles and plastics cover the raw PETN core. The textiles used provide tensile strength and flexibility, as well as resistance to abrasion and cutting, extremes of heat and cold and water and oil penetration.

Primacord detonates along its entire length at a velocity of approximately 7,000 m/s – 8,000 m/s (23,000 ft. /s – 26,246 ft. /s). As a transmission medium, it can act as a downline between the initiator and the blast area, and as a trunkline connecting several different explosive charges. As a timing mechanism any common length of detonating cord detonates very reliably and appears to explode instantaneously. Typical uses include mining, quarrying, drilling, construction/demolition, and warfare applications. It can also be used as an explosive item by itself; several wraps around a tree will cut a tree cleanly. Although it does not lose its explosive properties by exposure to low temperatures, the covering becomes stiff and cracks when bent. Great care is required in using detonating cord primers in arctic conditions. "Cordtex" and "Primacord" are two of many trademarks which have slipped into use as a generic term for this explosive material.

c. Expanding Tube Assembly (XTA)

Expanding Tube Assembly (XTA) is also known as Expanding Shielded Mild Detonating Cord (XSMDC). For some aircraft applications it is a formed steel tube containing an MDC. Formed into an oval shape and sealed on both ends by loaded booster shells or manifolds. The tube can be used as a separating device for stage separation, unlock medium or canopy jettison and thrust mechanism to induce thrust between two structures.

d. Detacord

Detacord is not very common. Detacord is produced by extruding datasheet through small-hole dies.

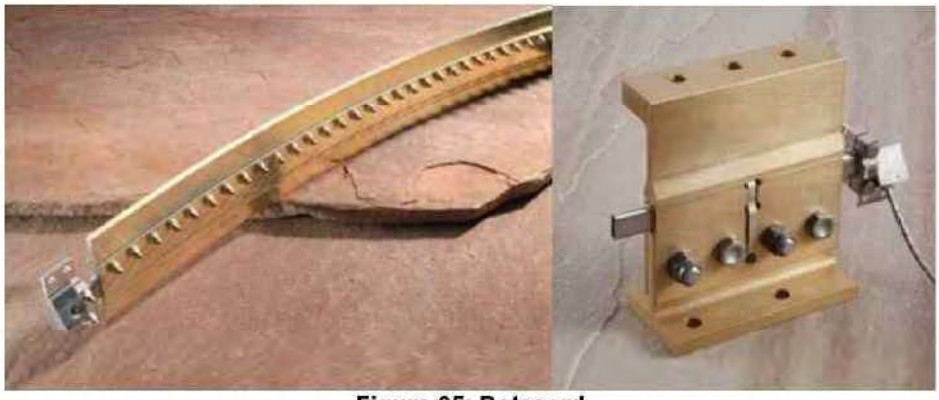


Figure 65: Detacord

e. Shock Tube

A shock tube detonator is a non-electric explosive fuse or initiator in the form of small-diameter hollow plastic tubing used to transport an initiating signal to an explosive charge by means of a percussive wave traveling the length of the tube. Nonel shock tube is a small diameter, three-layer plastic tube coated on the innermost wall with a reactive explosive compound. The most common product is 3 mm outer diameter and 1 mm inner diameter, with a tiny dusting of HMX/aluminum explosive powder on the tubing's inner surface. Shock tube is safer and more reliable than detonating cord with the same quantity of explosive. When initiated, shock tube propagates a low energy signal, similar to a dust explosion, at approximately 2000 m/sec (6,500 ft. /sec) along the tube's length with minimal disturbance to the outside of the tube. Being non-electrical and non-metallic, shock tubes are less sensitive to static electricity and radio frequency energy and thus have replaced many uses of electric detonators and are safer to handle and store than detonating cord. A version containing an explosive gas mixture has the additional advantage of being entirely inert until the tubing is charged with the gas.

Figure 66: Shock Tube

f. LSC and CSC

A shape charge will normally have an optimum distance from its target where the greatest shock is achieved due to overlapping shock waves. Linear Shaped Charge (LSC) is an explosive enclosed in a seamless metal sheath and fabricated in continuous lengths shaped in the form of an inverted "V". When detonated, the V-shaped metal liner with explosive core produces a uniform linear cutting action. This cutting action, known as the "Monroe effect", can be accentuated by controlling the LSC dimensions and configuration, explosive type and load, liner thickness and continuity. At detonation, the focusing of the explosive high pressure wave as it becomes incident to the side wall causes the metal liner of the LSC to collapse–creating the cutting force. If the standoff distance is optimum, collapse of the LSC will be complete before it reaches the target as a plasma jet. This high velocity jet impacts the target with pressures exceeding the target's yield strength and literally pushes the target material to either side of the path of the jet.
The cutting ability of LSC is affected by a number of variables, including the detonation rate of the explosive core load, the characteristics of the metal liners and the density of the material being cut. There is, however, a general scaling guide which may be used to determine the penetration as related to core load, in that penetration of a given material is essentially proportional to the square root of the core load.

The LSC may be formed using any malleable metal, but is typically copper, aluminum, lead or silver. Copper is generally used with most large core loads, but for some applications, Aluminum is recommended to provide structural integrity. For small core loads where flexibility is required, lead is preferred, while silver is

reserved primarily for use with thermally-resistant explosive core loads. The explosive core loads commonly used in LSC's are RDX, HMX, PETN and HNS.

Figure 67: LSC / LSC with Initiator Block

Flexible, Linear-Shaped Charge (FLSC) is a continuous explosive core encased in a seamless metal sheath, such as aluminum, copper, lead, tin, or silver. Shaped in the form of an inverted "V," the continuous liner and explosive produce uniform linear cutting action. FLSC can be supplied in a grain size as small as 7gr/ft. or as large as 4600 gr/ft.

Conical Shape Charge (CSC) is a typical device that consists of a solid cylinder of explosive with a metal-lined conical hollow in one end and a central detonator, array of detonators, or detonation wave guide at the other end. The CSC will normally have an optimum distance from its target where the greatest shock is achieved due to overlapping shock waves. CSCs are used in FTSs. The design of the CSC is simple and technically sound. PBXN is a common and excellent explosive material to use both for initiation reliability and cutting jet performance. The enormous pressure generated by the detonation of the explosive drives the liner contained within the hollow cavity inward to collapse upon its central axis. As the liner collapses the material collides and forms a high-velocity jet of metal moving forward along the axis capable which can penetrate several inches of steel and other materials.

Figure 68: CSC

Chapter 12: DEFINITIONS, TERMS, AND ACRONYMS

Above Ground Magazine (AGM) – Any building or structure, except for an operating building used for the storage of explosives. This includes trucks, trailers, railcars, aircraft or etc.

Ammonium Nitrate – A colorless crystalline salt, NH_4NO_3, used in fertilizers, explosives, and solid rocket propellants.

ANFO – Ammonium Nitrate and Fuel Oil

ANSI – American National Standards Institute

AP – Ammonium Perchlorate

APCP – Ammonium Perchlorate Composite Propellant

Barium Nitrate – a colorless crystalline toxic salt $Ba(NO_3)_2$ used chiefly in pyrotechnics (as in green lights) and in explosives

Booster - an explosive charge augmenting the initiating component of an explosive train to cause ignition or detonation of the main explosive charge or to increase the output of the assembly.

Brisance – the shattering capability of a high explosive, determined mainly by its detonation pressure. The term originates from the French verb "briser", which means to break or shatter. Brisance is of practical importance for determining the effectiveness of an explosion in fragmenting shells, bomb casings, grenades, structures, and the like.

Bridge wire - A resistance wire incorporated into an EED to convert electrical energy into heat to cause ignition of the pyrotechnic material.

CAD – Cartridge Actuated Devices

CFS - Canopy Fracturing System

CFIS - Canopy Fracturing Initiation System

CG – Compatibility Group

Class 1, Division 1 Explosives (1.1) – These are generally defined as materials which function by substantial instantaneous release of gas and heat; materials such as black powder that can be easily caused to deflagrate by sparks or small flame; and solid explosives which contain no liquid explosive ingredient and which, when unconfined, can be detonated by a blasting cap. Included in this class are high explosives, trinitrotoluene (TNT), amatol, tetryl, pentolite, and commercial dynamite.

Class 1, Division 2 Explosives (1.2) – These are defined as those explosives that, when initiated, produce fragmenting projectiles as well as shock wave. Included in this class are, grenades, warheads, bomblets, etc.

Class 1, Division 3 Explosives (1.3) – These are defined as those explosives, which in general function by rapid combustion rather than detonation and include some explosive devices such as special fireworks, flash powders, some pyrotechnic signal devices, and liquid, or solid propellant explosives, which include some smokeless powders. Examples are ammunition, jet thrust units, rocket, and JATO igniters.

Class 1, Division 4 Explosives (1.4) – These are defined as certain types of manufactured articles which contain Class 1.1 or Class 1.2 explosives or both, as components, but in restricted quantities, and certain types of fireworks. These explosives include electric squibs, primers, safety fuse, mild detonating fuse, explosive cable cutters, igniters, etc.

Compatibility – Chemical property of materials to coexist without adverse reaction fo an acceptable period of time.

Confined Detonating Cord (CDC) - A detonating cord surrounded by a flexible sheath of plastic, fiber fabric, or combinations thereof that confines the effects of the explosive core. Generally used for energy transfer between multiplexed components in a ordnance system.

Cryogenic – the study of the production of very low temperature (below −150 °C, −238 °F or 123 K) and the behavior of materials at those temperatures.

Conical Shape Charge (CSC) –

CTPB – Carboxyl-Terminated PolyButadiene

Cyclotrimethylenetrinitramine (RDX) - A secondary explosive. Color: white.

Deflagration - A rapid chemical reaction in which the output heat is sufficient to enable the reaction to proceed and accelerate without the input of heat from another source. a surface phenomenon with the reaction proceeding towards the unreacted material along the surface at sub-sonic velocity. The effect of a true deflagration under confinement is an explosion.

Detonation - A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure that proceeds from the reacted to the unreacted materials at supersonic velocity ranging from 2,000 to 8,500 mps. When the detonation is located on or near the surface of the ground, a crater normally characterizes it.

Detonator – A pyrotechnic device capable of initiating detonation in a subsequent high explosive component.

Device - Any device other than an EED, which contains explosives and/or mixtures of explosives and when initiated, produces pyrotechnics, gases, or flames.

DOT – Department of Transportation

Earth Covered Magazine (ECM) – An aboveground, earth-covered structure intended for the storage of explosives, pyrotechnics, propellant, or UN Class 1 hazardous materials that meets soil cover depth and slope requirements.

EELP - Explosives, Energetic Liquids, and Pyrotechnics

EES – Emergency Egress System

Electro-Explosive Device (EED) – A device containing some reaction mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action.

Electrostatic Discharge (ESD) – An arching of electric charge across a gap between two points not in contact or through a nonconductor when the voltage exceeds the dieelectric breakdown voltage of the nonconductor. All static electricity hazards are initiated by this sudden energy release or discharge mechanism.

EMR – ElectroMagnetic Radiation

ERP – Effective Radiated Power

ESO – Explosive Safety Officer

Ethyl Centralite – Gunshot residue. Chemical formula is $C_{17}H_{20}N_2O$

ETL – Explosive Transfer Line

Exothermic – characterized by or formed with evolution of heat

Explosion - A rapid chemical reaction with the generation of high temperature, flame and gas, or, a shock wave that proceeds at greater than the speed of sound, depending on the type of explosive material that has been initiated.

Explosive - The term "explosive" or "explosives" includes any chemical compound or mechanical mixture which, subjected to heat, impact, friction, detonation or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gasses which exert pressure in the surrounding medium. The term applies to detonating and deflagrating materials.

Explosive Bolt – A bolt that is intended to be fractured at a predetermined point by a contained or inserted explosive charge for the purpose of releasing a load.

Exploding Bridge wire (EBW) Device - An exploding bridge wire device is defined as an electro-explosive device in which the bridge wire is designed to be exploded (disintegrated) by a high energy electrical discharge which in turn causes the explosive charge to react.

Explosive Train - An explosive train consists of elements arranged according to decreasing sensitivity and increasing potency. The explosive train starts with an initiator usually made with a primary explosive or propellant. The initiator fires into a detonator usually made with a primary or secondary explosive. The detonator fires into a booster containing a secondary explosive. The booster then fires into the secondary explosive main charge.

FAE – Fuel Air Explosive

FCDC – Flexible Confined Detonating Cord

FDC – Flexible Detonating Cord

First Touch Rule – If you are considered charged, one must consider where the discharge is going to take place by considering the handler's first touch. Always avoid making the "first touch" or connection to the explosive device first.

FLSC – Flexible Linear Shape Charge

Fluorine – a nonmetallic halogen element that is isolated as a pale yellowish flammable irritating toxic diatomic gas

Fragmentation – Breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place.

FTS – Flight Termination System

Gelatinizer – Agent that thickens a fluid into a gelatin. Includes starch and deltrin.

GSE – Ground Support Equipment

Grounding – Practice of providing an electrical path from one or more conductive objects to ground.

Hazard – Any condition that may result in the occurrence or contribute to the severity of an accident.

Hexanitrostilbene (HNS) - A secondary explosive. Color--buff to pale yellow.

High Explosive (HE) – An explosive in which the transformation from its original composition and form, once initiated, proceeds with virtually instantaneous and continuous speed through the total mass, accompanied by rapid evolution of a large volume of gas and heat, causing very high pressure and widespread shattering effect.

HERO – Hazards of Electromagnetic Radiation to Ordnance

HC – hexachlorethane

HMX – Tetramethylene tetranitramine

HTPB – Hydroxy-Terminated Polybutadiene

Hypergolic – Self igniting upon contact of fuel and oxidizer, without a spark or external aid.

Inert – Containing no explosives or chemical agents. Shows no exothermic decomposition or incompatibility with energetic material.

IFU – Initiator Firing Unit

Igniter - Usually defined as any type of ignition cartridge, which is designed to ignite a secondary charge.

Intraline Distance (ILD) – The minimum distance permitted between any two buildings within one operating line. Separation distance expected to protect explosive materials in buildings from propagation detonation due to blast effects, but not against the possibility of propagation detonation due to fragments.

IMR – Black Powder Manufacturer

Initiator - An initiator is also a primer, just as is an igniter, however, the term initiator is more commonly used in conjunction with high explosive applications.

IRMU - Initiator Resistance Measurement Unit

Lead Azide - A sensitive primary explosive. Color-White.

LDS – Lightning Detection System

LH_2 – Liquid Hydrogen

LSC – Linear Shape Charge. a metal tube containing a core of high explosive, formed into a "V" or chevron shape to produce a cutting jet

LOX – Liquid Oxygen

LPS – Lightning Protection System

Magazine/Bunker - A structure that is designed or specifically designated for the storage of explosives.

Maximum Credible Event (MCE) - The hypothetical worst single event that is likely to occur from a given quantity and disposition of explosives, chemical agents, or reactive material. The event must be realistic with a reasonable probability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluation on this basis may then be used as a basis for effects calculations and casualty prediction.

MDC – Mild Detonating Cord

MDF – Mild Detonating Fuse

MMH – Monomethyl Hydrazine

NASA – National Aeronautics and Space Administration

ND: YAG - Neodymium-Doped Yttrium Aluminum Garnet; a crystal that is used as a lasing medium for solid-state lasers

Net Explosive Weight (NEW) – The total quantity, expressed in pounds, of explosive material or pyrotechnics in an item.

Nitrocellulose – A pulpy or cottonlike polymer derived from cellulose treated with sulfuric and nitric acids and used in the manufacture of explosives, collodion, plastics, and solid monopropellants.

Nitroglycerin – A thick, pale yellow liquid, $C_3H_5N_3O_9$, that is explosive on concussion or exposure to sudden heat. It is used in the production of dynamite and blasting gelatin and as a vasodilator in medicine.

Nitroguanidine – A chemical compound that is a colorless, crystalline solid. It melts at 232 °C and decomposes at 250 °C. It is not flammable and is an extremely low sensitivity explosive; however, its detonation velocity is high.

NSI – NASA Standard Initiator

Oxidizer – Oxidizing agent; especially one used to support the combustion of a rocket propellant

PBXN-(5) – Plastic Bonded Explosive. The 5 is a specific Navy blend consisting of 95% HMX and 5% binder

PETN - Pentaerythrite Tetranitrate, a secondary explosive more sensitive than RDX or HNS.

PIC - Plastic Igniter Cord

Placard – a notice posted in a public place, a small card or metal plaque

PPE – Personal Protective Equipment

POV – Personally Owned Vehicle

Primary Explosive - A sensitive explosive, one of the first elements in an explosive train. Very sensitive to heat and shock.

Primer – a device for priming; especially a cap, tube, or wafer containing percussion powder or compound used to ignite an explosive charge.

Propellant - An energetic material that is employed in an environment where it burns (sometimes at a high rate) but without the destructive force of an explosive. Under certain conditions involving mass and shape factors, a propellant also functions as an explosive.

PTR – Public Transportation Route

Pyrotechnics - This generic term is used throughout the space program in lieu of "ordnance" to avoid the connotation of weaponry, as in "pyrotechnic devices". Pyrotechnic devices include all devices and assemblies contained or operated/actuated by propellant and/or other explosives.

Quantity Distance (QD) – Quantity of explosives material and distance separation relationships which provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Quantity Distance tables.

SDS – Safety Data Sheet

Secondary Explosive - Explosive materials that are relatively insensitive to heat or impact and must be initiated by a suitable primary explosive or another secondary explosive. Secondary explosives are generally more brisant and more powerful than primary explosives; synonymous with "high explosive".

Sensitivity - The characteristics of an explosive or component which expresses its susceptibility to initiation by externally applied energy; may apply to electrical, shock, or other stimuli.

TASS - Thermally Activated Safety System

Tertiary – Of a third

TNT – Trinitrotoluene

TRS - Transparency Removal System

TTS – Thrust Termination System

UNO – United Nations Organization

WP – White Phosphorus

XTA – Expanding Tube Assembly

ZPP - Zirconium Potassium Perchlorate oxidizer

ATTACHMENT II.F

CONTINGENCY PLAN

ATTACHMENT II.F - HAZARDOUS WASTE CONTINGENCY PLAN

II.F.1. Contingency Plan

The Contingency Plan is a stand-alone document which is provided to each agency, organization or local community which may be called to action as part of the plan. However, the version of this document (Exhibit II.F-1) within the permit has been shortened by referencing rather than duplicating MSDS located elsewhere in the permit.

EXHIBIT II.FF-1

Contingency Plan
Open Burning Area

Virginia Department of Environmental Quality
Division of Land Protection and Revitalization
Office of Financial Responsibility and Waste Programs

Permit No. VA7800020888
Expiration Date: April 13, 2028

CONTINGENCY PLAN

Open Burning Area

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337

July 2015

EXHIBIT II.F-1 - CONTINGENCY PLAN

TABLE OF CONTENTS

1.0 SITE INFORMATION II.F-3
1.1 Facility Name II.F-3
1.2 Site Location II.F-3
1.3 Site Operator II.F-3
1.4 Description of Facility Operations II.F-3
2.0 EMERGENCY COORDINATOR AND OTHER RESPONSIBLE PERSONNEL. II.F-3
2.1. Emergency Coordinator II.F-3
2.2. Environmental Coordinator II.F-4
3.0 Responsibilities II.F-5
3.1. Witness II.F-5
3.2. Fire Department Dispatcher II.F-6
3.3. Incident Commander II.F-7
3.3.1. Evacuation Procedures II.F-9
3.3.2. Procedures Assessment II.F-10
3.3.3. Prevention of Reoccurrence II.F-11
3.4. Environmental Office II.F-12
4.0 Follow-up Actions II.F-13
4.1. Remediation of Area II.F-13
4.2. Decontamination of Emergency Equipment II.F-13
4.2.1 Small Equipment II.F-13
4.2.2 Large Equipment II.F-14
4.3. Follow-up Reports II.F-15
4.4. Security Staff Responsibilities II.F-16
5.0 Administrative issues II.F-16
5.1. Mutual Aid Agreements II.F-16
5.2. Hazmat Emergency Equipment II.F-17
5.3. Locations of Copies of this Contingency Plan II.F-18
5.4. Review and Revision of this Contingency Plan II.F-18
Appendix 1: Regulatory Compliance and Cross Reference Matrices II.F-20

Appendix 2: Copies of Aid Agreements II.F-30

1.0 SITE INFORMATION

1.1 Facility Name

National Aeronautics and Space Administration (NASA)
Goddard Space Flight Center
Wallops Flight Facility (WFF)
Open Burning (OB) Area

1.2 Site Location

34200 Fulton Street
Wallops Island, Virginia 23337

1.3 Site Operator

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia, 23337

1.4 Description of Facility Operations

The OB Area located on the shoulder of the dike road at the southwestern corner of Wallops Island, consists of four subunits (ground embedded cylinders) and one open burn pad assembly. The rocket motor and igniter are placed inverted into a cylinder or attached to the pad motor head assembly. The igniter is set off by battery hook-up behind a protective barrier. The distance between the barrier and burn area is specified in a ground safety plan prepared for each type of rocket motor. Burned motors and igniters are inspected for visible signs of untreated material. If untreated material is present in the motor, then the motor is re-ignited or the material removed and re-ignited on the burn pad. NASA uses open burning as the preferred method of treatment for rocket propellants and igniters because of the highly reactive nature of these materials. This method is considered the safest treatment method and is conducted in a manner to minimize impacts to the environment.

2.0 EMERGENCY COORDINATOR AND OTHER RESPONSIBLE PERSONNEL

2.1. Emergency Coordinator

The WFF Fire Department responds to emergencies at WFF including Wallops Island. The Fire Chief or Captain on Duty serve as Incident Commander, taking responsibility for all emergency response activities and, therefore, most responsibilities of the Emergency Coordinator found in Title 40, Parts 264.55 and 264.56 of the Code of Federal Regulations (CFR). He also fulfills the responsibilities

of the unnamed position in 40 CFR § 112.20(h)(1)(i). The remainder of this document will use the terms Incident Commander rather than Emergency Coordinator. The Incident Commander shall be thoroughly familiar with all aspects of the facility's contingency plan, all operations and activities at the facility, the location and characteristics of wastes handled, the location of all records for the facility, and the facility layout. The Fire Chief and all captains will attend WFF annual OB (Integrated) Contingency Plan training offered by the WFF Environmental Office and annually review the WFF OB Area Contingency Plan. A copy of these sign-in sheets will be placed in the OB Area Operating Record. In addition, this person shall have the authority to commit the resources necessary to execute the contingency plan. The Incident Commander will have a support group available for consultation and assistance in determining the course of mitigation of the problem. This group includes the WFF Safety, Environmental, Security, and Public Affairs staffs.

The Fire Department may be reached for emergencies at extension 911 on the facility and at (757) 824-1313 from off the facility. The radio frequency labeled as Channel 1 on all WFF handheld radios is reserved for use by the Fire Department and may be used in lieu of the telephone. Requests to external agencies for additional emergency services and personnel can be handled by the Fire Department. 911 Dispatchers man the emergency console twenty four hours per day and a Fire Captain is on duty 24 hours per day; therefore, cell phone numbers for those individuals are not included in this plan.

2.2. Environmental Coordinator

The Environmental Office will assist the Fire Department by supplying technical information and notifying external agencies. If a chemical release occurs that is above a reportable quantity (i.e., CERCLA, EPCRA), the Environmental Office will immediately report the release to external agencies. The Environmental Office will also conduct reporting to agencies on a non-emergency basis. This non-emergency reporting includes written reports to meet regulatory requirements. Either of the personnel below can fulfill the function of Environmental Coordinator. Contact will be made by the Fire Department in any emergency. The Fire Department will contact the following personnel in the order in which they appear:

Member	Facility Phone	Mobile Phone	Home Address
Theodore J. Meyer (Associate Chief, Medical and Enviornmental Division)	x1987	(443) 366-2268	30170 Providence Dr Salisbury MD 21804
Richard Owen Hooks (Alternate) (Environmental Engineer)	x1941	(443) 523-2697	1490 Shavox Rd, Salisbury MD 21804

3.0 Responsibilities

The Fire Department will be at the OB Area prior to, during, and immediately after all Open Burning activities. Therefore, all incident responses will be initiated by the Fire Department. In the event of No-Fire, all personnel will remain behind the barricade. Further instructions are found in the Open Burning Procedure Work Instruction found in Exhibit II.C-1 of the OB Area permit. Small amounts of unburned, ejected propellant will be removed from the site, when cool enough to handle. These incidents are not considered an emergency and are therefore not covered in this contingency plan. Incidents covered in the remainder of this contingency plan will involve fire, or uncontrolled petroleum or hazardous materials releases.

3.1. Witness

Fire Department personnel, who will already be on the scene, will assume the responsibility of the "witness" during an incident.

In case of an emergency, all personnel must first evaluate and ensure their own safety and notify co-workers in the area.

After the initial safety of personnel is ensured, the witness will observe the material and character of the incident and determine as quickly and safely as possible the following: whether the material is petroleum or hazardous materials; whether it is controlled* or not; whether it is immediately dangerous or not:

*The material is **controlled** if it is very unlikely to migrate and has not entered waters of the State (i.e., sewers, drains, pond, or stream.)

If the material is petroleum and controlled:

CALL the Environmental Coordinators listed in Section 1.2 of this plan or the Environmental Office at extension 1987 or 1718.

If additional Fire Department resources are required, the witness will report as much of the following information as possible to the 911 Dispatcher:

1. Name of reporting party;
2. Type/name of material released;
3. Location of release;
4. Status of release:
    a. Controlled/contained or migrating,

b. Pose an imminent threat to people, facilities, or the environment,

c. Entered any waters such as the intracoastal waterway or the Atlantic Ocean, or

d. Entered soil;

5. Cause of release;

6. Estimated quantity and flow rate of release; and

7. Time of release.

3.2. Fire Department Dispatcher

Any incident covered in this contingency plan will involve fire, uncontrolled petroleum, or hazardous materials. Therefore, the Fire Department, who will already be on the scene, will initiate a response.

1. Dispatcher alerts remaining Fire Department personnel according to internal fire department protocol. These may include Captain on Duty; Fire Inspector; Fire Lieutenant; engine, ambulance, and crash vehicles and crews; Fire Department personnel and equipment at Wallops Island; or Haz-Mat Unit.

2. Dispatcher notifies WFF Security.

3. If it is determined that the incident involves a release of hazardous material or petroleum, the dispatcher completes an incident report form and notifies the Environmental Office.

After an Incident Commander has been established (the Incident Commander will be discussed later in section 3.3), the dispatcher may need to notify others as directed by the Incident Commander. The following is a list of contacts that may be necessary depending upon the size of the incident. The Fire Department maintains a list of these telephone numbers.

1. Mutual Aid Requests (see Section 5.1)

2. Facility Operation Manager for the Open Burning Area

3. Public Affairs

4. Environmental

5. Facilities Engineering

6. Facilities Maintenance

7. Supply

8. Transportation

9. Radio Communications

10. Telecommunications

11. Documentation

12. Optical

13. Chemical Laboratory

14. Range Operations

3.3. Incident Commander

Unless already present at the OB Area, the Incident Commander will obtain all data available from the Fire Department Emergency Console or the witness. The Incident Commander may actually be the witness and then perform the next steps.

The Incident Commander must move to the site of the emergency if he/she is not already there. At the site, the Incident Commander must determine the apparent character, intensity, and size of the incident. Based upon the initial assessments made by the Incident Commander, additional staff and equipment may be summoned. Responsibilities may be delegated according to the Incident Command System or Incident Management System as defined in the Fire Department's Standard Operating Procedures.

The Incident Commander shall be responsible for the overall management of the incident, from the time an incident is reported through termination of the command. With the WFF Safety, Environmental, Security, and Public Affairs staffs available for consultation, the Incident Commander shall ensure that the following responsibilities are met:

i. Assess the situation.

ii. Initiate the incident command system.

iii. Isolate the site and establish access control points.

iv. Establish a command post.

v. Establish hazard zone boundaries, taking into account the magnitude of the problem, wind direction, and adjacent structures. Initiate protective actions and evacuate surrounding area, if necessary.

vi. Identify the character, source, amount, and extent of any released materials by observation or examining facility records or manifests and, if necessary, by chemical analysis.

vii. Initiate basic hazard and risk assessment activities based on types and quantities of materials involved.

viii. In cooperation with the Environmental Office, notify appropriate state and local agencies. (see Section 3.4)

ix. Notify additional resources, if necessary, including a Response Contractor for cleanup assistance. If a response contractor is required, the Environmental Coordinator will be notified first. The following response companies are available on a 24-hour basis, unless otherwise noted. This list is maintained to provide contacts in the event that an oil or hazardous waste emergency exceeds WFF's resources.

Response Company	Telephone	Capabilities
Clean Venture, Inc. 2031 Inverness Avenue Baltimore, MD 21230	(410) 368-9170 (800) 347-7672	Oil, medical wastes, hazardous materials, TSD facility, underground storage tanks, explosives
MARCOR Remediation, Inc. 308 Mill Street Salisbury, MD 21801-4242	(410) 742-6161 (800) 247-0369	Oil, hazardous materials, underground storage tanks, soil remediation
Reactive Management Corporation 1025 Executive Blvd. Suite 101 Chesapeake, VA 23320	(757) 436-1033	Explosives, reactives, medical wastes, hazardous wastes, small oil

x. Select and use the appropriate personal protection equipment.

xi. Initiate spill containment and control procedures.

xii. Notify WFF senior management.

xiii. In accordance with Fire Department Emergency Operations Plan, make official announcements concerning the emergency and need for public action. Notify the WFF Public Affairs Office for press releases.

xiv. Take samples of residues, if necessary, for proper characterization.

xv. Mitigate the hazard to the point where the scene is determined non-hazardous and no longer a threat to human health and the environment. In the case of a fire or explosion, initiate emergency response immediately. In the case of a spill/release, initiate emergency response if:

- There is a possibility of toxic fumes, fire, or explosion that present imminent hazards to personnel, property, or the environment;
- The material cannot be contained within the immediate work area;
- Facility personnel are not trained to contain the release; or
- Any material is released directly into surface waters.

xvi. Implement decontamination activities for PPE and contaminated areas.

xvii. Ensure that contaminated materials and/or residues are containerized or packaged.

The Incident Commander shall ensure the following criteria are met:

i. Cleanup procedures do not pose a compatibility threat between released substances and cleaning agents. Safety Data Sheets (SDS) of both the released substance and the cleaning agent will be reviewed to ensure compatibility. The Environmental Office will be consulted as necessary.

ii. Leaks and cracks are not present in the clean-up containers.

iii. Unusual heat is not generated in the containers.

iv. Residual waste materials are isolated.

v. All emergency equipment listed in the contingency plan are cleaned and fit for their intended use or are replaced before operations are resumed.

vi. The time, date, and details of any incident that required implementing the contingency plan are noted in the operating record.

3.3.1. Evacuation Procedures

There are no personnel permanently housed or working at the OB Area. During OB operation personnel are behind a barricade 1250 feet away from the OB Area. Only personnel involved in the operation are behind the barricade. Accordingly, evacuation is unlikely and would be limited to few personnel. The Incident commander does

have the ability to evacuate a larger area if needed. If an incident presents a threat to personnel, the following procedure will be followed:

- Spread the alarm verbally.
- If evacuation is required from an area beyond the OB Area or to include personnel not involved with OB operations, the alarm will be spread via an outdoor warning tone or voice, radio, and/or cell phone text.
- Once personnel have evacuated the area will be barricaded or closed to prevent further entry.

Personnel may evacuate in several directions from the OB Area. In most cases, personnel should travel north on the roadway until they are a safe distance from the event. If that direction is blocked, personnel may go east to the ocean or south along the beach. Appendix 3 includes maps of OB Area, evacuation routes, and the surrounding area.

3.3.2. Procedures Assessment

During an open burn event, SDS will be available for the burning material. These will provide helpful details and must be consulted for data regarding the characteristics of the material and the nature of the hazards.

The WFF Fire Department Standard Operating Procedures include sections on identifying materials and on hazard/risk assessment. The Department's investigator may obtain any identifying numbers such as a hazardous material identifying placard on a truck or other vehicle, look at shipping papers or manifests, or obtain information from site personnel. Motor shapes, sizes, or types may also be valuable information. The Department of Transportation (DOT) guidebook, North American Emergency Response Guidebook (ERG) or other authoritative publication may be used to research the material's identifying numbers or names.

A full list of materials for disposal will be maintained at all times and should be available during OB Area operations. This information on manifests, on MSDS, or on other appropriate documents should be used to obtain data useful to control the danger. A list of typical rocket motors, their propellant compositions, hazards and MSDS can also be found in Appendix 4 or in the OB Area Permit Waste Analysis Plan Exhibit II.B-1

Various tools may be used to obtain data to make assessments. The Incident Commander will make visual on-site assessment from a safe distance. Requests for information may be made to the facility operation manager or nearby workers. Additional tools may be used as noted below:

Tool:	Likely information available:
Report of initial witness	Location Incident type Magnitude Materials involved Threats to personnel, facilities, or environment
Facility maps	Location of incident Facility surroundings under potential threat Environmental surroundings under potential threat
Facility operation manager	Materials involved Personnel involved
Distant visual assessment	Incident type Magnitude Materials involved, possibly
Nearby personnel	Incident history Personnel involved Materials involved
MSDS	Material hazards Safe handling techniques
Hazardous material inventory database	Materials involved Other nearby materials which may be threatened
Field analytical instruments such as: LEL Meter Oxygen Meter Photoionization Detector Other instruments	Materials involved Level of hazard Level of contamination
Field samples and chemical analysis Soil Sediment Ground water Surface water	1. Level of contamination 2. Remediation end point

In order to effectively manage the use of these tools and the data obtained from them, the Incident Commander may establish an Investigation and Planning Sector, as part of the Incident Command System, with appropriate personnel to assess the hazard.

3.3.3. Prevention of Reoccurrence

During and after an emergency, the Incident Commander shall take all reasonable measures necessary to ensure that fires, explosions, and releases do not occur, reoccur, or spread to other hazardous waste at the facility. These measures shall include, where applicable, stopping processes and operations, collecting and containing released substances, and removing or isolating containers.

3.4. Environmental Office

The Environmental Office is contacted by the Fire Department if the spill involves either uncontrolled petroleum or hazardous materials or is a threat to personnel, the facility, or the environment. The Environmental Office assumes the following responsibilities:

If the spill is greater than 25 gallons of petroleum or has entered or has the potential to enter the waters of the Commonwealth, the Tidewater Regional Office of the Virginia Department of Environmental Quality (DEQ), must be notified within 2 hours at (757) 518-2000 (or on the internet at http://www.deq.virginia.gov/Programs/PollutionResponsePreparedness/PollutionReportingForm.aspx). Also, the Virginia Department of Emergency Management at (800) 468-8892 and the National Response Center at (800) 424-8802 (or on the internet at http://www.nrc.uscg.mil/report.htm) must be notified, within 2 hours. The Environmental Office will give the following information to all parties:

1. Time of discharge;

2. Location of discharge;

3. Type and quantity of release;

4. The extent of injuries, if any;

5. The possible hazard to human health or the environment, outside the facility; and

6. Name, address, and telephone number of person making the report, and all other pertinent and necessary information.

If a release, fire, or explosion occurs, which threatens human health or the environment outside the facility or if a release exceeds the reportable quantity of a hazardous material (i.e., CERCLA, EPCRA), it must be reported immediately to the National Response Center at (800) 424-8802 or on the internet at http://www.nrc.uscg.mil/report.htm, the DEQ at (757) 518-2000, and the Virginia Department of Emergency Management at (800) 468-8892. The full list of minimum reportable quantities is found in Contingency Plan Appendix 1 Regulatory Compliance and Cross-Reference Matrices. This list is referenced from 40 CFR § 117.3.

The Environmental Staff shall be available to the Incident Commander to assist in the following areas:

- Substantiating regulatory compliance;

- Managing environmental aspects of site restoration including decontamination of personnel, equipment, and the scene;

- Transporting, if practicable, the containerized contaminated debris and materials; and

- Assisting with arrangements for either onsite remediation or offsite transportation, treatment, storage, and disposal of hazardous wastes, including sampling for waste identification, by an EPA permitted transportation, storage, and disposal facility.

4.0 Follow-up Actions

4.1. Remediation of Area

The incident area must be thoroughly remediated and decontaminated before OB Area operations may be resumed. Contaminated soil or water must be containerized, characterized and disposed of in accordance with state and federal regulations. All remediation and decontamination must be documented in the follow-up reports listed below in Section 4.3 before operations may resume.

4.2. Decontamination of Emergency Equipment

The decontamination wash waters (wastewaters), rinseates, soils, and residues collected in the decontamination areas will be managed as potentially contaminated with hazardous waste and tested for the HCOCs and TCLP constituents, as identified in the OB Area Permit. All hazardous wastes will be disposed of in accordance with state and federal regulations.

Any disposable items, such as protective clothing, sampling equipment, filters, clean-up materials, decontamination liner materials, etc., will be containerized, characterized and disposed of in accordance with state and federal regulations.

4.2.1 Small Equipment

A decontamination area will be set up for all non-disposable response equipment decontamination. The area will be set up on plastic and down gradient of the OB units.

All non-disposable response equipment will be decontaminated after use. An area for cleaning equipment will be established as close as possible to the work area. A layer of plastic will be placed on a level surface. Buckets or other appropriate containers will be used for capturing the rinseate and holding the wash-water during the cleaning process.

The equipment shall be decontaminated, as follows:

A. The decontamination procedures for equipment (EPA Region IV, Standard Operating Procedures and Quality Assurance Manual, 1986), will be as follows:

1. Remove loose material by brushing or scraping. The material removed will be properly containerized and disposed of in accordance with all applicable state and federal hazardous and solid waste regulations.

2. The equipment will then be washed with a non-phosphate detergent. All decontamination wash waters will be collected and containerized for proper disposal in accordance with state and federal regulations.

3. Rinse with tap water, rinse with methanol or propanol, then rinse with distilled or de-ionized water. These decontamination rinse waters will be collected and containerized for proper disposal in accordance with state and federal regulations.

4. If metal contamination is present, a rinse with 10 percent nitric acid will also be needed. This acid rinse will be followed by another distilled or de-ionized water rinse. This rinseate shall be collected and containerized for proper disposal in accordance with state and federal regulations.

5. Equipment will be allowed to air dry then stored in aluminum foil or plastic bags to prevent contamination.

In addition, the following procedures shall be established for the proper decontamination of personal protective equipment (PPE).

1. PPE will be decontaminated between uses/areas, and upon completion of work.

2. All decontamination will take place in the temporary decontamination area.

4.2.2 Large Equipment

If, the decontamination of heavy equipment is necessary, a temporary decontamination area for this heavy equipment will be constructed. The area will be graded to at least a 2 percent slope toward one corner. A berm constructed of sand bags, or equivalent material, will be placed around the edges. The area will be lined with a plastic liner to prevent infiltration of decontamination wafers into the underlying soils. The liner must be able to sustain the stress caused by moving of heavy equipment in and out of the area. The decontamination waters must drain to an appropriate container; no accumulation of liquids on the liner is allowed. This collected liquid will be tested for appropriate disposal and disposed of in accordance with state and federal regulations. All decontamination shall occur in the

decontamination area constructed and waste generated will be properly handled in accordance with all applicable state and federal hazardous and solid waste regulations. The decontamination procedures for heavy equipment are:

1. Heavy equipment used to remove contaminated soil will be decontaminated by appropriate abrasive methods (i.e., scraping and/or brushing). The material removed will be properly containerized and disposed of in accordance with all applicable state and federal hazardous and solid waste regulations.

2. Equipment will then be cleaned with a high-pressure wash. A non-phosphate detergent shall be used. All decontamination wash waters will be collected and containerized for proper disposal in accordance state and federal regulations.

3. The heavy equipment will then be rinsed with water, rinsed with methanol or propanol, and then rinsed with distilled or de-ionized water. This decontamination rinseate will be collected and containerized for proper disposal in accordance with state and federal regulations.

4. If heavy metal contamination is present, a rinse with 10 percent nitric acid may also be needed. This acid rinse will be followed by another water rinse. These rinse waters shall be collected and containerized for proper disposal in accordance with state and federal regulations.

5. Equipment will be allowed to air dry then covered in plastic sheeting to prevent contamination.

Before operations are resumed, the decontamination of emergency equipment and the disposal of generated wastes will be documented in the follow-up reports listed below in Section 4.3.

4.3. Follow-up Reports

A written report must be submitted to the Secretary of the DEQ and to the EPA Regional Administrator, within 15 days of the incident. This report must include the following:

1. The name, address and telephone number of the operator and the facility;

2. The date, time and type of incident;

3. The name and quantity of material(s) involved;

4. The extent of injuries;

5. An assessment of actual or potential hazards to human health or the environment;

6. The estimated quantity and disposition of recovered material that resulted from the incident;

7. The remediation procedures used and results obtained; and

8. The decontamination procedures employed.

The addresses of these agencies are listed below. These reports must be filed before operations may be resumed. Send one copy of the report to each of the following addresses:

Director, Tidewater Regional Office
Commonwealth of Virginia
Department of Environmental Quality
5636 Southern Boulevard
Virginia Beach, VA 23462

Director, Office of Financial Responsibility and Waste Programs
Department of Environmental Quality
PO Box 1005
Richmond, VA 23218

United States Environmental Protection Agency
Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

4.4. Security Staff Responsibilities

The WFF has both a fully trained 24-hour security force and fully trained NASA Federal Officers who will assist the Emergency Coordinator in any evacuation procedures, site access, and security measures.

5.0 Administrative issues

5.1. Mutual Aid Agreements

The Fire Department has established a mutual aid agreement for such emergency services as firefighting, rescue, Haz-mat response and emergency medical services (including basic life support and advanced life support) with the Accomack County Fire and Rescue Commission. This agreement also covers the Virginia Department of Emergency Services response. It is noteworthy that the office of the Director of Emergency Medical Services for Accomack County (life support services) also holds the position of Director of Emergency Medicine at Shore Memorial Hospital.

NASA Wallops Flight Facility has a complete staff of round-the-clock protective services personnel who are trained to respond to security emergencies. In addition NASA Wallops Flight Facility employs special agents who work during Monday through Friday work week and for special events. NASA Wallops Flight Facility does not envision any emergencies at the Open Burning Area which could not be responded to by the WFF Fire Department, mutual aid Fire Departments, the WFF protective services personnel and the WFF special agents.

A letter from Peninsula Regional Medical Center, Salisbury, Maryland states that they are "well prepared to handle any and all hazardous material exposure of … Wallops employees. Due to the size and capability of the onsite security."

Copies of any written agreements are included in Appendix 2 and are also available for review at the Wallops Fire Department.

5.2. Hazmat Emergency Equipment

No equipment is stored at the OB Area. Therefore, this section discusses the equipment that the Fire Department either brings to OB operations or would have available. The following emergency equipment inventory is for Fire Department No. 2 on Wallops Island.

The Fire Department on Wallops Island consists of 1 Structural Pumper fire truck with a total capacity of 2,839 liters (750 gallons) of water and 227 liters (60 gallons) of foam. On the Island, three water storage towers 56,781, 189,270, and 189,279 liters (150,000, 50,000 and 50,000 gallons) provide water to a water hydrant system maintained at 5300 liters per minute at 19 kilograms per square centimeter (1,400 gallons per minute at 42 pounds per square inch). In addition, a 378,541 liter (100,000 gallon) storage tank located on the mainland provides water to the Island. The closest water hydrant to the OB area is located approximately 609 meters (2,000 feet) away at the Virginia Commercial Spaceport. Hydrant flow tests are performed annually by the fire department to ensure the water supply system is functioning properly. Structural Pumper fire trucks are used at the open burning area that can pump 1250 gallons per minute. In the event additional capacity is needed, 3 fire trucks are available from the Main Base which can provide 34,068 liters (9,000 gallons) of water and 4,542 liters (1200 gallons) of AFFF foam pumping at a rate of 2000 gallons per minute.

Fire Department No. 2 currently stocks the following spill response equipment:

Quantity	Item	Description and Usage	Capacity	Total Capacity
6	Absorbent clay (50 pound bag)	Absorb and prevent the spread of spills	10 gallons oil per 50 pound bag	80 gallons oil
321	Absorbent Pads	Absorb and prevent the	20 ounces of	50.2 gallons oil

		spread of spills	oil per pad	
3	Pig Pillows	Absorb and prevent the spread of spills	0.5 gallons oil per pillow	1.5 gallons oil
6	Pig Pans	Absorb and prevent the spread of spills	0.5 gallons oil per pillow	3 gallons oil
2 (20 ft)	10 foot Booms	Absorb and prevent the spread of spills	2 gallons oil per 10 feet	4 gallons oil

Fire Department No. 2 currently stocks the following personal protective equipment:

Quantity	Item	Description and Usage
1 box (50 count)	Nitrile Gloves	Chemical hand protection for compatible chemicals
11 pairs	Black rubber gloves	Oil and acid protection for hands
20 pairs	Chemical resistant rubber boots	Chemical foot protection for compatible chemicals
18 sets	NFPA Turnout Gear	Fire and chemical hand, body, and foot protection for compatible chemicals
11	Level A suits	Fully encapsulating chemical protection
4	ONESuit	Fully encapsulating fire and chemical protection
6	SCBA packs	Self-contained breathing air
6	Spare SCBA cylinders	Self-contained breathing air
10	Tyvek suits	Chemical body protection for compatible chemicals

5.3. Locations of Copies of this Contingency Plan

Copies of this contingency plan will be maintained in X-55 Launch Support Services Building in the OB records area, at the Fire Department, at the Environmental Office, and in various administrative files at the WFF. Copies have been sent to all mutual aid facilities described above in Section 5.1 of the Contingency Plan.

5.4. Review and Revision of this Contingency Plan

The plan must be reviewed and revised as necessary when the following occurs:

1. After an emergency incident,

2. When personnel listed in this document change,

3. When the contingency plan for the WFF base is reviewed and modified as necessary,

4. At Open Burn permit renewal, or

5. Other times as deemed necessary by management personnel.

This review and any conclusions must be documented and the latest date of review placed at the head of this plan.

Appendix 1: Regulatory Compliance and Cross Reference Matrices
Reportable quantities

NOTE: The first number under the column headed ‘‘RQ’’ is the reportable quantity in pounds. The number in parentheses is the metric equivalent in kilograms. For convenience, the table contains a column headed ‘‘Category’’ which lists the code letters ‘‘X’’, ‘‘A’’, ‘‘B’’, ‘‘C’’, and ‘‘D’’ associated with re-portable quantities of 1, 10, 100, 1000, and 5000 pounds, respectively.

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Acetaldehyde	C	1,000 (454)
Acetic acid	D	5,000 (2,270)
Acetic anhydride	D	5,000 (2,270)
Acetone cyanohydrin	A	10 (4.54)
Acetyl bromide	D	5,000 (2,270)
Acetyl chloride	D	5,000 (2,270)
Acrolein	X	1 (0.454)
Acrylonitrile	B	100 (45.4)
Adipic acid	D	5,000 (2,270)
Aldrin	X	1 (0.454)
Allyl alcohol	B	100 (45.4)
Allyl chloride	C	,000 (454)
Aluminum sulfate	D	5,000 (2,270)
Ammonia	B	100 (45.4)
Ammonium acetate	D	5,000 (2,270)
Ammonium benzoate	D	5,000 (2,270)
Ammonium bicarbonate	D	5,000 (2,270)
Ammonium bichromate	A	10 (4.54)
Ammonium bifluoride	B	100 (45.4)
Ammonium bisulfite	D	5,000 (2,270)
Ammonium carbamate	D	5,000 (2,270)
Ammonium carbonate	D	5,000 (2,270)
Ammonium chloride	D	5,000 (2,270)
Ammonium chromate	A	10 (4.54)
Ammonium citrate dibasic	D	5,000 (2,270)
Ammonium fluoborate	D	5,000 (2,270)
Ammonium fluoride	B	100 (45.4)
Ammonium hydroxide	C	1,000 (454)
Ammonium oxalate	D	5,000 (2,270)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Ammonium silicofluoride	C	1,000 (454)
Ammonium sulfamate	D	5,000 (2,270)
Ammonium sulfide	B	100 (45.4)
Ammonium sulfite	D	5,000 (2,270)
Ammonium tartrate	D	5,000 (2,270)
Ammonium thiocyanate	D	5,000 (2,270)
Amyl acetate	D	5,000 (2,270)
Aniline	D	5,000 (2,270)
Antimony pentachloride	C	1,000 (454)
Antimony potassium tartrate	B	100 (45.4)
Antimony tribromide	C	1,000 (454)
Antimony trichloride	C	1,000 (454)
Antimony trifluoride	C	1,000 (454)
Antimony trioxide	C	1,000 (454)
Arsenic disulfide	X	1 (0.454)
Arsenic pentoxide	X	1 (0.454)
Arsenic trichloride	X	1 (0.454)
Arsenic trioxide	X	1 (0.454)
Arsenic trisulfide	X	1 (0.454)
Barium cyanide	A	10 (4.54)
Benzene	A	10 (4.54)
Benzoic acid	D	5,000 (2,270)
Benzonitrile	D	5,000 (2,270)
Benzoyl chloride	C	1,000 (454)
Benzyl chloride	B	100 (45.4)
Beryllium chloride	X	1 (0.454)
Beryllium fluoride	X	1 (0.454)
Beryllium nitrate	X	1 (0.454)
Butyl acetate	D	5,000 (2,270)
Butylamine	C	1,000 (454)
n-Butyl phthalate	A	10 (4.54)
Butyric acid	D	5,000 (2,270)
Cadmium acetate	A	10 (4.54)
Cadmium bromide	A	10 (4.54)
Cadmium chloride	A	10 (4.54)
Calcium arsenate	X	1 (0.454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Calcium arsenite	X	1 (0.454)
Calcium carbide	A	10 (4.54)
Calcium chromate	A	10 (4.54)
Calcium cyanide	A	10 (4.54)
Calcium dodecylbenzenesulfonate	C	1,000 (454)
Calcium hypochlorite	A	10 (4.54)
Captan	A	10 (4.54)
Carbaryl	B	100 (45.4)
Carbofuran	A	10 (4.54)
Carbon disulfide	B	100 (45.4)
Carbon tetrachloride	A	10 (4.54)
Chlordane	X	1 (0.454)
Chlorine	A	10 (4.54)
Chlorobenzene	B	100 (45.4)
Chloroform	A	10 (4.54)
Chlorosulfonic acid	C	1,000 (454)
Chlorpyrifos	X	1 (0.454)
Chromic acetate	C	1,000 (454)
Chromic acid	A	10 (4.54)
Chromic sulfate	C	1,000 (454)
Chromous chloride	C	1,000 (454)
Cobaltous bromide	C	1,000 (454)
Cobaltous formate	C	1,000 (454)
Cobaltous sulfamate	C	1,000 (454)
Coumaphos	A	10 (4.54)
Cresol	B	100 (45.4)
Crotonaldehyde	B	100 (45.4)
Cupric acetate	B	100 (45.4)
Cupric acetoarsenite	X	1 (0.454)
Cupric chloride	A	10 (4.54)
Cupric nitrate	B	100 (45.4)
Cupric oxalate	B	100 (45.4)
Cupric sulfate	A	10 (4.54)
Cupric sulfate, ammoniated	B	100 (45.4)
Cupric tartrate	B	100 (45.4)
Cyanogen chloride	A	10 (4.54)
Cyclohexane	C	1,000 (454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
2,4-D Acid	B	100 (45.4)
2,4-D Esters	B	100 (45.4)
DDT	X	1 (0.454)
Diazinon	X	1 (0.454)
Dicamba	C	1,000 (454)
Dichlobenil	B	100 (45.4)
Dichlone	X	1 (0.454)
Dichlorobenzene	B	100 (45.4)
Dichloropropane	C	1,000 (454)
Dichloropropene	B	100 (45.4)
Dichloropropene-Dichloropropane (mixture)	B	100 (45.4)
2,2-Dichloropropionic acid	D	5,000 (2,270)
Dichlorvos	A	10 (4.54)
Dicofol	A	10 (4.54)
Dieldrin	X	1 (0.454)
Diethylamine	B	100 (45.4)
Dimethylamine	C	1,000 (454)
Dinitrobenzene (mixed)	B	100 (45.4)
Dinitrophenol	A	10 (45.4)
Dinitrotoluene	A	10 (4.54)
Diquat	C	1,000 (454)
Disulfoton	X	1 (0.454)
Diuron	B	100 (45.4)
Dodecylbenzenesulfonic acid	C	1,000 (454)
Endosulfan	X	1 (0.454)
Endrin	X	1 (0.454)
Epichlorohydrin	B	100 (45.4)
Ethion	A	10 (4.54)
Ethylbenzene	C	1,000 (454)
Ethylenediamine	D	5,000 (2,270)
Ethylenediamine-tetraacetic acid (EDTA)	D	5,000 (2,270)
Ethylene dibromide	X	1 (0.454)
Ethylene dichloride	B	100 (45.4)
Ferric ammonium	C	1,000 (454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
citrate		
Ferric ammonium oxalate	C	1,000 (454)
Ferric chloride	C	1,000 (454)
Ferric fluoride	B	100 (45.4)
Ferric nitrate	C	1,000 (454)
Ferric sulfate	C	1,000 (454)
Ferrous ammonium sulfate	C	1,000 (454)
Ferrous chloride	B	100 (45.4)
Ferrous sulfate	C	1,000 (454)
Formaldehyde	B	100 (45.4)
Formic acid	D	5,000 (2,270)
Fumaric acid	D	5,000 (2,270)
Furfural	D	5,000 (2,270)
Guthion	X	1 (0.454)
Heptachlor	X	1 (0.454)
Hexachlorocyclopentadiene	A	10 (4.54)
Hydrochloric acid	D	5,000 (2,270)
Hydrofluoric acid	B	100 (45.4)
Hydrogen cyanide	A	10 (4.54)
Hydrogen sulfide	B	100 (45.4)
Isoprene	B	100 (45.4)
Isopropanolamine dodecylbenzenesulfonate	C	1,000 (454)
Kepone	X	1 (0.454)
Lead acetate	A	10 (4.54)
Lead arsenate	X	1 (0.454)
Lead chloride	A	10 (4.54)
Lead fluoborate	A	10 (4.54)
Lead fluoride	A	10 (4.54)
Lead iodide	A	10 (4.54)
Lead nitrate	A	10 (4.54)
Lead stearate	A	10 (4.54)
Lead sulfate	A	10 (4.54)
Lead sulfide	A	10 (4.54)
Lead thiocyanate	A	10 (4.54)
Lindane	X	1 (0.454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Lithium chromate	A	10 (4.54)
Malathion	B	100 (45.4)
Maleic acid	D	5,000 (2,270)
Maleic anhydride	D	5,000 (2,270)
Mercaptodimethur	A	10 (4.54)
Mercuric cyanide	X	1 (0.454)
Mercuric nitrate	A	10 (4.54)
Mercuric sulfate	A	10 (4.54)
Mercuric thiocyanate	A	10 (4.54)
Mercurous nitrate	A	10 (4.54)
Methoxychlor	X	1 (0.454)
Methyl mercaptan	B	100 (45.4)
Methyl methacrylate	C	1,000 (454)
Methyl parathion	B	100 (45.4)
Mevinphos	A	10 (4.54)
Mexacarbate	C	1,000 (454)
Monoethylamine	B	100 (45.4)
Monomethylamine	B	100 (45.4)
Naled	A	10 (4.54)
Naphthalene	B	100 (45.4)
Naphthenic acid	B	100 (45.4)
Nickel ammonium sulfate	B	100 (45.4)
Nickel chloride	B	100 (45.4)
Nickel hydroxide	A	10 (4.54)
Nickel nitrate	B	100 (45.4)
Nickel sulfate	B	100 (45.4)
Nitric acid	C	1,000 (454)
Nitrobenzene	C	1,000 (454)
Nitrogen dioxide	A	10 (4.54)
Nitrophenol (mixed)	B	100 (45.4)
Nitrotoluene	C	1,000 (454)
Paraformaldehyde	C	1,000 (454)
Parathion	A	10 (4.54)
Pentachlorophenol	A	10 (4.54)
Phenol	C	1,000 (454)
Phosgene	A	10 (4.54)
Phosphoric acid	D	5,000 (2,270)
Phosphorus	X	1 (0.454)
Phosphorus	C	1,000 (454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
oxychloride		
Phosphorus pentasulfide	B	100 (45.4)
Phosphorus trichloride	C	1,000 (454)
Polychlorinated biphenyls	X	1 (0.454)
Potassium arsenate	X	1 (0.454)
Potassium arsenite	X	1 (0.454)
Potassium bichromate	A	10 (4.54)
Potassium chromate	A	10 (4.54)
Potassium cyanide	A	10 (4.54)
Potassium hydroxide	C	1,000 (454)
Potassium permanganate	B	100 (45.4)
Propargite	A	10 (4.54)
Propionic acid	D	5,000 (2,270)
Propionic anhydride	D	5,000 (2,270)
Propylene oxide	B	100 (45.4)
Pyrethrins	X	1 (0.454)
Quinoline	D	5,000 (2,270)
Resorcinol	D	5,000 (2,270)
Selenium oxide	A	10 (4.54)
Silver nitrate	X	1 (0.454)
Sodium	A	10 (4.54)
Sodium arsenate	X	1 (0.454)
Sodium arsenite	X	1 (0.454)
Sodium bichromate	A	10 (4.54)
Sodium bifluoride	B	100 (45.4)
Sodium bisulfite	D	5,000 (2,270)
Sodium chromate	A	10 (4.54)
Sodium cyanide	A	10 (4.54)
Sodium dodecylbenzenesulfonate	C	1,000 (454)
Sodium fluoride	C	1,000 (454)
Sodium hydrosulfide	D	5,000 (2,270)
Sodium hydroxide	C	1,000 (454)
Sodium hypochlorite	B	100 (45.4)
Sodium methylate	C	1,000 (454)
Sodium nitrite	B	100 (45.4)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Sodium phosphate, dibasic	D	5,000 (2,270)
Sodium phosphate, tribasic	D	5,000 (2,270)
Sodium selenite	B	100 (45.4)
Strontium chromate	A	10 (4.54)
Strychnine	A	10 (4.54)
Styrene	C	1,000 (454)
Sulfuric acid	C	1,000 (454)
Sulfur monochloride	C	1,000 (454)
2,4,5-T acid	C	1,000 (454)
2,4,5-T amines	D	5,000 (2,270)
2,4,5-T esters	C	1,000 (454)
2,4,5-T salts	C	1,000 (454)
TDE	X	1 (0.454)
2,4,5-TP acid	B	100 (45.4)
2,4,5-TP acid esters	B	100 (45.4)
Tetraethyl lead	A	10 (4.54)
Tetraethyl pyrophosphate	A	10 (4.54)
Thallium sulfate	B	100 (45.4)
Toluene	C	1,000 (454)
Toxaphene	X	1 (0.454)
Trichlorfon	B	100 (45.4)
Trichloroethylene	B	100 (45.4)
Trichlorophenol	A	10 (4.54)
Triethanolamine dodecylbenzenesulfonate	C	1,000 (454)
Triethylamine	D	5,000 (2,270)
Trimethylamine	B	100 (45.4)
Uranyl acetate	B	100 (45.4)
Uranyl nitrate	B	100 (45.4)
Vanadium pentoxide	C	1,000 (454)
Vanadyl sulfate	C	1,000 (454)
Vinyl acetate	D	5,000 (2,270)
Vinylidene chloride	B	100 (45.4)
Xylene (mixed)	B	100 (45.4)
Xylenol	C	1,000 (454)
Zinc acetate	C	1,000 (454)

40 CFR § 117.3, TABLE 117.3—REPORTABLE QUANTITIES OF HAZARDOUS SUBSTANCES DESIGNATED PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT		
Material	Category	RQ in pounds (kilograms)
Zinc ammonium chloride	C	1,000 (454)
Zinc borate	C	1,000 (454)
Zinc bromide	C	1,000 (454)
Zinc carbonate	C	1,000 (454)
Zinc chloride	C	1,000 (454)
Zinc cyanide	A	10 (4.54)
Zinc fluoride	C	1,000 (454)
Zinc formate	C	1,000 (454)
Zinc hydrosulfite	C	1,000 (454)
Zinc nitrate	C	1,000 (454)
Zinc phenolsulfonate	D	5,000 (2,270)
Zinc phosphide	B	100 (45.4)
Zinc silicofluoride	D	5,000 (2,270)
Zinc sulfate	C	1,000 (454)
Zirconium nitrate	D	5,000 (2,270)
Zirconium potassium fluoride	C	1,000 (454)
Zirconium sulfate	D	5,000 (2,270)
Zirconium tetrachloride	D	5,000 (2,270)

[50 FR 13513, Apr 4, 1985, as amended at 51 FR 34547, Sept 29, 1986; 54 FR 33482, Aug 14, 1989;
58 FR 35327, June 30, 1993; 60 FR 30937, June 12, 1995]

The applicable regulations are found in 40 CFR § 264.50 through 40 CFR § 264.55. 40 CFR Parts §264.50 and §264.51 describe applicability and purpose and do not require contents in the plan.

Regulatory section	Plan section	Comments
§264.52(a)	2.0, plus others	Actions of facility personnel
52(b)	Does not require contents	Revised version of SPCC allowed
52(c)	1.1, 2.3, 4.1	Arrangements with local police, fire departments and others
52(d)	2.3	Who is emergency coordinator
52(e)	4.2	List of emergency equipment on site
52(f)	2.3.1	Evacuation plan
§264.53	4.3	Placement of copies of contingency plan
§264.54	4.4	Occasions for amendment of the contingency plan
§264.55	1.0, 2.3	Emergency coordinator
§264.56(a)	1.0, 2.0, 3.3	Internal and external notifications
56(b)	2.1, 2.2, 2.3, 2.3.2	Characteristics of release
56(c)	2.3	Assessment of hazards
56(d)	2.4, 3.3	External notifications
56(e)	2.3, 2.3.3	Segregation of hazardous materials from incident
56(f)	2.3, 3.2	Safety of operational equipment
56(g)	3.1	Clean up of hazardous waste
56(h)	3.1, 3.2	Clean up of emergency equipment and others
56(i)	2.4, 3.3	Initial follow-up reports
56(j)	3.3	Full follow-up reports

Appendix 2: Copies of Aid Agreements

PARTIALLY REIMBURSABLE SPACE ACT AGREEMENT
BETWEEN
ACCOMACK COUNTY VIRGINIA
AND
NASA GODDARD SPACE FLIGHT CENTER'S WALLOPS FLIGHT FACILITY
FOR
JOINT EMERGENCY PLANNING, RESPONSE, AND MANAGEMENT ACTIVITIES
AT THE WALLOPS FLIGHT FACILITY

ARTICLE 1. AUTHORITY AND PARTIES

In accordance with The National Aeronautics and Space Act, as amended (51 U.S.C. 20113(e)), this Agreement is entered into by the NASA Goddard Space Flight Center Wallops Flight Facility located at Wallops Island, VA 23337 (hereinafter referred to as "NASA GSFC," "GSFC," "NASA WFF," "WFF," or "NASA") and Accomack County Department of Public Safety located at 24420 Lankford Hwy, Tasley, VA 23441, (hereinafter referred to as "Accomack County," "County" or "PARTNER"). NASA and Partner may be individually referred to as a "Party" and collectively referred to as the "Parties."

ARTICLE 2. PURPOSE

NASA WFF and Accomack County wish to jointly plan, respond to, and manage emergency response activities during times of man-made and natural disasters as well as to provide for mutual aid responses for emergency services. Man-made disasters could include either NASA or NASA tenant mission activities with potential impacts that extend beyond WFF boundaries, or other man-made disasters. Natural disasters include but are not limited to hurricanes, storms, or floods. Emergency services for mutual aid services include fire fighting, rescue, Haz-mat and emergency medical services (ALS/BLS).

ARTICLE 3. RESPONSIBILITIES

A. Accomack County will use reasonable efforts to:

1. Work with NASA WFF to plan for and manage potential public safety issues associated with mission or other man-made activities which have the potential for emergency response and management activities beyond the boundaries of the WFF. The boundaries of WFF include the WFF Main Base, the Wallops Mainland, and Wallops Island. Among other things, this collaborative work may include planning meetings, drills, mission support and launch support.

2. Participate in one (1) annual pre-hurricane season planning and coordination meeting with NASA WFF.

3. Participate in one (1) pre-launch planning and coordination meeting with WFF prior to major launches at WFF.

4. Participate and coordinate with NASA technical points of contact, or their designee, on the projected path, and potential severity of a major storm or hurricane on a daily basis from 72 hours in advance of the projected landfall.

5. As part of the 72 hour planning for a specific storm, the County shall also notify the designated NASA agreement representative in writing, or by email, to reserve the number of NASA dormitory rooms the County requires to support law enforcement, emergency management, and utility recovery personnel. The County shall reimburse NASA for the cost of dormitory services.

6. Respond to requests for mutual aid made by the WFF dispatch center or an on scene NASA incident commander at an emergency or event. A County representative shall determine the amount and type of equipment and the number of personnel to be furnished. The expectation is that county resources will not be called in unless the resources are essential for the nature of the emergency or event, not due to expediency or other discretionary reasons.

7. Request mutual aid from NASA through the Accomack County or Chincoteague (9-1-1) center to the WFF dispatch center. Request for aid shall include the requested amount and type of equipment, personnel requested, and shall specify the location where assistance is required.

8. Release the WFF mutual aid response organization when the services requested are no longer required. Additionally, the WFF mutual aid resources responding may be recalled by WFF dispatch for emergency response on the WFF. Notice of the recall will be provided to on-scene incident commander.

9. Be completely responsible for all emergency shelter operations, if provided. Therefore, at a minimum, the County will be responsible for security/law enforcement, health and safety, documentation and control, and escort and removal of all personnel from the WFF at the earliest safe opportunity.

B. NASA/will use reasonable efforts to:

1. Notify the County emergency management office when planned mission or other WFF man-made activities have the potential for emergency response and management activities beyond the boundaries of the WFF to protect the safety of the public. The boundaries of the WFF include the WFF Main Base, the Wallops Mainland, and Wallops Island.

2. Participate in a minimum of one (1) annual pre-hurricane season planning and coordination meeting with the County.

3. Participate in one (1) pre-launch planning and coordination meeting with the County prior to major launches at WFF.

4. Provide up to 25 dormitory rooms (including back-up power) in building F-5 for up to 25 law enforcement, emergency management, and utility recovery personnel. All such personnel shall be U.S. citizens. Personnel may occupy dormitory facilities for the duration of the storm, and for a minimum of 48 hours after recovery operations have begun. The County may pre-position personnel in the dormitory 48 hours in advance of the storm, subject to the availability of the dorm rooms. The designated on-site NASA point of contact shall provide the designated county point of contact the keys, temporary badges, and other information for use of the dorm rooms.

5. Provide one designated on-site point of contact for all matters relating to the use and logistics of the WFF dorm rooms.

6. Participate in recovery and any post emergency management briefings or meetings with the county.

7. Respond to requests for mutual aid made by the Accomack County or Chincoteague (9-1-1) center or an on scene incident commander at the emergency or event. A WFF representative shall determine the amount and type of equipment and the number of personnel to be furnished. The expectation is that WFF resources will not be called in unless the resources are essential for the nature of the emergency, not due to expediency or other discretionary reasons.

8. Request mutual aid from the WFF dispatch center to Accomack County or Chincoteague (9-1-1) center. Requests for aid shall include the requested amount and type of equipment, personnel requested, and shall specify the location where assistance is required.

9. Release the County mutual aid response organization when the services requested are no longer required or when the County resources responding are needed within the area for which it normally provides services. In that case, the County resources may be recalled by the County with immediate notification to the NASA on scene incident commander.

10. Respond to an Accomack County emergency request to provide a shelter of last resort, at the sole discretion of NASA, and under the terms and conditions specified by NASA for the specific emergency.

ARTICLE 4. SCHEDULE AND MILESTONES

The planned major milestones for the activities defined in the "Responsibilities" clause are as follows:

Annual Pre-Hurricane season Planning Meeting	3rd Quarter each Federal Fiscal Year
Pre-Launch planning and coordination meeting	Prior to Major Orbital Launches

ARTICLE 5. FINANCIAL OBLIGATIONS

1. Partner agrees to fully reimburse NASA for costs in the event the County requests emergency response support from NASA as outlined in the scope of this agreement. The scope of this agreement explicitly does not include support from the County to NASA that is beyond the mutual aid defined in this agreement. In no event will NASA transfer any U.S. Government funds to Partner under this Agreement. The nature of emergencies and events varies greatly. If the nature of the emergency or event requires County services or effort in excess of the mutual aid scoped herein, NASA shall reimburse the County thorugh a separate intergovernmental order. Payment must be made by Partner in advance of initiation of NASA's efforts at such time as the emergency situation occurs. The parties agree that the terms of reimbursement for NASA WFF's participation shall include, but not be limited to, fuel for generators in excess of 24 hours of usage, long distance phone calls, and any dormitory services provided. As an estimate, NASA dorm rooms cost for FY 2011 is $33.00 per night, but these rates are subject to variations each year. NASA will estimate the cost of services to the County as reasonably in advance of the event as possible. NASA shall bill the County for all services actually rendered within 30 days of the delivery of services. Payment shall be made within 30 days of notice from NASA on the final cost of all services received in support of this agreement.

2. Payment shall be payable to the National Aeronautics and Space Administration through [choose one form of payment: U.S. Treasury FEDWIRE Deposit System, Federal Reserve Wire Network Deposit System, pay.gov at https://www.nssc.nasa.gov/portal/site/customerservice/menuitem.bb29c518138071c056969daf4dd72749, or check.] A check should be payable to NASA Goddard Space Flight Center and sent to:

NASA Shared Service Center (NSSC)-FMD Accounts Receivable
Attn: For the Accounts of NASA Goddard Space Flight Center
Bldg. 1111, C Road
Stennis Space Center, MS 39529

3. NASA will not provide services or incur costs beyond the available funding amount. Although NASA has made a good faith effort to accurately estimate its costs, it is understood that NASA provides no assurance that the proposed effort under this Agreement will be accomplished for the above estimated amount. Should the effort cost more than the estimate, Partner will be advised by NASA as soon as possible. Partner shall pay all costs incurred and have the option of canceling the remaining effort, or

providing additional funding in order to continue the proposed effort under the revised estimate. Should this Agreement be terminated, or the effort completed at a cost less than the agreed-to estimated cost, NASA shall account for any unspent funds within One (1) year after completion of all effort under this Agreement, and promptly thereafter, return any unspent funds to Partner.

4. Notwithstanding any other provision of this Agreement, all activities under or pursuant to this Agreement are subject to the availability of funds, and no provision of this Agreement shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, Title 31 U.S.C. § 1341.1.

ARTICLE 6. PRIORITY OF USE

Any schedule or milestone in this Agreement is estimated based upon the Parties' current understanding of the projected availability of NASA personnel, facilities and equipment. In the event that NASA's projected availability changes, Partner shall be given reasonable notice of that change, so that the schedule and milestones may be adjusted accordingly. The Parties agree that NASA usage of the facilities, equipment, and personnel shall have priority over the usage planned in this Agreement. Should a conflict arise, NASA in its sole discretion shall determine whether to exercise that priority. Likewise, should a conflict arise as between two commercial users, NASA, in its sole discretion, shall determine the priority as between the two users. This Agreement does not obligate NASA to seek alternative government property or services under the jurisdiction of NASA at other locations.

ARTICLE 7. NONEXCLUSIVITY

This Agreement is not exclusive; accordingly, NASA may enter into similar Agreements for the same or similar purpose with other U.S. private or public entities.

ARTICLE 8. LIABILITY AND RISK OF LOSS

1. Partner hereby waives any claims against NASA, its employees, its related entities, (including, but not limited to, contractors and subcontractors at any tier, grantees, investigators, customers, users, and their contractors and subcontractors, at any tier) and employees of NASA's related entities for any injury to, or death of, Partner employees or the employees of Partner's related entities, or for damage to, or loss of, Partner's property or the property of its related entities arising from or related to activities conducted under this Agreement, whether such injury, death, damage, or loss arises through negligence or otherwise, except in the case of willful misconduct.

2. Partner further agrees to extend this unilateral waiver to its related entities by requiring them, by contract or otherwise, to waive all claims against NASA, its related entities, and employees of NASA and employees of NASA's related entities for injury, death, damage, or loss arising from or related to activities conducted under this Agreement.

ARTICLE 9. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

NASA and Partner agree that the information and data exchanged in furtherance of the activities under this Agreement will be exchanged without use and disclosure restrictions unless required by national security regulations (e.g., classified information) or otherwise agreed to by NASA and Partner for specifically identified information or data (e.g., information or data specifically marked with a restrictive notice).

ARTICLE 10. USE OF NASA NAME AND NASA EMBLEMS AND RELEASE OF GENERAL INFORMATION TO THE PUBLIC

1. NASA Name and Initials

Partner agrees the words "National Aeronautics and Space Administration" and the letters "NASA" will not be used in connection with a product or service in a manner reasonably calculated to convey any impression that such product or service has the authorization, support, sponsorship, or endorsement of NASA, which does not, in fact, exist. In addition, with the exception of release of general information in accordance with paragraph 3 below, Partner agrees that any proposed public use of the NASA name or initials (including press releases resulting from activities conducted under this Agreement and all promotional and advertising use) shall be submitted by Partner in advance to the NASA Assistant Administrator for Public Affairs or designee ("NASA Public Affairs") for review and approval. Approval by NASA Public Affairs shall be based on applicable law and policy governing the use of the NASA name and initials.

2. NASA Emblems

Use of NASA emblems/devices (i.e., NASA Seal, NASA Insignia, NASA logotype, NASA Program Identifiers, and the NASA Flag) are governed by 14 C.F.R. Part 1221. Partner agrees that any proposed use of such emblems/devices shall be submitted to NASA Public Affairs for review and approval in accordance with such regulations.

3. Release of General Information to the Public

NASA or Partner may, consistent with Federal law and this Agreement, release general information regarding its own participation in this Agreement as desired.

ARTICLE 11. DISCLAIMER OF WARRANTY

Equipment, facilities, technical information, and services provided by NASA under this Agreement are provided "as is." NASA makes no express or implied warranty as to the condition of such equipment, facilities, technical information, or services, or as to the condition of any research or information generated under this Agreement, or as to any products made or developed under or as a result of this Agreement including as a result of the use of information generated hereunder, or as to the merchantability or fitness for a

particular purpose of such research, information, or resulting product, or that the equipment, facilities, technical information, or services provided will accomplish the intended results or are safe for any purpose including the intended purpose, or that any of the above will not interfere with privately owned rights of others. Neither the government nor its contractors shall be liable for special, consequential or incidental damages attributed to such equipment, facilities, technical information, or services provided under this Agreement or such research, information, or resulting products made or developed under or as a result of this Agreement.

ARTICLE 12. DISCLAIMER OF ENDORSEMENT

NASA does not endorse or sponsor any commercial product, service, or activity. NASA's participation in this Agreement or supply of equipment, facilities, technical information, or services under this Agreement does not constitute endorsement by NASA. Partner agrees that nothing in this Agreement will be construed to imply that NASA authorizes, supports, endorses, or sponsors any product or service of Partner resulting from activities conducted under this Agreement, regardless of the fact that such product or service may employ NASA-developed technology.

ARTICLE 13. COMPLIANCE WITH LAWS AND REGULATIONS

The Parties shall comply with all applicable laws and regulations including, but not limited to, safety, security, export control, and environmental laws and regulations. Access by Partner to a NASA facilities or property, or to a NASA Information Technology (IT) system or application, is contingent upon compliance with NASA security and safety policies and guidelines including, but not limited to, standards on badging, credentials, and facility and IT system/application access.

With respect to any export control requirements:

(a) The Parties will comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in performing work under this Agreement. In the absence of available license exemptions/exceptions, the Partner shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data and software, or for the provision of technical assistance.

(b) The Partner shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of work under this Agreement, including instances where the work is to be performed on-site at NASA and where the foreign person will have access to export-controlled technical data or software.

(c) The Partner will be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions or exceptions.

(d) The Partner will be responsible for ensuring that the provisions of this Article apply to its Related Entities.

ARTICLE 14. TERM OF AGREEMENT

This Agreement becomes effective upon the date of the last signature below and shall remain in effect until the completion of all obligations of both Parties hereto, or 5 years from the date of the last signature, whichever comes first.

ARTICLE 15. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Agreement by providing 90 calendar days written notice to the other Party. In the event of such termination, Partner will be obligated to reimburse NASA for all costs for which the Partner was responsible and that have been incurred in support of this Agreement up to the date the termination notice is received by the non-terminating Party. Where Partner terminates this Agreement, Partner will also be responsible for termination costs.

ARTICLE 16. CONTINUING OBLIGATIONS

The rights and obligations of the Parties that, by their nature, would continue beyond the expiration or termination of this Agreement, e.g., "Liability and Risk of Loss" and "Intellectual Property Rights"and "Financial Obligations" shall survive such expiration or termination of this Agreement.

ARTICLE 17. MANAGEMENT POINTS OF CONTACTS

The following personnel are designated as the principal points of contact between the Parties in the performance of this Agreement.

Technical Points of Contact

NASA Wallops Flight Facility
Kenneth E. Volante
Emergency Management Coordinator
Mail Stop: 803.2
Wallops Island, VA 23337
Phone: 757-824-1159
Fax: 757-824-1518
kenneth.e.volante@nasa.gov

Accomack County Department of Public Safety
Jason R. Loftus
Director, Public Safety
PO Box 102
Tasley, VA 23441
Phone: 757-824-3610
Fax: 757-789-3063
jloftus@co.accomack.va.us

ARTICLE 18. DISPUTE RESOLUTION

Except as otherwise provided in the article entitled "Priority of Use," the article entitled "Intellectual Property Rights – Invention and Patent Rights" (for those activities governed by 37 C.F.R. Part 404), and those situations where a pre-existing statutory or regulatory system exists (e.g. under the Freedom of Information Act, 5 U.S.C. § 552), all disputes concerning questions of fact or law arising under this Agreement shall be referred by the claimant in writing to the appropriate person identified in this Agreement as the "Management Points of Contact." The persons identified as the "Management Points of Contact" for NASA and the Partner will consult and attempt to resolve all issues arising from the implementation of this Agreement. If they are unable to come to agreement on any issue, the dispute will be referred to the signatories to this Agreement, or their designees, for joint resolution. If the Parties remain unable to resolve the dispute, then the NASA signatory or that person's designee, as applicable will issue a written decision that will be the final agency decision for the purpose of judicial review. Nothing in this section limits or prevents either Party from pursuing any other right or remedy available by law upon the issuance of the final agency decision.

ARTICLE 19. MODIFICATIONS

Any modification to this Agreement shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Any modification that creates an additional commitment of NASA resources must be signed by the original NASA signatory authority, or successor, or a higher level NASA official possessing original or delegated authority to make such a commitment.

ARTICLE 20. ASSIGNMENT

Neither this Agreement nor any interest arising under it will be assigned by the Partner or NASA without the express written consent of the officials executing this Agreement.

ARTICLE 21. APPLICABLE LAW

U.S. Federal law governs this Agreement for all purposes, including, but not limited to, determining the validity of the Agreement, the meaning of its provisions, and the rights, obligations and remedies of the Parties.

ARTICLE 22. INDEPENDENT RELATIONSHIP

This Agreement is not intended to constitute, create, give effect or otherwise recognize a joint venture, partnership, or formal business organization, or agency agreement of any kind, and the rights and obligations of the Parties shall be only those expressly set forth herein.

ARTICLE 23. SIGNATORY AUTHORITY

The signatories to this Agreement covenant and warrant that they have authority to execute this Agreement. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WALLOPS FLIGHT FACILITY

BY: _____
William A. Wrobel
Director of Wallops Flight Facility
Building F-6
Wallops Island, VA 23337

DATE: 18 October 2011

ACCOMACK COUNTY
DEPARTMENT OF PUBLIC SAFETY

BY: _____
Jason Loftus
Director, Public Safety
PO Box 102
Tasley, VA 23441
jloftus@co.accomack.va.us

DATE: 10/20/2011

EMERGENCY SERVICE ASSOCIATES, P.A.
PENINSULA REGIONAL MEDICAL CENTER
100 EAST CARROLL STREET
SALISBURY, MARYLAND 21801
410-543-7742

Mrs. Carolyn Turner
Wallops Flight Facility
Building F 160
Wallops Island, VA 23337

October 30, 2007

Dear Captain on Duty:

Please be advised that Peninsula Regional Medical Center's Emergency Department is most willing and well prepared to handle any and all hazardous material exposures of your wallops employees. We are a 24/7 fully functional emergency department and appreciate the opportunity to meet your potential needs.

If you have any questions, please let me know.

Sincerely,

William Todd, M.D.
Medical Director
Emergency Department, PRMC

MARTIN O'MALLEY
GOVERNOR

ANTHONY G. BROWN
LT GOVERNOR

STATE OF MARYLAND
MARYLAND STATE POLICE

Aviation Command
3023 Strawberry Point Road
Baltimore, Maryland 21220-5513
(410) 238-5800

COLONEL
TERRENCE B. SHERIDAN
SUPERINTENDENT

December 30, 2009

Ms. Diane Weller, RN
Health Unit
NASA Goddard Space Flight Center
Wallops Flight Facility
Building F-160
Wallops Island, VA 23337-5099

Dear Ms. Weller;

This letter is in response to your request to update the response capabilities of the Maryland State Police Aviation Command to the Wallops Flight Facility in the event of a medical or traumatic emergency. Our policy has not changed since the previous correspondence. Requests for medevac transports, from areas up to 30 nautical miles from the borders of Maryland, will still be considered for dispatch, consistent with the aircraft fleet's availability, and our ability to still respond to requests from within Maryland.

Medevac requests from out-of-state must still meet criteria for air transport set forth in the Maryland Medical Protocols for Pre-Hospital Providers, as if the patient were within Maryland. In addition, patients who have been exposed to hazardous materials or excessive radiation are generally not considered for air transport.

Our out-of-state contact number for medevac requests is 410-706-8080.

Should you require additional information regarding the Maryland Medical Protocols, you may consult the website of Maryland's EMS Agency at www.miemss.org; or the State Air Medical Director's Office at 410-706-0880. In addition, you may feel free to contact me or a member of my Flight Operations Staff at 410-238-5800.

Sincerely,

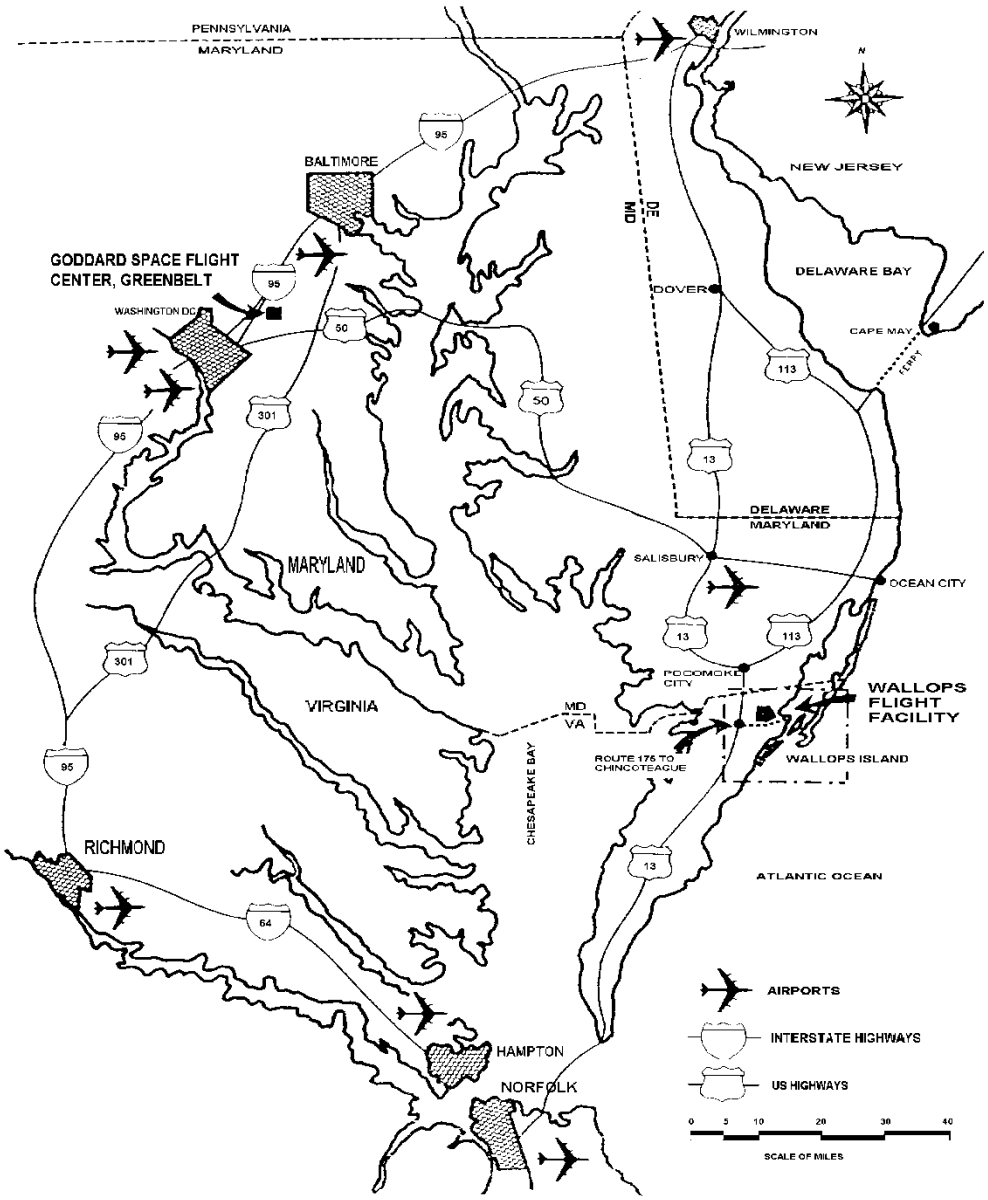
A.J. McAndrew, Major
Commander, Aviation Command
Maryland State Police

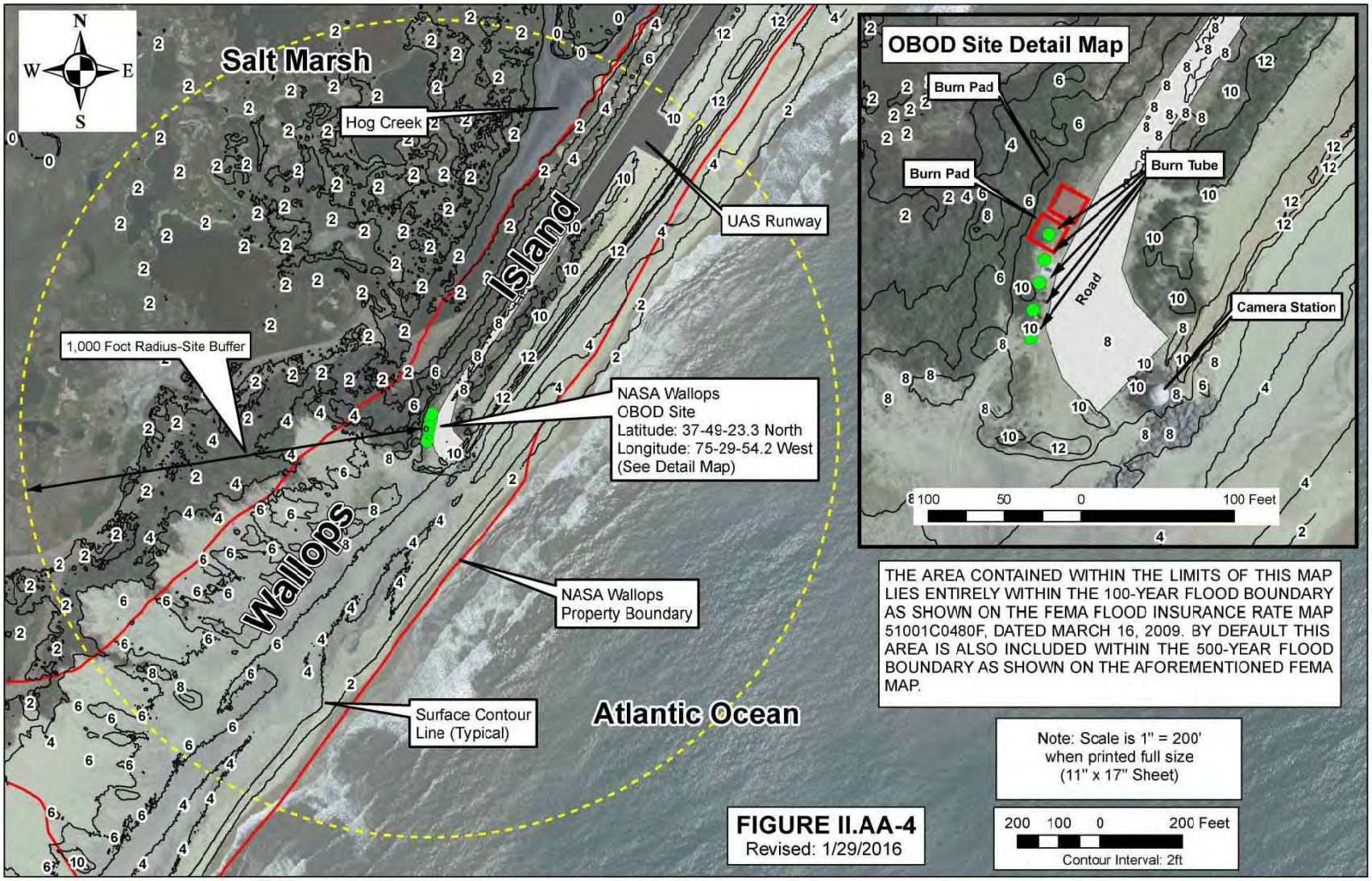
AJM:WPK

"Maryland's Finest"

Appendix 3: Maps

Atlantic Ocean
Wallops Island
Bogues Bay
Cat Creek
Wallops Mainland
Hog Creek
OB Area
Womans Bay
803
Evacuation Route
Fire Hydrant
Potable Water Well
Roads
WFF Property Boundary
Prepared by: Susan Dunn
WFF Environmental Office
Date: 5/6/2015
2012 Imagery
Feet
0
1,500
3,000


PENNSYLVANIA
MARYLAND
WILMINGTON
N
NEW JERSEY
BALTIMORE
95
MD
DE
GODDARD SPACE FLIGHT CENTER, GREENBELT
WASHINGTON DC
DELAWARE BAY
DOVER
CAPE MAY
FERRY
50
113
301
13
DELAWARE
MARYLAND
MARYLAND
SALISBURY
OCEAN CITY
POCOMOKE CITY
WALLOPS FLIGHT FACILITY
VIRGINIA
MD
VA
ROUTE 175 TO CHINCOTEAGUE
WALLOPS ISLAND
CHESAPEAKE BAY
RICHMOND
64
ATLANTIC OCEAN
AIRPORTS
INTERSTATE HIGHWAYS
US HIGHWAYS
HAMPTON
NORFOLK
0 5 10 20 30 40
SCALE OF MILES


N
W
E
S
Salt Marsh
Hog Creek
Wallops
Island
UAS Runway
1,000 Foot Radius-Site Buffer
NASA Wallops
OBOD Site
Latitude: 37-49-23.3 North
Longitude: 75-29-54.2 West
(See Detail Map)
NASA Wallops
Property Boundary
Surface Contour
Line (Typical)
Atlantic Ocean
OBOD Site Detail Map
Burn Pad
Burn Pad
Burn Tube
Road
Camera Station
100 50 0 100 Feet
THE AREA CONTAINED WITHIN THE LIMITS OF THIS MAP LIES ENTIRELY WITHIN THE 100-YEAR FLOOD BOUNDARY AS SHOWN ON THE FEMA FLOOD INSURANCE RATE MAP 51001C0480F, DATED MARCH 16, 2009. BY DEFAULT THIS AREA IS ALSO INCLUDED WITHIN THE 500-YEAR FLOOD BOUNDARY AS SHOWN ON THE AFOREMENTIONED FEMA MAP.
Note: Scale is 1" = 200'
when printed full size
(11" x 17" Sheet)
200 100 0 200 Feet
Contour Interval: 2ft
FIGURE II.AA-4
Revised: 1/29/2016

Appendix 4: Rocket Motor Propellant Composition, Hazards, and MSDS (If you are viewing this in the OB Area Permit , refer to the Waste Analysis Plan Exhibit II.B-1)

ATTACHMENT II.G

CLOSURE PLAN

ATTACHMENT II.G - CLOSURE PLAN

II.G.1. Closure Plan

Wallops Flight Facility intends to continue to operate the hazardous waste OB Area until the facility ceases operation. It is, therefore, not possible to state an exact year for closure of the OB hazardous waste treatment area. When operations cease or the need for the permitted site, or portion thereof, no longer exists, closure will be implemented in accordance with Closure Plan; Exhibit II.G-1.

EXHIBIT II.GG-1

CLOSURE PLAN

Virginia Department of Environmental Quality
Division of Land Protection and Revitalization
Office of Financial Responsibility and Waste Programs

Permit No. VA7800020888
Expiration Date: April 13, 2028

CLOSURE AND POSTCLOSURE PLAN

Resource Conservation and Recovery Act Treatment Storage and Disposal Facility– Open Burning Area

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

EPA ID # VA7800020888

July 2015

EXHIBIT II.G-1- CLOSURE AND POST CLOSURE PLAN

TABLE of CONTENTS

1. INTRODUCTION.....II.G-3

2. CLOSURE PERFORMANCE SSTANDARDS.....II.G-3

3. FACILITY DESCRIPTION, LOCATION AND BACKGROUND II.G-5

4. OPEN BURNING AREA DESCRIPTION, LOCATION AND BACKGROUND...II.G-6

5. OVERVIEW OF CLOSURE PROCEDURES II.G-10

6. HAZARDOUS CONSTITUENTS OF CONCERN.....II.G-15

7. QUALITY ASSURANCE/QUALITY CONTROL PLAN AND PROCEDURES .II.G-17

8. CLOSURE SAMPLING AND ANALYSES PLAN.....II.G-19

8.1.1. Instrument Calibration II.G-19
8.1.2. Sample Containers II.G-19
8.1.3. Sample Labeling II.G-19
8.1.4. Data Collection II.G-20
8.1.5. Sample Preservation II.G-20
8.1.6. Chain-of-Custody Control II.G-21
8.2.1. Soil and Subsoil Sampling II.G-21
8.2.2. Runoff Sampling II.G-22
8.2.3. Groundwater Sampling II.G-23
8.2.4. Wash and Rinseate Sampling II.G-23
8.2.5. Structures Sampling II.G-23
8.3.1. Background Soil Samples II.G-24
8.3.2. Background Rinseate Samples II.G-24
8.3.3. Background Groundwater II.G-24

9. HEALTH AND SAFETY PLAN FOR CLOSURE ACTIVITIES.....II.G-26

10. CLEAN CLOSURE DECONTAMINATION STANDARDS II.G-26

10.2.1. Upper Tolerance Limits Procedure II.G-29
10.2.2. Alternate Statistical Procedure II.G-30

11. HWMU WASTE INVENTORY REMOVAL AND MANIFESTS TO A TSD II.G-31

12. DECONTAMINATION OR DISPOSAL OF HWMUS – EQUIPMENT, STRUCTURES, AND SOILS II.G-32

12.2.1. Conditions That Trigger Excavation II.G-34
12.2.2. Vertical Extent of Excavation II.G-34
12.2.3. Horizontal Extent of Excavation II.G-35

12.2.4. Storage, Treatment, and Disposal of the Excavated Soil, Subsoils, Construction Debris,and/or Residues II.G-36
12.2.5. Backfilling Areas of Excavation II.G-36

13. TEMPORARY DECONTAMINATION AREAS and PROCEDURES II.G-36

14. MANAGEMENT, CHARACTERIZATION, AND DISPOSAL OF CLOSURE GENERATED WASTES II.G-38

15. CLOSURE COST ESTIMATE WITH SUPPORTING CALCULATIONS II.G-40

16. FINANCIAL ASSURANCE FOR CLOSURE.....II.G-41

17. SCHEDULE FOR CLOSURE.....II.G-41

18. CLOSURE PLAN AMENDMENT, CONTINGENT CLOSURE, AND POSTCLOSURE PLANS.....II.G-41

19. CERTIFICATION OF CLOSURE BY OWNER/OPERATOR and Professional Engineer (P. E.) II.G-43

20. CLOSURE REPORT.....II.G-44

APPENDIX B: MATERIAL SAFETY DATA SHEETS II.G-47

1. INTRODUCTION

In accordance with the Virginia Hazardous Waste Management Regulations (VHWMR), as codified in the Virginia Administrative Code, Title 9, Agency 20, Chapter 60 (9 VAC 20-60-12), the Resource Conservation and Recovery Act (RCRA) regulations, the Hazardous and Solid Waste Amendments (HSWA) of RCRA, and the Virginia Department of Environmental Quality (DEQ), Draft Guidance Manual for Closure Plans For Hazardous Waste Management Facilities, dated September 28, 2001, National Aeronautics and Space Administration (NASA) Goddard Space Flight Center's (GSFC's) Wallops Flight Facility (WFF) submits this closure and post-closure plan for the Open Burning (OB) area, as part of its renewal permit application for a RCRA Part B permit. The Wallops Flight Facility (WFF) is located on Wallops Island, Virginia, and operates under the Subpart X Miscellaneous Units, Open Burning Permit issued September 20, 2005 using United States Environmental Protection Agency (EPA) identification (ID) number VA7800020888. WFF is also a large quantity generator.

This closure plan is designed to achieve final closure of the OB Area hazardous waste management units (HWMUs). The OB Area will have achieved clean closure, when all hazardous waste or hazardous waste constituents of concern (HCOCs) have been removed from the HWMUs to levels such that direct contact with any parts of the HWMU or any HCOCs that remain after closure will not pose a threat to human health and/or the environment, nor adversely impact any environmental media in excess of the DEQ established exposure levels.

Achievement of clean closure will be demonstrated by the systematic removal of hazardous wastes, by decontamination of the equipment, structures, and soils and subsoils (if needed), and by comparison of the HCOCs in the sample compliance data to one of the three decontamination standards in this closure plan.

If this facility is unable to attain clean closure for the hazardous waste management units, an amended closure plan and post-closure plan will be submitted to the DEQ for approval to provide for closure with hazardous waste closed in-place, and for the post-closure care and use of the property, respectively.

2. CLOSURE PERFORMANCE SSTANDARDS

This closure plan has been developed to ensure that closure activities will be conducted in such a manner that the OB Area will not require any post-closure maintenance and control. This closure plan describes the work to be conducted to ensure that the OB Area HWMUs are closed in a manner that:

1. Minimizes the need for further maintenance or control;

2. Controls, minimizes, or eliminates, to the extent necessary to prevent threats to human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated run-off, or waste deposition products to the ground,

3. Surface waters, or the atmosphere;

4. Complies with the closure requirements of 40 CFR § 264, as applicable; and

5. Meets the requirements of the VHWMR, as codified in 9 VAC 20-60-264.

This closure plan requires the removal of any soil and residual contamination present in or around the burn units and the burn pad to the extent that the remaining soil and residual contaminants do not pose an unacceptable threat to human health and the environment. It also requires the safe and effective disposal of contamination, contaminated run-off, or waste decomposition products to the soil, groundwater, surface water, or atmosphere.

Achievement of clean closure will be demonstrated by the systematic removal of hazardous wastes, by decontamination of the equipment, structures, and soils and subsoils (if needed), and by comparison of the HCOCs in the sample compliance data to one of the three decontamination standards in this closure plan. In order to achieve clean closure, the applicable standards for both soil and groundwater must be met.

The OB Area will be considered clean closed, requiring no further closure activities if one of the following conditions is met:

1. The concentrations of HCOCs in the compliance samples are below the method detection limits of the analytical test methods,

2. The concentrations of HCOCs in the compliance samples are below or not statistically different from the background sample levels, or

3. The concentrations of HCOCs in the compliance samples are at or below DEQ approved risk-based levels.

If performance standards 1, 2, or 3 are achieved, the OB Area soil will be considered to be clean closed. If the standards cannot be achieved, the structures and soils may

be removed and disposed of at a regulated treatment facility as a means to comply with the closure requirements of VHWMR and RCRA.

3. FACILITY DESCRIPTION, LOCATION AND BACKGROUND

GSFC's WFF is owned and operated by NASA. It is located in Virginia on the Atlantic Coast of the Delmarva Peninsula (Appendix A, Figure A-1) approximately 64 kilometers (40 miles) southeast of Salisbury, Maryland, and 113 kilometers (70 miles) north of the Chesapeake Bay Bridge - Tunnel. Chincoteague Island, Virginia, is approximately 8 kilometers (5 miles) east of the Main Base.

The Main Base facilities were constructed in 1941 through 1958 by the US Government as a Navy base for flight operations and for naval ordnance testing. In 1959, the Navy closed the base and NASA acquired the Main Base. Since 1959, NASA has demolished obsolete buildings, renovated other buildings for adaptability to their missions, and constructed new facilities.

In 1945, the National Advisory Committee for Aeronautics purchased 34 hectares (85 acres) of land on the southern portion of Wallops Island and leased 405 hectares (1000 acres) from a group of sportsmen who used the island for fishing and hunting. An operating base was established on Wallops Island by the Langley Field Research Center, which included the construction of a launch site. Historically, research at Wallops was concentrated on obtaining aerodynamic data at transonic and low supersonic speeds, as part of the effort to penetrate the sound barrier of flight. Today, WFF (NAICS Code 927110) is used primarily to obtain scientific data about the atmosphere and the space environment, conduct aeronautical research, and perform space and terrestrial applications experiments.

The WFF is a complex of three separate land areas known as the Main Base, the Mainland, and Wallops Island. WFF is a facility of the Goddard Space Flight Center located in Greenbelt, Maryland.

The Main Base is a land area of 902 hectares (2,230 acres), bordered on the east by 6 kilometers (4 miles) of marshland, which separates it from Chincoteague Island. This area contains the Wallops Headquarters, Administrative Offices, tracking facilities, a range control center, rocket and fuel storage depots, rocket vehicle inspection facilities, several support shops, an approved Federal Aviation Administration airport, military family housing units, and bachelor's quarters.

The Mainland and Wallops Island jointly comprise a land area of 1740 hectares (4,300 acres), and are located approximately 11 kilometers (7 miles) southeast of the Main Base. Wallops Island is connected to the Mainland by a causeway and bridge

that cross 3 kilometers (2 miles) of salt marsh, which is interlaced with small creeks and is bisected by the Intracoastal Waterway. Wallops Island is approximately 11 kilometers (7 miles) long and 0.8 kilometers (0.5 miles), in width at its widest point. Wallops Island borders the Atlantic Ocean on the east, and the Chincoteague inlet on the north. Wallops Island was joined with Assawoman Island to the south when the inlet between them was closed by a storm in 1986. The inlet was temporarily reopened in 1987 but has since filled in and remains closed today. Large and small scale topographic maps can be found in OB permit Attachment II.A, Facility Description.

The Mainland provides a site for long-range radar, communications, and optical tracking installations. Wallops Island contains the OB Area, launch sites, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, U. S. Navy facilities, tracking facilities, and other related service support facilities. In 2003, an Unmanned Aerial Vehicle (UAV) runway was built on the access road just north of the OB Area.

The Mainland and Wallops Island operate as a large quantity generator under EPA ID number VA7800020888. NASA was issued this number in 1988. NASA stores hazardous waste generated under this EPA ID number at Building U-81, a less-than-90-day accumulation area. This building is located on Wallops Mainland. NASA has been using the OB Area since 1972. In 1988, NASA submitted a RCRA Part B Permit Application and was issued a Subpart X permit on September 20, 2005.

For further information, please contact the Environmental Group Lead at NASA Goddard Space Flight Center, Wallops Flight Facility, Building F-160, Code 250.W, Wallops Island, Virginia, 23337 or by telephone at (757) 824-1987 or (757) 824-1718 or fax at (757) 824-1819.

4. OPEN BURNING AREA DESCRIPTION, LOCATION AND BACKGROUND

4.1 Site Geology and Hydrogeology

Located within the Atlantic Coastal Plain physiographic province, WFF is underlain by approximately 2,135 meters (7,000 feet) of sediment that lies atop crystalline basement rock. The sedimentary section, ranging in age from Cretaceous to Quaternary period, consists of a thick sequence of non-marine deposits overlain by a much thinner sequence of marine sediments. The two uppermost stratigraphic units at WFF are the Yorktown Formation and the overlying Columbia Group sediments, which are not subdivided into formations.

The southern end of Wallops Island consists of nearly level to steep, very deep, moderately well to excessively drained, Fisherman Assateague fine sands complex. The area relies on natural drainage patterns to intercept and divert flow. The maximum elevation of the southern end of Wallops Island is 4.3 meters (14 feet) above mean sea level.

The VDEQ has identified four major aquifers on the Eastern Shore of Virginia: the Columbia aquifer and the three aquifers comprising the Yorktown-Eastover multi-aquifer system.

The water table aquifer, known as the Columbia aquifer, primarily consists of Pleistocene sediments of the Columbia Group. It is unconfined and typically overlain by wind-deposited beach sands, silts, and gravel. The aquifer occurs between depths of 1.5 to 18.3 meters (5 and 60 feet) below the ground surface. The water table ranges from depths of 0 to 9.1 meters (0 to 30 feet) below the ground surface. Groundwater flow is generally east and north toward nearby creeks and the marsh area that separates Chincoteague Island from the mainland.

The Yorktown-Eastover aquifer system is a multi-aquifer unit consisting of late Miocene and Pliocene deposits and is composed of the sandy facies of the Yorktown and Eastover Formations. The top of the shallowest confined Yorktown-Eastover aquifer at WFF is found at depths of approximately 30.5 meters (100 feet) below the ground surface. It is separated from the overlying Columbia aquifer by a 6.1 to 9.1-meter (20 to 30-foot) confining layer (aquitard) of clay and silt. The Yorktown-Eastover aquifers are classified as the upper, the middle, and the lower Yorktown-Eastover aquifers. Correspondingly, each Yorktown-Eastover aquifer is overlain by the upper, middle, and lower Yorktown-Eastover aquitards. In the Wallops area, the lower Yorktown-Eastover aquifer contains the freshwater/saltwater interface, which occurs at a depth of approximately 91 meters (300 feet) below mean sea level.

The Wallops Island's unconfined surface aquifer (Holocene beach sands) drains groundwater vertically from 1 to 2 meters (3 to 6 feet) until meeting the water table, then flows down-gradient to either interior marshes or the ocean. Recharge to the water table aquifer is through direct infiltration of rainwater, and through gains from Hog Creek and the adjoining marshes. Recharge to the Miocene Aquifer is from the central portions of the Eastern Shore in Maryland. Flow gradients on Wallops Island vary in direction relative to seasonal and tidal influences on head pressure.

Seven monitoring wells were installed in September 1998. Data used to characterize the water table aquifer was collected from slug tests conducted on monitoring well 1. The test results indicated a hydraulic conductivity (K) of 0.00115 feet per second and

a transmissivity (T) of 4.5 square feet per second. Groundwater flow is generally to the northeast.

As a result of the major storm event of November 11-13, 2009, the original background monitoring well MW-3 was damaged and was deemed inoperable. The Permittee submitted an Open Burn Area Proposed Background Well (MW-4) Analysis Report, dated February 9, 2010. The above Report proposed an original point-of-compliance well, MW-4, to serve as the new background monitoring well, replacing the damaged background well MW-3. In a letter dated April 5, 2010, the DEQ determined that MW-4 was a suitable replacement background well. On May 6, 2010, the Permittee requested a Class 2 permit modification to replace MW-3 with MW-4 as the facility background well. MW-4 was approved as the OB Area background well on August 3, 2010.

4.2 Open Burning Area

Open Burning is considered the safest treatment method for hazardous waste rocket motors and igniters and is conducted in a manner to minimize impacts to the environment. The rocket motors and igniters are considered hazardous waste because they meet the characteristic of reactivity (D003) and some have secondary toxicity characteristics for chromium (D007) or lead (D008). HCOCs are discussed in Section 6.0. The OB Area (refer to figures found in OB permit Attachment II.A Facility Description), located on the shoulder of the dike road at the southwestern corner of Wallops Island, consists of four subunits (ground embedded cylinders) and one open burn pad assembly. Subunits 1 and 3 are vertical steel cylinders made from Taurus rocket motor casings (refer to figures found in OB permit Attachment II.H Plans and Specifications for Open Burn Units). Subunits 1 and 3 are 0.6 meters (1.9 feet) in diameter, stand 0.8 meters (2.6 feet) above the ground surface, and are embedded 2.3 meters (7.5 feet) below the ground and filled with concrete. Subunit 2 is a vertical steel cylinder made from a Nike rocket motor casing. Subunit 2 is 0.4 meters (1.4 feet) in diameter, stands 1.1 meters (3.5 feet) above the ground surface, and is embedded 2.2 meters (7.1 feet) below the ground surface. Subunit 2 also is filled with concrete. Subunit 4 (refer to figures found in OB permit Attachment II.H Plans and Specifications for Open Burn Units) is 0.7 meters (2.4 feet) in diameter, stands 1.10 meters (3.6 feet) above the ground surface, and is embedded 3.1 meters (10.2 feet) below the ground surface. The subunits 1, 2, and 3 were constructed around 1989. Subunit 4 was installed in 2012.

The open burn pad assembly (refer to figures found in OB permit Attachment II.H, Plans and Specifications for Open Burn Units) is a 4.6 meters (15 feet) square by 46 centimeters (18 inches) thick concrete pad with a steel plate in the center for motor head attachment. The unit is equipped with a burn pad cover and is surrounded by a

berm. Four cable tie downs are used to stabilize the motors. The pad was constructed around 1996.

The OB Area is within the 100-year floodplain. The subunits are covered when not in use to prevent entry and accumulation of precipitation. The subunits also have concrete bases to prevent contact between constituents, subsurface soils, and groundwater. A berm and cover for the pad has been designed and will be in use prior to the permit approval. Runoff, which should not come in contact with contaminated media, is directed across the access road to the east and north and across vegetation to the south and west. Runoff is not collected and does not impact other drainage structures on the Island. Runoff from the OB Area infiltrates into the sandy soil surrounding the units.

Any rocket motor treated at the OB Area, follows guidelines and measures, which have been approved by the WFF Safety Office. The rocket motor and igniter are placed inverted into a cylinder or attached to the pad motor head assembly. The igniter is set off by a battery hook-up, from behind a protective barrier. The distance between the barrier and burning area is specified in a ground safety plan prepared for each rocket motor type. Burned motors and igniters are inspected for visible signs of untreated material. If untreated material is present in the motor, then the motor is reignited or the material removed and reignited on the burn pad.

Occasionally, propellant is removed from a motor(s) when modifications are required. Propellant (not in a motor casing), ash, residue, or ejected material are placed on the burn pad in a burn pan. A squib igniter is fabricated, and the material is ignited. Any unburnable material is containerized, sampled for characterization, if necessary, and any hazardous waste is disposed of through WFF's hazardous waste disposal contractor.

4.3 Past Releases

On July 30, 2013, several fires developed in the immediate vicinity of the OB Area and one fire in the State of Virginia marsh, northwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. During the inspection process of the motor, inconsistencies were found in the Taurus rocket motor, which were similar to those found in the motor which caused the fire on July 17, 2013. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, positioned additional equipment and manpower at the site to respond to the fire, should one occur. As a result, all fires on WFF property were immediately extinguished. The fire on Virginia state property was extinguished within 45 minutes.

On July 17, 2013, several fires developed in the State of Virginia marsh, northwest, west, and southwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, responded to the fire. Additional water tankers were supplied by the Atlantic Virginia Volunteer Fire Department. All permit procedures were followed during treatment. A Ground Safety representative was also present during operations. The fire self-extinguished at approximately 9:16 p.m.

On October 25, 2010, two small fires, each scarring approximately patches of grass and brush covering an area of approximately 10 feet by 10 feet. One fire extinguished itself and the other fire was extinguished with water by the on-scene Wallops Fire Department. The fire, which extinguished itself, was approximately 30 feet northeast of the burn pad, on the road. The second fire was approximately 20 feet southwest of the burn pad in the brush. The ejected material was from Arcas motor grain.
On March 25, 2009, during routine Open Burn (OB) Area operations, the on-scene fire department personnel responded to two small brush fires at the facility. The fire did not occur outside the facility, did not result from a release of hazardous waste, and did not threaten human health or the environment.

On March 10, 1992, six Nike rocket motors were prepared for OB at the rocket motor disposal site on the south end of the island. These motors, which were manufactured in 1959, had been contaminated with sea water during the January storm which hit Wallops Island. Two of the six motors were prepared for open burning and at approximately 1430, the first motor was ignited without incident. Upon ignition of the second motor an anomaly occurred which resulted in the motor being ejected from the subunit. This motor hit the pavement in the vicinity of the tube from which it had been ejected and came to rest approximately 50 meters south of the tube in the marsh/beach area. There were no personnel injuries or significant property damage as a result of this anomaly. It should be noted that all necessary safety precautions were followed and all environmental restrictions adhered to during these disposal operations. The technicians also indicated several small brush fires were started by this motor. One fire was unique in that it was started approximately 150 meters west of and behind the barricade. All fires were extinguished by Damage Control, which, according to standard operating procedure, was stationed behind the barricade. These fires were most likely the result of burning propellant being ejected from the motor. Procedures were modified to prevent reoccurrence of this anomaly.

5. OVERVIEW OF CLOSURE PROCEDURES

The WFF OB Area is subject to the closure requirements of the VHWMR and RCRA regulations, under 40 CFR Part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities.

The OB subunits and burn pad (HWMUs) will be closed in accordance with the closure performance standards (Section 2.0) and closure requirements for a Subpart X hazardous waste treatment facility.

This closure plan is designed to provide documentation of the closure of the OB Area subunits and burn pad in accordance with the VHWMR and RCRA. Any hazardous waste constituents remaining after closure will not adversely impact any environmental media in excess of the DEQ established exposure levels and that direct contact with any constituents remaining from the site will not pose a threat to human health and/or the environment.

The closure procedures require that all wastes, waste residues, aggregates, soils, wastewaters, and rinseates that are generated from the closure activities of the HWMUs be segregated and stored in separate containers, and representatively sampled and tested to assure compliance with the VHWMR and RCRA. All wastes, wastewaters, rinseates, soils, and residues related with the closure of the HWMUs will be stored on-site in temporary storage containers in accordance with regulations. No waste piles will be created during closure activities. Waste debris, soils, and residues will be stored in large roll-off containers, if needed.

The Regional Office of DEQ will be notified of the temporary (less-than-90-day) storage of hazardous waste and other wastes associated with closure at the OB Area. The Regional Office will be notified a minimum 45 days prior to commencement of closure activities.

In accordance with the EPA's Contained-in Policy, contaminated environmental debris or media is subject to regulation under RCRA if they contain hazardous waste. Contaminated residues and environmental media contain hazardous waste when the following occurs:

- When the residues or media (e.g., soil, aggregate, wastewaters, etc.) exhibit a characteristic of hazardous waste in accordance with 40 CFR Part 261, Subpart C, Characteristics of hazardous Waste, § 261.20.

- When a residue, waste, or wastewater removed from a regulated unit, which manages a listed waste under 40 CFR Part 261, Subpart D, Lists of Hazardous Wastes, contains a hazardous constituent from Part 261 Appendix VI or VIII.

- When the media are contaminated with concentrations of hazardous waste constituents that are above health or risk-based levels.

Any soil, subsoil, and equipment contaminated with hazardous waste and any leachate from the HWMUs are required to be managed as a hazardous waste if the concentration of HCOCs exceeds the current EPA Regional Screening Level (RSL) Table industrial Risk-Based Screening Level (RBSL) for direct exposure to soils, and/or the contaminated soil exhibits a characteristic of a hazardous waste in accordance with the VHWMR and RCRA. That is, any soils, subsoils, sediments, materials, wastewaters, or equipment contaminated with hazardous waste constituents are required to be disposed in a permitted hazardous waste landfill, unless demonstrated by testing that they are nonhazardous in accordance with specified decontamination standards of the approved closure plan and the VHWMR and RCRA regulations.

The demonstration by testing includes the analyses for all HCOCs specified in the approved closure plan, analyses to demonstrate that the materials are not characteristic hazardous waste.

All soils, subsoils, sediments, materials, wastewaters, or leachate or other wastes generated during closure that are demonstrated to be hazardous must be treated or disposed so to comply with 40 CFR Part 268, Land Disposal Restrictions, Subpart D, Treatment Standards, 40 CFR § 268.40, Applicability of Treatment Standards.

All waste materials generated in the closure process that are demonstrated as non-hazardous are required to be disposed of as a solid waste in accordance with the VHWMR. Disposal of all nonhazardous wastes will require documentation of disposal from the authority regulated under the Virginia Solid Waste Management Regulations (VSWMR).

Wastewaters generated in the closure process that are demonstrated as nonhazardous are required to be disposed to a publicly or privately owned wastewater treatment plant regulated by the Clean Water Act (CWA) or equivalent. Disposal of all nonhazardous wastewaters will require documentation of prior approval for disposal, and documentation of disposal from the authority regulated under the CWA.

Hazardous waste is not stored at the OB Area. No hazardous waste will be stored in the OB Area at closure. The maximum amount of propellant to be disposed of per year is 30.4 metric tonnes (33.5 tons) based on Virginia Synthetic Minor Air Permit 40909. To date, the maximum amount of propellant burned in a year has been 20 metric tonnes (22 tons) in 1998 and 2013. The design capacity is 16.9 metric tonnes

(18.6 tons) based on the propellant weight of one GEM 46 rocket motor being burned in one day.

The rocket motors and igniters are considered hazardous waste primarily because they meet the characteristic of reactivity (D003). In 40 CFR § 261.23 (a) (6 and 8) reactivity is defined as follows:

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(8) It is a forbidden explosive as defined in 49 CFR § 173.54, or a Division 1.1, 1.2, or 1.3 explosive as defined in 49 CFR § 173.50 and 173.53.

Rocket motors treated at the OB Area are reactive because they are Class 1.1 through 1.3 explosives. Further discussion can be found in Section 4.0 and Section 6.2.

Certain rocket motors or igniters may also exhibit the toxicity characteristic for chromium (D007) or lead (D008) because based on their MSDS it is assumed that they would fail the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels found in 40 CFR § 261.24 Table 1.

Since hazardous waste is not stored at the OB Area, hazardous waste requiring removal would be limited to contaminated soil, structures, waste residues, wastewaters, and rinseates. All hazardous waste will be managed in accordance with the VHWMR and RCRA and a Health and Safety Plan will be developed for the facility closure.

A decontamination area will be set up prior to dismantling of facility structures. The area will also be used for all non-disposable sampling equipment decontamination. The area will be sufficiently sized and sloped to allow the decontamination of the OB subunits; subunit covers burn pad cover and large equipment. All structures, wastewaters, rinseates, soils, and residues will be characterized in accordance with Section 14.0 and disposed of in accordance with the VHWMR, RCRA, and Land Disposal Restrictions (LDR) to a permitted TSD if found to be a hazardous waste. The steel cylinders will be extracted from the ground and placed in the decontamination area. The cylinders will be steamed cleaned and allowed to air dry. The steel cylinders will be characterized, demilitarized, and if found to be nonhazardous, recycled as scrap metal.

No decontamination waters will be allowed to collect in the decontamination area. Water from steam cleaning and decontamination will be collected in drums and characterized. If the decontamination waters are not a hazardous waste and meet the

permit requirements of WFF's wastewater treatment plant, it will be treated there. The concrete burn pad and pans will be sampled to characterize the material prior to disposal.

The discrete grab samples will be scraped and cored from the concrete pad. If it is determined that the pad is nonhazardous, the concrete will be disposed of in a sanitary or construction landfill. If the sample results indicate that the material is hazardous, then an attempt will be made to decontaminate the burn pad. The burn pans will be characterized and disposed of as hazardous waste. At this point, the pad will be removed from the ground and placed in the decontamination area. The pad will be double washed and rinsed. After the material has air-dried a second series of grab samples will be collected and analyzed. If the material remains hazardous the pad will be broken up, containerized, and disposed of as hazardous waste. Wash and rinse waters will be collected and disposed of as hazardous waste.

If soil excavation is necessary due to contamination, the soil will be excavated to the predetermined depth via the sample analysis. The excavated soil shall be appropriately containerized (i.e., in drums or roll-off containers) and sampled for appropriate waste classification. If the soil is deemed to be a hazardous waste, the soil will need to be managed and disposed as hazardous waste. If the soil is not deemed hazardous waste, then the excavated soil will be disposed of in accordance with VSWMR.

The OB Area will have achieved clean closure, when all hazardous waste or hazardous waste HCOCs have been removed from the HWMU to levels such that direct contact with any parts of the HWMU or any HCOCs that remain after closure will not pose a threat to human health and/or the environment, nor adversely impact any environmental media in excess of the DEQ established exposure levels.

Achievement of clean closure will be demonstrated by the systematic removal of hazardous wastes, by decontamination of the equipment, structures, and soils and subsoils (if needed), and by comparison of the HCOCs in the sample compliance data to one of the three decontamination standards in this closure plan. In order to achieve clean closure, the applicable standards for both soil and groundwater must be met.

The OB Area will be considered clean closed, requiring no further closure activities if one of the following conditions is met:

1. The concentrations of HCOCs in the compliance samples are below the method detection limits of the analytical test methods,

2. The concentrations of HCOCs in the compliance samples are below or not statistically different from the background sample levels, or

3. The concentrations of HCOCs in the compliance samples are at or below DEQ approved risk-based levels.

If performance standards 1, 2, or 3 are achieved, the OB Area soil will be considered to be clean closed. If the standards cannot be achieved, the structures and soils may be removed and disposed of at a TSD facility as a means to comply with the closure requirements of VHWMR and RCRA.

6. HAZARDOUS CONSTITUENTS OF CONCERN

6.1. Maximum Waste Inventory

NASA does not store hazardous waste at the OB Area. No hazardous waste will be stored in the OB Area at closure. The maximum amount of propellant to be disposed of per year is 30.4 metric tonnes (33.5 tons) based on Virginia Synthetic Minor Air Permit 40909. To date, the maximum amount of propellant burned in a year has been 20 metric tonnes (22 tons) in 1998 and 2013. The design capacity is 16.9 metric tonnes (18.6 tons) based on the propellant weight of one GEM 46 rocket motor being burned in one day.

6.2. Hazardous Waste Determination

The rocket motors and igniters are considered hazardous waste primarily because they meet the characteristic of reactivity (D003). In 40 CFR § 261.23(a) (6 and 8) reactivity is defined as follows:

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(8) It is a forbidden explosive as defined in 49 CFR § 173.54, or a Division 1.1, 1.2, or 1.3 explosive as defined in 49 CFR § 173.50 and 173.53.

Rocket motors treated at the OB Area are reactive because they are Class 1.1 through 1.3 explosives.

Certain rocket motors or igniters may also exhibit the toxicity characteristic for chromium (D007) or lead (D008) because based on their MSDS it is assumed that they would fail the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels found in 40 CFR § 261.24 Table 1.

All residues, debris, soils, wastes, wastewaters, etc., that are generated during closure will be analyzed for TCLP constituents in addition to the required testing of established HCOCs to establish whether the wastes generated are hazardous waste or nonhazardous.

6.3. Analytical Procedures

Each type of rocket motor and igniter varies in the type and quantity of reactive constituents. The percent composition of the chemicals is proprietary/classified information and not provided in most cases by the manufacturer. Safety Data Sheets are included in Appendix B (refer to OB Permit Exhibit II.B-1 OB Area Waste Analysis Plan). The (HCOCs) are those hazardous constituents historically managed at the OB Area and the HWMUs, which are identified in RCRA under 40 CFR § 261, Appendix VII, Basis for Listing Hazardous Wastes, and Appendix VIII, Hazardous Constituents. Groundwater monitoring parameters are based upon constituents required in the Open Burn/Open Detonation Groundwater Monitoring Plan (GMP). The HCOCs for closure of HWMUs are listed in Table 1 along with the respective analytical test method.

All samples collected pursuant to this closure plan will be analyzed for all hazardous constituents of concern (HCOC) specified in Table 1. All analytical methods are in accordance with SW-846, Test Methods for Evaluating Solid Waste, Third Edition, 1986, EPA as updated by Updates I, II, IIB, III, IIIA, IVA, and IVB (SW-846).

Table 1
Hazardous Constituents of Concern Analytical Test Methods Table

Hazardous Constituent	SW-846 Method	PQL/EQL (ug/Kg)	MDL (ug/Kg)
Ammonia	SM4500-NH3-BG	2500	1000
Chromium, total	6010C low	500	100
Cyanide, total	9014R/9010B/9012B	750	125
Diethyl phthalate (DEP)	8270	333	83.3
Dibutylphthalate	8270	333	83.3
Dioxins and Furans	1311 and 8830 or 8270		
Lead, total	6020/6010C low	250	75
Maleic Anhydride	8270		
Nitrates	9056	2500	330
Nitrites	9056	2500	330

Nitroglycerin	8332/8330/8330A	1000	250
Perchlorate	6850	20	5
Phenols	9065/EPA420.4	1	0.2
Toluene di isocyanate (TDI)	8270	660	660
Cyanide, total	9014R/9010B/9012B	750	125

*In accordance with SW-846, the definitions of a PQL/EQL and MDL are as follows:

EQL - The estimated quantitation limit (EQL) is the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the MDL. However, it may be nominally chosen within these guidelines to simplify data reporting. For many analytes, the EQL analyte concentration is selected as the lowest non-zero standard in the calibration curve. Sample EQLs are highly matrix-dependent. The EQLs in SW-846 are provided for guidance and may not always be achievable.

MDL – The method detection limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

6.4. Lab Selection

The laboratory performing sample analysis will be a laboratory regularly engaged in performing hazardous waste profile analyses and will use only approved EPA methods for the type of analysis required. Laboratory reports will provide PQLs/EQLs and the MDLs for each parameter and medium tested. Furthermore, the laboratory shall have a comprehensive Quality Assurance/Quality Control (QA/QC) Program in place. NASA will notify DEQ of the selected laboratory and submit the laboratories QA/QC Plan prior to the start of closure activities at the OB Area. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

7. QUALITY ASSURANCE/QUALITY CONTROL PLAN AND PROCEDURES

7.1. Quality Assurance/Quality Control

The facility and laboratory performing the analytical testing will follow quality assurance and quality control (QA/QC) procedures consistent with Chapter one of SW-846. SW-846, Chapter One, Section 3.4.1, Control Samples, specifies the following:

1. Control samples are QC samples that are introduced into a process to monitor the performance of the system. Control samples, which may include blanks (e.g., trip, equipment, and laboratory), duplicates, spikes, analytical standards, and reference materials, can be used in different phases of the data collection process beginning with sampling and continuing through transportation, storage, and analysis.

2. Each day of sampling, at least one field duplicate, and one equipment rinseate should be collected for each matrix sampled. If this frequency is not appropriate for the sampling equipment and method, then the appropriate changes should be clearly identified in the quality assurance project plan (QAPP). When samples are collected for volatile organic analysis, a trip blank is also recommended for each day that samples are collected. In addition, for each sampling batch (20 samples of one matrix type), enough volume should be collected for at least one sample so as to allow the laboratory to prepare one matrix spike and either one matrix duplicate or one matrix spike duplicate for each analytical method employed. This means that the following control samples are recommended:

   - Field duplicate (one per day per matrix type)
   - Equipment rinseate (one per day per matrix type)
   - Trip blank (one per day, volatile organics only)
   - Matrix spike (one per batch [20 samples of each matrix type])
   - Matrix duplicate or matrix spike duplicate (one per batch)
   - As recommended by DEQ, a field blank will also be collected (one per day per matrix type).

Additional control samples may be necessary in order to assure data quality to meet the project-specific data quality objectives.

The QA/QC samples will be handled the same as all other environmental samples. Sample labeling, chain-of-custody, sample preservation, etc., will be discussed in Section 8.0.

The appropriate QA/QC samples, sample data, and laboratory data, and laboratory QA/QC control procedures specified within the closure plan will be discussed and summarized in the closure report as it pertains to the demonstration of closure.

All of the QA/QC laboratory data will be included with all other field and sampling data and will be provided in an Appendix of the Closure Report.

8. CLOSURE SAMPLING AND ANALYSES PLAN

8.1. Field Procedures

Field and laboratory activities for all sample collection and handling shall be done in accordance with SW-846 and as noted in the following sections. Prior to the sampling event, a laboratory will be contracted to perform the analytical requirements, and necessary materials obtained to perform the sampling. Sampling personnel will wear a new pair of gloves for each sample collected.

8.1.1. Instrument Calibration

All field analytical instruments shall be calibrated before each event and on each day of the event according to the manufacturer's specifications. The standards used for calibration shall be documented in the field logbook. Instruments shall also be thoroughly cleaned with deionized water between calibration standards and samples.

8.1.2. Sample Containers

All sample containers will be new and contaminant free. The sample containers will be provided by the laboratory. The containers to be used for samples for hazardous constituent analyses will be selected based on guidance found in SW-846.

8.1.3. Sample Labeling

All sample labeling will be done in the field with indelible/waterproof ink. Any error will be crossed out with a single line, dated, and initialed. Each sample container will be labeled with the following information:

- Site name;
- Sample identification number;
- Sample location with grid coordinates tied to established survey location. The sample location will have xyz coordinates denoting plan locations and depth;

- Date and time of collection;
- Type of preservation;
- Analysis required;
- Sample type (grab, composite);
- Sample matrix (soil, water, other); and
- Any other information pertinent to the sample.

8.1.4. Data Collection

A field logbook shall be utilized which contains the following information at a minimum:

- Project for which the sample is being collected;
- Date and time;
- Name of collector(s);
- Source of sample (including name, location, and sample type);
- Deviations from Sampling Plan or Standard Operating Procedures;
- Pertinent field data (pH, temperature, conductance, depth of sample, weather conditions, etc.);
- Unique sample or log number; and
- Sampling techniques.

8.1.5. Sample Preservation

Each sample will be placed into an appropriate and properly labeled sample container. All samples will be kept in a cooler and maintained at 4°C during shipment to the laboratory and until analyses are performed.

8.1.6. Chain-of-Custody Control

Strict chain-of-custody procedures will be maintained for all samples. A chain-of-custody form will be completed for each set of samples collected. The form is maintained as a record of sample collection, transfer, and receipt by the laboratory. Custody of samples will be maintained and documented from the time of sample collection to the completion of analysis. The laboratory conducting the sample analysis will provide chain-of-custody documentation. The chain-of-custody will be included in the final closure report as an appendix.

8.2. HWMU Sampling

8.2.1. Soil and Subsoil Sampling

The soil sampling area size for the purposes of soil sampling to determine clean closure is defined as the area affected by a release at the site. Though historical release information will be evaluated at the time of closure, from historical information thus far a conservative 15-meter (50-foot) radius around the cylinders and pad will be used at closure. Motors placed in the cylinders are approximately 2 meter (6 feet) above the soil surface. The tallest motor attached to the burn pad historically is approximately 6 meters (17 feet) above ground surface. The additional height and its effect on the trajectory of ejected material have been calculated and the potential impact area determined to be a 13-meter (42-foot) radius area around the burn pad.

The sample locations will be chosen based upon simple random sampling using a statistical sampling strategy, biased sampling (for known hot spots) or, alternatively, every grid node may be sampled. Please note, if random sampling is performed then the random number table used, in addition to the sampling locations, shall be provided to the DEQ with the closure certification report. For random sampling, the appropriate number of samples needed will be determined depending on the surface area size and possible statistical method to be used.

A grid will be established, over the OB Area. The size and number of grid locations will be determined based on approximate surface area and in accordance with sampling procedure outlined in SW-846. Sampling at a minimum of eight different soil sampling locations shall be obtained in the vicinity of the OB subunits and pad, and beneath the subunits and pad once they have been removed. Soil samples shall be obtained from the surface layer, the 0-15 centimeter (0-6 inch) layer, the 15-30 centimeter (6-12 inch) layer, the 30-46 centimeter (12-18 inch) layer, and the 46-61 centimeter (18-24 inch) layer. Soil samples will be collected using EPA standard operating procedures. The collection of soil samples for volatile organic compounds

and heavy metals analyses will follow SW-846. All sampling equipment will be decontaminated between samples to avoid cross-contamination at the various depths. Equipment decontamination shall be per the requirements of Section 13.1.

Should soil contamination be detected beneath a HWMU that exceeds the closure plan clean closure decontamination standards, then the horizontal extent of potential contamination outside the HWMU boundary will be evaluated by systematic soil sampling. The initial soil sampling scheme of the closure plan will be laterally extended beyond the initial sampling plan design by sampling in incremental 1 meter (3.3 feet) distances in each direction of the original HWMU sample grid until soil contamination is either not detected or is shown to be in compliance with the closure plan decontamination standards and performance standards.

In the above expanded soil sampling scheme, eight randomly selected sample locations will be established at the perimeter of each incremental 1 meter (3.3 feet) distance outside the original designated HWMU area; the eight random samples will include two samples per side. Sampling protocol (including sample depths and analyses) will follow procedures established for the initial soil sampling design of the HWMU.

The soil sampling data from each extended 1 meter (3.3 feet) sampling zone will not be statistically manipulated to allow a dilution effect of the original sample data or any subsequent extended 1 meter (3.3 feet) sampling zone. That is, each set of sampling data from each additional 1 meter (3.3 feet) of extended sampling area will be statistically evaluated separately from the original data set and any subsequent data sets created by the incremental 1 meter (3.3 feet) sampling protocol noted above.

Should excavation be required, removed soil shall be containerized in drums or roll-off containers. Sampling from such containers for characterization prior to disposal shall consist of multiple grab samples composited into one. All solid and hazardous wastes will be characterized in accordance with 40 CFR § 264 and 268 and Section 14.0 prior to disposal.

8.2.2. Runoff Sampling

After analyzing the topography, a minimum of five samples will be taken from the receiving stormwater ditch which could have received runoff from the burn pad prior to the construction of its berm and cover. The random sampling methodology is satisfactory to select sediment sample locations. The sediment sampling protocols (including sample depths and analyses) will follow procedures established for the soil sampling design of the HWMU. Sediment samples should be from the 0-15 centimeter (0-6 inch) layer, the 15-30 centimeter (6-12 inch) layer.

8.2.3. Groundwater Sampling

Groundwater data generated via the GMP will be utilized to evaluate the groundwater at closure.

8.2.4. Wash and Rinseate Sampling

Verification of the decontamination of HWMU structures and equipment involves the collecting final rinseate water samples from the structure and collecting separate final rinseate from each individual piece of equipment of the HWMU. The final rinseate is to utilize analyte-free (deionized) water.

The final rinseate samples are taken after all of the hazardous wastes have been removed from the unit structure and the individual equipment. Also, after the HWMU and equipment have been cleaned, pressure washed, steam cleaned, and rinsed, etc., in accordance with the decontamination procedures specified in Section 13.0. The final rinseate of each HWMU structure and each piece of equipment are to be individually sampled and tested for the HCOCs to determine whether the HWMU structure and individual equipment meets the decontamination standards.

Wash waters and rinse waters from the HWMU and equipment will be combined in common containers and tested to establish the proper method of disposal. All wastes, washwaters, and rinse waters generated during closure will be sampled as discrete samples and tested for HCOCs and for TCLP parameters to characterize the waste for disposal in accordance with regulations.

8.2.5. Structures Sampling

The discrete grab samples will be scraped and cored from the concrete pad. A minimum of five samples shall be taken from the concrete. Sampling will be performed to characterize the waste as a hazardous waste. All solid and hazardous wastes will be characterized in accordance with 40 CFR § 264 and 268 and Section 14.0 prior to disposal.

8.3. Background Sampling

All background samples will be collected using EPA standard operating procedures. Background samples will be labeled, collected, handled, preserved, and shipped in a manner identical to the closure compliance samples of the same mediums. All QA/QC procedures discussed in Section 7 will be followed for the background samples. These samples will be analyzed for the HCOCs, as listed in Table 2, and in

accordance with the requirements of SW-846. All sampling equipment will be decontaminated between samples to avoid cross-contamination at the various depths per the requirements of Section 13.

8.3.1. Background Soil Samples

The background locations shall be selected in an area uncontaminated by site operations and from an area containing soils geologically similar to the compliance sample soils. The proposed location shall be submitted to the DEQ for approval prior to sampling.

Soil borings will be used to verify and document the nature and properties of the background soils in comparison with soils and subsoils from the HWMU. Discrete soil samples will be collected from each boring. A geologist will be present on-site during the sampling to insure that the background soils collected are representative of the soils.

A minimum of eight discrete sampling locations will be used. Background samples will be obtained from the surface layer, the 0-15 centimeter (0-6 inch) layer, the 15-30 centimeter (6-12 inch) layer, the 30-46 centimeter (12-18 inch) layer, and the 46-61 centimeter (18-24 inch) layer.

8.3.2. Background Rinseate Samples

Background rinseate samples will be taken from the water supply which is the source of wash water and rinseate water in the decontamination of the HWMUs. If the potable water source is to be used for decontamination, then potable water will be collected from the cold water tap after running the tap fully open for a minimum period of 5 minutes.

Background final rinseate samples may also be taken from a background structure which is of similar construction materials to the HWMU structure, if the background structure has not been impacted by the facility's HWMUs operations and HCOCs managed at the facility site. The final rinseate samples from a background structure will be taken after decontamination by washing and rinsing in the same manner as the HWMUs undergoing closure.

8.3.3. Background Groundwater

Background groundwater will be as stated in the Groundwater Monitoring Plan (GMP).

8.4. Report Content

Laboratories will provide a report that includes the following, at a minimum:

1. Title page
2. Sample analysis request form, field chain of custody
3. Internal chain-of-custody
4. Date and time of analysis, name of analyst and analyte
5. Method summary
6. Sample data:
    a. Analytical reports
    b. Method detection limits (MDL)
    c. Practical quantitation limits (PQL)
7. Quality control summary:
    a. Duplicate
    b. Matrix spike
    c. Matrix spike duplicate
    d. Blank
    e. Laboratory control spike, if applicable
    f. Surrogate recovery summary forms
8. Sample holding time(s)
9. Signature by qualified professional

A summary of results compiled by chemical component will be provided in the form of a data summary table. The summary results should include as a minimum:

parameter (chemical component), analytical method, PQLs, MDLs, sample number, results, and units. A qualified professional shall sign the summary of results table. Non-detected analytes should be reported as the detection limit with the code "U" or specified as not detected (ND). Analytes detected above the detection limit, but below the quantitation limit (PQL, etc.), should be reported as an estimated concentration with the code "J". Analytical results shall be received as hard copy and electronically (i.e. Excel spreadsheet).

9. HEALTH AND SAFETY PLAN FOR CLOSURE ACTIVITIES

All personnel performing closure activities at the site shall be appropriately trained in accordance with all applicable Occupational Safety and Health Administration (OSHA) regulations. A Health and Safety Plan (HSP) meeting all applicable OSHA requirements must be developed for these closure activities. All personnel performing closure activities will be trained in the requirements of the HSP and the HSP will be provided to them prior to initiation of closure activities. Personnel will be required to sign the HSP indicating that they have read and understand it. The HSP will be available at all times when closure related activities are taking place.

The HSP shall designate a Site Safety Officer that will be present during all closure activities. The HSP shall provide steps for appropriate selection of personal protective equipment and for decontamination of personnel. The decontamination area shall be staged prior to closure activities commencing. The required notifications of the start of closure activities shall be made to the DEQ and appropriate local authorities. The boundaries of the closed OB Area will be defined, cordoned off, and posted to prevent unauthorized entry of site personnel during closure activities. Please note that entry to the site by the surrounding population is unlikely due to the presence of round-the-clock security at Wallops Island and badge requirements that prevent unauthorized entry. However, to insure no unauthorized entry during these closure activities, "NO ENTRY" signs shall be posted to minimize the possibility of unauthorized entry. The equipment decontamination area will be established and constructed as described in Section 13.0.

10. CLEAN CLOSURE DECONTAMINATION STANDARDS

The OB Area will be closed in accordance with the VHWMR and RCRA, 40 CFR § 264, Subpart G, §264.111, Closure Performance. The OB Area will have achieved clean closure, when all hazardous waste or hazardous waste constituents (HCOCs) have been removed from the HWMU to levels such that direct contact with any parts of the HWMU or any HCOCs that remain after closure will not pose a threat to human health and/or the environment, nor adversely impact any environmental media in excess of the DEQ established exposure levels.

Achievement of clean closure is demonstrated by the systematic removal of hazardous wastes, by decontamination of the equipment, structures, and soils and subsoils (if needed). Also, by comparison of the HCOCs in the sample compliance data to one of the three decontamination standards in this closure plan. In order to achieve clean closure, the applicable standards for both soil and groundwater must be met.

The OB Area will be considered clean closed, requiring no further closure activities if one of the following conditions is met:

1. The concentrations of HCOCs in the compliance samples are below the method detection limits of the analytical test methods,

2. The concentrations of HCOCs in the compliance samples are below or not statistically different from the background sample levels, or

3. The concentrations of HCOCs in the compliance samples are at or below DEQ approved risk-based levels.

If performance standards 1, 2, or 3 are achieved, the OB Area soil will be considered to be clean closed. If the standards cannot be achieved, the structures and soils may be removed and disposed of at a regulated treatment facility as a means to comply with the closure requirements of VHWMR and RCRA.

10.1. Analytical Non-detection

The analytical test methods with the lowest practical quantitation limit or estimated quantitation limit (PQL/EQL) for each HCOC must be used for the non-detection criterion to be the basis for clean closure.

In the rinseate, if a HCOC sample is above the detection limit, the performance standard will still be met if the HCOC is less than or equal to that of the corresponding HCOCs concentration in the equipment blank, field blank, raw water, or trip blank.

If soil and subsoil sample results analytical non-detection for all of the HCOCs analyzed using the approved test methods and detection limits, then the specific sample locations showing the non-detection will be deemed to be uncontaminated. If all soil and subsoil compliance samples result in non-detection for all HCOCs, then the soils and subsoils will meet the clean closure decontamination standard.

If soil and subsoil samples detect the presence of HCOCs, then the facility may demonstrate clean closure by one of the following:

1. Statistical comparison of the compliance samples HCOCs to the background levels HCOCs,

2. Risk assessment evaluation of the HCOCs present in the samples, or

3. Further decontamination (soil removal) and soil sampling to demonstrate achievement of non-detection levels or risk-based levels acceptable to the DEQ.

10.2. Statistical Comparison to Background

A background statistical comparison will be employed to determine if adequate decontamination has been achieved for decontamination of the HWMUs and, removal of contaminated soils or concrete. Background samples and compliance samples will be collected for the statistical comparison in accordance with Section 8.0.

The statistical comparison will satisfy the following performance standards:

1. The significance level will be no less than 5 percent throughout the statistical evaluation.

2. Determination of the minimum number of samples, treatment of outliers, and treatment of non-detected values will follow the Interim Guidance Document on the Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, EPA, April 1989; and Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Draft Addendum to the Interim Guidance, EPA, June 1992.

3. The sampling results satisfy the assumptions associated with the selected statistical method(s) including the minimum number of background/compliance samples and the distribution of data points.

4. Normality of the sample analytical results will be demonstrated for all of the HCOCs by the use of Probability Plots and the Shapiro Wilk test as specified in Chapter 1 of the EPA document Statistical Analysis of Groundwater Monitoring Data at the RCRA Facilities Addendum to Interim Final Guidance, July 1992.

5. If the statistical comparisons indicate that there is no significant difference between the background and/or risk-based sampling results, the compliance

sampling results are deemed to pass the background and/or statistical comparison, and the decontamination/closure is deemed to be adequate.

Statistical comparison of hazardous constituent concentrations in rinseate or soil samples to those of uncontaminated background samples may be made by the following procedures as specified below:

10.2.1. Upper Tolerance Limits Procedure

The tolerance limit method may only be used when the raw background data and the compliance data are normally distributed or the log transformation of the raw background data and the compliance data are normally distributed. Using the data from the analyses of the eight background samples, an upper tolerance limit (UTL) for each HCOC will be calculated as:

$$UTL = x + (K95(0.95,n) * s)$$

Where: x = the mean of the measured values.
s = the standard deviation of the measured values.
k = k-factor for one sided tolerance limit test.

The parameter K95(0.95,n) establishes the confidence interval for the UTL such that there is a 95 percent chance that at least 95 percent of the time, the actual constituent background concentration will be below the this upper bound. The table, K-Factors for One Sided Normal Tolerance Limits, identifies the value of this parameter as a function of n. The value of K for eight samples (n = 8) is 3.188.

The results of the analyses of the rinseate samples from the containment area or piece of equipment will be compared to the appropriate UTL for all HCOCs analyzed in accordance with this closure plan. If the concentration of every analyte in a sample is below the appropriate UTL, that item will meet the clean closure decontamination standard.

The results of the analyses of each soil sample will be compared to the appropriate UTL for all HCOCs in accordance with this closure plan. If the concentration of every analyte from all depths of a soil sample is below the appropriate UTL, that sampling location will be deemed to be uncontaminated. Should all soil samples be uncontaminated in this fashion, the soil will have met the clean closure decontamination standard. Should some soil samples demonstrate contamination, further soil sampling and removal will be conducted pursuant to Section 8 of this closure plan.

10.2.2. Alternate Statistical Procedure

If the background data is not normally or log-normally distributed, then an alternate non-parametric statistical procedure must be used.

A non-parametric Analysis of Variance (ANOVA) procedure such as the Kruskal-Wallis Test or the Wilcoxon Rank-Sum Test will be used. For the above procedures, at least eight soil samples from the HWMU and eight soil samples from the background soils will be compared. Decontamination of an area will be demonstrated by no significant statistical difference for data of all HCOCs between background and the HWMUs.

10.3. Risk Assessment for Closure

As an alternative to decontamination standards specified in 10.1 and 10.2 above, or in conjunction with, the concentrations of HCOCs detected may be compared to risk-based standards in an attempt to demonstrate that the detected concentrations do not pose an unacceptable level of risk to human health and the environment

All risk assessments will be conducted with the Virginia Unified Risk Assessment Model (VURAM) and VURAM User's Guide (2016), as amended by the DEQ, along with other risk-based guidance provided by the DEQ.

The risk goals/performance standards will be a hazard index of 1.0 for non-carcinogens and an individual carcinogenic risk of I x lO-06 and cumulative carcinogenic risk of I x lO-04. This risk assessment will be conducted assuming a future residential use of the property.

If the HWMU cannot meet the residential risk closure standards, then NASA may propose to modify this closure plan for industrial risk-based closure. An industrial land-use scenario may be used in derivation of the risk-based closure standards; however, limitation on land use will be placed on the property deed if the facility is closed by such standards. If industrial scenario for risk-based closure is necessary, the facility shall notify DEQ.

10.4. Alternative to Decontamination Standards for Soils

As an alternative to further decontamination procedures (at any time in the closure procedures), NASA may elect to demolish any or all portions of the OB Area and manage them as hazardous waste prior to transporting offsite for disposal at a permitted hazardous waste TSD facility.

If the above alternative to demonstrate clean-closure for soils is selected, then:

1. Sampling and analysis of underlying soils prescribed by the closure plan will be conducted to demonstrate clean closure.

2. Prior to implementation of this alternative, WFF shall submit a proposed soil sampling plan and amendment to the closure plan to DEQ for approval. Formal approval of the soil sampling plan and associated amendment to the closure plan by the DEQ will be required before implementation of this alternative.

11. HWMU WASTE INVENTORY REMOVAL AND MANIFESTS TO A TSD

The removal, transportation, treatment, storage, or disposing of all hazardous waste at the OB Area will be conducted in accordance with the VHWMR and RCRA, under 40 CFR § 264, Subpart G, § 264.112. The accumulation of hazardous waste will be carried out in accordance with RCRA, 40 CFR § 262, §262.34, and the accumulation period will be less than 90 days. The 90-day accumulation period will begin the day the waste is generated. Hazardous waste generated by the closure activities needs to be stored in a designated storage area or accumulation area on-site. The DEQ Regional Office will be notified 15 days prior to the facility use of any new accumulation areas.

11.1. Inventory Removal Summary Table

NASA does not store hazardous waste at the OB Area. No hazardous waste will be stored in the OB Area at closure. All hazardous waste in the OB Area during closure will be the result of closure or decontamination activities.

The OB Area closure report will provide a summary table of information related to the hazardous waste inventory removal from subunits 1, 2, 3, 4, and the burn pad. The closure report inventory removal summary table for each HWMU undergoing closure will include the following information:

1. A table title such as, HWMU OB Area – Hazardous Waste Inventory Removal Summary.

2. A description of the hazardous waste by chemical name and hazardous waste codes.

3. The amount of hazardous waste removed under each shipment (e.g., 20, 55-gallon drums, 2, 20 cubic yd. roll-off containers, etc.).

4. The corresponding inventory removal listing, which shows the number and size of the containers removed, the EPA hazardous waste code numbers on all of the containers shipped, and the dates of shipment to an off-site TSD. (This information must correspond with the information on the manifests. Copies of the manifests will be provided in an appendix of the closure report.)

11.2. Off-site TSD

The closure report shall identify the off-site TSD facility name, address, EPA ID Number, telephone number, and facility contact that will be used for disposal or treatment of the hazardous wastes removed during closure.

12. DECONTAMINATION OR DISPOSAL OF HWMUS – EQUIPMENT, STRUCTURES, AND SOILS

12.1. Demolition, Removal and Disposal of the OB Units

Prior to beginning the decontamination process, a pre-wash equipment sample blank should be collected by running deionized water through the decontamination equipment (high-pressure washer, steam equipment, etc.). Samples should be taken from the decontamination equipment spray nozzle, etc.

After high-pressure washing and rinsing the HWMUs a final rinseate sample will be collected from each HWMU. In addition, a post-rinse sample should be collected from the high pressure washing equipment by pouring deionized water over the surface area of the equipment similar to the pre-wash equipment sample blank.

A decontamination area will be set up prior to dismantling of facility structures. The structures to be decontaminated include the 4 subunits, the burn pad, and the burn pans. The area will also be used for all non-disposable sampling equipment decontamination. The area will be sufficiently sized and sloped to allow the decontamination of the OB subunits. The steel cylinders will be extracted from the ground and placed in the decontamination area. The cylinders will be steamed cleaned and allowed to air dry. The subunit covers and burn pad cover will also be steam cleaned and allowed to air dry. No decontamination waters will be allowed to collect in the decontamination area. Water from steam cleaning will be collected in drums and characterized in accordance with Section 14. After wastewater characterization is complete, the material will be properly disposed. If the wastewater is determined to be hazardous, the material will be disposed to a permitted hazardous waste TSD facility.

The concrete burn pad will be sampled to characterize the material prior to disposal. Characterization of the pad will be in accordance with the VHWMR. The discrete grab samples will be scraped and cored from the concrete pad. The material will be analyzed for the same waste constituents as the soil samples. If it is determined that the pad is nonhazardous, the concrete will be disposed of in a sanitary or construction landfill. If the sample results indicate that the material is hazardous, an attempt will be made to decontaminate the burn pad. At this point, the pad will be removed from the ground and placed in the decontamination area. The pad will be double washed and rinsed. After the material has air-dried a second composite sample will be collected and analyzed. If the material remains hazardous the pad will be broken up, containerized, and disposed of as hazardous waste. Wash and rinse waters will be collected and disposed of as hazardous waste.

The burn pans will be characterized and disposed of as hazardous waste.

After removal of the OB subunits 1, 2, 3, 4, and the burn pad, an independent Virginia registered professional engineer will thoroughly inspect the containment surface for cracks, gaps or other migration pathways through which contamination may have potentially migrated to the soils underneath and adjacent to the units. All cracks in the containment will be identified and included on the site survey for determining sampling locations in underlying soil.

As an alternative to further decontamination procedures, at any time in the closure procedures, the facility may elect to demolish any or all portions of the OB subunits or pad and manage them as hazardous waste (if necessary) prior to transporting off-site. Should this alternative be selected, a soil sampling plan and closure plan amendment will be submitted to DEQ for approval. Prior to removing the structure for disposal, the location of any cracks, gaps previously identified, will be marked for sampling of the underlying soil.

12.2. Excavation Plan

Should it be determined that removal of soils and concrete is required to achieve clean closure, demolition and disposal of the concrete structure and the underlying/adjacent soils will be performed in accordance with the following procedures:

1. WFF will procure an excavation contractor who will supply a HSP and furnish evidence that all employees have been trained to demolish and dispose of the concrete structure as outlined in Section 10.0 and the HSP.

2. The decontamination zone and work zone will be cordoned off and set up per the procedures in the HSP.

3. The contractor will demolish and excavate the affected concrete and soils. The decontamination procedures described in this plan will be utilized during all excavation activities.

12.2.1. Conditions That Trigger Excavation

Soils and subsoils which fail the statistical and/or VURAM risk-based analysis decontamination standards will be excavated to a depth where the soils and subsoils demonstrate compliance with the decontamination standards.

12.2.2. Vertical Extent of Excavation

The vertical extent of contamination should be established based upon the following:

1. The vertical extent of excavation will be based upon the extent of contamination that will be established by systematic vertical sampling of migration pathways and data evaluation using the clean closure decontamination standards (refer to Section 10.0). The proposed vertical sampling protocol and depths should be delineated.

2. Typically, the soil sampling depth intervals should be provided from the bottom of the HWMU structure to a depth of 1 meter (3.3 feet) below the structure. The typical soil sampling intervals beneath a HWMU are: the 0-15 centimeter (0-6 inch) layer, the 15-30 centimeter (6-12 inch) layer, the 30-46 centimeter (12-18 inch) layer, and the 46-61 centimeter (18-24 inch) layer.

3. If sampling and analyses of soils and/or sediments shows HCOCs at levels which exceed all decontamination standards, then the soil and/or sediment will be removed to the bottom depth of the first 15 centimeter (6 inch) sample interval which shows compliance with the decontamination standards. That is, excavation of soils will be to the bottom of the first clean sample depth interval. This ensures removal of all soil/sediment that are shown not to meet the clean closure standards.

4. If the initial sampling does not show compliance with decontamination standards at the deepest depths of the initially proposed sampling scheme (e.g. 2-ft), then additional vertical samples will be taken until samples show levels of HCOCs within the decontamination standards.

5. If soil or sediment contains HCOCs above the decontamination standards specified in Section 10.0 of this closure plan, soil or sediment excavation will be conducted down to maximum depth of one of the following:

    a. The bottom of the first soil sampling interval depth where sampling analytical data indicates compliance with the decontamination standards (clean closure conditions).

    b. The local seasonal low water table if less than 1.5 meters (5 feet). The seasonal low water table depth will be established with concurrence from the Office of Remediation Programs, DEQ.

    c. The local bedrock, if less than 1.5 meters (5 feet).

6. If soil contamination exists above the decontamination standard at depths greater than meters (5 feet), either DEQ will be formally notified for the potential need to amend the approved closure plan or to close the HWMU with hazardous waste closed in-place in accordance with the applicable regulations for the HWMU in the VHWMR.

12.2.3. Horizontal Extent of Excavation

The horizontal extent of contamination should be established based upon the following:

1. The horizontal extent of excavation will be based upon the extent of contamination that will be established by systematic sampling of migration pathways and data evaluation using the clean closure decontamination standards in Section 10.0.

2. If soils are contaminated beneath the HWMU which need removal to comply with decontamination standards and regulations, and if the secondary containment is insufficient to prevent runoff from the HWMU, the horizontal extent of the contamination will need to be determined.

3. Some sampling plans include soil sampling of an area outside the actual HWMU boundary by inclusion of a buffer area outside the HWMU (e.g., 2 - 3 feet) to assess the horizontal extent of the contamination outside the HWMU. The adequacy of the soil sampling plan to determine the horizontal extent of contamination should be based upon the nature of the site and the operations and management of the HWMU undergoing closure.

4. If the horizontal extent of the contamination is to be evaluated by a sampling scheme that includes a buffer zone outside the HWMU area proper, excavation will be conducted to include the buffer zone outside the HWMU boundary.

12.2.4. Storage, Treatment, and Disposal of the Excavated Soil, Subsoils, Construction Debris and/or Residues

The excavated soils, subsoils, construction debris, and residues should be stored in large roll-off containers. The sampling and analytical testing protocol for all soils, subsoils, sediments, debris, and residues are provided in this plan (See Section 5.0, Overview of Closure Procedures, and Section 8.0, Closure Sampling and Analyses Plan) to establish the proper means of disposal to comply with the VHWMR and RCRA.

12.2.5. Backfilling Areas of Excavation

Any areas of excavation will be backfilled with clean fill or soil to the original grade of the site prior to termination of closure activities. In addition, the site will also be seeded and vegetative cover established, where appropriate for the site, or reclaimed to similar conditions of the surrounding area.

Backfilling and reclamation of a HWMU site will not occur until the DEQ performs the closure site inspection and formally approves the clean closure of the HWMUs.

13. TEMPORARY DECONTAMINATION AREAS and PROCEDURES

The decontamination wash waters (wastewaters), rinseates, soils, and residues collected in the decontamination areas will be managed as potentially contaminated with hazardous waste and tested for the HCOCs and TCLP constituents, as specified in this closure plan. The proper management of the wastes generated from the closure activities will be based on the requirements specified in Section 14.0.

Any disposable items, such as protective clothing, sampling equipment, filters, clean-up materials, decontamination liner materials, etc., will be containerized and disposed of as hazardous waste.

13.1. Small Equipment

A decontamination area will also be set up for all non-disposable sampling equipment decontamination. The area will be set up on plastic and down gradient of the closure units.

All non-disposable sampling equipment will be decontaminated between each sample. An area for cleaning equipment will be established as close as possible to the work area. A layer of plastic will be placed on a level surface. Buckets or other appropriate containers will be used for capturing the rinseate and holding the wash-water during the cleaning process.

The equipment shall be decontaminated, as follows:

The decontamination procedures for sampling equipment (*EPA Region IV, Standard Operating Procedures and Quality Assurance Manual,* 1986) will be as follows:

1. Remove loose material by brushing or scraping. The material removed will be properly containerized and disposed of in accordance with all applicable state and federal hazardous and solid waste regulations.

2. The equipment will then be washed with a non-phosphate detergent. All decontamination wash waters will be collected and containerized for proper disposal in accordance Section 14.0 of this closure plan.

3. Rinse with tap water, rinse with methanol or propanol, then rinse with distilled or de-ionized water. These decontamination rinse waters will be collected and containerized for proper disposal in accordance with Section 14.0 of this closure plan.

4. If metal contamination is present, a rinse with 10 percent nitric acid will also be needed. This acid rinse will be followed by another distilled or de-ionized water rinse. This rinseate shall be collected and containerized for proper disposal in accordance with Section 14.0 of this closure plan.

5. Equipment will be allowed to air dry then stored in aluminum foil or plastic bags to prevent contamination.

In addition, the following procedures shall be established for the proper decontamination of personal protective equipment (PPE).

1. PPE will be decontaminated between uses/areas, and upon completion of work.

2. All decontamination will take place in the temporary decontamination area.

13.2. Large Equipment

If, during closure activities, the use of heavy equipment is necessary (i.e., soil boring sampling or soil removal), such as a backhoe or a hollow-stem auger drill, a temporary decontamination area for this heavy equipment will be constructed. The area will be graded to at least a 2 percent slope toward one corner. A berm constructed of sand bags, or equivalent material, will be placed around the edges. The area will be lined with a plastic liner to prevent infiltration of decontamination wafers into the underlying soils. The liner must be able to sustain the stress caused by moving of heavy equipment in and out of the area. The decontamination waters must drain to an appropriate container; no accumulation of liquids on the liner is allowed. This collected liquid will be tested for appropriate disposal (see Section 14.0). All decontamination shall occur in the decontamination area constructed and waste generated will be properly handled in accordance with all applicable state and federal hazardous and solid waste regulations. The decontamination procedures for heavy equipment are:

1. Heavy equipment used to remove contaminated soil will be decontaminated by appropriate abrasive methods (i.e., scraping and/or brushing). The material removed will be properly containerized and disposed of in accordance with all applicable state and federal hazardous and solid waste regulations.

2. Equipment will then be cleaned with a high-pressure wash. A non-phosphate detergent shall be used. All decontamination wash waters will be collected and containerized for proper disposal in accordance Section 14 of this closure plan.

3. The heavy equipment will then be rinsed with water, rinsed with methanol or propanol, and then rinsed with distilled or de-ionized water. This decontamination rinseate will be collected and containerized for proper disposal in accordance with Section 14.0 of this closure plan

4. If heavy metal contamination is present, a rinse with 10 percent nitric acid may also be needed. This acid rinse will be followed by another water rinse. These rinse waters shall be collected and containerized for proper disposal in accordance with Section 14 of this closure plan.

5. Equipment will be allowed to air dry then covered in plastic sheeting to prevent contamination.

14. MANAGEMENT, CHARACTERIZATION, AND DISPOSAL OF CLOSURE GENERATED WASTES

All closure generated wastes will be segregated from one another and stored in separate containers. No waste piles will be created. All wastes will be stored on site

for less than 90 days. NASA will notify DEQ at least 15 days prior to establishing a new waste accumulation area.

14.1. Disposal of Hazardous Waste

Any disposable items, such as protective clothing, sampling equipment, filters, clean-up materials, decontamination liner materials, etc., will be containerized and disposed of as hazardous waste.
All wastes generated from closure of the HWMUs (including but not limited to soil and concrete) will be managed as residues or media that is potentially contaminated with hazardous waste. Hazardous waste is required to be disposed in a permitted hazardous waste landfill or a RCRA TSD facility, unless demonstrated by testing that they are nonhazardous in accordance with specified decontamination standards of the approved closure plan and testing requirements for generated wastes specified in the VHWMR and RCRA.

Contaminated residues and/or environmental media contain hazardous waste when the following occurs:

1. When the residues or media (e.g., aggregate, wastewaters, soil, and groundwater, etc.) exhibit a characteristic of hazardous waste in accordance with 40 CFR § 261, Subpart C, Characteristics of hazardous Waste, 40 CFR § 261.20.

2. When a residue, waste, or wastewater removed from a regulated unit, which manages a listed waste under 40 CFR § 261, Subpart D, Lists of Hazardous Wastes, contains a hazardous constituent from Part 261 Appendix VI or VIII.

3. When a contaminated media (i.e., debris, soil, sediments, or groundwater) are contaminated with concentrations of hazardous waste constituents that are above health or risk-based levels.

The demonstration by testing includes the analyses for all HCOCs or underlying hazardous constituents (UHCs) managed at the facility that are identified in Part 261, Appendix VI and VIII, and an analyses to demonstrate that the waste or media does not exhibit a hazardous characteristic in accordance with Part 261, Subpart C, Characteristics of Hazardous Waste. This includes demonstration of compliance with the characteristics of ignitability, corrosivity, and reactivity and the toxicity characteristic.

All wastes (solids and liquids) generated during closure that are demonstrated to be hazardous must be disposed in a permitted hazardous waste landfill or a RCRA

permitted TSD facility. Disposal of regulated wastes must comply with 40 CFR § 268, Land Disposal Restrictions, Subpart D, Treatment Standards, 40 CFR § 268.40, Applicability of Treatment Standards, 40 CFR § 268.49, Alternative LDR Treatment Standards for Contaminated Soil, and comply with 40 CFR § 268.48, Universal Treatment Standards, for Wastewaters and Non-wastewaters.

Disposal of all hazardous wastes will require manifest documentation of shipment to a permitted TSD. Transportation of hazardous waste generated during closure activities will be in accordance with the VHWMR.

14.2. Disposal of Nonhazardous Solid Wastes

All waste materials (other than nonhazardous wastewaters) generated in the closure process that are demonstrated as nonhazardous are required to be disposed of as a solid waste in accordance with the VHWMR. Disposal of all nonhazardous wastes will require documentation of disposal from the authority regulated under the VSWMR.

14.3. Nonhazardous Wastewaters

Wastewaters generated in the closure process that are demonstrated as nonhazardous are required to be disposed to a publicly or privately owned wastewater treatment plant regulated by the Clean Water Act (CWA) or equivalent. Disposal of all non-hazardous wastewaters will require documentation of prior approval for disposal, and documentation of disposal from the authority regulated under the CWA.

14.4. Reusable Equipment

A list of equipment to be used during closure will be submitted to DEQ prior to commencement of closure. All reusable equipment that is used in the decontamination and closure process, including the large equipment, wet-dry vacuum, pressure washers, steam cleaners, sampling equipment, shovels, buckets, brooms, etc., will be thoroughly washed with a detergent solution, rinsed twice with clean water, rinsed with methanol or propanol and then rinsed with distilled water. A final rinseate using analyte free deionized water will be collected and tested for compliance with decontamination standards or the items will be disposed of as hazardous wastes.

15. CLOSURE COST ESTIMATE WITH SUPPORTING CALCULATIONS

Federal Government installations are exempt from the financial requirements of the hazardous waste regulations.

16. FINANCIAL ASSURANCE FOR CLOSURE

Federal Government installations are exempt from the financial requirements of the hazardous waste regulations.

17. SCHEDULE FOR CLOSURE

When the decision is made to close the OB Area, NASA will notify DEQ in writing at least 45 days prior to the closure commencement date. Closure may be extended upon request by the facility if it can be demonstrated that the unit or facility has the capacity to receive additional wastes. NASA will complete closure within 180 days of the approval; unless an extension per 40 CFR § 264.113 is approved.

If closure will exceed 180 days, NASA will submit a petition at least 30 days prior to the deadline of the closure period. A petition will be submitted if and only if any one of the following conditions is met:

1. Closure activities require longer than 180 days.

2. There is reasonable likelihood that another owner/operator will recommence operation of the unit within one year.

3. Closure would be incompatible with continued operations

Within 90 days after receiving the final volume of hazardous or non-hazardous wastes, NASA will remove from the unit or facility, or dispose of all hazardous wastes off-site, in accordance with this closure plan. Hazardous wastes generated during closure will only be accumulated for less than 90 days.

Within 60 days following the 180 day closure period, NASA will submit the closure certifications. The complete closure schedule is found in Appendix C.

18. CLOSURE PLAN AMENDMENT, CONTINGENT CLOSURE, AND POSTCLOSURE PLANS

18.1. Closure Plan Amendment

Amendment of the closure plan will be in accordance with the requirements of the regulations under 40 CFR § 264 Subpart H, 40 CFR § 264.112. These regulations specify the following requirements:

1. The written notification or request to the Director, DEQ, must include a copy of the amended closure plan for review and approval.

2. A written notification or a modification request to the Director, DEQ, must be submitted to authorize a change in the approved closure plan whenever the following occurs:

   a. Changes in operating plans or facility design that affect the closure plan.

   b. There is a change in the expected year of closure.

   c. In conducting partial or final closure activities, unexpected events require a modification of the approved closure plan.

3. The owner or operator must submit a written request for a permit modification including a copy of the amended closure plan for approval at least 60 days prior to the proposed change in facility design or operation, or no later than 30 days after an unexpected event has occurred which has affected the closure plan.

   a. If an unexpected event occurs during the partial or final closure period, the owner or operator must request a modification no later than 30 days after the unexpected event.

   b. The Director will approve, disapprove, or modify the amended plan in accordance with the procedures in parts 124 and 270.

4. In accordance with the authority under 40 CFR § 264.112(c)(4), the Director may request modifications to the closure plan under the conditions described in § 264.112(c)(2).

If amendment of the closure plan is required to close a HWMU with hazardous wastes closed in-place," NASA is required to close the HWMU in accordance with the closure requirements of a landfill. In these circumstances, the closure plan will need to be modified or amended to reflect the closure requirements of a landfill and post-closure plan must be developed to comply with the post-closure care requirements specified under § 264.310. Sections 264.310 and § state," after final closure, the owner or operator must comply with all post-closure requirements contained in §§264.117 through 264.120 including maintenance and monitoring throughout the post-closure care period. "

18.2. Post-closure Plan

NASA will make all attempts to close the OB Area in a condition of acceptable environmental standards and in accordance with the VHWMR. Once a determination is made that the site cannot clean close soils and/or unsaturated soils (i.e., groundwater) per this closure plan and the applicable requirements of the groundwater monitoring plan, NASA will submit a contingent closure plan and a contingent post-closure plan to DEQ within 60 days. If the site cannot demonstrate clean closure, the site will be closed under a contingent closure plan. Under this plan, the site will be closed as a landfill with the waste remaining in place and a cap installed to inhibit contaminant migration. Post-closure monitoring will be in accordance with the contingent post-closure plan. This program will continue for 30 years unless otherwise noted by the Director. In the event that clean closure is unattainable, a revised closure plan will be required to address the appropriate closure and post-closure requirements based on the conditions determined at the time of closure.

19. CERTIFICATION OF CLOSURE BY OWNER/OPERATOR and Professional Engineer (P. E.)

Closure certification and the closure report will be in accordance with the following certification requirements, which are delineated in the VHWMR and RCRA:

1. The owner/operator and an independent professional engineer, registered in the Commonwealth of Virginia, will both certify that the HWM facility (or HWMU subject to closure) has been closed in accordance with the specifications in the approved closure plan. The certification statements will be in accordance with 40 CFR § 264.115 and §270.11 and 9 VAC 20-60.14. B.4 of the VHWMR. The certifications will be by an authorized person described in 40 CFR §270.11(a) 030.A or by a duly authorized representative of that person as delineated in 40 CFR §270.11(b).

2. The certification of closure by the owner/operator and the professional engineer will be in accordance with the requirements of the VHWMR, under 40 CFR §270.11(d) and will be signed, dated, include the title of the person certifying the closure, and include the certification text that is specified within the regulations as follows:
3.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and

belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

2. The certification of closure will be submitted by registered mail to DEQ within 60 days of completion of closure (within 240 days after initiation of closure) within the Closure Report.

Prior to signing the closure certification statement, the engineer will review all procedures, systems, analytical data, laboratory reports, QA/QC Plan, QA/QC procedures, QA/QC data, calculations, statistical analyses, and risk-based assessment evaluations, criteria, and conclusions. The engineer's review will also include a determination that appropriate closure plan procedures, systems, including QA/QC procedures, have been followed and observed in the closure activities at the site and by the contracted laboratory, and that the appropriate equations have been correctly applied and calculated as specified in the closure plan and appropriate guidance documents of the EPA and DEQ. In addition, prior to certification of closure, the engineer's review will verify demonstration that the data verifies that the decontamination standards of the closure plan have been achieved, and that the facility has been closed in accordance with the closure performance standards of the approved closure plan.

20. CLOSURE REPORT

In support of the closure activities, a closure report will be submitted with the certifications. This closure report will contain all pertinent descriptions and documentation demonstrating that the closure has been performed in accordance with this plan. The report shall contain, at a minimum, the following information:

1. Certifications of Closure Statements of the owner/operator and the Professional Engineer (P. E.)

2. A summary of closure procedures and activities completed during decontamination and closure of each HWMU. The summary should include sufficient summary and detailed information from the approved closure plan. The closure report should refer the reader to the approved closure plan, when needed.

3. Documentation of HWMUs waste inventories have been removed and disposed to a regulated treatment storage or disposal (TSD) facility. Copies of manifest records shipment to a regulated TSD needs to be provided in an appendix.

4. Documentation of management and characterization of all wastes generated during closure activities in accordance with closure plan and the regulations. Copies of manifest records of the disposal of all closure generated wastes to a regulated TSD, solid waste disposal facility, or facility regulated under the clean water act, as appropriate.

5. Documentation of the sampling locations in the text and figures that correspond with the sample identities and information provided in the text, tables, and laboratory reports.

6. Documentation of the vertical and horizontal extent of excavation in both the narrative text and in figures, if applicable. The depth to clean soil samples, etc., will be demonstrated.

7. Documentation of all sampling analytical tests data, QA/QC plan, QA/QC procedures, and the QA/QC data.

8. Summary tables of all sampling data results to support the closure findings and conclusions.

9. A discussion and summary of QA/QC procedures, data results, implications, findings, and conclusions.

10. All statistical analyses and calculations supporting the closure conclusions.

11. All risk-based assessment calculations, summary tables, and evaluations, findings, and conclusions. Supporting risk-based information and calculations should be provided in the Appendices.

12. Appendices that include all: sampling and chain-of-custody documentation, laboratory data sheets and certifications for all compliance, background, and QA/QC samples.

13. For a facility subject to closure under the industrial/occupational scenario, or a facility which achieves closure in-place, a signed Notice of Use Limitation should also be included in the closure report.

APPENDIX A: FIGURES

Refer to OB Permit Attachment II.A Facility Description and Attachment II.H Plans and Specifications for Open Burn Units

APPENDIX B: MATERIAL SAFETY DATA SHEETS

Refer to OB Permit Exhibit II.B-1 OB Area Waste Analysis Plan

APPENDIX C: CLOSURE TIMELINE

CLOSURE TIMELINE

Activity	Days After Approval
Decision to close OB Area 1. Notify DEQ 45 days prior to commencement date 2. Advertise/award closure contract. 3. Preparation of health and safety plan for site closure.	0-30 days
Mobilization and Construction of Decontamination Area	30-45 Days
Subunits 1, 2, 3, 4, Sub unit Covers, and Burn Pad Cover Closure Process 1. Excavation and removal of cylinders. 2. High pressure steam cleaning (decontamination) of interior and exterior surfaces. 3. Collect and dispose waste residues and concrete. 4. Wipe sampling of surfaces. 5. Collection of containment area decontamination water samples. 6. Soil sampling beneath subunits 1,2,3, 4 7. Soil, wipe sampling and decontamination sampling analytical results received.	45-60 Days
Burn Pad Assembly Closure Process 1. High pressure steam cleaning (decontamination) of concrete exterior surface. 2. High pressure steam cleaning of the burn pan and cover. 3. Demolition and removal of concrete pad. 4. Collect and dispose waste residues and concrete. 5. Disposal of burn pans 6. Wipe sampling of surfaces. 7. Collection of containment area decontamination water samples. 8. Soil sampling beneath concrete burn pad assembly. 9. Analytical results received.	60-75 Days
Background Soil Sampling 1. Plan preparation and submission to DEQ for approval. 2. Background sampling and analysis 3. Analytical results received. 4. Statistical/risk review of analytical results from Subunits, Burn Pad Assembly and background soil sampling.	75-80 Days 80-90 Days
Contaminated Soils Excavation, Removal And Disposal, If Required	90-120 Days
1. Groundwater Sampling For Site Closure 2. Groundwater monitoring well sampling and analysis.	120-130 Days

3. Analytical results received. 4. Statistical/risk review of analytical results.	
Closure Report Prepared and Submitted with Certifications	130-180 Days

APPENDIX D: RISK-BASED CLOSURE

RISK-BASED CLOSURE

1.0. Introduction

This document discusses the protocol for conducting a risk assessment to implement closure of a hazardous waste management unit (HWMU) in accordance with the VHWMR and RCRA.

2.0. Risk-Based Evaluation

In order to estimate the risk for hazardous constituents of concern (HCOC) associated with the materials remaining in a HWMU, a risk assessment will be conducted according to the Virginia Unified Risk Assessment Model (VURAM) and VURAM User's Guide (2016), and the approved closure plan. The risk assessment report will contain the following sections:

- Site evaluation;
- Development of a site conceptual model;
- Identification of contaminants of concern;
- Identification of media and exposure pathways;
- Toxicity assessment;
- Estimation of contaminant concentration at the point of exposure; and
- Summary of health risk.

The submission instructions contained in Appendix IX of the Virginia Risk Guidance will be reviewed prior to submitting the report to confirm that all necessary risk issues have been addressed. The risk goals associated with the closure performance standards (risk goals) will include:

i. A total cumulative hazard index of 1.0 or less for non-carcinogens;

ii. A risk of 1E-06 or less for individual carcinogens;

iii. A total cumulative risk of 1E-04 or less for all carcinogens; and

iv. The concentrations of HCOC remaining in the HWMU will not result in contamination of other environmental media of concern, including the groundwater beneath the unit.

Compliance with the closure standard shall be verified by comparing the calculated individual and cumulative risk/hazard for all HCOC that failed the background statistical comparison (if such comparison is preformed) to the risk goals.

The risk assessment will be conducted assuming a future residential/industrial use of the property. The methodology and equations for estimating the exposure concentrations are presented in subsequent sections.

The initial step in the risk assessment will be to develop a Site Conceptual Exposure Model (SCEM), which depicts all potential exposure routes and media for the site and the receptors which may be exposed. Then HCOC for the risk assessment are identified.

In the next step, the exposure assumptions outlined in the Virginia Risk Guidance will be employed to estimate the risk. Information will also be taken as needed from U.S. EPA documents and databases (e.g., the Risk Assessment Guidance for Superfund (RAGS), and the Integrated Risk Information System (IRIS). The chemical intake equations and exposure parameter assumptions used to estimate risk (obtained from the Virginia Risk Guidance) are shown in Tables 1 through 4. Additional details on the approach and assumptions used for each potential exposure pathway are provided below.

As a part of the VURAM evaluation, fate and transport modeling is conducted to demonstrate that the residual concentrations of contaminants of concern would not result in contamination of other environmental media of concern including the groundwater underneath the closure unit. For this purpose, representative soil sample(s) will be collected around the unit (subjected to closure) for analysis. In certain situations, groundwater sampling is preferable.

3.0. Identification of Hazardous Constituents of Concern for Risk Assessment

For the purpose of VURAM evaluation associated with a HWMU, HCOC are those closure constituents present at concentrations statistically exceeding the background levels. If the concentrations of a closure constituent did not statistically exceed the background levels, no further risk-based evaluation for such constituent is required.

4.0. Exposure Assessment

The exposure assessment will identify transport mechanisms for the contaminants of concern that may potentially impact human receptors. The results of this assessment will be used to document the current and potential exposure posed by the HWMU.

With regard to the soil, a residential exposure will be assumed to document unrestricted closure of the soil. If the risk for potential residential exposure does not exceed the performance standards, unrestricted closure of soil will be accepted. If the

site cannot be clean closed for residential use, then the option to pursue restricted closure (commercial/ industrial) will be exercised.

Closure to the commercial/industrial scenario will require the facility to enact institutional controls and deed restrictions that eliminate the possibility of future residential use of the site. The requirements for establishing such a deed restriction are detailed in DEQ's *Guidelines for Developing Health-Based Cleanup Goals Using Risk Assessment at A Hazardous Waste Site Facility for Restricted Industrial Use*, dated June 1995.

Exposure routes will include ingestion, dermal absorption, and inhalation of vapors and dust particles.

With regard to impact to the groundwater beneath the HWMU, VURAM will be required to assess impact from residual soil contamination to the groundwater. If the groundwater does not qualify for clean closure, the scope of future groundwater monitoring will be discussed with DEQ. The groundwater exposure routes to be evaluated include ingestion, dermal absorption, and inhalation of volatiles emitted from the contaminated groundwater.

The exposure assumptions presented in the following sections are based on residential exposure. These constitute a reasonable maximum exposure scenario (RME), an exposure which is unlikely to occur but is reasonable.

4.1. Ingestion of Soil

The equation for potential chemical intake by soil ingestion onsite is included in Table 1. This scenario also assumes that weather or other conditions (e.g., frozen ground/snow/other cover) do not affect exposure and that all soil ingested is from contaminated areas of the site. These assumptions are protective of human health and the environment.

4.2. Dermal Contact with Soil

The equation for calculating the potential absorbed chemical dose by dermal contact with contaminated soil is provided in Table l. This scenario assumes that weather or other conditions (e.g., frozen ground/ snow or other cover) do not affect exposure, that contaminated soil remains on the skin long enough for the HCOC to be absorbed and that all soil adhering to the skin is from contaminated areas of the site.

The skin surface areas (SA) used in the dermal pathway have been identified in Virginia Risk Guidance as 4,860 cm2 for adults which is the 50th percentile value for the arms, hands, and lower legs (U.S. EPA, 1989b - See Attachment A). A skin-soil adherence factor of 1.45 mg/cm2 will be used in the dermal intake calculations. The U.S. EPA guidance for dermal exposure assessment [Dermal Exposure Assessment:

Principles and Applications, EPA/600/8-91/O11 B) states that a range of values from 0.1mg/cm2 to 1.5 mg/cm2 per event appear possible for dermal adherence factors (AF). In order to estimate the amount of a particular HCOC, which may potentially be absorbed through the skin, chemical-specific dermal absorption factors are used.

4.3. Inhalation Of Resuspended Soil

The equation for potential chemical intake by inhalation of resuspended contaminated soil is included in Table 1. An inhalation rate of 0.83 m3/hr will be used as specified in the Virginia Risk Guidance. This scenario assumes that the concentration of HCOC in indoor dust will be equal to that in outdoor soil and that weather or other conditions, (e.g., frozen ground/snow or other cover) do not affect resuspension or exposure. However, an appropriate model or equations in Table 1 will be used to estimate the potential amount of respirable particulate matter generated by wind erosion. The estimated generation rate for eroded particulate matter will then be used to derive an ambient air particulate concentration. Justification for and documentation of the model(s) used will be submitted to DEQ as part of the risk assessment.

4.4. Inhalation of Volatilized HCOC in Soil

Since the HCOC have appreciable vapor pressures they are expected to volatilize from soil. Inhalation of HCOC as volatilized vapors is considered for this risk assessment. The equations in Table 1 will be considered for estimating the intake for this condition.

5.0. Toxicity Assessment

The two principle indices of toxicity used in risk assessment are the Reference Dose (RfD) and the cancer Slope Factor (SF). A RfD is the intake or dose per unit of body weight (mg/kg-day) that is unlikely to result in toxic (non-carcinogenic) effects to human populations, including sensitive subgroups (e.g., the very young or elderly). The RfD allows for the existence of a threshold dose below which no adverse effects occur.

The SF is used to express the cancer risk attributable to a discrete unit of intake; that is, the cancer risk per milligram ingested per kilogram of body weight per day [(mg/kg-day]. The SF is an estimate of the upper-bound probability of an individual: developing cancer as a result of exposure to a particular-carcinogen. Unlike the RfD, the SF assumes that there is no threshold dose below which the probability of developing cancer is zero. Note that SFs are only developed for those chemicals, which have been shown to be carcinogens in man or in at least several animal species. A carcinogenic weight of evidence rating is used to describe the strength of the experimental evidence for carcinogenicity. The U.S. EPA has developed SFs for

most chemicals with weight of evidence ratings of "A" (known human carcinogen) or "B" (probable human carcinogen).

RfDs and SFs are derived by the U.S. EPA for the most toxic chemicals generally associated with chemical releases to the environment for which adequate toxicological data are available. If both the carcinogenic and non-carcinogenic effects of a particular compound are significant, both values may be established. However, in most cases only one value is available.

5.1. Inhalation and Oral RfDs and SFs

RfDs and SFs pertinent to the oral and inhalation exposure pathways will be obtained from IRIS database. The IRIS on-line database was established by the EPA to provide risk assessors with peer reviewed toxicological data on chemicals commonly encountered at environmental sites of contamination. If data is not available from IRIS, it will be obtained from the Health Effects Assessment Summary Tables (HEAST), a compilation of toxicity values produced by the EPA on a quarterly basis. The hierarchy presented in Appendix III of the Virginia Risk Guidance will be followed for using these sources.

5.2. Dermal RfDs and SFs

Chemical Specific Oral route Absorption Values (ABSoral) are used to adjust the oral RfD or SF, which is computed from an administered dose, for use in the dermal exposure pathway. This correction is necessary due to the differences in absorption between the skin and the gastrointestinal tract. By correcting the administered dose oral RfD or SF for the fraction expected to be absorbed in the gut, a dermal absorption factor can be used to estimate-the correct dose received through the skin.

6.0. Evaluation of Risk

Using the toxicity criteria and identified exposure pathways discussed above, and the procedures described in the Virginia Risk Guidance, the risk presented by the HCOC will be estimated. The estimated risk will consider the effects from multiple constituents and all routes of exposure. The risk goals will be a total cumulative hazard index of 1.0 for multiple carcinogens and a total cumulative carcinogenic risk of 1E-04 for multiple carcinogens. However, the risk from each individual carcinogen shall not exceed 1E-06 (i.e., one case of cancer per 1,000,000 population).

6.1. Estimation of Exposure Concentration

For the contaminants detected at the site, an exposure point concentration (EPC) for each exposure pathway will be calculated for each contaminant by estimating the 95th upper confidence limit (UCL) on the arithmetic mean of the concentrations. If the calculated 95th UCL is greater than the maximum detected concentration, then the

maximum detected concentration will be used as the EPC. The risk for contaminants will be calculated as per the equations and assumptions described in Tables 1 through 4. If for a contaminant both carcinogenic and non-carcinogenic risk-based cleanup goal exists, the lower of the two will be used as a pathway specific to estimate the risk.

6.2. Risk Estimation

Health risk assessments are based on the relationship involving intake, contaminant concentration, risk, and toxicity. Chronic daily intake (CDI), a product of intake and contaminant concentration, are estimated using the exposure equations and assumptions associated with each route of exposure. CDIs are then combined with the RfDs or SFs to determine the resulting risk. For carcinogen(s), cumulative potential risk (RISKc) will be calculated as follows:

$$RISKc = CDI_{ingestion} * SF_{ingestion} + CDI_{dermal} * SF_{dermal} + CDI_{inhalation\text{-}VOCs} * SF_{inhalation\text{-}VOCs} + CDI_{inhalation\ particles} * SF_{inhalation\text{-}particles}$$

For noncarcinogen(s), cumulative hazard index (HIc) will be calculated as follows:

$$Hic = CDI_{indigestion} / RfD_{ingestion} + CDI_{dermal} / RfD_{dermal} + CDI_{inhalation\text{-}VOCs} / RfD_{inhalation\text{-}VOCs} + CDI_{inhalation\text{-}particles} / RfD_{inhalation\text{-}particles}$$

Where, taking into account all HCOC and relevant exposure pathways, the excess cancer risk is 10-6 or the hazard index is 1.0.

Table 1 - Risk Assessment Algorithm for Carcinogenic Exposure

Exposure Route	Chronic Daily Intake (CDI), mg/L-dav	
	Residential Exposure	Occupational/Industrial Exposure
	CW x IRWadj x EF / *ATc*	*CW x IRWa x EFo x EDo* / *BWa x ATc*
	CW x IRAadj x EF x K / *ATc*	*CW x IRAa x EFo x EDo x K* / *BWa x ATc*
	CW x SAWadj x PC x ET x EF x EDc x CF / *ATc*	*CW x SAWa x PC x ET x EFo x EDo x CF* / *BWa x ATc*
	CS x IRSadj x CF x FI x EF / *ATc*	*CS x IRSa x CF x FI x EFo x EDo* / *BWa x ATc*
	CS x CF x SASadj x AF x ABS x EF / *ATc*	*CS x CF x SASa x AF x ABS x EFo x EDo* / *BWa x ATc*
	CS x VF x IRAadj x ET x EF / *ATc*	*CS x VF x IRAa x ET x EFo x EDo* / *Bwa x ATc*
	CS x PEF x IRAadj x ET x EF / *ATc*	*CS x PEF x IRAa x ET x EFo x EDo* / *BWa x ATc*

Table 2 - Risk Assessment Algorithm for Noncarcinogenic Exposure

Exposure Route	Chronic Daily Intake (CDI), mg/L-dav	
	Residential Exposure	Occupational/Industrial Exposure
	CW x IRWc x EF x EDc / *BWc x ATn*	*CW x IRWa x EFo x EDo* / *BWa x ATn*
	CW x •IRAn x EF x EDc x K / *BWc x ATn*	*CW x IRAa x EFo x EDo x K* / *BWa x ATn*
	CW x SAWn x PC x ET x EF x EDc x CF / *BWc x ATn*	*CW x SAWa x PC x ET x EFo x EDo x CF* / *BWa x ATn*
	CS x IRSc x CF x FI x EF x EDc / *BWn x ATn*	*CS x IRSa x CF x FI x EFo x EDo* / *BWa x ATn*
	CS x CF x SAc x AF x ABS x EF x EDc / *BWc x ATn*	*CS x CF x SA x AF x ABS x EFo x EDo* / *BWa x ATn*
	CS x VF x IRAc x ET x EF x EDc / *BWc x ATn*	*CS x VF x IRAa x ET x EFo x EDo* / *Bwa x ATn*
	CS x PEF x IRAc x ET x EF x EDc / *BWc x Atn*	*CS x PEF x IRAa x ET x EFo x EDo* / *BWa x ATn*

A carcinogenic risk assessment is based on adult exposure.

Table 3 - Age Adjusted Factors

$$IRA_{adj} = \frac{EDc \times IRAc}{Bwc} + \frac{(EDtot - EDc) \times IRAa}{BWa}$$

$$IRW_{adj} = \frac{EDc \times IRWc}{Bwc} + \frac{(EDtot - EDc) \times IRWa}{BWa}$$

$$SAWadj = \frac{EDc \times SAWc}{Bwc} + \frac{(EDtot - EDc) \times SAWa}{BWa}$$

$$IRSadj = \frac{EDc \times IRSc}{Bwc} + \frac{(EDtot - EDc) \times IRSa}{BWa}$$

$$SASadj = \frac{EDc \times SAc}{Bwc} + \frac{(EDtot - EDc) \times SAa}{BWa}$$

Note regarding age adjusted factor:
Because the contact rate with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risk during the first 30 years of life were calculated using the age adjusted factor. These factors approximate the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations or two age groups – small children and adults.

Table 4 - Exposure Variables Included in Tables 1, 2, and 3

Symbol	Term	Unit	Value	Reference
ABS	Absorption factor	-	User specified	
AF	Adherence factor	-	1.45	a, c
ATc	Averaging time carcinogens	days	25550	
ATn	Averaging time non-carcinogens	days	ED x 365	
BWa	Body weight	kg	70	c
BWc	Body weight child	kg	15	c
CF	Conversion factor	-	0.000001	-
CS	Chemical concentration in	mg/Kg-day	User specified	
CW	Chemical concentration in water	mg/L	User specified	
EDc	Exposure duration child	years	6	c
EDtotal ED	Exposure duration for carcinogen total or Residential	years	30	c
EDo	Exposure duration occupational	years	25	c
EF	Exposure frequency	days	350	c

ET	Exposure Time General/Occupational Groundwater Surface Water - ingestion Surface water – dermal Air-inhalation	hrs/day	8.0 0.2 2.6 2.6 24.0	c,d
FI	Fraction ingested Residential Occupational	-	 1.0 0.5	b
IRAa	Inhalation rate	m3/day	12	b
IRAadj	Inhalation rate – air adjusted	-	11.66	
IRAc	Inhalation rate	m3/day	12	b
IRAa	Inhalation rate adult	m3/day	20	b
IR	Ingestion rate food Fruit/veggies Fish	kg/day	0.28 0.122 0.054	c, d
IRSa	Ingestion rate soil adult	mg/day	100	b
IRSc	Ingestion rate soil child	mg/day	200	B
IRSadj	Ingestion - soil adjusted	-	114.29	b
IRWa	Ingestion rate water adult	L/day	2	b
IRWadj	Ingestion -water adjusted	L-y/kg-d	1.09	
IRWc	Ingestion rate water child	L/day	1	b

K	Volatilization factor, water to air	-	0.5	
PC	Permeability constant	cm/hr	User specified	b
PEP	Particulate emission factor	kg/m3	6.789926E08	f
SAWc	Surface area child groundwater dermal surface water dermal	cm2	7500	b,e
SASa SASc	Surface area soil occupational - adult child	cm2 /event	4500 1875	e
SASadj	Surface area soil ajusted,	cm2 /event	2290	
SAWa	Surface area for water contact adult	cm2	820	b
SAWadj	Surface area for water contact	cm2/event	9200	
VF	Volatilization factor, Soil to air	kg/m3	User specified	-

References:

a. Risk Assessment Guidance for Superfund, Volume I, EPA/540/1-89/002, December 1989.

b. Region III values.

c. Exposure Factors Handbook, EPA/600/8-89/043, July 1989.

d. Human health evaluation manual supplemental guidance, OSWER Directive 9285.6-03. March 25, 1991.

e. Dermal Exposure Assessment, Principles and Applications, Interim Report. EPA/600/8-91/011b. January 1992.

f. Technical Background Document for Draft Soil Screening Level Guidance. Office of Solid Waste and Emergency Response. EPA/540/R-94/101. December 1999

ATTACHMENT II.H

PLANS AND SPECIFICATIONS FOR OPEN BURN UNITS

ATTACHMENT II.H -PLANS AND SPECIFICATIONS FOR OPEN BURN UNITS

II.H.1. Physical Characteristics, Materials of Construction, and Dimensions

II.H.1.1. General

Open burning of rocket motor propellants and igniters is performed at the southwestern corner of Wallops Island. The area is located on the shoulder of a 3.7 meters (12 foot) wide asphalt access road. Four subunits and one open burn pad assembly are used for open burning of the rocket motor propellants and igniters. The subunits and burn pad run roughly parallel to the roadway at a distance of 0.9 meters (3.0 feet) to 1.5 meters (5.0 feet) west of the road (Figure II.HH-1). Figure II.HH-2 is the Subunits 1, 2, and 3 assembly drawing. Figure II.HH-3 is the burn pad assembly drawing. Figures II.HH-4 and II.HH-5 detail the burn pad berm and cover, respectively. Figure II.HH-6 is the burn pans. Figure II.HH-7 is Subunit 4. Figure II.HH-8 is a photograph of the OB Area.

II.H.1.2. Subunits

The individual subunits are described as follows from north to south:

- The open burn pad assembly is a 4.6 meters (15 feet square) by 46 centimeters (18 inches) thick concrete pad with a 0.41 meter (16 inch) high berm and a steel plate in the center for motor head attachment. Four cable tie downs are used to stabilize the motor. Two 0.3 meter by 0.6 meter (12 inch by 24 inch) carbon steel burn pans are used for burning propellant trimmings or residue on the burn pad. The 4.6 meters (15 feet square) pad cover is attached to the berm with tie down straps and screw anchors. Lift eye bolts are attached to the roof and are used to remove the roof for OB operations.

- Subunit No. 1 and 3 are vertical steel cylinders made from Taurus rocket casings with an outside diameter (OD) of 56 centimeters (23 inches). The subunit is 78 centimeters (31 inches) above and 229 centimeters (90.2 inches) below the ground surface. The total length of Subunit No. 1 is 307 centimeters (121.2 inches). (Subunit 3 is scheduled to be removed and undergo “closure” in 2012.)

- Subunit No. 2 is a vertical steel cylinder made from a Nike rocket casing with an outside diameter (OD) of 42 centimeters (16.5 inches). The subunit is 107 centimeters (42 inches) above and 191 centimeters (75.2 inches) below the ground surface. The total length of Subunit No. 2 is 323 centimeters (127.2 inches). The top surface of the concrete is reached at 282 centimeters (111 inches), yielding a calculated concrete thickness of 41.1 centimeters (16.2 inches).

- Subunit No. 4 is a vertical steel cylinder with an outside diameter (OD) of 76 centimeters (30 inches). The subunit is 107 centimeters (42 inches) above the ground surface and 311 centimeters (122.4 inches) below the ground surface. The total length of subunit No. 4 is 417.8 centimeters (164.5 inches).

II.H.1.3. Barricade

The designated OB Area is approximately 51 square meters (550 square feet). Sea grasses and bushy vegetation sparsely cover this area over coarse brown sand. A fiberglass barricade is located 381 meters (1250 feet) north of the burn pad. The barricade is 3 meters (10 feet) by 1.5 meters (5 feet) at the base and is 3 meters (10 feet) in height. The barricade is battered to the top with a final dimension of 3 meters (10 feet) by 0.6 meters (2 feet). The barricade is used to block the roadway prior to open burning and to act as a protective shield during treatment operations. The firing line is located behind the barricade. The firing line is connected to the igniter at the barricade prior to connection of the battery charge. All personnel and equipment will be behind the barricade during open burning. The barricade is portable and will be removed from the roadway after open burning activities are complete.

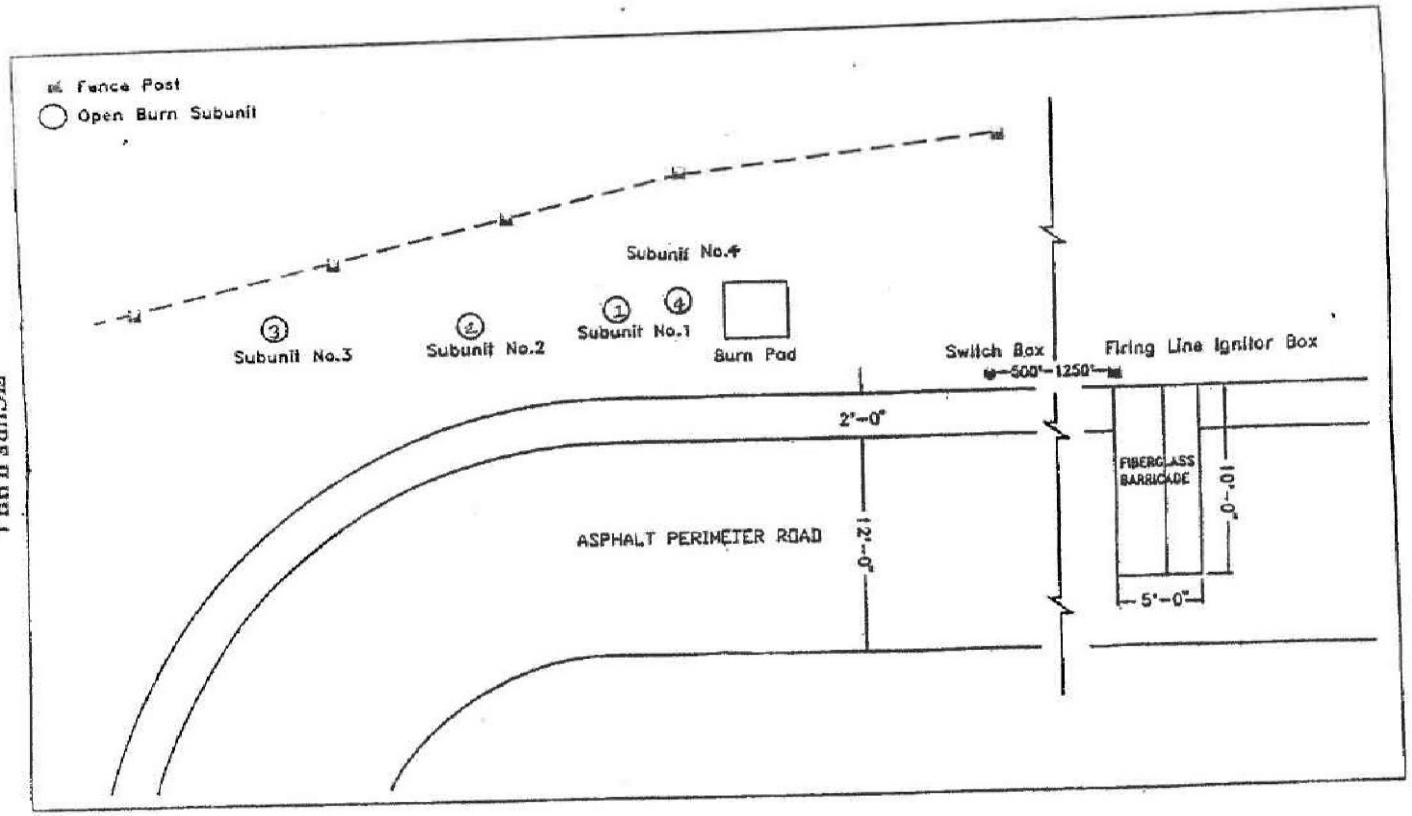


FIGURE II.H-1
OPEN BURN AREA LOCATION

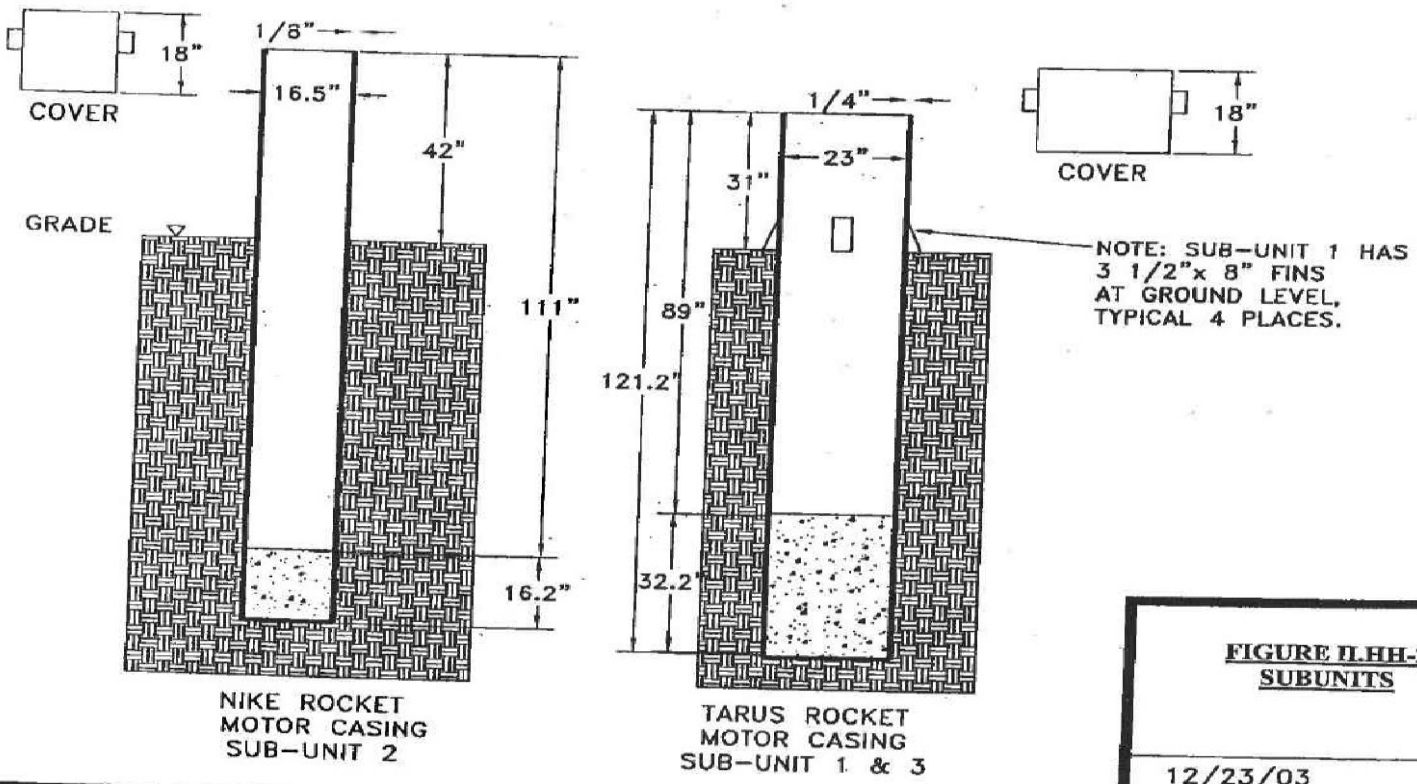
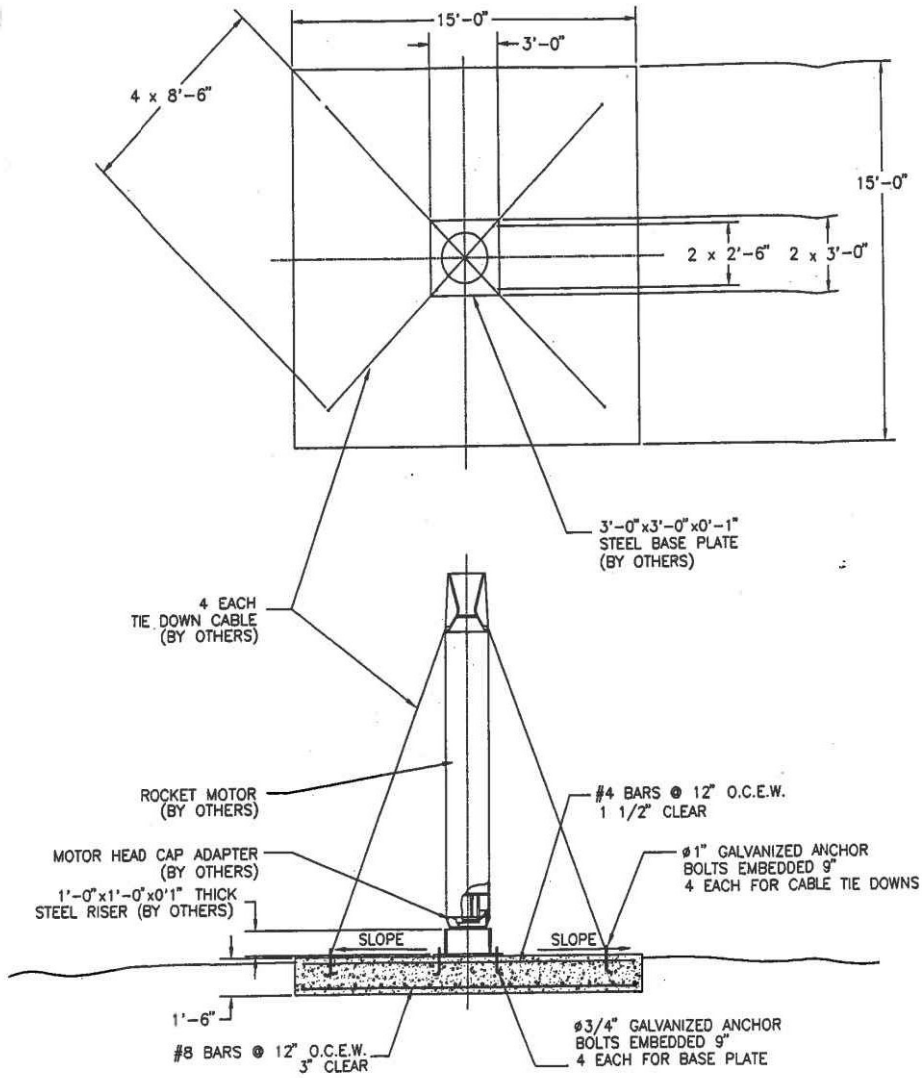


FIGURE II.HH-2
SUBUNITS

12/23/03

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. REMOVE BURRS AND BREAK SHARP EDGES .005 - .010 MAX.
2. INTERPRET DWG. PER ANSI Y 14.5 1988



STRUCTURAL DESIGN DATA

FOUNDATION DESIGN LOADS

ROCKET MOTOR WEIGHT	3937 LBS.
ACTUAL THRUST	112,000 LBS.
FACTOR OF SAFETY (FOUNDATION)	2

DESIGN LOADS APPLIED AT ORIGIN OF ADAPTOR ANCHOR BOLT CIRCLE
ANCHOR BOLTS, ADAPTOR, AND TIE-DOWN CABLES BY OTHERS

STRUCTURAL CONCRETE NOTES

1. ALL CAST-IN-PLACE CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4,000 PSI.
2. ALL CONCRETE SHALL HAVE AN APPROVED AIR-ENTRAINING ADMIXTURE.
3. ALL REINFORCING BARS SHALL BE NEW BILLET STEEL CONFORMING TO THE STANDARDS OF ASTM A615, GRADE 60.
4. ALL CONCTETE REINFORCEMENT SHALL BE DETAILED, FABRICATED, LABELED, SUPPORTED, AND SPACED IN FORMS AND SECURED IN PLACE IN ACCORDANCE WITH THE PROCEDURES AND REQUIREMENTS OUTLINED IN THE LATEST EDITION OF THE "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", ACI 318 AND THE "MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES", ACI 315.
5. MAXIMUM SLUMP SHALL BE 4". MINIMUM CEMENT CONTENT SHALL BE 6 SACKS.
6. MINIMUM CONCRETE COVER SHALL BE 3" FOR CONCRETE CAST AGAINST THE EARTH AND 1 1/2" FOR CONCRETE EXPOSED TO WEATHER.
7. MAXIMUM SIZE FOR COARSE AGGREGATE SHALL BE 3/4".
8. PROVIDE 1/16" PER 12" DRAINAGE SLOPE FROM CENTER OF PAD TO OUSIDE EDGI

FIGURE II.HH-3
BURN PAD

TEST_PAD	1/30	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION		DR.	CARL CU
				DES.	ROB MA
				CHK.	C. BARF
		OPEN BURN PAD ASSEMBLY			02715

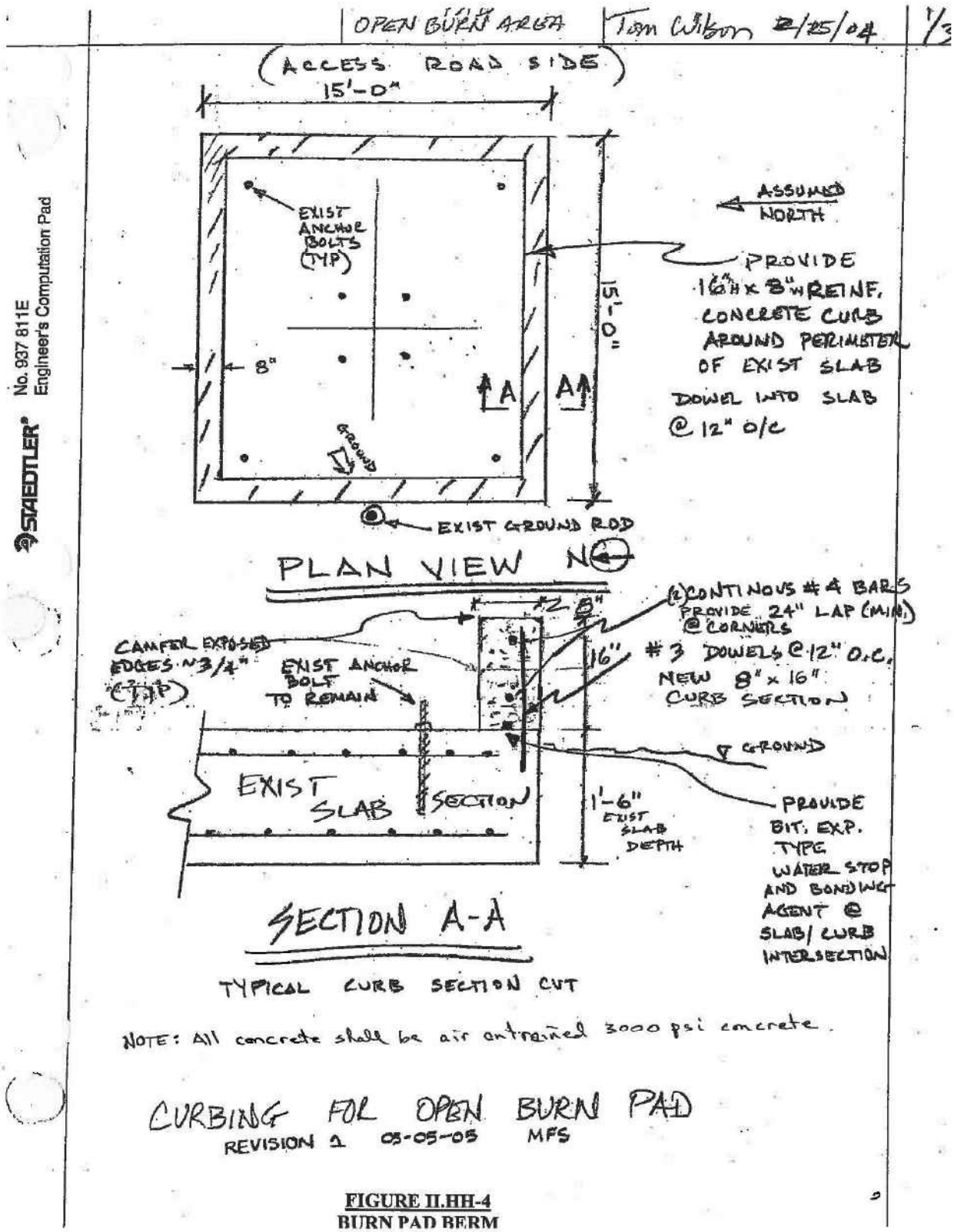
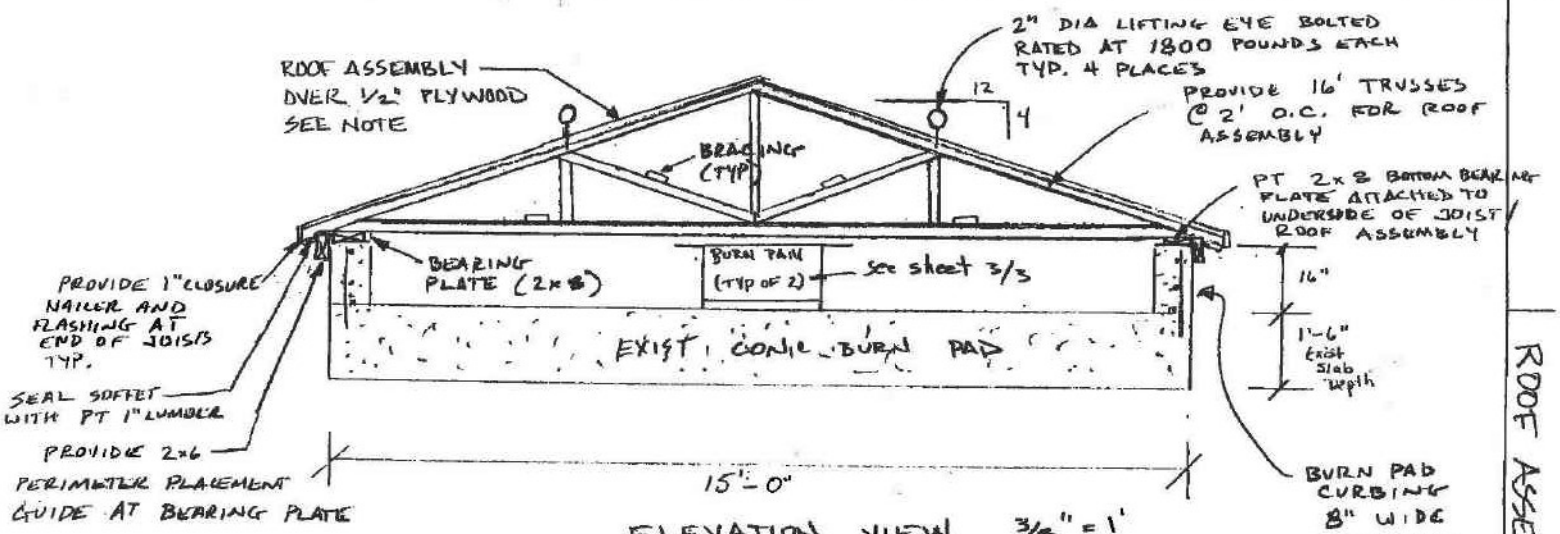


FIGURE II.HH-4
BURN PAD BERM

STAEDTLER® No. 937 811E Engineer's Computation Pad



ELEVATION VIEW 3/8" = 1'

NOTES:

1. TRUSSES AND ROOF SHALL BE RATED FOR 100 MPH WIND LOAD 35 PSF LIVE LOAD AND 20 PSF DEAD LOAD.
2. TRUSSES SHALL BE BRACED AND INSTALLED AS PER MANUFACTURERS PRINTED INSTRUCTIONS
3. ROOF ASSEMBLY SHALL INCLUDE 1/2" THICK PLYWOOD SHEATHING WITH 15# ROOFING FELT WITH 24 GAGE METAL PANEL ATTACHED TO SHEATHING. PROVIDE RIDGE CAP AND
4. STRUCTURE SHALL BE CONSTRUCTED AS PER BOCA BUILDING CODE 1986 ED.
5. PROVIDE TIE DOWN SYSTEM FOR REMOVABLE ROOF ASSEMBLY TIE DOWN STRAPS WITH SCREW ANCHORS (2 STRAPS / 4 ANCHORS AT A MINIMUM).
6. PROVIDE EXTRA BRACING TO STABLIZE ROOF ASSEMBLY AS REQUIRED FOR ROOF FRAME TO BE LIFTED ON AND OF BURN PAD CURBING

ROOF ASSEMBLY | TOM WILSON 2/25/14 | 2/

FIGURE II.HH-5
BURN PAD COVER

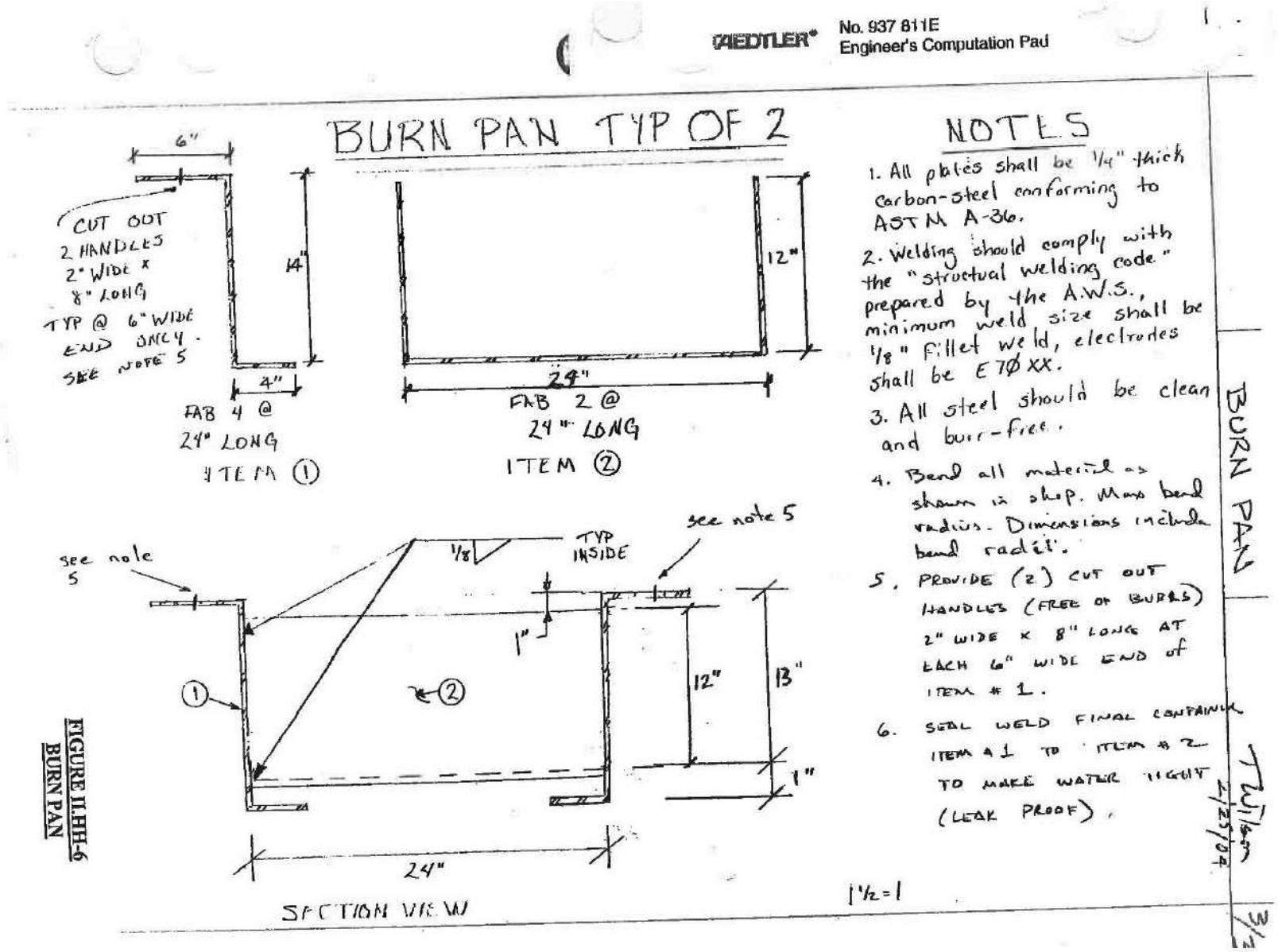
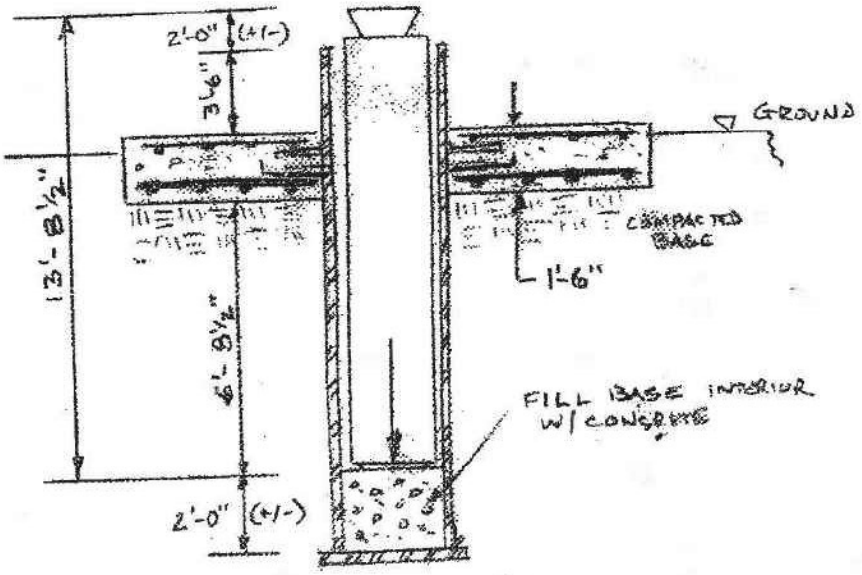


FIGURE II.HH-6
BURN PAN



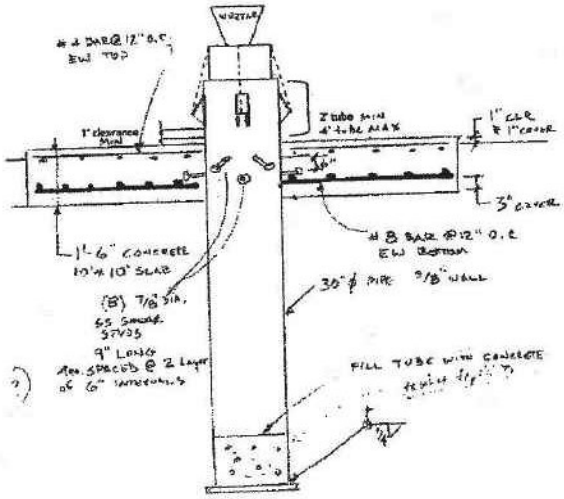


FIGURE II.HH-7

SUBUNIT 4

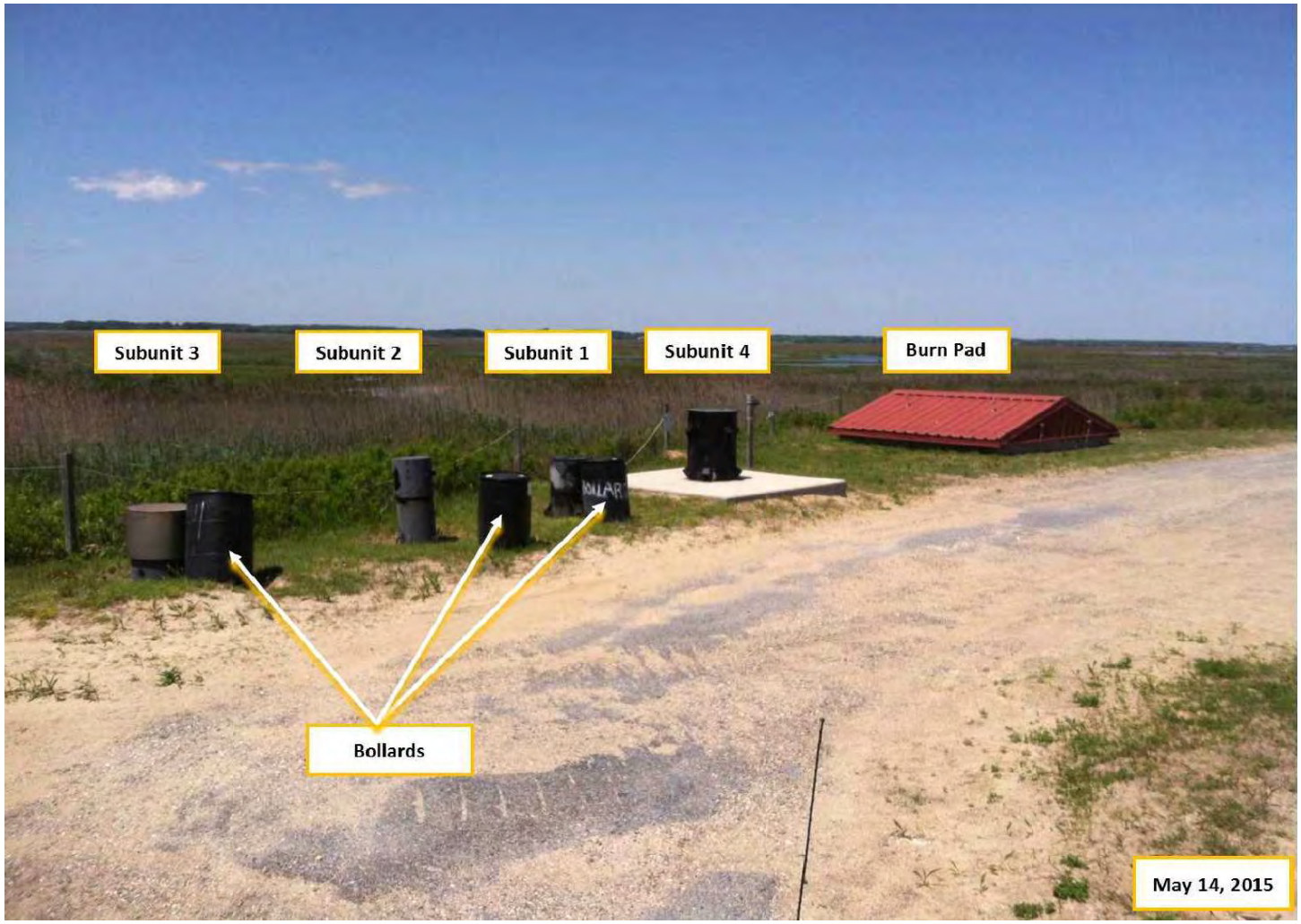


FIGURE II.HH-8

EXHIBIT II.H-1 - PLANS AND SPECIFICATIONS FOR OPEN BURN UNITS

Open Burn Subunit 4 Design Plans and Specifications
Submittals dated January 25, 2012, Revision 1, April 27, 2012, and May 2, 2012
Installation in 2012

National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

April 27, 2012

Reply to Attn of: 250.W

Ms. Leslie Romanchik
Director, Office of Hazardous Waste
Virginia Department of Environmental Quality
P.O. Box 10009
Richmond, VA 23240

Subject: VDEQ Electronic Communication (e-mail) from R. Criqui to M. Simko, dated 3/12/2012

Ref: Class 2 Permit Modification Request for NASA Goddard Space Flight Center's Wallops Flight Facility, Wallops Island, Virginia, Open Burning Area Permit VA7800020888

The Wallops Flight Facility is submitting the Open Burning Area VA7800020888 Subunit 4 Design, Revision 1, dated April 2012, as requested in the above referenced e-mail. In particular, the design was revised to incorporate the following items:

1. The required Certification Statement is signed, dated, and stamped by the P. E.

2. The design approach is included in Section 3.

    - Design calculations are included in Section 4. Specific requests such as f'c equals 4000 pounds per square inch and maximum soil pressure equals 2.0 kilopounds per square foot are discussed in the Construction Notes and Section 3, respectively.
    - Abbreviations are explained throughout the text and in Section 4.
    - All units of measure are included.
    - Soil preparation is described in Section 2 and the Construction Notes.
    - The use of the drilling log is explained in Section 3.
    - An elevation view and plan view of Subunit 4 is included in Section 4. Weld description and reinforcement requirements are discussed throughout the design.

If you have any questions or comments concerning this report, please contact Ms. Marianne Simko at (757) 824-2127.

Bonnie H. Crawford

Bonnie H. Crawford
Environmental Protection Specialist

Enclosure

cc: (w/o Enclosure)
200/Ms. C. Massey
250/Mr. E. Connell
250/Ms. C. Turner
840/Mr. S. Kremer
840/Mr. J. Valiant

OPEN BURNING AREA

VA7800020888

SUBUNIT 4 DESIGN

National Aeronautics and Space Administration

Goddard Space Flight Center

Wallops Flight Facility

Wallops Island, Virginia

REVISION 1

APRIL 2012

WFF OB Area Subunit 4 Design

ENGINEERING REVIEW

4/27/12
(Date)

Thomas F. Wilson
Senior Structural Engineer
NASA Wallops Flight Facility
Facilities Management Branch

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

COMMONWEALTH OF VIRGINIA
PAUL C. BULL
Lic. No. 032982
PROFESSIONAL ENGINEER

4·27·12
(Date)

Paul C. Bull, PE
Senior Civil Engineer
NASA Wallops Flight Facility
Facilities Management Branch

TABLE OF CONTENTS

SECTION		PAGE NUMBER
1.0	INTRODUCTION	1
2.0	DESCRIPTION OF SUBUNIT 4	1
3.0	BASIS OF DESIGN	2
4.0	DESIGN CALCULATIONS	3

ENCLOSURE A	Site Location Map
ENCLOSURE B	Pipe Data
ENCLOSURE C	Taurus Motor Data Sheet
ENCLOSURE D	Drilling Log and Boring Location Map

1. INTRODUCTION

Wallops Flight Facility (WFF) is located in Accomack County, Virginia, on the Atlantic Coast of the Delmarva Peninsula. It is located approximately 145 kilometers (90 miles) north of Norfolk, Virginia, and is comprised of three separate landmasses: Wallops Main Base, Wallops Mainland, and Wallops Island. The Open Burning (OB) Area is located on the south end of Wallops Island (Enclosure A).

NASA uses open burning as the preferred method of treatment for waste rocket motors and igniters. This method is considered the safest treatment of these materials. NASA has been using the OB area since 1972. In 1988, NASA submitted a RCRA Part B Permit Application and operated under interim status until the final Permit for Open Burning Treatment of Hazardous Waste was issued on September 20, 2005.

The Wallops Flight Facility (WFF) is requesting to modify the Open Burning Area. On January 25, 2012, NASA submitted to the Virginia Department of Environmetnal Quality a Class 2 permit modification request. The Class 2 permit modification would install a new subunit between the Burn Pad and Subunit 1. Subunit 3 would be removed, leaving the number of subunits unchanged at 3. The new subunit would be designated Subunit 4. The number of subunits would remain unchanged at 3. This modification will offer a preferred method of open burning for permitted motors up to 28 inches in diameter.

2. DESCRIPTION OF SUBUNIT 4

Subunit 4 will be similar to the existing subunits at the OB area. The design function of the subunit is to hold an inverted, nozzle up, rocket motor during the open burning of hazardous waste rocket motor propellant. Please refer to Open Burn Subunit 4 Elevation View, page 4.

The subunit will consist of an ASTM A252 Grade 2 30-inch outside diameter structural pipe (Enclosure B) with a 5/8 inch wall thickness. Please refer to Open Burn Subunit 4 Elevation View. The pipe is designed to contain the rocket motor and provide structural rigidity. Four hook hold down assemblies will be welded onto the structural pipe with ¼ inch continuous fillet welds as shown on the Hook Hold Down Assembly Detail, page 5. Each Hook Hold Down Assembly will be used to anchor the rocket motor to the structutal steel pipe to prevent lateral movement. Headed Concrete Anchors (HCA) or headed stainless steel shear studs will be welded to the structural pipe in an alternate fashion as shown in the Open Burn Subunit 4 Elevation view. The HCA will be used to connect the structural steel pipe to the concrete foundation.

The pipe will be embedded in the soil so that 3.5 feet remain above the surface. The soil shall be prepared as described in Construction Notes #6. The upper 5 feet of soil levels on Wallops Island is generally fine sand (sp) and has fairly good load bearing capacity at upper levels. The pipe will be centered in a 10-foot square concrete foundation. The foundation will be constructed with reinforcement as shown in Open Burn Subunit Elevation and as described in the Construction Notes. Additional reinforcement will be added as shown in the Open Burn Subunit 4 Plan View around the hole created by the structural pipe to reduce cracking and increase strength in this area. Please also refer to the additional notes inserted on the drilling log in Enclosure D. The concrete shall be cast-in-place in accordance with Construction Notes #1 and #2.

The base of the structural pipe will be capped with an A36 32-inch diameter 5/8 thick steel plate. The bottom of the structural pipe will be be filled with 2 feet of concrete to prevent the release of hazardous constituents within the subunit.

A cover assembly will be constructed to prevent the collection of stormwater within the subunit when not in use. The cover assembly will be constructed of galvanized sheet metal of 1/16 inch thickness, 2 handles and four fasteners. The fasteners will attach the handles to the cover so that the cover can easily be removed.

Figure 1 Cover Assembly

Anticorrosion and rust coating will be applied to cover assembly and the exterior of the structual pipe as described in Construction Notes #7 to protect the subunit from the corrosive coastal environment.

Additional construction notes can be found on page 6.

3. BASIS OF DESIGN

The design analysis will be checked against Taurus motor data sheet included in Enclosure C. The Taurus motor represents the maximum thrust which would be used in this subunit.

The design calculations begin on page 7 with a listing of data from Enclosure B Pipe Data, Enclosure C Taurus Motor Data Sheet, and Enclosure D Drilling Log. The location of Hole B-05 is shown on the map in Enclosure D. The boring was drilled in 2009 at a location several

yards south of the proposed Subunit 4. The topography and the soil structure of the area is expected to be identical. The maximum allowable soil bearing capacity is conservatively assumed to be 2000 psf and is consistent with the assumption used in the permit required calculations for Subunits 1 through 3, as well as all other spread footings located on Wallops Island.

The design calculations check resultant applied forces against allowable soil bearing capacity to ensure that the footing or foundation is adequately sized to support the downward motor thrust, the motor weight, and the pipe weight. The welds of the bottom steel plate to the structural pipe and the welds of the HCA to the structural pipe were checked against these same loads.

The footing was checked for 2-way or punching shear from localized forces and 1-way or bending shear. In both cases the design shear, ϕVc, was found to be less than the maximum shear, Vu. The bending reinforcement bar shear that could result from off center rocket motor thrust was also evaluated.

The structutal steel pipe was checked for tension force due to the thrust of the rocket motor straight downward and the shear force if the rocket shifts in the pipe creating an angular force. The bending force, Fb, which would be created if an explosion within the rocket motor caused a side blow-out was also checked.

The welds of these assemblies were checked for the resultant force, fr. Finally the number and diameter of the HCA were checked.

4. DESIGN CALCULATIONS AND CONSTRUCTION NOTES

Abbreviations and symbols are located on page 10.

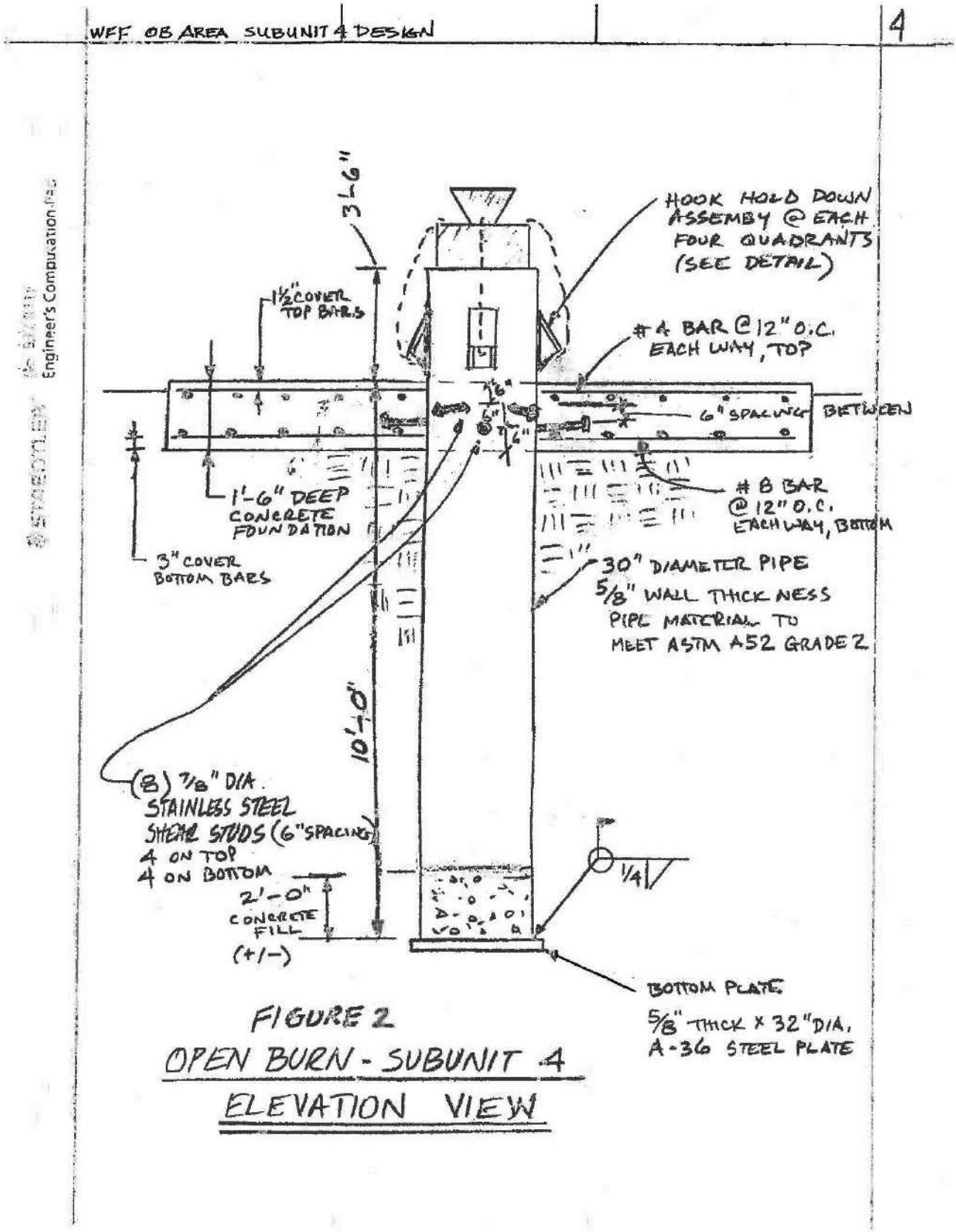


FIGURE 2
OPEN BURN - SUBUNIT 4
ELEVATION VIEW

WFF OB AREA SUBUNIT 4 DESIGN

5

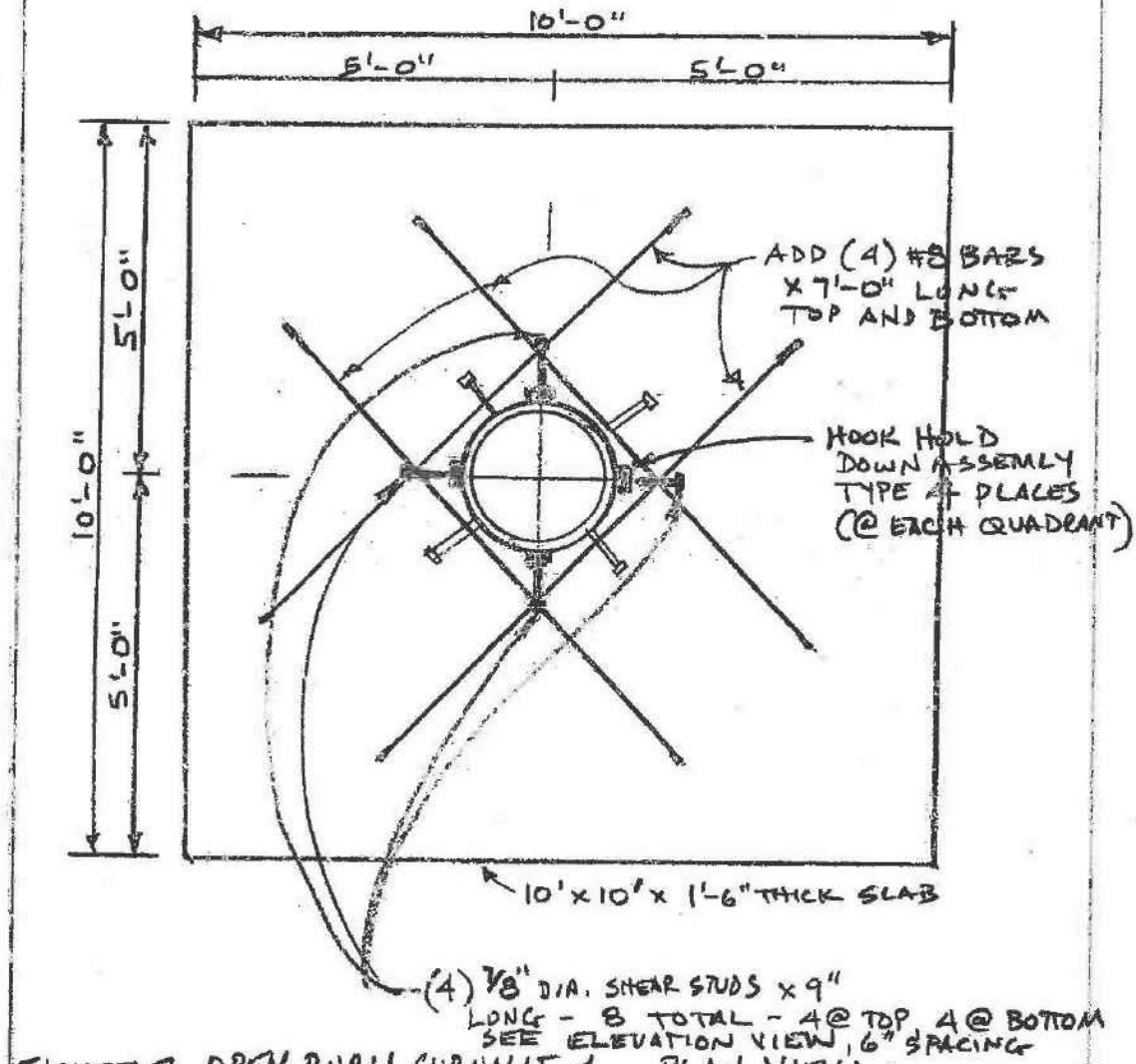
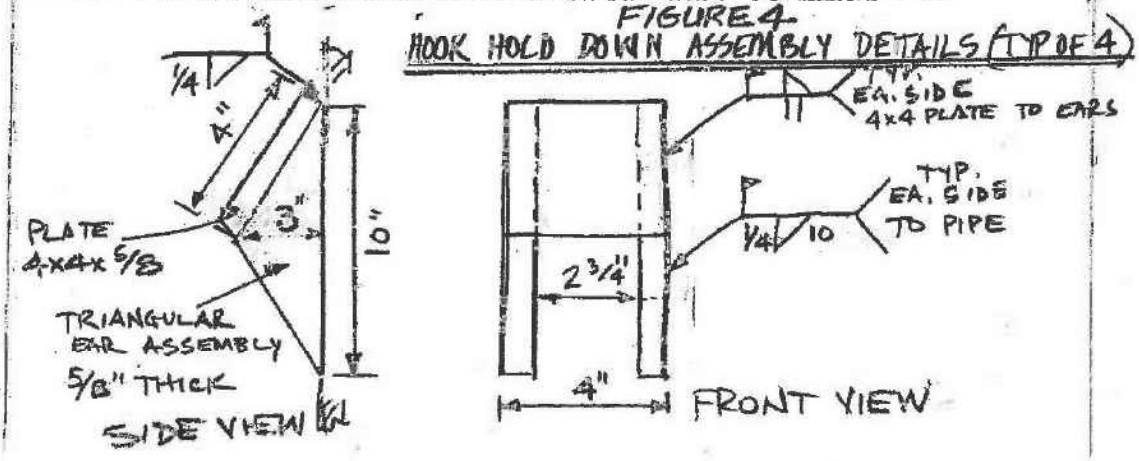


FIGURE 3 OPEN BURN-SUBUNIT 4 PLAN VIEW

FIGURE 4
HOOK HOLD DOWN ASSEMBLY DETAILS (TYP OF 4)



WFF OB AREA SUBUNIT 4 DESIGN 6

PROPERTIES OF 30" DIA. x 5/8" WALL PIPE : D=30", d=28.75"

ASTM A252 GRADE 2 STRUCTURAL PIPE (PILING PIPE)
Tensile strength (minimum) = 60,000 psi
Yield Strength (minimum) = 35,000 psi
Unit weight = 196#/LF TOTAL WEIGHT PIPE = 2.8K

$$\text{Area, } A = \frac{\pi (D^2 - d^2)}{4} = 57.68 \text{ IN}^2$$

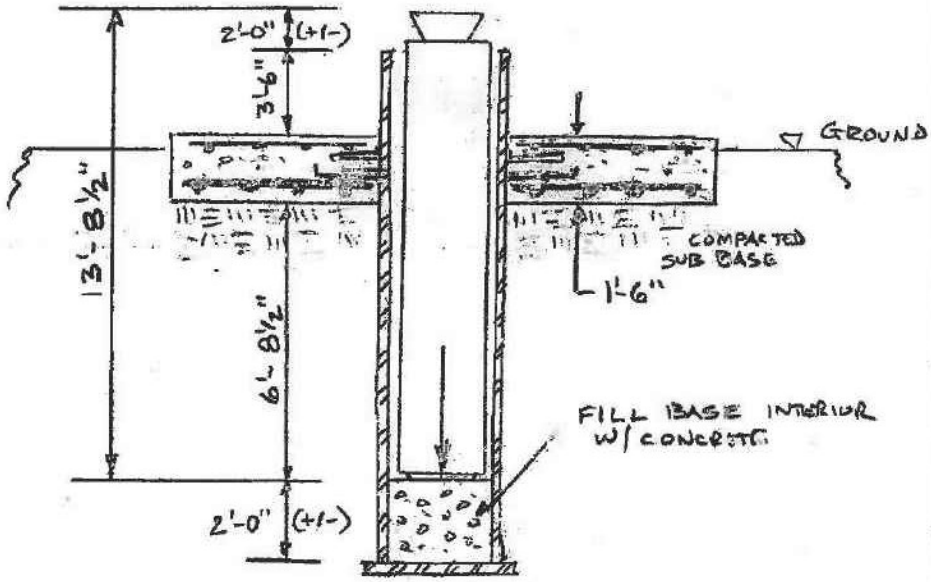
$$\text{Section Modulus, } S = \frac{\pi (D^4 - d^4)}{32\,D} = 415 \text{ IN}^3$$

TAURUS ROCKET MOTOR LOADS / Properties

THRUST (MAX) = 121K (SAY 125K) over ~3.5 sec
MOTOR WEIGHT = 2.89K (SAY 3K)
MOTOR DIA. = ~23 → 24.5"
MOTOR LENGTH = 164.53" = ~ 13'-8 1/2" (INCLUDES NOZZLE)

CONCRETE PAD/
SOIL CONDITIONS (SEE ENCLOSURE 1, SOIL BORING)

MAX SOIL PRESSURE = 2.0 KSF
f'c = 4000 psi
weight Concrete = 0.15 kcf (x 1.5' DEEP = 0.225 KSF)
TOP REINFORCEMENT = # 4 BARS @ 12" O.C.E.W.
Bottom Reinforcement = # 8 BARS @ 12" O.C.E.W



WFF OB AREA SUBUNIT 4 DESIGN 7

CHECK SOIL BEARING

P = TOTAL LOAD ON SOIL (ROCKET THRUST LOAD) = 125^{k} (THRUST) + 3^{k} (MOTOR WEIGHT) + 2.8^{k} (PIPE WEIGHT) = 130.8 KIPS

SOIL RESISTANCE (ALLOW) LESS CONCRETE (2000 PSF) − (225 PSF) = 1775 PSF P_a = 1.775 ksf

P/P_a = 130.8 KIPS / 1.775 K/SF = 73.7 SF REQ'D

Actual Footer size = 10' SQ = 100 SF > 73.7 SF ∴ OK

CHECK WELD CAPACITY ON PIPE TUBE (BASE)

CIRCUM. = πd = π(30") = 94.25"

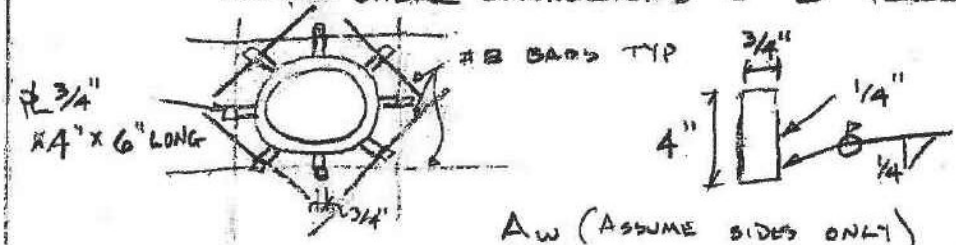
ASSUME 1/4" FILLET WELD, F_u = 50 KSI (MIN)
(MIN SIZE FOR 5/8" TO 5/8" STEEL, PER AISC TABLE J2.4)

L = ALLOW LOAD / IN OF WELD, S = SIZE of weld, 1/4"

L = 0.707 (1/4)(.3)(50 KSI) = 2.65 KIP/IN (OF WELD) SHEAR

CAPACITY OF BASE = 94.25"(2.65 K/IN) = 250^{K} > 130.8^{K} ∴ OK

USE ALTERNATE HEADED CONCRETE ANCHORS (HCA's) OR PLATE CONNECTORS (BELOW):
CHECK SHEAR CONNECTORS @ 8 PLACES



A_w (ASSUME SIDES ONLY)
8 BARS x 2 SIDES x 4" WELD = 64 IN.

CAPACITY OF SHEAR CONNECTORS (64 IN WELD)(2.65 K/IN) = 170^{K} > 130.8^{K} ∴ OK

WFF OB AREA SUBUNIT 4 DESIGN 8

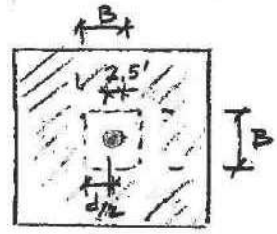
ANALYZE AS SQUARE FOOTING: (ASSUME 10' x 10' sq)

$P = 125^K + 3^K$ (ROCKET MOTOR) $+ 2.8^K$ (PIPE $= 130.8^K$

$P_a = 2.0$ ksf $- 0.15$ kcf $\times 1.5' = 1.775$ ksf

$P_u = 1.7 * 130.8$ kips $/(10' * 12''/1)^2 = 0.015$ ksi

* check 2-way shear



$d = 18'' - 3'' - 1'' \; 14''$

$B = 30'' + 14'' = 44''$

$V_u = 0.015 \text{ ksi} * [(10' * 12''/1)^2 - (44)^2]$

$V_u = 190.7$ kips

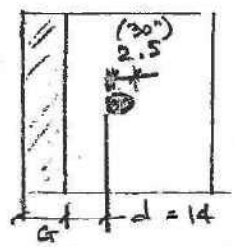
$V_c = 4\sqrt{f'_c}\, b_o d$

$= \dfrac{4\sqrt{4000}\,[4(44) * 14]}{1000} = 623.3^K$

$\phi V_c = .85(623.3^K) = 529.8^K > 190.7^K (V_u)$ ∴ OK

∴ No shear Reinf. Req'd

* check 1-way shear



$G = (5' * 12''/1) - 15'' - 14'' = 31''$

$V_u = 0.015(10 * 12''/1) * 31'' = 55.8^K$

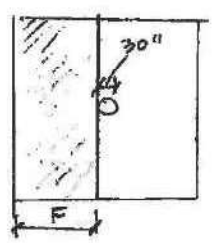
$V_c = 2\sqrt{f'_c}\, b_w d$

$V_c = \dfrac{2\sqrt{4000}\,(10 * 12''/1)(14'')}{1000} = 212.5^K$

$\phi V_c = .85(212.5) = 180.6^K > V_u = 55.8^K$

∴ OK, No shear reinforcement Req'd.

* check bending & rebar



$F = 60'' - 15'' = 45''$

$M_u = P_u \times b \dfrac{F^2}{2}$

$= 0.015 \text{ ksi} * (10'(12''/1) * (45)^2/2$

$= 1{,}822.5$ IN-K

Req'd $\bar{K} = M_u/\phi b d^2 = 1822.5 \text{ IN-K}/(0.9)(10 * 12''/1)(14)^2$

$= 0.0861$ ksi

req'd $\rho = (0.85 * 4 \text{ ksi}/60 \text{ ksi}) * \left(1 - \sqrt{1 - \dfrac{2(0.0861)}{.85 * 4 \text{ ksi}}}\right)$

$= (0.0567)(0.0257) = 0.0015$

Req'd $A_s = 0.0015 * 10(12''/1) * 14 = 2.52 \text{ IN}^2/10 \text{ FT}$

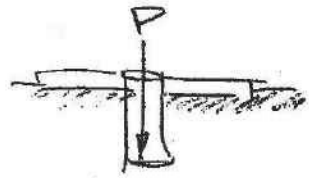
$2.52 \text{ IN}^2/10 = 0.252 \text{ IN}^2/\text{FT} < 0.78 \text{ IN}^2/\text{FT}$ (USED

∴ OK

WFF OB AREA SUBUNIT A DESIGN 9

CHECK PIPE:

TENSION FORCE (ASSUME STRAIGHT FORCE DOWN AT BASE) $f_T = P/A$



where P = ROCKET/THRUST LOAD
= 130.8 KIPS

and A = Area of pipe (cross section steel area)
= 57.68 IN²

$$f_t = P/A = \frac{130.8 \text{ KIPS}}{57.68 \text{ IN}^2} = 2.27 \text{ KSI}$$

MAX ALLOWABLE TENSION FORCE ON PIPE, $F_t = 0.6 F_y$

$F_t = 0.6 F_y = 0.6(35 \text{ KSI}) = 21.0 \text{ KSI}$

SINCE $F_{t(ALLOW)} = 21.0 \text{ KSI} > f_{t(ACTUAL)} = 2.27 \text{ KSI}$

∴ OK

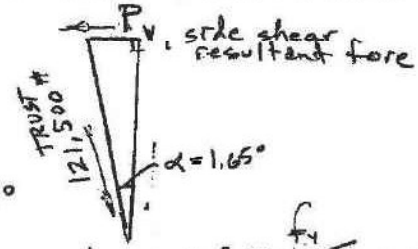
CHECK PIPE SHEAR FORCE: ASSUME ROCKET SHIFTS INSIDE TUBE, AND RESULTANT FORCE ACTS AT AN ANGLE

MAX ALLOWABLE SHEAR, F_v, on tube $F_v = .4 F_y$
$= .4(35 \text{ KSI})$
$= 14 \text{ KSI}$

Pipe Inside Diameter, ID = 28.75"
Outside Diameter of Rocket Casing OD = 24"

Room for displacement = ID − OD = 28.75" − 24.0" = 4.75"

$\tan\alpha = \frac{4.75}{164.5} = 1.65°$



$\tan 1.65° = \frac{f_v}{121{,}500 \text{ lbs}}$

$P_v = 3{,}500 \text{ lbs}$

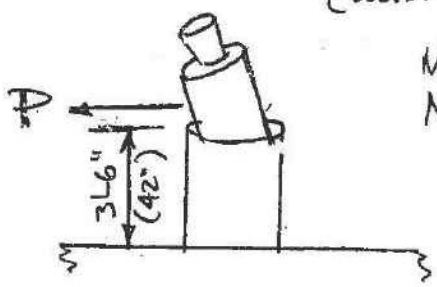
$$\frac{P_v}{A} = \frac{3{,}500 \text{ lbs}}{57.68 \text{ IN}^2} = 60.7 \text{ psi}$$

$f_{v\,ACTUAL} = 60.7 \text{ psi} < F_{v\,ALLOWABLE} = 14{,}000 \text{ psi}$ ∴ OK

WFF OBAREA SUBUNIT 4 DESIGN 10

CHECK PIPE

BENDING FORCE Assume side Blow out at top (Worst Case, Virtually Impossible)



$M_{MAX} = Pl$

$M_{MAX} = 125^K(42") = 5{,}250$ IN-K

$S_{PIPE} = 415$ IN^3

$f_{b_{ACTUAL}} = \frac{M}{S} = \frac{5{,}250 \text{ IN-K}}{415 \text{ IN}^3} = 12.65$ KSI

$F_{b(ALLOWABLE)} = .6F_y = .6(35 \text{ KSI}) = 21$ KSI

SINCE ALLOWABLE $F_b = 21.0$ KSI > ACTUAL, $f_b = 12.65$ KSI ∴ OK

ABBREVATIONS / SYMBOLS

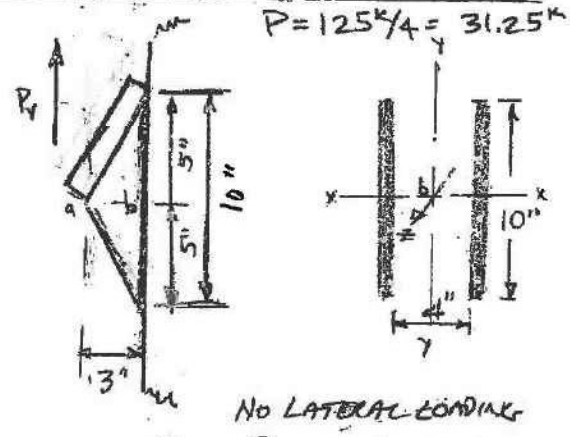
O.C. - on center
@ - at
E.W. - each way
DIA. - diameter
EA. - each
TYP. - typical
K - Kip (1,000 pounds)
KCF - kips per cubic foot
KSF - kips per square foot
LF - Linear foot
IN. - INCH
#, LB - pound
L, l - Length
SQ - square
PL - plate
HCA - Headed Concrete Anchor
AISC - American Institute of Steel Construction
ID - Inside Diameter
OD - Outside Diameter
> - Greater than

WFF OB AREA SUBUNIT 4 DESIGN

11

CHECK HOOR HOLD DOWN ASSEMBLY

$P = 125^K/4 = 31.25^K$



WELD PROPERTIES

$A_w = 20''$

$S_x = \frac{d^2}{3} = \frac{10^2}{3} = 33.3 \text{ IN}^2$

$P = 31.25^K$

$M = 31.25^K(3'') =$

$M_x = 93.75 \text{ IN-K}$

NO LATERAL LOADING

$f_v = \frac{P_v}{A} = \frac{31.25}{20} = 1.5625$

$f_b = \frac{93.75 \text{ IN-K}}{33.3 \text{ IN}^2} = 2.8153$

$f_R = \sqrt{(1.5625)^2 + (2.8153)^2} = 3.22 \text{ K/IN OF WELD}$

$W_{REQD} = \frac{3.22 \text{ K/IN}}{0.707(0.3)(60 \text{ KSI})} = 0.25 \text{ IN REQUIRED}$

USE 1/4" FILLET WELD

∴ OK

Thrust over 4 points acting up is not realistic, as rocket will face downwards.

Very conservative, but still works

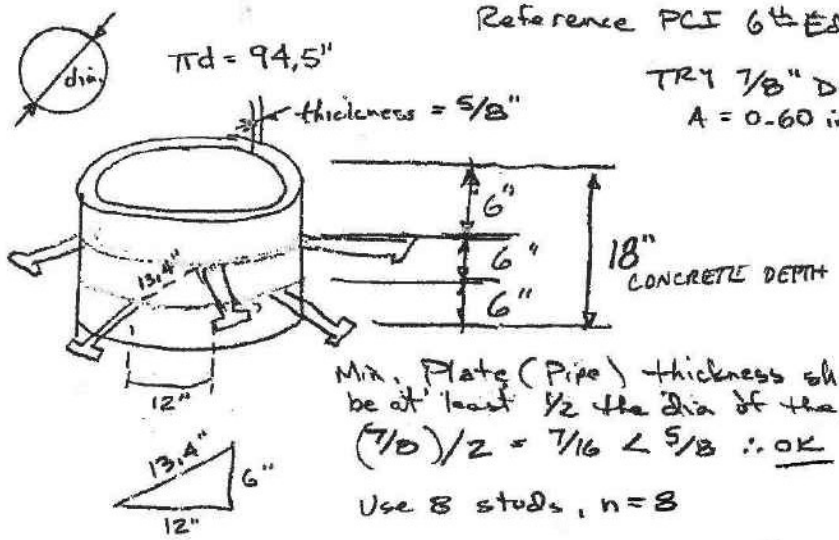
WEF OB AREA SUBUNIT 4 DESIGN 12

HEADED CONCRETE ANCHORS (HCA)

HEADED STAINLESS STEEL SHEAR STUDS

(Note: SS studs can be welded to Carbon Steel or SS)

Reference PCI 6th Edition



TRY 7/8" DIA STUDS
A = 0.60 in²

Min. Plate (Pipe) thickness should be at least 1/2 the dia of the stud
(7/8)/2 = 7/16 < 5/8 ∴ OK

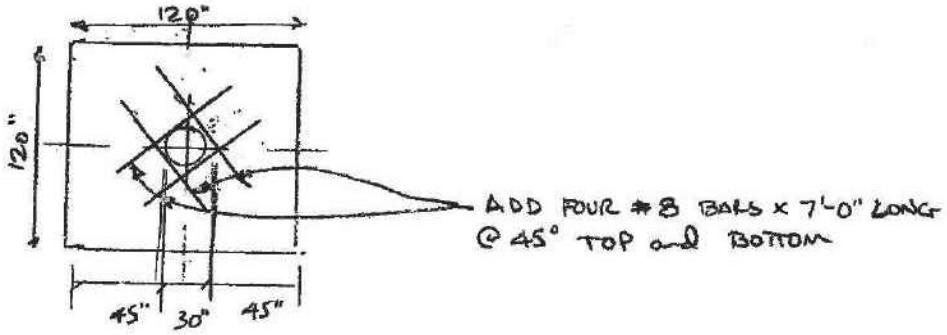
Use 8 studs, n = 8

STEEL CAPACITY, SHEAR STUD CAPACITY (ϕV_{ns}) where ϕ is strength reduction factor (FS) shear

$$\phi V_{ns} = \phi n_s A_n f_{ut}$$

$$\phi V_{ns} = 0.65(8)(.60)(65) = 202.8 \text{ kips} > 125 \text{ kips (THRUST)}$$

∴ OK

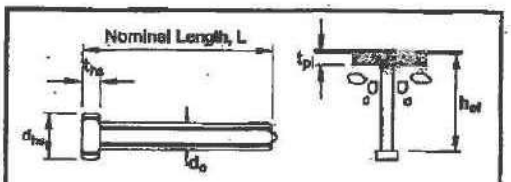


13

CHECK STUDS (CONTINUED)

Stud Dimensions

- Table 6.5.1.2
- Page 6-12



$h_{ef} = L + t_{pl} - h_{hs} - 3/8"$

Shank Diameter, d_o (in.)	Shank Area, A_{se} (in.^{2})	Head Diameter, d_{hs} (in.)	Head Thickness, t_{hs} (in.)	Bearing Area, A_{brg} (in.^{2})
1/4	0.05	1/2	3/16	0.15
3/8	0.11	3/4	9/32	0.33
1/2	0.20	1	5/16	0.59
5/8	0.31	1 1/4	5/16	0.92
3/4	0.44	1 1/4	3/8	0.79
7/8	0.60	1 3/8	3/8	0.88

Headed Concrete Anchors (HCA)

Steel Capacity

OR "SHEAR STUDS"

$$\phi V_s = \phi N_s = \phi \cdot n \cdot A_{se} \cdot f_{ut}$$

Where

ϕ = steel strength reduction factor
= 0.65 (shear) ←
= 0.75 (tension)

V_s = nominal shear strength steel capacity

N_s = nominal tensile strength steel capacity

n = number of headed studs in group

A_{se} = nominal area of the headed stud shank

f_{ut} = ultimate tensile strength of the stud steel, f_y = 60,000 psi (min)

Reference PCI, 6th Edition

Construction Notes

1. Cast-In-Place concrete for this structure shall be in accordance with the American Concrete Institute (ACI) "Building Code Requirements for Reinforced Concrete and Commentary" ACI 318-08 and ACI 318R-08.
2. Concrete shall be normal weight air-entrained and shall obtain a 28 day compressive strength (f'c) of 4000 PSI max course aggregate size shall be ¾".
3. Reinforcing materials shall be ASTM A615 grade 60, deformed, use grade 40 for ties spacers.
4. Minimum concrete cover for reinforcing steel is as indicated on drawings shall govern when in conflict with ACI 318-08. 3" cover bottom bars (min) 1 -1/2" cover for the top bars.
5. All reinforcing steel and pipe and other embedded items shall be accurately placed in the positions shown and adequately tied and supported to prevent displacement. Forms shall be installed to prevent sidewall pressure to blow out form. Rebar placement will also require inspection prior to pouring concrete.
6. Install 30" Diameter pipe into ground and compact soil around pipe. Provide soil stabilization and compaction as necessary. Recommend addition of Crusher Run base and vibratory compaction of subgrade. Disturb as little of subgrade as possible. Satisfactory inspection of subgrade shall be performed by Facilities Engineering Inspector prior to placing rebar.
7. All above ground welds to pipe shall be protected or performed after pipe is installed. Exterior of pipe below grade shall be coated with bituminous coating prior to placement. Apply bituminous (waterproof) coating in accordance with manufacturers printed instructions. Elevation and plumbness of pipe extending out of concrete is critical. Prevent water from entering pipe. Provide a cover assembly made of 1/16" thick (minimum) galvanized sheet metal. Covers shall have two handles and 4 fastener attachments so that it can be easily removed and/or secured to the top of the exposed pipe.
8. Welding shall conform to AWS D1.1 "Structural Welding Code-Steel." Weld electrodes shall be E70XX. Provide ¼" continuous fillet welds unless otherwise noted.
9. Structural steel plates and bars shall conform to ASTM A36.
10. Structural Pipe shall conform to ASTM A52 Grade 2.
11. Headed Concrete Anchors (HCA) or Shear Studs shall be installed conforming to ACI 318-08 Appendix D, Anchoring to Concrete. Studs strength shall be a minimum of Grade 60, Stainless Steel (SS).

ENCLOSURE (A)

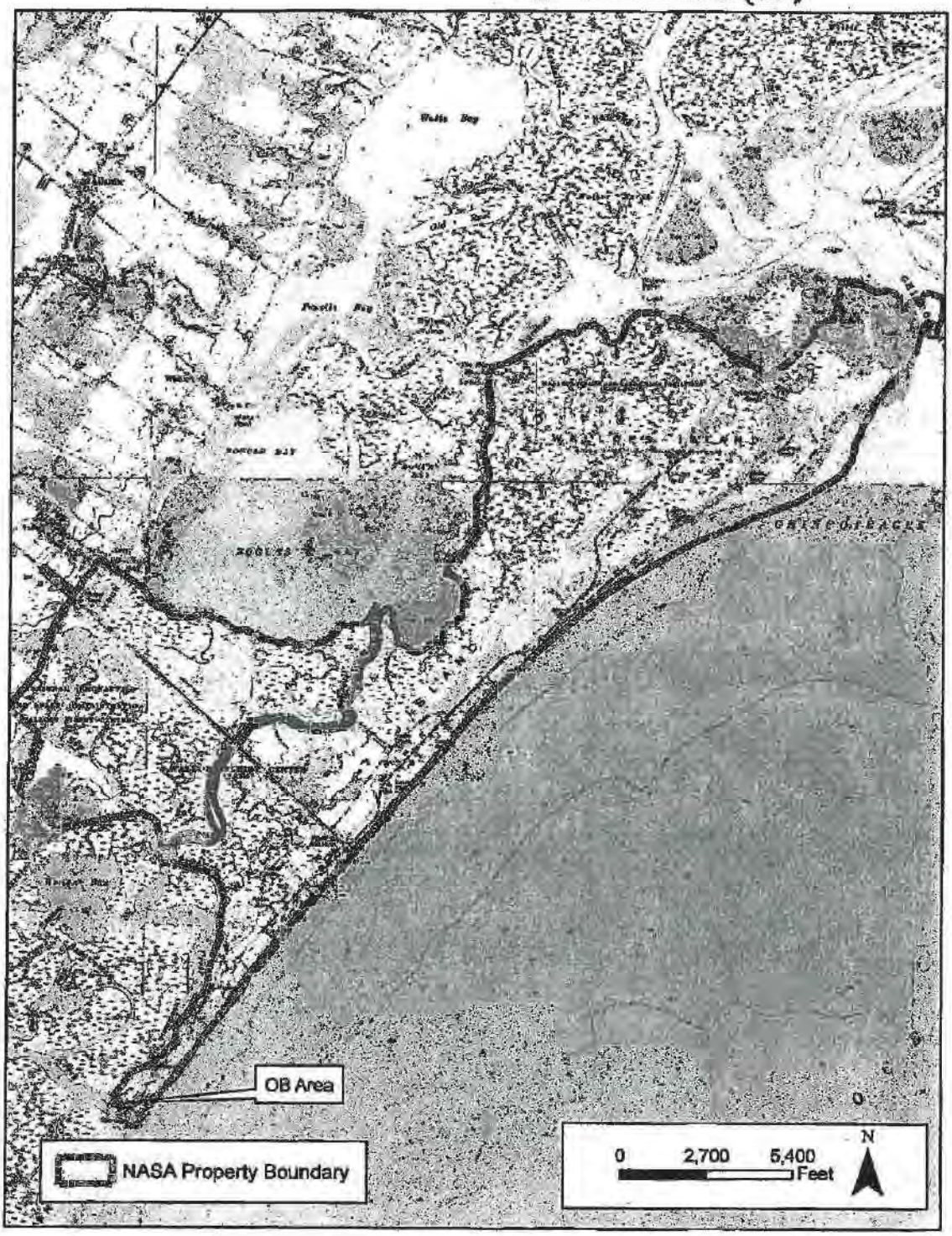


Figure A.2 NASA WFF Mainland and Island Topography

ENCLOSURE (B)

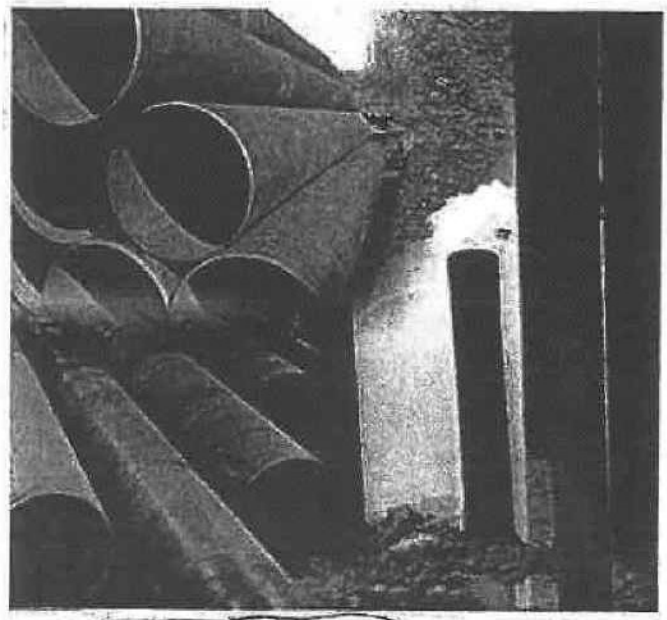
ASTM A252

Independence Tube has been producing square and rectangular products for over thirty-five years. Our experience with these products has led to the creation of our round and pipe size line. Independence Tube can now supply your pipe piling needs with the same excellence.

Independence Tube is now manufacturing ERW Pipe Piling to ASTM A252 in Grades 1, 2, and 3. Pipe Piling is produced from 6.625" O.D. to 12.750" O.D. in walls from .188" to .625" up to 78 feet long.

The most popular Pipe Piling sizes of 10.75" OD and 12.75" OD are produced in our Decatur, Alabama Division on a 4-week production cycle for your immediate needs.

When it comes to the versatility of designing with tube and pipe products, designers, architects, and engineers specify Independence Tube. *We have expanded our product line to expand your possibilities.*



	Grade 1	Grade 2	Grade 3
Tensile strength, min. psi	50,000	60,000	66,000
Yield strength, min. psi.	30,000	35,000	45,000
Elongation in 2 in. %	30	25	20

WEIGHT

Each length of pipe shall not vary more than 15% over or 5% under its theoretical weight, calculated using its length and its weight per unit length.

WALL THICKNESS TOLERANCE

Wall thickness at any point shall not be more than 12.5% under the specified nominal wall thickness.

OUTSIDE DIMENSION TOLERANCES

Outside diameter shall not vary more than ±1% From the specified outside diameter.

Call your Account Representative for floor stock availability or go on-line at www.independencetube.com.

Independence Tube
Chicago Decatur Marseilles
Your 1st Choice in Steel Tubular Products

ENCLOSURE (C)

Taurus Data Sheet:

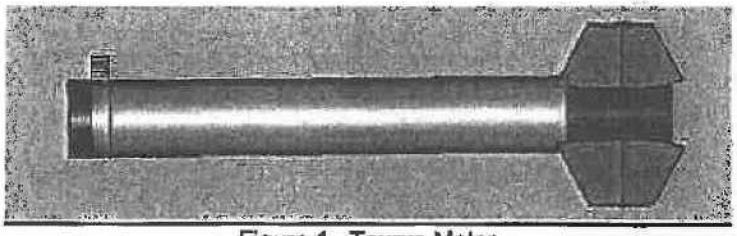


Figure 1. Taurus Motor

- **General Information:**

Sponsoring Agency:	Bureau of Naval Weapons
Manufacturer:	Allegany Ballistics Laboratory / Radford Army Ammunition Plant
Manufacturing Process:	Cartridge Loaded
Motor Designation:	M31A1, Improved Honest John
DOD Service:	ARMY
Hazard Classification:	1.1

- **Motor Data:**

Principal Diameter:	22.87 in
Total Length (including nozzle):	164.53 in
Inert Weight:	1227.3 lb
Propellant Weight:	1662.9 lb
Total Weight:	2890.2 lb
Mass Fraction:	0.575
Total Motor CG *:	70.2 in (loaded) 67.1 in (expended)

* CG distance from the head end

Table 1. Weight Breakdown for Taurus Motor [1]

Component	Nominal Weight (lb)
Case-Nozzle Assembly	1020.3
Igniter and Safearm Assembly	25.0
Beaker and Slivers	182.0
Inert Weight	1227.3
Propellant	1662.9
Total Weight	2890.2

ENCLOSURE (C)

- **Performance Data (Sea Level):**

	-40 °F	85 °F	130 °F
Burn Time (sec)	3.599	3.265	2.931
Action Time (sec)	3.916	3.587	3.257
Maximum Pressure (psia)	1095	1237	1379
Average Pressure during Action Time (psia)	974	1065	1155
Maximum Thrust (lb)	97,072	110,459	123,845
Average Thrust during Action Time (lb)	89,470	99,737	110,003
Total Impulse (lb-sec)	352,034	357,052	362,069
Propellant Specific Impulse (sec)	212	215	218

- **Physical Properties:**

- **Igniter**

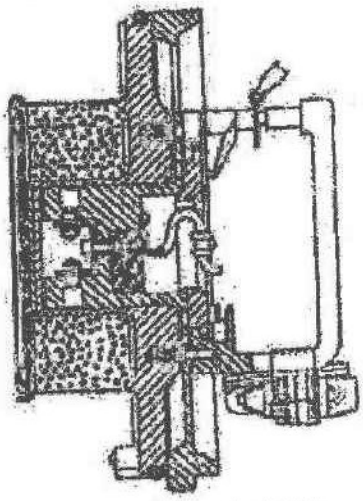


Figure 2. Taurus Igniter [1]

Name: XM58

ENCLOSURE (C)

Description:	Uses 2 Mk2 Mod 2 Squibs
Charge:	750 g USF-2D $BKNO_3$ pellets
Ignition delay:	0.033 sec
Igniter resistance:	0.5 ohm
Min current for reliable ignition:	2.9 amps

Safe/Arm Device: Manual alignment plates in igniter

- **Motor Case**

Material:	4130 Steel
Length	164.53 in
Outer Diameter:	22.75 in
Thickness (minimum):	0.156 in
Fabrication Method:	Roll and Weld
Hydrostatic Test Pressure:	1675 psig

- **Insulation**

Liner (between inhibitor and case):
- Weight: 44.5 lbs
- Composition: Vibradamp and Pyrolock
- Thickness: 0.060 in minimum body, 0.040 in minimum nozzle

Restrictor (inhibitor):
- Weight: 180 lb
- Composition: Cellulose Acetate
- Location: Forms casting mold for grain
- Thickness: 0.245 in

Head End Insulation:
- Weight: 1.0 lb
- Composition: Pyrolock

- **Nozzle / Exit Cone**

Shape:	15° half angle cone
Throat Area:	59.1 sq. in.
Expansion Ratio:	5.13
Thrust Coefficient:	1.49 (at –40 °F), 1.508 (at 130 °F)
Nozzle Material:	4130 Steel
Insert:	None

- **Propellant**

ENCLOSURE (c)

Name: ARP
Type: Double Base
Formulation:
- 49.9% Nitrocellulose
- 36.4% Nitroglycerine
- 13.7% Other Ingredients

Geometry: 4-point cruciform tapered inward from aft end
Flame Temp (@ P_c = 1000 psig): 4040 °F
Rb range: 0.35 to 0.90 (300 psi to 1500 psi)
Rb @ 1000 psi: 0.76 in/sec
Propellant density: 0.0581 lb/in^3
Isp: ~219 sec
Method of Manufacture: Cast into inhibitor
Grain Dimension:
- Length: 122.87 in
- Diameter: 21.93 in
- Web Thickness: 2.51 in

Design Parameters (@ ignition):
- Burning Surface to Throat Area Ratio: 190
- Port to Throat Area Ratio: 2.64

Exhaust Gas Composition (@ 14.7 psia)
- 13.0% CO_2
- 39.6% CO
- 22.7% H_2O
- 12.9% H_2
- 11.8% N_2

Resonance Rods: Cruciform type of 1010-1020 steel covered with Pyrolock; attached to head closure

Grain Supports and Retainers: Pyrolock-covered steel plate held against grain by 6 springs; supported from the head closure

ENCLOSURE (C)

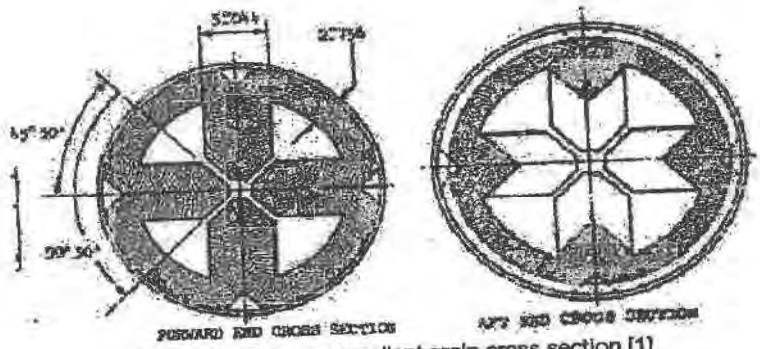


Figure 2. Taurus propellant grain cross section [1]

- **Storage Instructions**

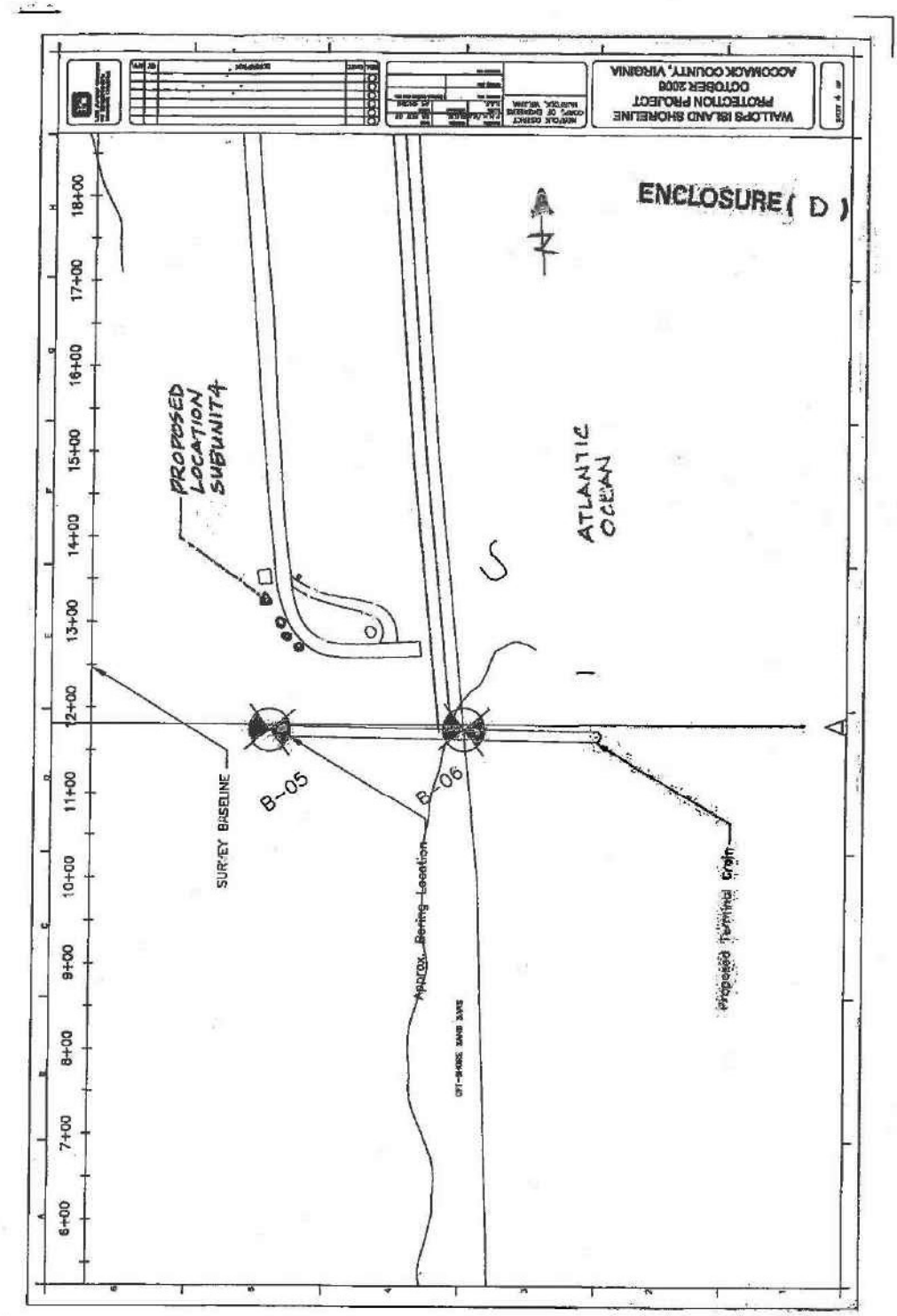
- **Performance**

- **Associated Procedures**

13-1-6	Taurus Static Firing
30-20-2	Taurus Motor First Stage Assembly
30-20-3	Taurus Orion Launcher Installation and Prelaunch
30-20-5	Modification of XM-58 Taurus Igniter for First Stage Motor
30-20-6	Modification of XM-58 Taurus Igniter for Second Stage Motor
VS60620	Taurus Motor Assembly BBXI and BBXII Vehicles
VS55943	Taurus Motor Removal, Inspection, Modification, and Installation into the Shipping Container
VS60914	Configuration of the AML 20K Launcher at PFRR Pad III for Taurus
VS60590	Configuration of MRL 7.5K Launcher at PFRR Pad 1 for Taurus Vehicles
VS60621	Modification of XM-58 Taurus Igniter for Second Stage Motor

- **References**

[1] CPIA. "Improved Honest John." February 1964. Unit 394.


WALLOPS ISLAND SHORELINE
PROTECTION PROJECT
OCTOBER 2003
ACCOMMACK COUNTY, VIRGINIA
ENCLOSURE (D)
PROPOSED
LOCATION
SUBUNIT 4
ATLANTIC
OCEAN
SURVEY BASELINE
B-05
B-06
Approx. Boring Location
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00

ENCLOSURE (D)

ENCLOSURE (D) Hole No. B-05

DRILLING LOG | DIVISION: CENAO | INSTALLATION: Wallops Flight Facility | SHEET 1 OF 2 SHEETS

1. PROJECT: Shoreline Restoration and Infrastructure Protection Program
2. LOCATION (Coordinates or Station): Wallops Island, Virginia N 3,836,963.1 E 12,349,669.0
3. DRILLING AGENCY: Fishburne Drilling Inc.
4. HOLE NO. (As shown on drawing title and file number): B-05
5. NAME OF DRILLER: Tim Donahue
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 50.0
10. SIZE AND TYPE OF BIT: 2.75" Tri-Cone Rotary
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-550X
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 13 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER: NA
16. DATE HOLE: STARTED 2/10/2009 | COMPLETED 2/10/2009
17. ELEVATION TOP OF HOLE: +13.5 ±
18. TOTAL CORE RECOVERY FOR BORING: %
19. GEOLOGIST: L. Jones

ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, dept weathering, etc., if significant) g
13.5-5.5	0.0		(SP) Fine sand, dry, tan ASSUME 2000 psf bearing (conservative)	0' to 2'	1-2-3-3 N=5	H = Weight of Hammer
			— 3'-0" WATER	2' to 4'	3-2-3-3 N=5	
			(SP) same, saturated	4' to 6'	1-1-1-2 N=2	
8.0	5.5		(SP) Fine to medium sand, trace of fine gravel, saturated, orange-tan	6' to 8'	1-1-1-1 N=2	WATER @ 3'-0" BELOW GRADE
5.8	7.7		(CH) Clay lense			
5.6	7.9		(SP) Fine sand, moist, light brownish tan	8' to 10'	2-3-3-5 N=6	
3.9	9.6		(SP) Fine sand, trace of shell fragments, moist, grayish light brown			BLOW COUNTS DECREASE TO N = 2 @ 4'-0" BELOW GRADE
0.5	13.0		color change to light gray	13' to 15'	5-5-6-7 N=11	NOTES: → KEEP FOUNDATION UP HIGH 1'-6" BELOW GRADE AND COMPACT TO ACHIEVE HIGHER COMPRESSIVE STRENGTH
-3.0	16.5		(SP) Fine to coarse sand, little shell fragments, moist, gray			
-6.0	19.5		(SP) Fine to medium sand, trace of shell fragments, moist, gray	18' to 20'	6-4-2-3 N=6	→ ASSUME 2000 PSF BASED ON SUBUNITS 1 THRU 3
-8.5	22.0		(CH) Silty clay, high plastic, moist, gray	23' to 25'	1-1-1-1 N=2	
-12.5	26.0		(SC) Clayey silty fine sand, medium plastic, moist, gray			
-15.4	28.9		(CH) Silty clay, trace of fine sand, trace of peat, high plastic, moist, gray	28' to 30'	1-0-1-0 N=1	
-18.5	32.0		(CH) Silty clay, high plastic, moist, gray			
-20.7	34.2		(PT) Peat, little silty clay, low plastic, moist brown	33' to 35'	1-1-0-1 N=1	
-22.5	36.0		(CH) Silty clay, high plastic, moist, gray	38' to 40'	H-1-1-1 N=2	

ENG FORM 1836

PROJECT: Shoreline Restoration and Infrastructure Protection Program | HOLE NO. B-05

ENCLOSURE (D)

Hole No. B-05

DRILLING LOG	DIVISION CENAO	INSTALLATION Wallops Flight Facility	SHEET 2 OF 2 SHEETS

1. PROJECT Shoreline Restoration and Infrastructure Protection Program	10. SIZE AND TYPE OF BIT 2.75" Tri-Cone Rotary
2. LOCATION (Coordinates or Station) Wallops Island, Virginia N 3,836,963.1 E 12,349,669.0	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Fishburne Drilling Inc.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-550X
4. HOLE NO. (As shown on drawing title and file number) B-05	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 13; UNDISTURBED
5. NAME OF DRILLER Tim Donahue	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER NA
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 2/10/2009; COMPLETED 2/10/2009
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE +13.5 ±
9. TOTAL DEPTH OF HOLE 50.0	18. TOTAL CORE RECOVERY FOR BORING %
	19. GEOLOGIST L. Jones

ELEVATION (feet) a	DEPTH (feet) b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	SAMPLE DEPTH (feet) e	SAMPLE BLOWS f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
13.5-5.5	0.0					
-28.5	42.0		(ML-CL) Clayey silt, trace of very fine sand, low plastic, very moist, gray	43' to 45'	2-3-6-10 N=9	
-33.0	46.5		(SC) Clayey silty very fine sand, medium plastic, moist, bluish gray	48' to 50'	2-2-2-3 N=4	
-36.5	50.0		Boring terminated at a 50 foot depth.			

ENG FORM 1836

PROJECT Shoreline Restoration and Infrastructure Protection Program | HOLE NO. B-05

Criqui, Richard (DEQ)

From: Wilson, Thomas F. (WFF-2280) [thomas.f.wilson@nasa.gov]
Sent: Wednesday, May 02, 2012 2:33 PM
To: Criqui, Richard (DEQ)
Cc: Simko, Marianne F. (WFF-200.C)[EG&G, Inc. (WICC)]; Bull, Paul C. (WFF-2280)
Subject: Supplimental Info on Open Burn Area (VA7800020888) Subunit 4 Design
Attachments: S3009085012050212360.pdf

Follow Up Flag: Follow up
Flag Status: Flagged

Richard,
It was good to speak with you today. I have attached the backup information (design formulas) as per our discussion today.
As per our discussion you had questions concerning the concrete footing design on page 8 of the calcs. Page 8 of design calcs have various equations which I made to try to be somewhat consistent with the older original design (by DBF, Inc March 18, 2004) as well as what I had in my (referencing) text books.
I have attached referencing equations from Design of Reinforced Concrete by Jack McCormac, as well as derivation of percentage of steel required from Reinforced Concrete Design by Wang, both are attached. The McCormac book has the equations and good description of the shear (one way & punching) equations. The Wang formula for finding ρ is generally (in my experience) done by using tables (based on f'c, fy, and $M/\phi bd2$). Since I was using the old calcs as a template I used the long formula used by DBF. Either way is generally acceptable.
I also attached the table (A.6, McCormac) for finding the As (Area of Steel) that I used for the 0.78 square inches per foot that we have in the bottom of the slab (#8 bars at 12" on center).
I hope this helps in satisfactorily explaining the footing design to your office.
Feel free to contact me if you have any other questions or comments.
Best Regards,
-Tom

Thomas F. Wilson, Code 228
Senior Structural Engineer - Experimental Facilities Development
NASA Wallops Flight Facility, Bldg N-161, Rm 120
Wallops Island, Virginia 23337
757-824-1570 (Work)
757-824-1831 (Fax)
757-710-1456 (Cell)

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DESIGN OF REINFORCED CONCRETE

Jack C. McCormac
Clemson University

Thomas Y. Crowell
Harper & Row Publishers
New York Hagerstown San Francisco London

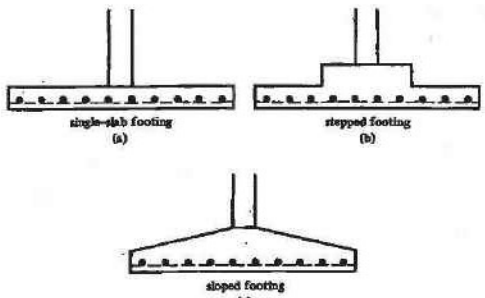

Figure 10.6

used where such shapes are dictated by the available space or where the cross sections of the columns are very pronounced rectangles.

Most footings consist of single slabs, such as the one shown in Figure 10.6(a), but if calculated thicknesses are greater than 3 or 4 ft, it may be economical to use stepped footings, that is, ones with pedestals or caps, as illustrated in Figure 10.6(b). The shears and moments in a footing are obviously larger near the column, with the result that greater depths are required in that area as compared to the outer parts of the footing. For very large footings, such as for bridge piers, stepped footings can give appreciable savings in concrete quantities.

Occasionally sloped footings [Figure 10.6(c)] are used instead of the stepped ones, but labor costs can be a problem. Whether stepped or sloped, it is considered necessary to place the concrete for the entire footing in a single pour to ensure the construction of a monolithic structure. If this procedure is not followed, it is desirable to use keys or shear friction reinforcing between the parts to insure monolithic action.

Before a column footing can be designed, it is necessary to make a few comments regarding shears and moments. This is done in the paragraphs to follow, while a related subject, load transfer from columns to footings, is discussed in the next section of this chapter.

Shears

There are two shear conditions that must be considered in column footings, regardless of their shapes. The first of these is one-way shear,

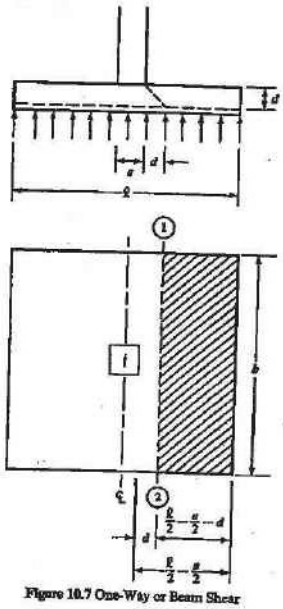

Figure 10.7 One-Way or Beam Shear

which is the same as that considered in wall footings in the preceding section. For this discussion reference is made to the footing of Figure 10.7. The total shear (V_u) to be taken along Section 1.2 equals the net soil pressure times the crosshatched area outside the section. In the expression to follow, b is the whole width of the footing from points 1 to 2. The maximum value of V_u if stirrups are not used equals ϕV_c equals $\phi 2\sqrt{f_c'}\,bd$ and the maximum depth required is as follows:

$$d = \frac{V_u}{\phi 2\sqrt{f_c'}\,b}$$

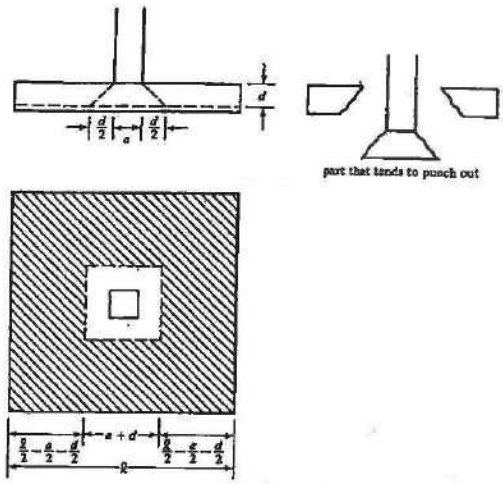

Figure 10.8 Two-Way or Punching Shear

The second shear condition is two-way or punching shear, with reference being made to Figure 10.8. The compression load from the column tends to spread out into the footing, opposing diagonal tension in that area, with the result that a square column tends to punch out a piece of the slab, which has the shape of a truncated pyramid. The ACI Code (11.11.1.2) states that the critical section for two-way shear is located at a distance $d/2$ from the face of the column and that the shear so computed must not exceed $\phi 4\sqrt{f_c'}\,b_o d$ if shear reinforcing is not provided.

The shear force V_u consists of all the net upward pressure on the cross-hatched area shown, that is, on the area outside the part tending to punch out. In the expression to follow, b_o is the perimeter around the punching area, equal to $4(a + d)$ in the figure, and the depth required for two-way shear is

$$d = \frac{V_u}{\phi 4\sqrt{f_c'}\,b_o}$$

Test have shown that when slabs are subjected to bending in two directions and when the long side of the supporting area is more than two times the short side the shear strength $V_c = 4\sqrt{f_c'}\,b_o d$ may be much too high. The Code 11.11.2 says that unless shear reinforcing is provided, V_c for punching or two-way shear may not exceed the following

$$V_c = \left(2 + \frac{4}{\beta_c}\right)\sqrt{f_c'}\,b_o d \le 4\sqrt{f_c'}\,b_o d$$

In this expression β_c is the ratio of the long side of the loaded area to the short side of the loaded area. For nonrectangular loaded areas V_c can be obtained with the same expression if β_c is considered to equal the maximum length of the effective loaded area divided by the maximum width measured perpendicular to the length.

Moments

The bending moment in a square reinforced concrete footing is the same about both axes due to symmetry. It should be noted, however, that the effective depth of the footing cannot be the same in the two directions because the bars in one direction rest on top of the bars in the other direction. The effective depth used for calculations might be the average for the two directions or, more conservatively, the value for the bars on top. This lesser value is used for the examples in this text. Although the result is some excess of steel in one direction, it is felt that the steel in either direction must be sufficient to resist the moment in that direction. It should be clearly understood that having an excess of steel in one direction will not make up for a shortage in the other direction.

The critical section for bending is taken at the face of reinforced concrete columns or at a distance halfway from the edge of the base plate and the face of the column if structural steel columns are used (Code 15.4.2).

The determination of footing depths by the procedure described here will often require several cycles of a trial and error procedure. There are, however, many tables and handbooks available with which footing depths can be accurately estimated. One of these is the previously mentioned *CRSI Handbook*. In addition, there are many rules of thumb used by designers for making initial thickness estimates, such as 20% of the footing width or the column diameter plus 3 in. and so on.

The flexural steel percentage calculated for footings is very often less than $200/f_y$. The ACI Code (10.5.3), however, states that in slabs of uniform thickness the minimum area and maximum spacing of reinforcing bars in the direction of bending shall be as required for shrinkage and temperature reinforcement. Most designers feel that the combination of high shears and low ρ values that often occur in footings is not good practice and thus use $200/f_y$ as a minimum.

Example 10.2 illustrates the design of an isolated column footing.

EXAMPLE 10.2

Design a square column footing for a 16-in. square tied column that supports a dead load $D = 200^k$ and a live load $L = 160^k$. The column is reinforced with 8 #8 bars, the base of the footing is 5 ft below grade, and the soil weight is 100 #/ft³. $f_y = 40{,}000$ psi, $f_c' = 4{,}000$ psi, and $q_a = 5{,}000$ psf.

SOLUTION

Assume 22-in. footing ($d = 17.5$ in.)

$$q_a = 5{,}000 - \left(\tfrac{22}{12}\right)(150) - \left(\tfrac{60}{12}\right)(100) = 4408 \text{ psf}$$

$$A \text{ required} = \frac{360}{4.408} = 81.7 \text{ ft}^2$$

Use 9′0″ × 9′0″ footing = 81.0 ft²

Bearing pressure for strength design

$$q_u = \frac{(1.4)(200) + (1.7)(160)}{81.0} = 6.81 \text{ ksf}$$

Depth required for two-way or punching shear (Figure 10.9)

$$b_o = (4)(33.5) = 134''$$

$$V_u = (81.0 - 2.79^2)(6.81) = 498.6^k$$

$$d = \frac{V_u}{\phi 4\sqrt{f_c'}b_o} = \frac{498{,}600}{(0.85)(4\sqrt{4{,}000})(134)} = 17.30 + 4.5 = 21.8'' < 22'' \quad \text{ok}$$

16 + 17.5 = 33.5″ = 2.79′

Figure 10.9

Depth required for one-way shear (Figure 10.10)

$$V_u = (9.00)(2.375)(6.81) = 145.6^k$$

$$d = \frac{V_u}{\phi 2\sqrt{f_c'}b} = \frac{145{,}600}{(0.85)(2\sqrt{4{,}000})(108)} = 12.54 + 4.5 = 17.04'' < 22'' \quad \text{ok}$$

use 22″ depth

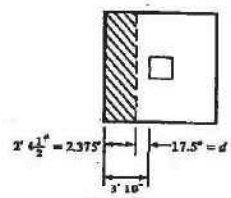

Figure 10.10

Steel area

$$M_u = (3.83)(9.00)(6.81)\left(\frac{3.83}{2}\right) = 449.5 \text{ ft-k}$$

$$\frac{M_u}{\phi b d^2} = \frac{(12)(449{,}500)}{(0.9)(108)(17.5)^2} = 181.2 \left(\rho < \frac{200}{f_y}\right)$$

$$\text{Use } \rho = \frac{200}{40{,}000} = 0.005$$

$$A_s = (0.005)(17.5)(108) = 9.45 \text{ in.}^2$$

use 10 #9 bars in both directions

Development length

required development $l_d = 25''$

actual development length furnished = 46 − 3 = 43″ > 25″ ok

10.7 LOAD TRANSFER FROM COLUMNS TO FOOTINGS

All forces acting at the base of a column must be satisfactorily transferred into the footing. Compressive forces can be transmitted directly by bearing, while uplift or tensile forces must be transferred by developed reinforcing.

A column transfers its load directly to the supporting footing over an area equal to the cross-sectional area of the column. The footing surrounding this contact area, however, supplies appreciable lateral support to the directly loaded part with the result that the loaded concrete in the footing can support more load. Thus for the same grade of concrete, the footing can carry more load than can the column.

At the base of the column, the permitted bearing strength is $\phi(0.85f_c'A_1)$ (where ϕ is 0.70), but it may be multiplied by $\sqrt{A_2/A_1} \gtrsim 2$ for bearing

EXAMPLE 10.2

Design a square column footing for a 16-in. square tied column that supports a dead load $D = 200^k$ and a live load $L = 160^k$. The column is reinforced with 8 #8 bars, the base of the footing is 5 ft below grade, and the soil weight is 100 #/ft³. $f_y = 40{,}000$ psi, $f'_c = 4{,}000$ psi, and $q_a = 5{,}000$ psf.

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$$A \text{ required} = \frac{360}{4{,}408} = 81.7 \text{ ft}^2$$

Use 9′0″ × 9′0″ footing = 81.0 ft²

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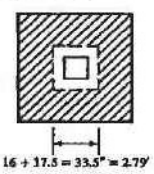

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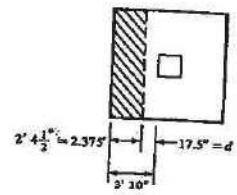

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$$\text{Use } \rho = \frac{200}{40{,}000} = 0.005$$

$$A_s = (0.005)(17.5)(108) = 9.45 \text{ in.}^2$$

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At the base of the column, the permitted bearing strength is $\phi(0.85f'_c A_1)$ (where ϕ is 0.70), but it may be multiplied by $\sqrt{A_2/A_1} \leq 2$ for bearing

Table A.5 Minimum Beam Width (in.) According to the 1977 ACI Code[a, b]

Size of Bars	Number of Bars in Single Layer of Reinforcement							Add for Each Added Bar
	2	3	4	5	6	7	8	
#4	6.1	7.6	9.1	10.6	12.1	13.6	15.1	1.50
#5	6.3	7.9	9.6	11.2	12.8	14.4	16.1	1.63
#6	6.5	8.3	10.0	11.8	13.5	15.3	17.0	1.75
#7	6.7	8.6	10.5	12.4	14.2	16.1	18.0	1.88
#8	6.9	8.9	10.9	12.9	14.9	16.9	18.9	2.00
#9	7.3	9.5	11.8	14.0	16.3	18.6	20.8	2.26
#10	7.7	10.2	12.8	15.3	17.8	20.4	22.9	2.54
#11	8.0	10.8	13.7	16.5	19.3	22.1	24.9	2.82
#14	8.9	12.3	15.6	19.0	22.4	25.8	29.2	3.39
#18	10.5	15.0	19.5	24.0	28.6	33.1	37.6	4.51

Table shows minimum beam widths when stirrups are used.
For additional bars, add dimension in last column for each added bar.
For bars of different size, determine from table the beam width for smaller size bars and then add last column figure for each larger bar used.
[a] Assumes maximum aggregate size does not exceed three-fourths of the clear space between bars.
[b] Values given for smaller bars include minimum bend radius for stirrups.

Table A.6 Areas of Bars in Slabs (in.²/ft)

Spacing, in.	Bar No.								
	3	4	5	6	7	8	9	10	11
3	0.44	0.78	1.23	1.77	2.40	3.14	4.00	5.06	6.25
3½	0.38	0.67	1.05	1.51	2.06	2.69	3.43	4.34	5.36
4	0.33	0.59	0.92	1.32	1.80	2.36	3.00	3.80	4.68
4½	0.29	0.52	0.82	1.18	1.60	2.09	2.67	3.37	4.17
5	0.26	0.47	0.74	1.06	1.44	1.88	2.40	3.04	3.75
5½	0.24	0.43	0.67	0.96	1.31	1.71	2.18	2.76	3.41
6	0.22	0.39	0.61	0.88	1.20	1.57	2.00	2.53	3.12
6½	0.20	0.36	0.57	0.82	1.11	1.45	1.85	2.34	2.89
7	0.19	0.34	0.53	0.76	1.03	1.35	1.71	2.17	2.68
7½	0.18	0.31	0.49	0.71	0.96	1.26	1.60	2.02	2.50
8	0.17	0.29	0.46	0.66	0.90	1.18	1.50	1.89	2.34
9	0.15	0.26	0.41	0.59	0.80	1.05	1.33	1.69	2.08
10	0.13	0.24	0.37	0.53	0.72	0.94	1.20	1.52	1.87
12	0.11	0.20	0.31	0.44	0.60	0.78	1.00	1.27	1.56

Table A.7 Design of Rectangular Beams and Slabs

n and f_c'	f_s	f_c	k	j	ρ_n	K
10 (2,500)	18,000	1,000	0.357	0.881	0.0099	157
		1,125	0.385	0.872	0.0120	189
	20,000	1,000	0.333	0.889	0.0083	148
		1,125	0.360	0.880	0.0101	178
	24,000	1,000	0.294	0.902	0.0061	133
		1,125	0.319	0.894	0.0075	160
9 (3,000)	18,000	1,200	0.375	0.875	0.0125	197
		1,350	0.403	0.866	0.0151	235
	20,000	1,200	0.351	0.883	0.0105	185
		1,350	0.377	0.874	0.0128	223
	24,000	1,200	0.340	0.897	0.0078	167
		1,350	0.336	0.888	0.0095	20
8 (4,000)	18,000	1,600	0.416	0.861	0.0185	286
		1,800	0.444	0.852	0.0222	341
	20,000	1,600	0.390	0.870	0.0156	272
		1,800	0.419	0.860	0.0188	324
	24,000	1,600	0.345	0.884	0.0116	246
		1,800	0.375	0.875	0.0141	295
7 (5,000)	18,000	2,000	0.438	0.854	0.0243	374
		2,250	0.467	0.844	0.0292	443
	20,000	2,000	0.412	0.863	0.0206	355
		2,250	0.441	0.853	0.0248	423
	24,000	2,000	0.368	0.877	0.0154	323
		2,250	0.396	0.868	0.0186	387

Note: ρ_n = required percentage of steel.

Table A.8 Balanced Ratio of Reinforcement ρ_b for Rectangular Sections with Tension Reinforcement Only

f_y \ f_c'		2,500 psi (17.2 MPa) $\beta_1 = 0.85$	3,000 psi (20.7 MPa) $\beta_1 = 0.85$	4,000 psi (27.6 MPa) $\beta_1 = 0.85$	5,000 psi (34.5 MPa) $\beta_1 = 0.80$	6,000 psi (41.4 MPa) $\beta_1 = 0.75$
Grade 40 40,000 psi (275.8 MPa)	ρ_b	0.0309	0.0371	0.0495	0.0582	0.0655
	$0.75\rho_b$	0.0232	0.0278	0.0371	0.0437	0.0492
	$0.50\rho_b$	0.0155	0.0186	0.0247	0.0291	0.0328
Grade 50 50,000 psi (344.8 MPa)	ρ_b	0.0229	0.0275	0.0367	0.0432	0.0486
	$0.75\rho_b$	0.0172	0.0206	0.0275	0.0324	0.0365
	$0.50\rho_b$	0.0115	0.0138	0.0184	0.0216	0.0243
Grade 60 60,000 psi (413.7 MPa)	ρ_b	0.0178	0.0214	0.0285	0.0335	0.0377
	$0.75\rho_b$	0.0134	0.0161	0.0214	0.0252	0.0283
	$0.50\rho_b$	0.0089	0.0107	0.0143	0.0168	0.0189
Grade 75 75,000 psi (517.1 MPa)	ρ_b	0.0129	0.0155	0.0207	0.0243	0.0274
	$0.75\rho_b$	0.0097	0.0116	0.0155	0.0182	0.0205
	$0.50\rho_b$	0.0065	0.0078	0.0104	0.0122	0.0137

K_t	torsional stiffness of member; torsional moment per unit rotation about longitudinal axis of member (Sec. 18.20; Chaps. 17 and 19)
K_{ti}	stiffness of rotational spring at end i of member ij, causing slip angle ψ_i (Chap. 17)
K_{tj}	stiffness of rotational spring at end j of member ij, causing slip angle ψ_j (Chap. 17)
L_1	span measured in the direction of the equivalent frame for two-way systems, measured center-to-center of supports (Chap. 16)
L_2	span transverse to L_1, measured center-to-center of supports (Chap. 16)
L_a	length of straight embedment provided beyond inflection point or beyond center of support at simple supports (cannot be taken greater than the larger of d or $12d_b$ for ACI-12.2.3)
L_d	development length for a straight bar; distance bar must be embedded to develop its nominal tensile strength
L_{db}	basic development length for a straight bar (before any modifications for favorable or unfavorable factors)
L_{dh}	development length of standard hooked bar in tension (Fig. 6.11.2), measured from critical section to outside end of hook (straight embedment length between critical section and start of hook [point of tangency] plus radius of bend and one bar diameter) = L_{hb} times applicable modification factors
L_{hb}	basic development length of a standard hooked bar in tension; basic value of L_{dh} defined by Fig. 6.11.2
L_n	clear span
L_u	unsupported length of a compression member (Sec. 13.7; Chap. 15)
m	ratio of the volume of longitudinal bars to volume of closed hoops, $A_sx_1/[2A_t(x_1 + y_1)]$ (Sec. 18.6)
	$f_y/(0.85f'_c)$, stress ratio
	number of tension bars; for several sizes, $m = A_s/A_b$ for largest bar) (Sec. 4.12)
M_{1b}	smaller of primary moments at ends of member in a *braced frame*
M_{1s}	smaller of primary moments at ends of member in an *unbraced frame*
M_{2b}	larger of primary moments at ends of member in a *braced frame*
M_{2s}	larger of primary moments at ends of member in an *unbraced frame*
M_b	portion transferred by flexure out of the total moment M to be transferred between column and slab at a joint (Sec. 16.18)
M_c	$\delta_b M_{1b} + \delta_s M_{2s}$, magnified factored moment to use in design of compression member (Chap. 15)
M_{cr}	cracking moment, $f_r I_g/y_t$
M_D	dead load moment (Chaps. 14 and 21)
M_{D+L}	dead load plus live load moment (Chap. 14)
M_{equiv}	$C_m M_{max}$, equivalent primary uniform moment along a braced member (Chap. 15)
M_f	primary bending moment (function of x) (Chap. 15)
M_f^-	maximum primary bending moment
M_{max}	maximum service moment for condition under which deflection is computed
M_n	nominal moment strength
M_{nb}	nominal moment strength when member is subject to flexure alone (Chap. 19)
M_{nb}	nominal moment strength per unit distance along a yield line (Chap. 18)
M_{nc}	nominal moment strength for beam having no compression steel, $C_c(d - a/2)$
M_{nsb}	$w_{nsb}L^2/8$; $M_D - M_{positive}$ (Chap. 21)
M_{ns}	nominal moment strength added by compression steel, $C_s(d - d')$
M_{nx}	nominal moment strength about the x axis, $P_n e_y$ (Sec. 13.21)
M_{ny}	nominal moment strength about the y axis, $P_n e_x$ (Sec. 13.21)
M_o	moment at midspan on a simply supported beam
	nominal moment strength M_n for member subject to flexure alone (Chap. 13)
	full statical moment on a two-way slab system (Sec. 16.3)
M_{0i}	fixed end moment at end i of a flexural member ij (Sec. 18.10 and Chap. 17)
M_{0i}	sum of M_{ij} and moment necessary to cancel unwanted slope, $[(1 + F_{ti}S_{ji})M_{ij} - (F_{ti}S_{ji})M_{ji}]/T_2$
M_{0j}	fixed end moment at end j of a flexural member ij (Sec. 18.10 and Chap. 17)
M_{0j}	sum of M_{ij} and moment necessary to cancel unwanted slope, $[(1 + F_{tj}S_{ij})M_{ij} - (F_{tj}S_{ij})M_{ji}]/T_2$ (Sec. 17.4)
M_{ox}	nominal moment strength for bending about the x axis when axial compression is zero (Sec. 13.21)
M_{oy}	nominal moment strength for bending about the y axis when axial compression is zero (Sec. 13.21)
M_-	net negative midspan moment

Reinforced Concrete Design

Fourth Edition

Chu-Kia Wang
Charles G. Salmon
University of Wisconsin—Madison

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slab) of the T in tension, and also with the bottom (the stem of width b_w) of the T in tension. Such an analysis will show that with the *slab in compression*, Eq. (3.7.7) using $\rho = \rho_w = A_s/b_w d$ will give

$$\min \rho \geq \frac{(150 \text{ to } 250)^*}{f_y} \tag{3.7.9}$$

For the *slab in tension* on the T-section,

$$\min \rho \geq \frac{(300 \text{ to } 600)^\dagger}{f_y} \tag{3.7.10}$$

Thus, ACI-10.5.1 is a reasonable requirement for isolated rectangular beams and the usual positive moment orientation for T-sections. It is unconservative for T-sections with the slab in tension. The authors believe that minimum reinforcement should be used in both positive and negative moment regions, and particularly on cantilevers.

Note that ACI-10.5.2 permits a waiver of Eq. (3.7.8) whenever ϕM_n equals or exceeds $1.33M_u$. The philosophy is that extra safety is a satisfactory substitute for having a ductile failure mode.

3.8 DESIGN OF RECTANGULAR SECTIONS IN BENDING WITH TENSION REINFORCEMENT ONLY

In the design of rectangular sections in bending with tension reinforcement only, the problem is to determine b, d, and A_s from the required value of $M_n = M_u/\phi$, and the given material properties f'_c and f_y.

The two conditions of equilibrium are

$$C = T \tag{3.8.1a}$$

and

$$M_n = (C \text{ or } T)\left(d - \frac{a}{2}\right) \tag{3.8.1b}$$

Since there are three unknowns but only two conditions, there are many possible solutions. If the reinforcement ratio ρ is preset, then from Eq. (3.8.1a)

$$0.85 f'_c ba = \rho b d f_y$$

$$a = \rho\left(\frac{f_y}{0.85 f'_c}\right)d \tag{3.8.2}$$

Substituting Eq. (3.8.2) into Eq. (3.8.1b),

$$M_n = \rho b d f_y\left[d - \frac{\rho}{2}\left(\frac{f_y}{0.85 f'_c}\right)d\right] \tag{3.8.3}$$

*195 for flange width equal to four times web width and flange thickness equal to 50% of total

A strength *coefficient of resistance* R_n may be obtained by dividing Eq. (3.8.3) by bd^2 and letting

$$m = \frac{f_y}{0.85 f'_c} \tag{3.8.4a}$$

Thus

$$R_n = \frac{M_n}{bd^2} = \rho f_y(1 - \tfrac{1}{2}\rho m) \tag{3.8.4b}$$

The relationship between ρ and R_n for various values of f'_c and f_y is shown in Fig. 3.8.1.

In some situations the values of b and d may be preset, which is equivalent to having R_n preset; then ρ may be determined by solving the quadratic equation (3.8.4). Thus

$$R_n = \rho f_y(1 - \tfrac{1}{2}\rho m)$$

from which

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mR_n}{f_y}}\right) \tag{3.8.5}$$

The procedure (without being concerned with certain practical decisions) to be used in the strength design of rectangular sections with tension reinforcement only involves the following steps:

1. Assume a value of ρ equal to or less than $0.75\rho_b$, but greater than the minimum ρ of $200/f_y$ (ACI-10.5). The balanced value ρ_b may be obtained from basic principles or from Eq. (3.5.4),

$$\rho_b = \frac{0.85\beta_1 f'_c}{f_y}\left(\frac{87{,}000}{87{,}000 + f_y}\right)$$

and

for $f'_c \leq 4000$ psi $\quad \beta_1 = 0.85$

for $f'_c > 4000$ psi $\quad \beta_1 = 0.85 - 0.05\left(\frac{f'_c - 4000}{1000}\right) \geq 0.65$

2. Determine the required bd^2 from

$$\text{required } bd^2 = \frac{\text{required } M_n}{R_n}$$

in which

$$R_n = \rho f_y(1 - \tfrac{1}{2}\rho m)$$

with

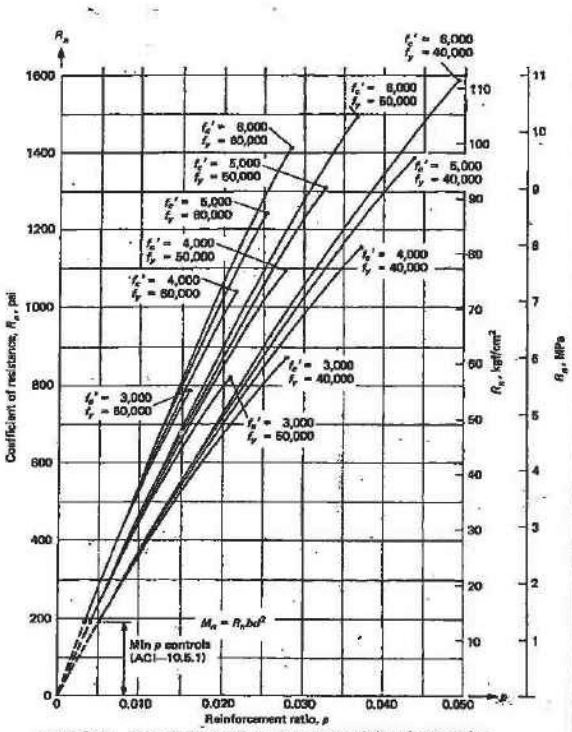

Figure 3.8.1 Strength curves (R_n vs ρ) for singly reinforced rectangular sections. Upper limit of curves is at $0.75\rho_b$.

3. Choose a suitable set of values of b and d so that the provided bd^2 is approximately equal to the required bd^2. (Note: Actually d is not chosen, rather the overall depth h is chosen and d is computed from h while maintaining the desired minimum protective cover.)

a. By formula (most exact),

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mR_n}{f_y}}\right)$$

b. By curves (Fig. 3.8.1)

c. By approximate proportion (on the safe side if revised R_n is smalle than original R_n), the revised ρ is

$$\rho \approx (\text{original } \rho)\frac{(\text{revised } R_n)}{(\text{original } R_n)}$$

It may be noted from Fig. 3.8.1 that the relationship between R and ρ is approximately linear over short distances, even though th actual equation is a quadratic one.

5. Compute A_s from

$$A_s = (\text{revised } \rho)(\text{actual } bd)$$

6. Select reinforcement and check the strength of the section to b certain that

$$\phi M_n \geq M_u \quad \text{or} \quad M_n \geq \frac{M_u}{\phi}$$

EXAMPLE 3.8.1 Determine a set of values of b, d, and A_s that will carr a factored bending moment M_u of 400 ft-kips. Use $f_c' = 4000$ psi and $f_y =$ 40,000 psi.

Solution: (a) Establish the limits within which the reinforcement ratio ρ ca be chosen. From Eq. (3.5.4),

$$\rho_b = \frac{0.85\beta_1 f_c'}{f_y}\left(\frac{87{,}000}{87{,}000 + f_y}\right) = \frac{0.85(0.85)(4)}{40}\left(\frac{87}{87 + 40}\right) = 0.0495$$

$$\max \rho = 0.75\,\rho_b = 0.0371$$

From ACI-10.5.1,

$$\min \rho = \frac{200}{f_y} = \frac{200}{40{,}000} = 0.005$$

(b) Choose reinforcement ratio ρ, determine corresponding require beam size, and select actual beam size. Arbitrarily assume that $\rho = 0.0$ (any choice within prescribed limits is acceptable here),

$$m = \frac{f_y}{0.85f_c'} = \frac{40}{0.85(4)} = 11.76$$

$$R_n = \rho f_y(1 - \tfrac{1}{2}\rho m) = 0.03(40{,}000)[1 - \tfrac{1}{2}(0.03)(11.76)] = 988 \text{ psi}$$

$$\text{required } M_n = \frac{M_u}{\phi} = \frac{400}{0.90} = 444 \text{ ft-kips}$$

required M_n = (444/12,000)

MODULE III

OPERATING CONDITIONS

MODULE III- OPERATING CONDITIONS

III.A GENERAL DESCRIPTION OF OPEN BURNING (OB)

Rocket motor propellants and igniters treated at the OB Area are thermally treated within the rocket motor or igniter casing, which serves as a containment device. The existing area consists of four OB subunits and a burn pad used to thermally treat various rocket motor propellants and igniters in order to render them non-reactive. The rocket motor with igniter is placed inside a steel subunit. The subunit acts as a secondary containment device and is made from a larger rocket motor casing.

Motors with diameters larger than the steel subunits are burned on the open burning pad assembly. Motors are inverted and attached to the motor head assembly fixture in the center of the pad. Four cable tie downs are attached to the motor for lateral stability. The propellants and igniters are reactive, but are not likely to detonate during treatment due to their inherent design.

Occasionally, propellant is burned which is not in a rocket motor casing. Rocket motor propellants are modified or downloaded periodically at Building M-15, Rocket Motor Storage Building, to meet specific project needs. When this occurs, the propellant trimmings are placed in a non-static cloth bag inside an approved container, labeled as Hazardous Waste, and placed in the Satellite Accumulation Area. Accumulated waste propellant will be burned at the OB Area during the next scheduled rocket motor burn event or when stored quantities approach 208 liters (55 gallons). Hazardous waste is manifested prior to transportation from the Main Base to the OB Area. When this material is ready for burning, the propellant is placed in the burn pan on the burn pad and ignited with a fabricated squib (igniter). The material usually burns completely leaving no residue. Ejected material and residue are also burned in this manner.

III.B STANDARD OPERATING PROCEDURES

Standard operating procedures for treatment of rocket motors were developed and approved by the Branch Head of the Carrier Systems Branch and Range Safety Office for each type of rocket motor and igniter. These procedures are included in Exhibit II.C-1 in Attachment II.C - Inspection Schedule.

Only certified rocket motor operators and technicians (see Section II.E - Personnel Training) are to perform the open burning preparation and operation activities.

OB operations are conducted between 9:01 am and 3:00 pm. OB operations will not be conducted in adverse conditions. Weather conditions will be closely monitored so that OB operations are not disrupted by adverse weather. Adverse conditions include, but are not limited to, cold weather, precipitation, electrical storms, flooding, and

high winds. Additional considerations that prohibit OB operations include rocket launches and other range activities.

After initiation of the igniter, open burning completely treats the propellant within the rocket motor casing. A minimum 1-hour cooling time is allowed to pass prior to inspection of the OB Area.

The rocket motor casing is removed from the OB Area and is taken to the NASA scrap yard on the Main Base located near the main gate. The completed work instructions and inspection checklists are kept in the OB files in Building X-55.

III.C ROCKET MOTORS AND IGNITERS

The general chemical composition of typical propellants and igniters that are thermally treated at the OB Area is given in Table 1 (Exhibit II.B-1). Each type of rocket motor and igniter varies in the type and quantity of reactive constituents. The percent composition of the chemicals is proprietary/classified information and, therefore, not provided in most cases by the manufacturer.

Typical rocket motors and igniters thermally treated at this facility and the amount of propellant in each rocket motor are summarized in Table 2 (Exhibit II.B-1).

Safe disposal of motors and igniters, which are determined to be a solid waste and classified as a hazardous waste requires thermal treatment. Treatment at the OB Area will be based on published data and inspection information for the motors and igniters. General information and Material Safety Data Sheets (MSDS) for propellants and igniters is available in the General Services Building X-55 on Wallops Island. This data is sufficient to determine the chemical suitability of the material for OB. This information will be reviewed prior to treatment; if there is a question as to the suitability of a particular motor or igniter for OB, additional data will be gathered to resolve the issue. The rocket motor or igniter will be visually inspected prior to treatment to ensure that it can be safely and effectively treated.

Based on the information in Table 1, the waste accepted for thermal treatment will be considered hazardous prior to treatment because of its reactivity characteristic; Hazardous Waste Code D003. The rocket motors and igniters are considered hazardous waste because they meet the characteristic of reactivity. Rocket motors treated at the OB Area are reactive because they are Class 1.1 through 1.3 explosives. Hazardous waste codes for individual constituents are listed in Table 1; however, U codes would not apply to the propellant mixtures containing these constituents. Applicability of toxic waste codes D007 and D008 would depend on the percentage of the constituent in the propellant composition. Certain rocket motors or ignitors may exhibit the toxicity characteristic for chromium (D007) or lead (D008) because based on their MSDS it is assumed that they would fail the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels found in 40 CFR § 261.24 Table 1.

Hazard characteristics analyses will not be performed at this point to avoid the dangers associated with the handling of reactants.

Rocket motors are designed for complete combustion of all products. Typically, after OB treatment is complete, no materials remain in the motor or are expelled from the motor. A Post Burn inspection is conducted as the final step of the work instructions included in Attachment II.C Inspection Schedule The OB Area will be visually examined after each use to verify that no materials were ejected. If materials are expelled they will be collected for further OB treatment. Rocket motor casings and igniters will be inspected for visible signs of untreated material. The primary constituents of the residue (if present) after thermal treatment will be trace amounts of reactant material and, in some cases, propellant sealant. The residue will be removed and re-ignited on the burn pad. The process will be repeated until thermal treatment is complete. Any unburnable material is to be containerized, sampled for characterization, if necessary, in accordance with 40 CFR § 261 and the OB Area Waste Analysis plan, and disposed of through WFF's hazardous waste disposal contractor. The container will be stored at Building U-81, less-than-90-day-accumulation area for less than 90 days. The rocket motor casings and igniters, after treatment and removal of any residue and will be labeled "excess" and sold as scrap metal.

III.D PROPELLANT TREATMENT RATE

The maximum amount of propellant to be treated of per year is 30.4 metric tonnes (33.5 tons) based on Virginia Synthetic Minor Air Permit 40909.

III.E WASTE GENERATED OFFSITE

Rocket motor propellants and igniters designated for thermal treatment may originate from storage buildings on the WFF Main Base or Wallops Island. Manifests and shipping documents will be inspected and reviewed to ensure that the materials received match the identity of the waste designated for thermal treatment. Rocket motor propellants and igniters are delivered directly to the OB Area for burning. They are delivered to the OB Area when scheduled for open burning. Rocket motor propellants and igniters are not stored at the OB Area.

III.F CONTROL OF EJECTED WASTE DURING BURNING

Rocket motors are designed for complete combustion of all products. Typically, after OB treatment is complete, no material remains in the motor or has been expelled from the motor. The casing remains intact. The chemical compounds are designed and blended in the correct proportions to react stoichiometrically, resulting in complete combustion of the reactants.

On occasion, thermal treatment of rocket motors may create less than 0.45 kilograms (1 pound) of residual material during burning. The residual material is typically the result of the incomplete burning of the acetate liner that separates the propellant from the casing.

A small portion of residue or propellant may be ejected during treatment, but this does not typically occur. The OB Area will be visually examined after each use to verify that no materials were ejected. If materials are expelled, they are to be collected for further OB treatment. Refer to Attachment II.C, Inspection Schedule regarding Post Burn inspections.

Ejected material is collected and burned on the pad. When conditions prevent immediate burning, ejected material would be stored in non-conductive containers at Building U-81 until the next OB event or for less than 90 days whichever, occurs sooner. During storage, the residue is to be characterized.

Igniters, like rocket motors, are designed for complete combustion with no materials remaining after treatment. If residue is produced, it is typically less than 10 grams (0.4 ounces). Residue is collected, characterized, and reignited or disposed of off-site in less than 90 days.

III.G DETERIORATION OR MALFUNCTION PROCEDURES

The requirements of 40 CFR § 264.15(c) require the owner/operator to "remedy any deterioration or malfunction of equipment or structures which the inspection reveals to ensure that the problem does not lead to an environmental or human health hazard." All facility or equipment deteriorations or malfunctions found during inspection will be corrected before OB continues. In the event of an accidental release or emergency situation, specific response procedures are included in the Attachment II.F - Contingency Plan. These response procedures are based on guidance from the *NPR 8715.2 NASA Emergency Management Program Procedural Requirements, NPR 8715.3 NASA General Safety Program Requirements* (w/Change 9 dated, 2/08/13, and RSM2002C Range Safety Manual for GSFC WFF.

III.H PREVENTION OF ACCUMULATED PRECIPITATION

The accumulation of precipitation within the containment devices is prevented at the OB Area. The rocket motors that house the propellant and/or igniter to be burned, serve as their own containment device. The motors and igniters will not be transported to the OB Area for treatment unless weather conditions are favorable. After treatment, the rocket motor casings are inspected for unburned reactants, reignited if necessary, cleaned of any remaining residue, removed from the site and recycled as scrap metal. Approximately 0.45 kilograms (1 pound) of residue may be generated after each motor treatment and less than 10 grams (0.35 ounces) of residue after each igniter treatment.

The bottom of each subunit is capped and sealed to prevent percolation of precipitation into the groundwater. The subunits are also provided with stainless steel precipitation covers. These covers offer additional protection against potential rainfall accumulation. Each cover is equipped with handles to allow personnel to easily move the cover on and off the subunit. The covers fit tightly and remain on the subunits during non-operational periods.

The burn pad is flat and above grade. A cover and berm prevent run-on and runoff from occurring. The pad will remain covered when not in use. This will prevent precipitation from accumulating on the pad. The soil around the pad is graded to prevent run-on.

III.I RESIDUE AND SOIL MANAGEMENT

Management of the residue is performed to prevent environmental contamination through the air, soil, subsurface, and surface water pathways. Residue is potentially generated at two locations in and around the OB subunits: within the device (motor), as a result of the thermal treatment process; and surrounding the subunits or burn pad in the event material is ejected. Following a burn, a Post Burn inspection is performed; refer to Attachment II.C, Inspection Schedule. The casing and surrounding soil are to be inspected and any residue collected. Collected soil and residue are placed in separate containers. The residue is placed on the burn pad for reigniting to help ensure that all materials have reacted. A squib (igniter) is fabricated and used to ignite the material. After reigniting the residue, any material remaining is placed in the soil container.

Containerized material (soil and residue) is characterized to determine waste characteristics in accordance with the OB Waste Analysis Plan, Attachment II.B, and disposed of at an appropriate solid waste or hazardous waste management facility. Residue found or known to exhibit a hazardous waste characteristic is packaged, labeled, and disposed of as a RCRA hazardous waste.

Analytical results are kept in the Open Burning Area files, Building X-55, for a minimum of three years following disposal at a RCRA-permitted hazardous waste facility. The residue is temporarily held onsite at Building U-81 for less than 90 days. The rocket motor casings and igniters, after treatment and removal of any residue, are classified as RCRA "empty" and will be sold as scrap metal.

III.J FIRE HAZARD MINIMIZATION

Ejection of burning materials during treatment could result in the deposition of hot embers on the ground adjacent to the containment device. This fire hazard is minimized at the OB Area since it is located in sparse vegetated sandy soil surrounded almost entirely by water or marsh. In addition, the WFF Fire Department

will be onsite during OB operations. Procedures and equipment will be immediately available for fire protection during treatment operations, as discussed in Attachment II.F, Contingency Plan.

III.K MINIMUM PROTECTIVE DISTANCES

The minimum safety distance for open burning is applied for Wallops Island operations. The largest motor, which could be treated at the OB Area is a GEM 46 with a propellant weight of 1,662.5 kilograms (3,665.2 pounds). The minimum distance to the property of others must be 690 meters (2,260 feet) based on the quantity of propellant treated at Wallops Island.

As shown on Figure II.A-4, although the minimum protective distance is outside of the property boundaries, it is uninhabited. The WFF Security Office controls access to Wallops Island. During an operation, access is restricted to personnel involved in operations only. The U.S. Coast Guard and the U.S. Navy control the navigable waters surrounding Wallops Island. Refer to Figure II.A-4 for Island map and boundaries.

III.L REQUIREMENTS FOR IGNITABLE, REACTIVE, OR INCOMPATIBLE WASTES

The waste propellants and igniters to be treated by OB are of similar composition and are compatible. The residue remaining after OB will be considered reactive until proven otherwise. The requirements for handling this material are stated in Attachment II.D – Security Provisions and Procedures to Prevent Hazards.

III.M WASTE MINIMIZATION PLAN

Waste will be minimized at the OB Area through the extensive process of determining other uses for each rocket motor. Rocket motors, which do not meet contractor performance standards, may be used on missions where minor flight performance is not an issue.

Rocket motors also may be used by NASA on university, on student, or other missions. Rocket motors may be tested to determine the extent of deviation from performance standards. Other users will also be found for rocket motors. In addition, many times rocket motors manufactured by commercial manufacturers can be returned.

III.N OPEN BURNING OF PROPELLANT, EXPLOSIVE AND PYROTECHNIC-CONTAMINATED SOLVENTS

No solvents of any kind are to be burned at the WFF OB unit.

TABLE III-1 ROCKET PROPELLANT AND IGNITERS

Name	Chemical Formula	Hazardous Waste Codes
(Al) Aluminum Al	$C_8H_8O_8N_8$	D003
(AP) Ammonium Perchlorate	NH_4ClO_4	D003
Bis-Neopentyl Glycol Azelate	Proprietary Formula	Unlisted
(BPN) Boron Potassium Nitrate	$BKNO_3$	D003
Candelilla wax	$C_{13}H_{64}$	Unlisted
Carbon Black	C	Unlisted
Circo Light Oil	$C_{15}H_{32}$	Unlisted
Copper chromate	CuCrO4 .2CuO .2H_2O	D007
Cupric Oxide	CuO	Unlisted
(CTPB) Carboxy-terminated Polybutadiene	$(C_4H_6)_{100}C_2H_2O_4$	Unlisted
(DDI) Desmodour diiocyanate	$C_{38}H_{72}N_2O_2$	Unlisted
Dibutylphthalate	$C_{16}H_{22}O_4$	U069
(DEP) Diethyl phthalate	$C_6H_4(CO_2C_2H_5)_2$	U088
Di Functional Aziridine	Proprietary Formula	Unlisted
Di(2-ethylhexyl) Adipate	$C_{22}H_{42}O_4$	Unlisted
Di (Butoxyethoxy) Formal	$C_{17}H_{36}O_6$	Unlisted
Diphenylguanidine	$(C_6H_5NH)_2C{=}NH$	Unlisted
(DDI) Dimeryl Diisocyanate	$C_{12}H_{18}N_2O_2$	
Dioctyl Sebacate	$(CH_2)_8(COOC_8H_{17})_2$	Unlisted
Di-n-Propyl Adipate	$C_3H_7OOC(CH_2)_4COOC_3H_7$	Unlisted
(DMP) Dimethylaminomethyl- substituted phenols	$C_6H_4OHCH_2N(CH_3)_2$	Unlisted
(DOA) Dioctyladipate	$[CH_2CH_2COOH_2CH(C_2H_5)C_4H_9]_2$	Unlisted
(DOS) Dioctylsebacate	$(C_4H_8COOC_8H_{17})_2$	Unlisted
(DOZ) Dioctyl azelate	$C_{25}H_{48}O_4$	Unlisted
(DPA) di-n-propyl adipate	$(C_6H_5)_2$ NH	Unlisted
(DTBHQ)2,5-Di-Tert-Butylhydroquinine	$[(CH_3)_3C]_2C_6H_2$-1,4-$(OH)_2$	Unlisted
Epon 812		Unlisted
Epoxy/(ERL 2795) Epoxy resin	$-OCH_2CHOCH_2$	Unlisted
Ethyloxyrane polymer		Unlisted
(FeAA) Iron acetylacetate	$C_{15}H_{21}O_6Fe$	Unlisted
Ferric (iron) oxide	Fe_2O_3	Unlisted
(Flexzone-6H) n-phenyl-n'cyclohexyl-p-phenylenediamine	$C_{18}H_{22}N_2$	Unlisted
(Flexzone/DTBH) Phenylene diamine/ hydroquinone	$C_6H_4(NH_2)_2$	Unlisted

Name	Chemical Formula	Hazardous Waste Codes
Graphite	C	Unlisted
(HDI) 1 6-Hexamethylene Diisocyanate	$C_8H_{12}N_2O_2$	Unlisted
(HMX) "Her majesty's explosive", cyclotetramethylenetetranitramine	$C_4H_8N_8O_8$	D003
(HTPB) Hydroxy Terminated Polybutadiene	$C_{73}H_{110}O_6$*	Unlisted
(HX-752) Propylene imine product of isophalic acid	$CH_2HCNHCH_2$	Unlisted
Hycar 1300 Synthetic elastomers	$C_{70}H_{100}N_{3.5}O_{1.5}$*	Unlisted
(IPDI) Isophorone diisocyanate	$C_{12}H_{18}N_2O_2$	Unlisted
Isophorone Diisocyanate Polymer with Hydroxyl Terminated Polybutadiene	$C_{85}H_{128}N_2O_8$	Unlisted
Isodecyl Pelargonate	$C_{19}H_{38}O_2$	Unlisted
Laminac	Proprietary formula	Unlisted
(LBR) Lead beta-resorcylate	$C_{14}H_{10}O_8Pb$	D008
Lead 2-ethyl hexoate	$PbC_5H_{11}COOC_2H_4$	D008
Lead salicylate	$Pb(OOCC_6H_4OH)_2.H_2O$	D008
Lead stearate	$C_{36}H_{70}O_4Pb$	D008
(MAPO) tris 1-(2-methyl) aziridinyl phosphine oxide	$C_9H_{18}N_3OP$	Unlisted
Magnesium	Mg	D003
Maleic Anhydride	$C_2H_2(CO)_2O$	U147
Methylene Bis-Di-t-Butyl-P-Cresol	$C_{15}H_{24}O$	Unlisted
Monobasic copper salicylate	$Cu(OOCC_6H_4ON)_2.H_2O$	Unlisted
MT-4 bonding agent	Proprietary formula	Unlisted
(NC) Nitrocellulose	$C_{12}H_{16}(ONO_2)_4\ O_6$	D003
(2-NDPA) 2-nitrodiphenyl amine	$C_6H_5NHC_6H_4NO_2$	Unlisted
(NDPA) n-phenyl-beta-napthylamine	$C_{10}H_7NHC_6H_5$	Unlisted
(NG) Nitroglycerin	$C_3H_5N_3O_9$	D003
(Ngu) Nitroguanidine	$CH_4N_4O_2$	D003
Octylene oxide	Mixed $CH_3\ (CH_2)_5\ CHCH_2O$ & $CH_3\ (CH_2)_4\ CHCH(CH_3)O$	Unlisted
(Parabar 441) 2,6-di-tert-butyl-p-cresol	$[C(CH_3)_3]_2CH_3C_6H_2OH$	Unlisted
(PBAA) Polybutadiene acrylic acid	C70H104O4*	Unlisted
Pluracol TP	$(C_3H_6O)n\ (C_3H_6O)n\ (C_3H_6\ O)n\ C_6H_{14}O_3$	Unlisted
(PMAPO) bis 1-(2 methyl) aziridinyl phosphine oxide	$C_{12}H_{17}N_2OP$	Unlisted
Poly 1,4-butylene glycol	$HOCH_2CH_2CH_2CH_2OH$	Unlisted
Polyether Polyol	$H\text{-}(O\text{-}CH_2\text{-}CH_2)_n\text{-}OH$	Unlisted
(PPG) Polypropylene glycol	$HO\ (C_3H_6O)_n\ H$	Unlisted

Name	Chemical Formula	Hazardous Waste Codes
(PS) Polysulfide	$[-CH_2S_2S_2-]_n$	Unlisted
(PU) Polyurethane	$R_1NHCOOR_2$	Unlisted
(PVC) Polyvinylchloride	$(-H_2CCHCl-)_x$	Unlisted
Potassium perchlorate	$KClO_4$	D003
1,2-Propanediol	$C_3H_8O_2$	Unlisted
Quinone Dioxime	$C_6H_6N_2O_2$	Unlisted
(RDX) "Royal daughter's explosive", cyclotrimethyl- enetrinitramine	$C_3H_6N_6O_6$	D003
Resorcinol	$C_6H_4(OH)_2$	U201
Sodium Nitrate	$NaNO_2$	Unlisted
(S) Sulfur	S	Unlisted
(TA) Triacetin	$C_3H_5(OCOCH_3)_3$	Unlisted
(TDI) Toluene di isocyanate	$CH_3C_6H_3\ (NCO)_2$	U223
(TEA) Triethanol amine	$(HOCH_2CH_2)_3N$	Unlisted
Teflon resin	$(C_2F_4)_n$	Unlisted
(TEPAN) Tetraethylene Pentamine Acrylonitrile	$C_{14}H_{32}N_6O_2$	Unlisted
Tri-(Monylphenyl) Pyosphite		Unlisted
Tricalcium phosphate	$Ca_3O_8P_2$	Unlisted
(TPB) Triphenylbismuth	$C_{18}H_{15}Bi$	Unlisted
Vegetable Oil	$C_{54}H_{100}O_7$	Unlisted
Viton A Copolymer	Proprietary Formula	Unlisted
Zinc Stearate	$Zn\ (C_{18}H_{35}O_2)_2$	Unlisted
(ZrC) Zirconium carbide	ZrC	Unlisted

TABLE III-2 - ROCKET MOTORS AND IGNITERS TO BE THERMALLY TREATED

Motor	Propellant (lbs.)	Length (in.)	Diameter (in.)
2.75" FFAR MK40	5.9	48	2.75
2.75" FFAR MK66	7.2	50	2.75
Aerotek Hobby Motors	0.5	1.8	1.5
Apache	131	107.5	7
Arcas	65	60.7	4.45
Arcas Igniter	<1	1.9	1.3
Aerojet Jr Igniter	0.62	3	2
ATACM MK124	1,600	79	24
Black Brant III	447	147	10.2
Black Brant MK Series	2,198	223	17.2
Black Brant Standard	2,198	223	17.2
Black Brant Igniter	1.5	8	1.5
Cajun	118.5	107.7	7
CRV-7/C14	10.2	31	2
CRV-7/C15 and C16	10.2	31	2
Improved Malemute	1106	130	16
Improved Malemute Igniter	3	6	3
Improved Orion	647	105.5	14
Javelin III	258	104	9
Javeline III Igniter	0.5	2	1
Lance	2,800	246	21.6
Lance Igniter	2	3	1.5
Lynx MK 104	795	113	13.5
M26	216	78	9
M37 Spin Motor	2	13.5	3.75
M37 Regrain Spin Motor	3	13.5	3.75
M57A1	3,665.2	85.25	38
Malemute	1,115	114	17.25
Malemute Igniter	3	6	3
MK12 Terrier	1202	155	18
MK 70 Terrier	1500	155	18
MK12 and MK70 Terrier Igniter	1.87	9	7.5
NASA Tracking Flare	<1	1.9	1.3
Nihka	756	76	17.2
Nike	750	145.2	16.5
Oriole	2,148	155	22

Motor	Propellant (lbs.)	Length (in.)	Diameter (in.)
Orion	604	105.5	14
Orion Igniter	2	6	2
Peregrine	2950	220	20
Sidewinder	60	75.5	5
Star 3A (MER TIRS)	1.0	7.5	3.2
Star 6B	13.5	17	6.5
Star 20	602	58.5	19.7
Star 20 Igniter	1.5	5	2
Super Arcas	40	76	4.5
Super Loki	38	78.1	4
Super Loki Igniter	0.25	2	1
Talos	2,803	134.5	30.9
Taurus	1,663	166.125	23
Tomahawk	387	142	9
Tomahawk Igniter	4	3	4
Ute I	550	77	16.5
Ute Igniter	0.5	4	3
Viper	148.8	107	6.5
Zuni	50	176.5	5

MODULE IV

SITE-WIDE CORRECTIVE ACTION

MODULE IV - SITE-WIDE CORRECTIVE ACTION

IV.A MODULE HIGHLIGHTS - BACKGROUND

The United States Environmental Protection Agency (US EPA) and NASA WFF entered into an Administrative Agreement on Consent under RCRA §7003 (Docket No: RCRA-03-2004-0201TH). This Agreement was signed in September 2004 and directs NASA to conduct the on-going remedial investigation activities in accordance with the requirements of CERCLA (42 USC§9601-9675) under the authority of RCRA §7003 to fulfill the requirements of 40 CFR § 264.101.

The Agreement is included as Exhibit IV.A-1.

The referenced Administrative Agreement on Consent (AAOC) dated September 27, 2004, applies to NASA Wallops Flight Facility EPA Identification numbers VA7800020888 and VA8800010763. The intention of the AAOC was to require NASA to maintain a cleanup schedule for existing contaminated sites and report on progress. The AAOC is managed under the VDEQ Federal Facility Facilities Restoration Program and the EPA Facility Remediation and Site Assessment. NASA meets quarterly with EPA and VDEQ in administration of this consent order and annually adopts a site management plan. These meetings have never discussed the OB Area, nor has any EPA or VDEQ hazardous waste inspection of the OB Area ever referred to the AAOC.

The OB Area on the southern end of the island is just one hazardous waste activity covered by VA7800020888. The OB Area does not include launch sites, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, and tracking facilities described above. This language comes from #9 on page 6 of the AAOC which states:

> "NASA has identified the following areas where former waste disposal activities may have occurred at the Wallops Island Parcel: an open burn waste treatment area, launch sites, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, and tracking facilities."

The Annual Site Management Plan, a requirement of the AAOC, discusses the 2nd ASR (also called the Rocket Report), which was not finalized. The document concluded no feature or area was observed to warrant immediate safety or environmental actions to remedy past rocket operations.

In fiscal year (FY) 2006, to further supplement the facility-wide assessments discussed above, NASA initiated a second ASR focusing on operations post-1959 activities. The supplemental, or Phase II ASR, was also conducted by the USACE St. Louis District and evaluated operations conducted at WFF during the early years of NASA operations as well as operations conducted by other Federal Agencies under

existing tenant agreements. The ASR records and field investigation was conducted in FY 2007 and FY 2008. A draft report presenting the findings of the review was released during the second quarter of FY 2009. However, because the USACE also was conducting a facility-wide assessment, the report was not finalized under the NASA agreement. The draft report was submitted to the USACE, EPA, and DEQ for review to support the ongoing USACE investigation and to be used to support reaching a consensus on the identification of any additional potential areas of concern (AOC). Based on the review it was determined that no new NASA AOCs were identified.

All sites listed below have been investigated under the AAOC, executed between NASA and the EPA in 2004. The AAOC was issued under the authority of RCRA and by agreement integrates CERCLA into meeting the obligations. The AAOC applies to past historic releases of hazardous substances, waste, and/or constituents at WFF and identifies CERCLA response requirements, policies, and guidance as the primary process for planning and performing the work necessary to complete remedial and corrective actions. A topographic map showing these site locations is included as Exhibit IV-2.

IV.B CORRECTIVE ACTION UNITS

Site 4, Island Debris Pile

Site 4 was located in a remote area on northern Wallops Island and consisted of a heavily vegetated debris pile/open dump containing debris, rubble, and general refuse. The debris pile was approximately 400 feet long and 10 to 40 feet wide. Soil samples were initially collected at the site in 1996. Semi-volatile organic compounds (SVOCs), metals, pesticides, and petroleum hydrocarbons were found to be above background levels and asbestos was confirmed in one sample of debris. A historic review indicated the debris pile was likely in existence prior to 1959 and may have been used by the Navy prior to NASA ownership. A series of studies and debris characterization, removal, and disposal was conducted through 2007. A total of 327 tons of solid waste soil and debris were disposed at the Accomack County Landfill and approximately 186 tons of TPH and PCB-contaminated soils were removed and transported to Chemical Waste Management in Model, City, New York. In addition approximately 23 tons of scrap metal was removed from the site. A Site Investigation was then initiated and completed in 2008 and 2009. No unacceptable risks from exposure to groundwater were indicated, however results indicated potential unacceptable risks from exposure to PAHs in soil. A Non-Time Critical Removal Action (NTCRA) to address residual soil contamination was completed in 2011. A total of 2,491 tons of soil, 3.2 tons of root material, 1.7 tons of general debris, and 3.2 tons of metal were removed and disposed during the NTCRA. A No Further Action decision was signed by EPA, Virginia DEQ, and NASA in February 2012.

Sites 5 and 12, Paint Stain and Former Wind Tunnel

Sites 5 and 12 were collocated on Wallops Island and consisted of contamination associated with former painting operations and historic wind tunnel activities. Site 5 encompassed approximately 2 acres and was located adjacent to a paint booth. Contamination originating from the paint booth occurred in the past because of an inadequate exhaust venting from the building. The paint booth exhaust was rebuilt to minimize emissions and undergoes annual inspection by Virginia DEQ. Site 12 encompassed approximately 3.4 acres and included a former wind tunnel facility and the surrounding upland and marsh areas. The wind tunnel facility was constructed in 1947 and was used through 1960. Soil, groundwater, and sediment samples were initially collected at the sites in 1996. Analytical results indicated elevated levels of PCBs, SVOCs, and metals in surface soils and sediments. A Remedial Investigation (RI) was completed in 2001 to define the nature and extent of the contamination and to support a decision regarding the need for and type of remedial response actions at the sites. Additional groundwater, soil, sediment, surface water, and ecological tissue samples were collected and analyzed. Results indicated concentrations of PAHs exceeded risk based concentrations for industrial receptors, the sites posed an unacceptable risk to human health, and that levels of contamination in surface soils and sediments presented a potential risk to ecological receptors. A removal action was implemented in 2003 to address the immediate human health risks. A total of 2,936 tons of soil were removed during this initial removal action.

Additional RI activities were completed from 2003 - 2005, which included additional soil, groundwater, surface water, and ecological tissue sampling analysis. The RI Report was submitted to EPA and Virginia DEQ in 2006 and finalized in 2008. Metals, PAHs, and PCBs were identified in soils at levels that warranted further response actions. A Feasibility Study, which was finalized in 2009, identified excavation and offsite disposal as the preferred alternative for Sites 5 and 12. A Proposed Remedial Action Plan proposing the preferred remedy was completed in 2010 and no public comments were received. The Record of Decision was approved by EPA and Virginia DEQ in 2011. Remedial Design and Remedial Action Work Plans were prepared and finalized in 2012. Remedial Action field investigation activities began in March 2013, excavation activities began in April 2013, and site restoration was complete in June 2013. The final Remedial Action Completion Report was approved in June 2013 and EPA issued a Certificate of Completion stating the cleanup of Sites 5 and 12 was complete.

South End Disposal Area

The South End Disposal Area consisted of an elevated berm located perpendicular to the shoreline at the south end of Wallops Island. The berm which was a former debris pile that served as a physical shoreline erosion barrier, contained soil, sand, concrete and metal debris, and Munitions and Explosives of Concern (MEC). The berm, which was created in the early 1980's, was approximately 105 feet long, 28 feet wide, and up to 8 feet high, however historic photographs indicated the original

length of the disposal area was approximately 450 feet in length. Due to continuous erosion over time, a large portion of the South End Disposal Area was eroded into the ocean. The site was identified in 2009 after a series of storms caused significant beach erosion and military munitions were exposed within the berm. Air Force Explosive Ordnance Disposal (EOD) units responded and treated the exposed munitions (3.5-inch M28 and M29 Rockets). A total of 21 rocket propelled grenades (RPGs) and NASA-related spin motors and rocket debris were identified and removed by the EOD unit between November 2009 and March 2010. In May 2010, EPA, Virginia DEQ, and NASA agreed to address the potential safety hazards by conducting a limited response action to remove and treat the remaining MEC items. The removal action, which was completed in October and November 2010, consisted of excavating the berm and shallow soils and removing and treating the MEC. Sixteen additional RPGs and two NASA spin motors were removed and treated during the early action. NASA prepared a Preliminary Assessment of the South End Disposal Area, which included a review of historical records and aerial photographs, and a series of interviews with current and former NASA employees. Based on the findings of the Preliminary Assessment, a focused sampling study to complete the screening process was completed. Soil and groundwater sampling activities were completed at the site in November 2012. All samples were analyzed for VOCs, SVOCs, PCBs, and metals. In addition, the groundwater samples were analyzed for perchlorate. Results indicated VOC, SVOC, PCBs, and perchlorate were either non-detect or were detected in soil and groundwater at trace levels well below the Regional Screening Levels. Metal concentrations in soil were within expected values for Wallops Island, and based on the human health risk-ration evaluation, would not cause unacceptable risks under current or hypothetical future residential use. A potentially unacceptable risk was presented under the hypothetical future residential/potable use of site groundwater due to aluminum and manganese concentrations. Under Virginia regulations, potable wells would not be allowed at the site due to periodic flooding from extreme tides and storm events, and the water would need desalinization treatment to be potable. In March 2014, EPA and Virginia DEQ concurred no additional investigations or response actions were warranted for the site under CERCLA.

Area of Interest-20 and North Island Transformer Sites

Area of Interest (AI)-20 was a pole-mounted transformer located in a remote area at the north end of Wallops Island. AI-20 was identified during a Preliminary Assessment conducted by the U.S. Army Corps of Engineers (USACE) under the Formerly Used Defense Sites Program. A Site Inspection completed in 2012 identified elevated PCBs in surface soils surrounding the transformer and pole. The investigation at AI-20 prompted NASA to conduct a review of historic maps and photos and site reconnaissance to determine if other transformers remained on the island. As a result, 17 potential electrical poles/transformer locations were identified on the north end of Wallops Island and were grouped into the North Island Transformer (NIT) Sites. All transformers/poles were abandoned remnants of power

supply structures installed by the Navy in the 1950s. Separate site screening sampling activities were conducted at AI-20 and the NIT Sites in 2014 and 2015. Based on site findings, NASA, EPA, and Virginia DEQ determined Time-Critical Removal Actions for soils were necessary to address the PCB releases at AI-20 and two NIT locations (NIT-1 and -17); NIT-7 and NIT-14 required transformer removal only. Following additional screening investigations, no further action was necessary at the remaining NIT locations since PCBs were not detected. An Action Memorandum was prepared and public notice issued for AI-20 in July 2015. Removal actions for AI-20 were completed in August 2015. Site closure for AI-20 is anticipated in spring 2016. An Action Memorandum was issued for NIT-1, NIT-7, NIT-14, and NIT-17 was prepared and public notice was issued in January - March 2016. Removal actions were completed in June 2016, with site closure anticipated in August 2016.

IV.C PRESENT AND HISTORICAL RELEASES

In addition to the above discussion, past releases at the OB Area are discussed in Section 4.3 of the Closure and Post Closure Plan and restated below. Following these releases, no additional groundwater monitoring was conducted and there were no complaints or enforcement actions.

On July 30, 2013, several fires developed in the immediate vicinity of the OB Area and one fire in the State of Virginia marsh, northwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. During the inspection process of the motor, inconsistencies were found in the Taurus rocket motor, which were similar to those found in the motor which caused the fire on July 17, 2013. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, positioned additional equipment and manpower at the site to respond to the fire, should one occur. As a result, all fires on WFF property were immediately extinguished. The fire on Virginia state property was extinguished within 45 minutes.

On July 17, 2013, several fires developed in the State of Virginia marsh, northwest, west, and southwest of the OB Area. The fires occurred as a result of small pieces of ejected propellant from the open burning of one Taurus motor. The Wallops Flight Facility Fire Department, which is on-scene for all OB operations, responded to the fire. Additional water tankers were supplied by the Atlantic Virginia Volunteer Fire Department. All permit procedures were followed during treatment. A Ground Safety representative was also present during operations. The fire self-extinguished at approximately 9:16 p.m.

On October 25, 2010, two small fires, each scarring approximately patches of grass and brush covering an area of approximately 10 feet by 10 feet. One fire extinguished itself and the other fire was extinguished with water by the on-scene Wallops Fire Department. The fire, which extinguished itself, was approximately 30 feet northeast

of the burn pad, on the road. The second fire was approximately 20 feet southwest of the burn pad in the brush. The ejected material was from Arcas motor grain.

On March 25, 2009, during routine Open Burn (OB) Area operations, the on-scene fire department personnel responded to two small brush fires at the facility. The fire did not occur outside the facility, did not result from a release of hazardous waste, and did not threaten human health or the environment.

On March 10, 1992, six Nike rocket motors were prepared for OB at the rocket motor disposal site on the south end of the island. These motors, which were manufactured in 1959, had been contaminated with sea water during the January storm which hit Wallops Island. Two of the six motors were prepared for open burning and at approximately 1430, the first motor was ignited without incident. Upon ignition of the second motor an anomaly occurred which resulted in the motor being ejected from the subunit. This motor hit the pavement in the vicinity of the tube from which it had been ejected and came to rest approximately 50 meters south of the tube in the marsh/beach area. There were no personnel injuries nor significant property damage as a result of this anomaly. It should be noted that all necessary safety precautions were followed and all environmental restrictions adhered to during these disposal operations. The technicians also indicated several small brush fires were started by this motor. One fire was unique in that it was started approximately 150 meters west of and behind the barricade. All fires were extinguished by Damage Control, which, according to standard operating procedure, was stationed behind the barricade. These fires were most likely the result of burning propellant being ejected from the motor. Procedures were modified to prevent reoccurrence of this anomaly.

EXHIBIT IV.A-1: ADMINISTRATIVE AGREEMENT ON CONSENT

UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

REGION III

IN THE MATTER OF: National Aeronautics and Space Administration Wallops Island, Virginia RESPONDENT NASA GSFC Wallops Flight Facility Route 803 Wallops Island, Virginia 23337 EPA I.D. No. VA8800010763 GSFC/NASA Wallops Flight Facility Route 798 Wallops Island, Virginia 23337 EPA I.D. No. VA7800020888 FACILITY	ADMINISTRATIVE AGREEMENT ON CONSENT U.S. EPA Docket Number: RCRA-03-2004-0201TH Proceeding under Section 7003 of the Resource Conservation and Recovery Act, as amended, 42 U.S.C. § 6973.

ADMINISTRATIVE AGREEMENT ON CONSENT

ADMINISTRATIVE AGREEMENT

TABLE OF CONTENTS

I. JURISDICTION 2

II. PARTIES BOUND 2

III. STATEMENT OF PURPOSE 3

IV. FINDINGS OF FACT 4

V. CONCLUSIONS OF LAW AND DETERMINATIONS 7

VI. WORK TO BE PERFORMED 8

A. RCRA-CERCLA INTEGRATION 8

B. EARLY ACTIONS 9

C. SITE MANAGEMENT PLAN 11

D. REMEDIAL INVESTIGATION 12

E. FEASIBILITY STUDY 13

F. PUBLIC COMMENT AND PARTICIPATION 13

G. REMEDIAL DESIGN/REMEDIAL ACTION(S) 14

H. SUBMISSIONS/EPA APPROVAL/ADDITIONAL WORK 17

VII. QUALITY ASSURANCE 19

VIII. PUBLIC COMMENT AND REVIEW OF AGREEMENT 20

IX. ON-SITE AND OFF-SITE ACCESS 20

X. SAMPLING AND DATA/DOCUMENT AVAILABILITY 22

XI. RECORD PRESERVATION 23

XII. PROJECT COORDINATORS 23

XIII. NOTIFICATION 24

XIV. DELAY IN PERFORMANCE/STIPULATED PENALTIES 26

XV. DISPUTE RESOLUTION 28

XVI. ENFORCEABILITY 30

XVII. FORCE MAJEURE AND EXCUSABLE DELAY 31

XVIII. FUNDING 32

XIX. RESERVATION OF RIGHTS 32

XX. OTHER CLAIMS 33

XXI. OTHER APPLICABLE LAWS 34

XXII. NOTICE OF NON-LIABILITY OF EPA 34

XXIII. SUBSEQUENT MODIFICATION 34

XXIV. SEVERABILITY 35

XXV. TERMINATION AND SATISFACTION 35

XXVI. ATTORNEYS' FEES 35

XXVII. EFFECTIVE DATE 35

ATTACHMENT

Attachment 1 Index of Administrative Record

UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

REGION III

IN THE MATTER OF: National Aeronautics and Space Administration Wallops Island, VA RESPONDENT NASA GSFC Wallops Flight Facility Route 803 Wallops Island, Virginia 23337 EPA I.D. No. VA8800010763 GSFC/NASA Wallops Flight Facility Route 798 Wallops Island, Virginia 23337 EPA I.D. No. VA7800020888 FACILITY	ADMINISTRATIVE AGREEMENT ON CONSENT U.S. EPA Docket Number: RCRA-03-2004-0201TH Proceeding under Section 7003 of the Resource Conservation and Recovery Act, as amended, 42 U.S.C. § 6973.

ADMINISTRATIVE AGREEMENT ON CONSENT

The parties to this Administrative Agreement on Consent ("Consent Agreement" or "Agreement"), the United States Environmental Protection Agency ("EPA") and the National Aeronautics and Space Administration ("NASA") (collectively, the "Parties"), having agreed to enter into this Consent Agreement, it is therefore agreed that:

I. JURISDICTION

1. This Consent Agreement is issued pursuant to the authority vested in the Administrator of the EPA by Section 7003 of the Resource Conservation and Recovery Act of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984 (collectively referred to hereinafter as "RCRA"), 42 U.S.C. Section 6973. The authority vested in the Administrator has been delegated to the Regional Administrators by EPA Delegation No. 8-22-C dated March 20, 1985 and further delegated to the Director of the Waste and Chemicals Management Division on September 1, 1998.

2. On March 6, 1986, EPA granted the Commonwealth of Virginia (the "Commonwealth" or "Virginia") authorization to operate a state hazardous waste program in lieu of the federal program, pursuant to Section 3006(b) of RCRA, 42 U.S.C. § 6926(b) and since that time, EPA has authorized revisions to Virginia's hazardous waste program. The Commonwealth, however, does not have authority to enforce Section 7003 of RCRA. The Commonwealth has been given notice of this Consent Agreement pursuant to Section 7003(a) of RCRA, 42 U.S.C. § 6973(a).

3. EPA enters into this Consent Agreement with NASA, the owner and operator of the following two facilities: (1) Wallops Main Base located at NASA GSFC /Wallops Flight Facility, Route 803 Wallops Island, Virginia 23337 (EPA I.D. No. VA8800010763) (the "Main Base Parcel") and (2) Wallops Island located at GSFC/NASA Wallops Flight Facility, Route 798, Wallops Island, Virginia 23337 (EPA I.D. No. VA7800020888) (the "Wallops Island Parcel"). NASA consents to this Consent Agreement and agrees to comply with its terms and will not contest EPA's authority to enter into this Consent Agreement and to enforce its terms. Further, NASA will not contest EPA's authority to compel compliance with this Consent Agreement in any subsequent enforcement proceedings, require NASA's full or interim compliance with the terms of this Consent Agreement, or impose sanctions for violations of this Consent Agreement.

II. PARTIES BOUND

1. This Consent Agreement shall apply to and be binding upon EPA, NASA and their agents, successors and assigns.

2. No change in ownership of any property covered by this Consent Agreement, or in the organization or status of NASA, shall in any way alter, diminish, or otherwise affect NASA's obligations and responsibilities under this Consent Agreement.

3. NASA is responsible for complying with this Consent Agreement and for ensuring that all work performed pursuant to this Consent Agreement is conducted in accordance with the requirements of this Consent Agreement. NASA shall provide written notification of the requirements of this Consent Agreement as well as provide an opportunity to review it upon request to all supervisory personnel, contractors, subcontractors, laboratories, and consultants retained to conduct or monitor any portion of the work performed pursuant to this Consent Agreement and shall do so within seven (7) calendar days of the effective date of this Consent Agreement or date of such retention, whichever is later. All contracts, agreements or other arrangements with such persons shall require such persons to conduct or monitor the work in accordance with the requirements of this Consent Agreement. Notwithstanding the terms of any such contract, agreement or arrangement, NASA is responsible for complying with this Consent Agreement and for ensuring that all such persons perform such work in accordance with this Consent Agreement.

4. In the event of any change in ownership or operation of the Main Base Parcel and/or the Wallops Island Parcel, NASA shall notify EPA in writing of the nature of any such change no later than fifteen (15) calendar days after the effective date of such change. In addition, NASA shall provide a copy of this Consent Agreement to any successor to the Main Base Parcel and/or the Wallops Island Parcel at least fifteen (15) calendar days prior to the effective date of such change. Nothing stated in this Paragraph 4 shall relieve NASA from complying with the terms and conditions of this Consent Agreement in the time and manner specified herein.

III. STATEMENT OF PURPOSE

1. In entering into this Consent Agreement, the mutual objectives of EPA and NASA are: (1) to control the human and ecological exposure to releases of hazardous substances, solid wastes, hazardous wastes and/or hazardous constituents from any medium; (2) to perform Early Actions ("EA"), as necessary, to prevent or mitigate threats to public health or the environment; (3) to perform a Remedial Investigation ("RI") to determine fully the nature and extent of any release of hazardous substances, solid wastes, hazardous wastes and/or hazardous constituents at or from the Main Base and/or Wallops Island Parcels; (4) to perform a Feasibility Study ("FS") to identify and evaluate alternatives for remedial action(s) necessary to prevent or mitigate migration or releases of hazardous substances, solid wastes, hazardous wastes and/or hazardous constituents at or from the Main Base and/or Wallops Island Parcels; and (5) to implement and monitor, if applicable, the remedial alternative(s) approved by EPA.

IV. FINDINGS OF FACT

1. NASA is a federal agency and is a "person" as defined in Section 1004(15) of RCRA, 42 U.S.C. § 6903(15). NASA is subject to the requirements of Section 6001 of RCRA, 42 U.S.C. § 6961, including compliance with the requirements of RCRA in the same manner as a person, as defined in Section 1004(15) of RCRA, 42 U.S.C. § 6903(15).

2. NASA has owned and operated the Wallops Flight Facility ("WFF") located on Route 175, in Wallops Island, Accomack County, Virginia since 1959. The WFF consists of three landmasses: Wallops Main Base, Wallops Mainland and Wallops Island. This Consent Agreement is issued to NASA for the Wallops Main Base ("Main Base Parcel") and Wallops Island ("Wallops Island Parcel"). The Wallops Island Parcel includes the Wallops Mainland.

3. On September 29, 1992, NASA submitted to Virginia a Notification of Regulated Waste Activity, pursuant to Section 3010 of RCRA, 42 U.S.C. § 6930, in which NASA stated that it had handled, stored, treated, transported and/or disposed of hazardous wastes with the following hazardous wastes identification numbers at the Main Base Parcel: D001, D002, D003, D004, D006, D007, D008, D009, D011, D018, D026, D035, D037, D039, F001, F002, F003, F005, F006, U019, U165, U210, U220 and M001, as identified in 40 C.F.R. §§ 261.21 through 261.24, 261.31 and 261.33.

4. NASA's activities at the Main Base Parcel include metal plating and etching, cleaning of tools and machines, generation of acidic overflow from recovery of photographic silver, handling of aircraft fuel spills and contaminated aircraft fuels, waste oil disposal and storage of aviation fuel. During these activities, NASA has used volatile organic compounds ("VOCs"), semi-volatile organic compounds ("SVOCs"), polychlorinated biphenyls ("PCBs"), and total petroleum hydrocarbons ("TPHs") in its operations at the Main Base Parcel.

5. In 1990, NASA conducted a site investigation ("SI") of an area at the Main Base Parcel known as the Waste Oil Dump ("WOD"). In the SI Report, NASA states that waste oils were transported to the WOD and dumped onto the soil surface. Sample results obtained during the SI revealed the presence of metals, VOCs, and SVOCs in the soils at the WOD. Groundwater sampling results obtained during the SI in the WOD area showed that groundwater associated with the WOD had been contaminated with lead and chromium at concentrations exceeding their respective Maximum Contaminant Levels ("MCLs") promulgated by EPA pursuant to the Safe Drinking Water Act, 42 U.S.C. §§ 300f et seq.

6. In March 2001, NASA completed a Remedial Investigation and Feasibility Study

("RI/FS") for the WOD and reported the results in a RI/FS Report. EPA reviewed the surface soil sample results summarized in the RI/FS Report and identified ten chemicals that were present at levels above applicable screening values for either human or ecological receptor exposure. These chemicals are considered Chemicals of Potential Concern ("COPCs") and require further evaluation. The applicable screening values for human and ecological risk include either Region III Risk Based Concentrations ("RBCs"), Biological Technical Assistance Group ("BTAG") values, or site specific background levels. EPA also reviewed groundwater sample results summarized in the RI/FS Report and identified three constituents as COPCs because they were present at levels above their respective MCLs or their applicable action level. A summary of these COPCs is presented in Table 1, below.

Table 1

Chemicals of Potential Concern ("COPC")	Maximum Concentration	Screening Values ([A]RBCs (residential) or [B]BTAG)	Risk category
Surface Soils			
Benzo(a)pyrene	1,200 µg/kg	87 µg/kg 100.0 µg/kg	[A]Human Health [B]Ecological
Aluminum	1.06×10^7 µg/kg	1,000 µg/kg	[B]Ecological
Arsenic	2900 µg/kg	430 µg/kg	[A]Human Health
Benzo(g,h,i)perylene	550 µg/kg	100.0 µg/kg	[B]Ecological
Chrysene	405 µg/kg	100.0 µg/kg	[B]Ecological
Indo(1,2,3-cd)pyrene	140 µg/kg	100.0 µg/kg	[B]Ecological
4,4'-DDE	310 µg/kg	< 100.0 µg/kg	[B]Ecological
4,4"-DDT	260 µg/kg	< 100.0 µg/kg	[B]Ecological
Chromium (not speciated)	11000 µg/kg	7500 µg/kg	[B]Ecological
Lead	60,500 µg/kg	10.0 µg/kg	[B]Ecological
Groundwater			
Arsenic	88.2 µg/l	10 µg/l	[C]Human Health

Chemicals of Potential Concern ("COPC")	Maximum Concentration	Screening Values ([A]RBCs (residential) or [B]BTAG)	Risk category
Groundwater			
Lead	62.8 µg/l	*0 mg/l	[C]Human Health
Thallium	3.0 µg/l	2 µg/l	[C]Human Health

[A]RBCs - EPA Region III Risk Based Concentrations for a residential scenario (updated April 2003)
[B]BTAG - Region III Biological Technical Assistance Group based on soil fauna levels (dated August 9, 1995)
[C]MCLs - Maximum Contaminant Levels or MCLs (dated July 2002)
* - Action level for lead is 0.015 mg/l
ug/kg - micro grams per kilogram
ug/l - micrograms per liter
mg/l - milligrams per liter

Manganese, vanadium, Total Petroleum Hydrocarbon (TPH)-Gasoline Range Organics (GRO) and TPH-Diesel Range Organics (DRO), detected at concentrations of 3,510 ug/l, 3.09 ug/l, 4,000 ug/l and 83,000 ug/l respectively, were also identified as COPCs for the human health risk assessment in the RI/FS. Manganese and vanadium do not have promulgated screening levels and are noncarcinogens that have associated toxic effects. The detection of TPH-GRO and TPH-DRO provide qualitative information that gasoline and diesel type materials are present in the groundwater despite the removal action that was conducted.

7. As part of the RI/FS, NASA conducted an Ecological Risk and Human Health Risk Assessment ("Risk Assessment"). For the human health risk evaluation, the Risk Assessment indicated that future use of groundwater as a potable source at the Main Base Parcel may pose potentially significant health risks to residential adults and children.

8. On August 25, 1992, NASA submitted to Virginia a Notification of Regulated Waste Activity, pursuant to Section 3010 of RCRA, 42 U.S.C. § 6930, in which NASA stated that it had handled, stored, treated, transported and/or disposed of hazardous wastes with the following hazardous wastes identification numbers at the Wallops Island Parcel: D001, D002, D003, D007, D008, D035, D039, F003, F005, F006, U220, U133, P068 and M001 as identified in 40 C.F.R. §§ 261.21 through 261.24 and 261.33.

9. NASA has identified the following areas where former waste disposal activities may have occurred at the Wallops Island Parcel: an open burn waste treatment area, launch sites, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, and tracking facilities.

10. NASA investigated an area on Wallops Island known as the Debris Pile as part of a SI that was conducted in March of 1996. As a result of that investigation, in 1996, NASA conducted a magnetometer survey in the Debris Pile. NASA determined that the pile was approximately 400 feet long with a width ranging from approximately 10 feet to 40 feet. NASA also took three subsurface soil samples and compared them with a background soil sample that was collected during the same event. Elevated levels of SVOCs and metals were detected in three of the samples, pesticides were detected in one sample and petroleum hydrocarbons in two of the samples.

11. Based on the findings above, EPA has determined that NASA's past handling, storage, treatment, transportation and/or disposal of solid wastes, hazardous wastes and/or hazardous constituents at the Main Base Parcel and the Wallops Island Parcel may present an imminent and substantial endangerment to health or the environment.

12. The Parties agree that for petroleum releases, NASA, with oversight by the Virginia Department of Environmental Quality (VDEQ), will manage the response actions.

13. The Parties agree that currently, formerly used defense (FUD) sites that are located at the Main Base and have been identified by the United States Corps of Engineers ("Corp"), are being managed by the Corps.

V. CONCLUSIONS OF LAW AND DETERMINATIONS

1. NASA is a person within the meaning of Section 1004(15) of RCRA, 42 U.S.C. § 6903(15).

2. The COPCs listed in Table 1 in Section IV of this Consent Agreement are "solid wastes" as defined in Section 1004(27) of RCRA, 42 U.S.C. § 6903(27) and/or "hazardous wastes" as defined in Section 1004(5) of RCRA, 42 U.S.C. § 6903(5), within the meaning of Section 7003 of RCRA, 42 U.S.C. § 6973.

3. NASA is a person who has contributed to the handling, storage, treatment, and/or disposal of solid wastes and/or hazardous wastes at the Main Base Parcel and the Wallops Island Parcel, which may present an imminent and substantial endangerment to health or the environment.

4. The actions required by this Consent Agreement are necessary to protect public health and the environment.

VI. WORK TO BE PERFORMED

1. EPA acknowledges that NASA has previously undertaken and remains engaged in response measures at the Main Base and Wallops Island Parcels pursuant to NASA's authority under the Comprehensive Environmental Response, Compensation and Liability Act, as amended by the Superfund Amendments and Reauthorization Act of 1986, 42 U.S.C. §§ 9601 et seq ("CERCLA"). The Parties intend that such response measures will be integrated herein to achieve the purposes of this Consent Agreement. It is the intent of the Parties that work done and generated pursuant to NASA's authority under CERCLA prior to the effective date of this Agreement, be used to meet the requirements of this Consent Agreement as elements of the required action or Work to be Performed to the maximum extent feasible, upon submission to, and formal approval by, EPA.

2. Pursuant to Section 7003 of RCRA, 42 U.S.C. Section 6973, NASA agrees to and is hereby ordered to perform the following acts in the manner and by the dates specified herein. All work undertaken pursuant to this Consent Agreement shall be developed and performed, as appropriate and approved by EPA, in accordance with applicable law and relevant EPA guidance documents. Relevant guidance is available at: http://www.epa.gov/oerrpage/superfund/action/process/sfproces.htm, and are incorporated herein by reference.

3. The term "days" as set forth herein means calendar days unless otherwise specified.

4. The term "Site" as set forth herein means the Main Base and Wallops Island Parcels.

A. RCRA-CERCLA INTEGRATION

1. EPA and NASA intend to integrate NASA's CERCLA response obligations and RCRA corrective action obligations which relate to the release(s) of hazardous substances, solid waste, hazardous waste, hazardous constituents, pollutants and/or contaminants covered by this Agreement.

2. As provided in CERCLA Section 121(e)(1), NASA shall not be required to obtain permits for any CERCLA removal or remedial action conducted entirely on Site and any CERCLA response actions undertaken at the Main Base and Wallops Island Parcels shall be conducted as provided for in CERCLA, 42 U.S.C. § 9601, et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan ("NCP"), 40 C.F.R. Part 300.

3. Nothing in this Agreement shall alter NASA's authority with respect to removal actions conducted pursuant to CERCLA Section 104(a)(2), 42 U.S.C. § 9604(a)(2).

B. EARLY ACTIONS

1. NASA has recently completed CERCLA removal actions at the Main Base Parcel and the Wallops Island Parcel (as documented in the Administrative Record Index included as Attachment 1), and to the best of NASA's knowledge, Early Actions may not be necessary at this time. In the event that NASA and/or EPA determine that additional Early Actions are appropriate, these Early Actions will be addressed in accordance with this Section VI.B.

2. NASA shall evaluate available data and submit to EPA for approval a proposal for Early Actions ("EA") at the Main Base Parcel and the Wallops Island Parcel, as may be appropriate, as part of the description of current conditions provided in the Site Management Plan, as required by Section VI.C. of this Consent Agreement. Within forty-five (45) calendar days after EPA's review and approval of NASA's proposal, NASA shall submit to EPA an EA Workplan in accordance with Paragraphs IV.B. 7 through 10, immediately below, relevant guidance documents and applicable law. Upon receipt of EPA's approval of the EA Workplan, NASA shall implement the EPA-approved EA Workplan in accordance with the terms and conditions set forth therein.

3. If, after EPA's review of the description of current conditions, EPA determines that an early action(s) is necessary to address an immediate or potential threat to health or the environment at the Main Base Parcel and/or the Wallops Island Parcel, EPA will so notify NASA and shall identify an early action(s) which NASA shall perform. Such notification shall set forth the basis for EPA's determination. Within forty-five (45) calendar days of receipt of EPA's notification, NASA shall submit to EPA for approval an EA Workplan in accordance with Paragraphs VI.B. 7 through 10, immediately below, relevant guidance documents and applicable law. Upon receipt of EPA's approval of the EA Workplan, NASA shall implement the EPA-approved EA Workplan in accordance with the terms and conditions set forth therein.

4. If EPA and NASA agree that an Early Action(s) is necessary for circumstances other than those set forth in Paragraph VI.B.2, immediately above, at the Main Base Parcel and/or the Wallops Island Parcel, NASA shall identify an Early Action(s) which NASA shall perform. Within thirty (30) calendar days of identifying such Early Action(s), NASA shall submit to EPA for approval an EA Workplan in accordance with Paragraphs VI.B. 7 through 10, immediately below, relevant guidance documents and applicable law. Upon receipt of EPA's approval of the EA Workplan, NASA shall implement the EPA-

approved EA Workplan in accordance with the terms and conditions set forth therein.

5. In the event NASA identifies an immediate or potential threat to health or the environment at the Main Base Parcel and/or the Wallops Island Parcel resulting from new releases of hazardous substances, solid waste, hazardous waste and/or hazardous constituents not previously identified to EPA, NASA shall notify the EPA and Virginia Department of Environmental Quality ("VDEQ") Project Coordinators, orally within forty-eight (48) hours of discovery and notify EPA and VDEQ in writing within five (5) calendar days of such discovery summarizing the immediacy and magnitude of the threat to health and/or the environment. Upon written request from EPA setting forth the basis for its determination that an early action is necessary to address an immediate or potential threat to health or the environment, NASA shall submit to EPA for approval an EA Workplan, in accordance with Paragraphs VI.B. 7 through 10, immediately below, relevant guidance documents and applicable law. The EA Workplan shall identify one or more early actions that will address such threat as necessary to protect public health and the environment. Upon receipt of EPA's approval of the EA Workplan, NASA shall implement the EPA-approved EA Workplan in accordance with the terms and conditions set forth therein. If EPA determines that immediate action is required, the EPA Project Coordinator may orally authorize NASA to act prior to EPA's receipt of the EA Workplan.

6. If at any time EPA identifies an immediate or potential threat to health or the environment at the Main Base Parcel and/or the Wallops Island Parcel resulting from new releases of hazardous substances, solid waste, hazardous waste and/or hazardous constituents at or from those operable units and/or Areas of Concern not previously identified to EPA, EPA will notify NASA in writing. Within thirty (30) calendar days of receiving EPA's written notification setting forth the basis for its determination that an early action is necessary to address such threat, NASA shall submit to EPA for approval an EA Workplan in accordance with Paragraphs VI.B. 7 through 10, immediately below, relevant guidance documents and applicable law. The EA Workplan shall identify one or more early actions that will address such threat as necessary to protect public health and/or the environment. Upon receipt of EPA's approval of the EA Workplan, NASA shall implement the EPA-approved EA Workplan in accordance with the terms and conditions set forth therein. If EPA determines that immediate action is required, the EPA Project Coordinator may orally require NASA to act prior to NASA's receipt of EPA's written notification.

7. All EA Workplans shall ensure that the early actions are designed to mitigate immediate or potential threat(s) to health or the environment, and should be consistent with the cleanup objectives of, and contribute to the performance of any long-term remedy(ies) which may be required at the Main Base Parcel and/or the Wallops Island Parcel.

8. Each EA Workplan shall include the following sections, as appropriate, and approved by EPA: Early Action(s) Objectives, Public Involvement Plan, Data Collection Quality Assurance, Data Management, Design Plans and Specifications, Operation and Maintenance, Project Schedule for expeditious completion of Early Actions, Early Actions Construction Quality Assurance, and Reporting Requirements.

9. Concurrent with submission of an EA Workplan, NASA shall submit to EPA an EA Health and Safety Plan.

10. Upon receipt of EPA-approval of an EA Workplan, NASA shall implement the EPA approved EA Workplan in accordance with the terms and conditions contained therein.

C. SITE MANAGEMENT PLAN

1. Within sixty (60) calendar days from the effective date of this Agreement, NASA shall submit to VDEQ and EPA for approval a Site Management Plan ("SMP") for Fiscal Years 2005 and 2006 (FY 2005 - 2006). The SMP shall be used as a management tool in planning, reviewing and setting priorities for all response activities at the Site. The SMP shall be a two-year planning device and shall contain a timetable, plan or schedule which indicate the time and sequence of activities that will occur at the Site over the ensuing two fiscal years. To ensure that the SMP continues to function as a two-year planning device that is reflective of both ongoing and planned future activities, NASA shall update the SMP on an annual basis. Each annual update shall amend, revise and/or supplement the SMP, as appropriate, so that the SMP continues to address events that will occur at the Site over the following two fiscal years. For the purpose of the SMP, a fiscal year is the yearly time frame used by the United States Government that commences on October 1st of the given calendar year and ends on September 30th of the following calendar year.

2. The SMP shall, at a minimum:

   a. Provide a background of current and historic Site operations;

   b. Describe current Site conditions;

   c. Identify each operable unit ("OU") and Area of Concern ("AOC") at the Site and describe the nature of the proposed action(s) at each area, including those actions which are necessary to mitigate any immediate threat to public health or the environment;

d. List the schedules and the deadlines for all submissions and remedial, removal and response actions which are ongoing, planned and/or proposed over the course of the ensuing two fiscal years, including any deadlines already required by EPA in this Agreement.

3. Upon receipt of EPA approval of the SMP for Fiscal Years 2005 and 2006 and every subsequent SMP, NASA shall implement the EPA-approved SMP in accordance with the terms and schedules contained therein.

D. REMEDIAL INVESTIGATION

1. In accordance with the schedule established in the EPA-approved SMP, NASA shall submit to EPA a Workplan for a Remedial Investigation ("RI Workplan") at the Main Base and Wallops Island Parcels. The RI Workplan is subject to approval by EPA and shall be developed in accordance with, at a minimum, relevant EPA guidance documents and applicable law.

2. The RI Workplan shall be designed to determine the presence, magnitude, extent, direction, and rate of movement of any hazardous substances, solid wastes, hazardous wastes and/or hazardous constituents within and beyond the boundaries of the Main Base Parcel and Wallops Island Parcel. The RI Workplan shall document the procedures NASA shall use to conduct those activities necessary to: (A) characterize the source(s) of contamination; (B) characterize the potential pathways of contaminant migration; (C) define the degree and extent of contamination; (D) identify actual or potential human and/or ecological receptors; and (E) support the development of alternatives from which a remedial action(s) will be selected by EPA. NASA may propose to implement the work contained in the RI Workplan in a phased approach. A specific schedule for expeditious implementation of all activities shall be included in the RI Workplan.

3. The RI Workplan shall include: (A) a Project Management Plan; (B) a Data Collection Quality Assurance Plan; (C) a Data Management Plan; and (D) a Community Relations Plan.

4. Concurrent with the submission of the RI Workplan, NASA shall submit an RI Health and Safety Plan.

5. Upon receipt of EPA approval of the RI Workplan, NASA shall implement the EPA-approved RI Workplan in accordance with the terms and schedules contained therein. Upon completion of implementation of the RI Workplan, NASA shall submit to EPA for approval an RI Report, in accordance with the requirements and schedule contained in the

EPA-approved RI Workplan.

E. FEASIBILITY STUDY

1. In accordance with the schedule established in the EPA-approved SMP, NASA shall submit to EPA for approval a Feasibility Study ("FS") Report for the Main Base and Wallops Island Parcels. The FS Report shall be developed in accordance with relevant EPA guidance documents and applicable law as provided in Section VI.2.

F. PUBLIC COMMENT AND PARTICIPATION

1. After approval of the FS Report, EPA will make both the RI Report and the FS Report ("RI/FS"), a description of NASA's proposed remedial action(s), if any are so proposed by NASA, and NASA's justification for proposing selection of such remedial action(s) (the "Proposed Remedial Action Plan") available to the public for review and comment for at least thirty (30) calendar days.

2. Following the public review and comment period for the Proposed Remedial Action Plan, EPA will notify the public of the remedial action(s) agreed upon by NASA and EPA in a Record of Decision ("ROD"). If the remedial action(s) selected by EPA after consideration of public comments differs significantly from the remedial action(s) recommended in the ROD, EPA will explain in the ROD the basis for such difference.

3. Any decisions or determinations made by NASA and EPA pursuant to the Consent Agreement will be available for public review on Mondays through Fridays, from 9:00 a.m. to 4:00 p.m., by contacting the EPA Project Coordinator, Michelle Price-Fay, at (215) 814-3397 or the NASA Project Coordinator, Susan Fields, at (757) 824-1327.

G. REMEDIAL DESIGN/REMEDIAL ACTION(S)

1. Upon issuance of the ROD(s), said ROD(s) shall be incorporated into and become enforceable under this Consent Agreement.

2. Remedial Design

   a. In accordance with the schedule established in the EPA-approved SMP, NASA shall submit to EPA for approval a Remedial Design ("RD") Workplan. The RD Workplan shall provide for the design of the remedy set forth in the ROD(s). The

RD Workplan shall be developed in accordance with the ROD, relevant EPA guidance documents and applicable law. Upon its approval by EPA, the RD Workplan shall be incorporated into and become enforceable under this Agreement.

b. In accordance with the EPA-approved RD Workplan, NASA shall submit to EPA for approval a RD Report. The RD Report shall be developed in accordance with the ROD(s), relevant EPA guidance documents and applicable law.

3. Remedial Action Workplan

a. In accordance with the schedule established in the EPA-approved SMP, NASA shall submit to EPA for approval a Remedial Action ("RA") Workplan. The RA Workplan shall provide for construction and implementation of the remedy set forth in the ROD(s). The RA Workplan shall be developed in accordance with relevant EPA guidance documents and applicable law. Upon its approval by EPA, the RA Workplan shall be incorporated into and become enforceable under this Agreement.

b. In accordance with the EPA-approved RA Workplan, NASA shall submit to EPA for approval an RA Report. The RA Report shall be developed in accordance with relevant EPA guidance documents and applicable law.

4. Remedial Action Completion

a. NASA shall commence and complete implementation of the Remedial Action(s) selected in the ROD in accordance with the schedules and specifications set forth in the EPA-approved RD Report; the EPA-approved RA Workplan; and relevant EPA guidance documents and applicable law.

b. In accordance with the schedule established in the EPA-approved SMP, NASA shall submit to EPA for approval a Remedial Action Completion ("RAC") Report. The RAC Report shall be developed in accordance with relevant EPA guidance documents and applicable law and shall describe activities performed during implementation, provide actual specifications of the implemented remedial action(s), and provide a preliminary assessment of Remedial Action performance.

c. EPA shall determine, on the basis of the RAC Report and any other relevant information, whether the implemented Remedial Action(s) is consistent with the EPA-approved RD Report. If EPA determines that the implemented remedial action(s) is consistent with the EPA-approved RD Report and that the Remedial

Action(s) have achieved or are achieving all of the requirements set forth in the ROD and the performance criteria set forth in the RD Report, EPA shall approve the RAC Report.

d. If EPA determines that the implemented Remedial Action(s) is inconsistent with the EPA-approved RD Report and/or that the Remedial Action(s) have not achieved or are not achieving all of the requirements set forth in the ROD and the performance criteria established in the EPA-approved RD Report, EPA shall notify NASA in writing of those activities that must be undertaken to complete the Remedial Action(s) requirements and shall set forth a schedule for the completion of those activities. NASA shall complete the activities in accordance with the schedule set forth in the EPA notification.

5. Remedial Action Monitoring Plan/Operation and Maintenance/Assessment Reports

a. In accordance with the schedule established in the EPA-approved RAC Report, NASA shall submit to EPA for approval a Long-Term Remedial Action Monitoring Plan (if necessary), and an Operation and Maintenance Plan to VDEQ for review and EPA for approval in accordance with the schedule provided in the SMP, Section VI.C. Both the Long-Term Remedial Action Monitoring Plan and Operation and Maintenance Plan(s) finalized under this Agreement shall contain schedules for completion of the work describe therein, and these schedules, upon EPA approval, shall be incorporated into the SMP and become an enforceable part of this Agreement.

b. If based on the RA Assessment Report or any other information, EPA determines that the Remedial Action(s) are not meeting the objectives of addressing the contaminants in the soil, sediments, surface water and/or groundwater to attain the performance criteria established in the RA Design Report, EPA shall notify NASA in writing of those activities that must be undertaken to meet the objectives of the Remedial Action(s) and shall set forth a schedule for the completion of those activities. NASA shall complete the activities in accordance with the schedule set forth in the EPA notification.

c. No later than five years after the commencement of the Remedial Action and every five (5) years thereafter until receipt of approval by EPA of a Certificate of Completion submitted pursuant to paragraph VI.E.4.g, below, NASA shall submit a RAC Five-Year Remedial Assessment Report. Such Report shall contain an evaluation of the past and projected future effectiveness of the Remedial Action(s) in addressing the contaminants in the soil, sediments, surface water and/or groundwater to attain the performance criteria established in the RA Design

Report.

d. NASA may, as part of a RAC Five-Year Assessment Report, request that EPA approve, for the purposes of this Consent Agreement, an Alternative and/or Supplemental Remedial Action(s).

e. In the event EPA approves an Alternative and/or Supplemental Remedial Action(s) either in response to a request by NASA pursuant to paragraph VI.G.5.d, immediately above, or on its own initiative, EPA may provide NASA with a period of thirty (30) calendar days from the date NASA receives written notice from EPA of the approval of an Alternative and/or Supplemental Remedial Action(s) within which to reach an agreement with EPA regarding performance of the Alternative and/or Supplemental Remedial Action(s) in lieu of, or in addition to, the Remedial Action(s). Any such agreement between EPA and NASA shall be incorporated into and become enforceable under this Consent Agreement and NASA shall implement the activities required under any such agreement in accordance with any schedule and provisions contained therein.

f. Nothing in paragraph VI.G.5.e, immediately above, shall limit EPA's authority to require performance of Alternative and/or Supplemental Remedial Action(s) or to take any other appropriate action under RCRA, 42 U.S.C. §§ 6901 et seq. CERCLA 42 U.S.C. §§ 9601 et seq., or any other legal authority, including the issuance of a unilateral administrative order.

g. Within ninety (90) calendar days after NASA has fully performed the Remedial Action and the media cleanup standards described in the ROD have been attained, NASA shall submit a Certification of Completion for all Remedial Action(s) to EPA for approval in accordance with Section XIII.(NOTIFICATION) of this Consent Agreement. The Certification of Completion shall provide documentation sufficient to support a determination that media cleanup standards have been attained and include all available documentation supporting such a determination.

H. SUBMISSIONS/EPA APPROVAL/ADDITIONAL WORK

1. EPA will review Reports and Workplans submitted by NASA pursuant to this Agreement, and any other documents submitted pursuant to and/or agreed upon in this Consent Agreement ("Submissions") with the exception of progress reports, and will notify NASA in writing of EPA's approval or disapproval of each such Submission. In the event of EPA's disapproval, EPA shall specify in writing any deficiencies in the

Submission. Such disapproval shall not be subject to the dispute resolution procedures of Section XV, below.

2. Within forty-five (45) calendar days of receipt of EPA's comments on the Submission, or fifteen (15) calendar days in the case of an EA Workplan, NASA shall submit to EPA for approval a revised Submission, which responds to any comments received and/or corrects any deficiencies identified by EPA. EPA will review the revised submission and will either approve or disapprove of the Submission and notify NASA. Within thirty (30) calendar days after receipt of any such disapproval, NASA shall modify its Submission in conformance with EPA comments or initiate dispute resolution. Any Submission approved or revised by EPA under this Consent Agreement shall be deemed incorporated into and made an enforceable part of this Consent Agreement.

3. Beginning the first day of the sixth full month following the effective date of this Consent Agreement, and every six months on the first day of the month, throughout the period that this Consent Agreement is effective, NASA shall provide EPA with semiannual (every 6 months) progress reports. The semiannual progress reports shall provide information on the status of current response activities.

4. Four (4) copies of all Submissions as well as progress reports described in Paragraph VI.H.3 immediately above, required by this Consent Agreement shall be hand-delivered or sent via overnight mail, Return Receipt Requested, to the Project Coordinator designated pursuant to Section XII, "PROJECT COORDINATORS," below.

5. All work performed pursuant to this Consent Agreement shall be under the direction of the NASA Project Coordinator. Within ten (10) calendar days after the effective date of this Consent Agreement, NASA shall submit to EPA, in writing, the name, title, and qualifications of any contractors or subcontractors selected by NASA to be used in carrying out the terms of this Consent Agreement. Notwithstanding NASA's selection of the NASA Project Coordinator or any contractor and/or subcontractor, nothing herein shall relieve NASA of its obligation to comply with the terms and conditions of this Consent Agreement. EPA shall have the right to disapprove at any time based on performance and/or eligibility concerns, the use of the NASA Project Coordinator or any contractor or subcontractor selected by NASA. EPA's disapproval shall not be subject to review under Section XV of this Consent Agreement ("DISPUTE RESOLUTION") or otherwise. Within fifteen (15) calendar days of receipt from EPA of written notice disapproving the use of any NASA Project Coordinator or within 120 calendar days of receipt from EPA of written notice disapproving the use of any contractor or subcontractor, NASA shall notify EPA, in writing, of the name, title and qualifications of the personnel who will replace the personnel disapproved by EPA. NASA shall notify EPA within ten (10) calendar days prior to changing voluntarily the NASA Project

Coordinator, and/or contractors or subcontractors to be used in carrying out the terms of this Consent Agreement, and shall submit to EPA in writing, the name, title, and qualifications of such person(s).

6. If at any time after the effective date of this Consent Agreement, NASA proposes to change a contractor and/or subcontractor, NASA shall notify EPA and obtain a notice of acceptance of such change(s) from EPA before a new contractor and/or subcontractor performs, directs or supervises any work under this Consent Agreement. If EPA disapproves the selection of a proposed contractor and/or subcontractor, EPA will notify NASA in writing. NASA shall submit to EPA a list of at least three contractors and/or subcontractors, including the qualifications of each, that would be acceptable to NASA within thirty (30) calendar days of receipt of EPA's notice. EPA will provide written notice of the names of any contractor and/or subcontractor whose selection it would approve. NASA may select any contractor and/or subcontractor from that list and shall notify EPA of the name of the contractor and/or subcontractor selected within twenty-one (21) calendar days of receipt of EPA's written notice.

7. EPA may determine that certain tasks and deliverables including, but not limited to, investigatory work or engineering evaluation require additional work. These tasks and deliverables may or may not have been in the SMP, FS, RD, RA, RAC and/or Five-Year Assessment Report, or in the EA, RI, RD or RA Workplans and/or any other documents submitted pursuant to and/or agreed upon in this Consent Agreement. If EPA determines that such additional work is necessary, EPA shall request, in writing, that NASA perform the additional work and shall specify the reasons for EPA's determination that additional work is necessary. Within thirty (30) calendar days after the receipt of such request, NASA shall have the opportunity to meet or confer with EPA to discuss the additional work EPA has requested. In the event that NASA agrees to perform the additional work, this Consent Agreement shall be modified in accordance with Section XXIII, "SUBSEQUENT MODIFICATION," below, and such work shall be performed in accordance with this Consent Agreement. In the event NASA declines or fails to perform the additional work, EPA reserves the right to order NASA to perform such additional work and to disapprove of the SMP, RI, FS, RD, RA , RAC and/or Five-Year Assessment Reports, or the EA, RI, RD or RA Workplans.

8. Any reports, plans, specifications, schedules, other submissions and attachments required by this Consent Agreement are, upon written approval by EPA, incorporated into this Consent Agreement. Any noncompliance with such EPA-approved reports, plans, specifications, schedules, other submissions, and attachments shall be considered a violation of this Consent Agreement and shall subject NASA to the stipulated penalty provisions included in Section XIV, "DELAY IN PERFORMANCE/STIPULATED PENALTIES."

VII. QUALITY ASSURANCE

1. Throughout all sample collection and analysis activities, NASA shall use EPA-approved quality assurance, quality control, and chain-of-custody procedures, as specified in the EPA-approved RI Workplan. In addition, NASA shall:

   a. Ensure that the laboratories it uses for analyses perform such analyses according to the EPA methods included in "Test Methods for Evaluating Solid Waste" (SW-846, November 1986) or other methods deemed satisfactory to EPA. If methods other than EPA methods are to be used, NASA shall submit all analytical protocols to be used for analyses to EPA for approval at least thirty (30) calendar days prior to the commencement of analyses and shall obtain EPA approval prior to the use of such analytical protocols.

   b. Ensure that laboratories it uses for analyses participate in a quality assurance/quality control program equivalent to that which is followed by EPA. As part of such a program, and upon request by EPA, such laboratories shall perform analyses of samples provided by EPA to demonstrate the quality of the analytical data.

   c. Inform the EPA Project Coordinator at least fourteen (14) calendar days in advance of any laboratory analysis regarding which laboratory will be used by NASA and ensure that EPA personnel and EPA authorized representatives have reasonable access to the laboratories and personnel used for analysis.

VIII. PUBLIC COMMENT AND REVIEW OF AGREEMENT

1. Within thirty (30) calendar days of the date that EPA signs this Consent Agreement, EPA shall announce the availability of this Agreement to the public for review and comment. EPA shall accept comments from the public for a period of thirty (30) calendar days after such announcement. If sufficient interest warrants, as determined by EPA, a public meeting will be held. At the end of the comment period, EPA shall review all comments received during the above-described thirty (30) day period and/or at such public meeting, and shall either:

   a. determine that the Agreement should be made effective in its present form in which case EPA shall so notify NASA in writing and send NASA a copy of this Agreement executed by EPA. The Consent Agreement shall become effective on

the date of the receipt of such notice and copy of the Consent Agreement; or

b. determine that modification of the Consent Agreement is necessary, in which case EPA shall notify NASA in writing as to the nature of all required changes. If NASA agrees to the modifications, the Consent Agreement shall be so modified and shall become effective upon the receipt by NASA of an executed copy of the modified Consent Agreement.

2. In the event that the parties are unable to agree on modifications required by EPA as a result of public comment, this Agreement shall be withdrawn by EPA. In such an event, EPA reserves the right to take such action as may be necessary to protect public health and the environment, including but not limited to, issuance of a subsequent order to NASA or any other person in connection with the Main Base and/or Wallops Island Parcels under Section 7003 of RCRA.

IX. ON-SITE AND OFF-SITE ACCESS

1. On and after the effective date of this Consent Agreement, NASA shall provide to EPA and its employees, agents, consultants, contractors and other authorized and/or designated representatives, for the purposes of conducting and/or overseeing the work required by this Consent Agreement, or by any EPA-approved workplan prepared pursuant hereto, access to all property owned or controlled by NASA wherein work must be undertaken. NASA shall grant access to EPA and/or its authorized representatives who are U.S. Citizens and who provide valid government-issued photo identification. For Foreign Nationals, NASA shall grant access to EPA and/or its authorized representatives in accordance with the Procedural Requirements for Processing Requests for Access to NASA Installations or Facilities by Foreign Nationals or U.S. Citizens Who are Representatives of Foreign Entities (NPR 1371.2A, or most current version http://nodis3.gsfc.nasa.gov/displayAll.cfm?Internal_ID=N_PR_1371_002A_&page_name=all). Generally, requests for a visit by a Foreign National to a NASA Center are approved or disapproved within twenty (20) working days. If after the effective date of this Agreement, NASA's security requirements change such that access cannot be provided in the manner set forth herein, NASA must notify EPA in writing within ten (10) calendar days of such changes. Such access shall permit EPA and its employees, agents, consultants, contractors and other authorized and designated representatives to conduct all activities described in Paragraph IX.3 of this Consent Agreement. Such requirements shall not be applied to unreasonably hinder or delay the EPA from carrying out its responsibilities and authority pursuant to this Agreement.

2. To the extent that property wherein work required by this Consent Agreement must be

undertaken is presently owned or controlled by parties other than NASA, NASA shall use its best efforts to obtain site access agreements from the present owners. Best efforts shall include, but not be limited to, agreement to reasonable conditions for access and/or the payment of reasonable fees. Such access agreements shall be finalized as soon as practicable but no later than forty-five (45) calendar days after receiving EPA's written approval to proceed. Such agreements shall provide reasonable access for NASA and its employees, agents, consultants, contractors and other authorized and designated representatives to conduct the work, and for EPA and its designated representatives to conduct the activities outlined in Paragraph IX.3, below. In the event that any property owner refuses to provide such access or access agreements are not obtained within the time designated above, whichever occurs sooner, NASA shall notify EPA at that time, in writing, of all efforts to obtain access and the circumstances of the failure to obtain such access. EPA may then take steps to provide such access. NASA shall reimburse EPA for all costs incurred in obtaining access, including, but not limited to, attorneys fees and the amount of any just compensation and costs incurred by EPA.

3. In accordance with law and regulation and within the constraints of NASA Security requirements, as appropriate, EPA and its employees, agents, contractors, consultants and other authorized and designated representatives shall have the authority to enter and freely move about the location where the corrective actions and/or work is being performed at all reasonable times for the purposes of, inter alia: inspecting work required by this Consent Agreement, or by any EPA approved workplan prepared pursuant hereto, records, operating logs and contracts related to the Main Base and Wallops Island Parcels; reviewing the progress of NASA in carrying out the terms of this Consent Agreement; conducting such tests as EPA deems necessary; using a camera, sound recording or other documentary type equipment; and verifying the data submitted to EPA by NASA. NASA shall permit such persons to inspect and copy all records, files, photographs, documents and other writings, including all sampling and monitoring data, in any way pertaining to the work. The EPA shall have the right to enter all areas of the Site that are entered by contractors performing work under this Agreement.

4. Upon denial of any aspect of access, NASA shall provide an immediate explanation of the reason for the denial, including reference to the applicable regulations and upon request, a copy of such regulations. Within forty-eight (48) hours, NASA shall expeditiously provide a recommendation for accommodating the access request in an alternate manner.

5. Notwithstanding any provision of this Consent Agreement, EPA retains all of its access and information-gathering authorities and rights under RCRA and any other applicable statute and regulation.

X. SAMPLING AND DATA/DOCUMENT AVAILABILITY

1. NASA shall submit to EPA the results of all sampling and/or tests or other data generated by, or on behalf of, NASA in accordance with the requirements of this Consent Agreement, applicable law and relevant EPA guidance documents.

2. NASA shall notify EPA and the VDEQ, in writing, at least fourteen (14) calendar days in advance of any field activities, including but not limited to, well drilling, installation of equipment, or sampling. At the request of EPA, NASA shall provide or allow EPA or its authorized representatives to take split or duplicate samples of all samples collected by NASA pursuant to this Consent Agreement. Nothing in this Consent Agreement shall limit or otherwise affect EPA's authority to collect samples pursuant to applicable law, including, but not limited to, RCRA and CERCLA.

3. NASA may assert a business confidentiality claim covering all or part of any information submitted to EPA pursuant to this Consent Agreement in the manner described in 40 C.F.R. Section 2.203(b). Any assertion of confidentiality shall be adequately substantiated by NASA when the assertion is made in accordance with 40 C.F.R. Section 2.204(e)(4). Information subject to a confidentiality claim shall be disclosed only to the extent allowed by, and in accordance with, the procedures set forth in 40 C.F.R. Part 2, Subpart B. If no such confidentiality claim accompanies the information when it is submitted to EPA, it may be made available to the public by EPA without further notice to NASA. NASA shall not assert any confidentiality claim with regard to any physical, sampling, monitoring, or analytical data.

4. If NASA wishes to assert a privilege with regard to any document which EPA seeks to inspect or copy pursuant to this Consent Agreement, NASA shall identify the document, the privilege claimed, and the basis thereof in writing. For the purposes of this Consent Agreement, privileged documents are those documents exempt from discovery from the United States in litigation under the Federal Rules of Civil Procedure. NASA shall not assert a privilege with regard to analytical, sampling and monitoring data.

XI. RECORD PRESERVATION

NASA agrees that it shall preserve, during the pendency of this Consent Agreement and for a minimum of at least six (6) years after its termination, all data, records and documents in its possession or in the possession of its divisions, officers, directors, employees, agents, contractors, successors, and assigns which relate in any way to this Consent Agreement or to hazardous waste management and/or disposal at the Main Base and/or Wallops Island Parcels.

After six (6) years, NASA shall make such records available to EPA for inspection or shall provide copies of such records to EPA. NASA shall notify EPA at least thirty (30) calendar days prior to the proposed destruction of any such records, and shall provide EPA with a reasonable opportunity to inspect, copy and/or take possession of any such records. NASA shall not destroy any record to which EPA has requested access for inspection and/or copying until EPA has obtained such access or withdrawn its request for such access. Nothing in this Section XI shall in any way limit the authority of EPA under Section 3007 of RCRA, 42 U.S.C. Section 6927, or any other access or information-gathering authority.

XII. PROJECT COORDINATORS

1. EPA hereby designates Mrs. Michelle Price-Fay as the EPA Project Coordinator. NASA hereby designates Ms. Susan Fields as the NASA Project Coordinator. Each Project Coordinator shall be responsible for overseeing the implementation of the Consent Agreement. The EPA Project Coordinator will be EPA's primary designated representative at the Main Base and Wallops Island Parcels. To the maximum extent possible, all communications between NASA and EPA, and all documents, reports, approvals, and other correspondence concerning the activities performed pursuant to the terms and conditions of this Consent Agreement, shall be directed through the Project Coordinators.

2. Each party agrees to provide at least seven (7) calendar days written notice to the other party prior to changing Project Coordinators.

3. If EPA determines that conditions or activities at the Main Base and/or Wallops Island Parcels, whether or not in compliance with this Consent Agreement, have caused or may cause a release or threatened release of hazardous substances, solid wastes, hazardous wastes, hazardous constituents, pollutants or contaminants which threaten or may pose a threat to the public health or welfare or to the environment, EPA may direct that NASA stop further implementation of this Consent Agreement for such period of time as may be needed to abate any such release or threatened release and/or to undertake any action which EPA determines is necessary to abate such release or threatened release.

4. The absence of the EPA Project Coordinator from the Main Base and/or Wallops Island Parcels shall not be cause for the delay or stoppage of work.

XIII. NOTIFICATION

1. Unless otherwise specified, reports, correspondence, approvals, disapprovals, notices, or

other submissions relating to or required under this Consent Agreement shall be in writing and shall be sent as follows:

a. Four copies of all documents to be submitted to the EPA shall be sent to:

Mrs. Michelle Price-Fay
U.S. EPA, Region III (3HS13)
1650 Arch Street
Philadelphia, PA 19103-2029

b. Documents to be submitted to NASA shall be sent to:

Ms. Susan Fields
NASA Goddard Space Flight Center
Wallops Flight Facility
Building F-160 Room W157 Code 250. W
Wallops Island, Virginia 23337

c. One copy of all documents to be submitted to EPA shall also be sent to:

Mr. Paul Herman
Virginia Department of Environmental Quality
Office of Remediation Programs
629 East Main Street
Richmond, VA 23219

2. Any notice, report, certification, data presentation, or other document submitted by NASA pursuant to this Consent Agreement which discusses, describes, demonstrates, or supports any finding or makes any representation concerning NASA's compliance or noncompliance with any requirement of this Consent Agreement shall be certified by a duly authorized representative of NASA. A person is a "duly authorized representative" only if : (1) the authorization is made in writing; (2) the authorization specifies either an individual or position having responsibility for overall operation of the Site or activity (a duly authorized representative may thus be either a named individual or any individual occupying a named position); and (3) the written authorization is submitted to the Project Coordinator designated by EPA Section XII, "Project Coordinators," of this Order.

3. The certification required by paragraph 2, above, shall be in the following form:

I certify that the information contained in or accompanying this [type of submission] is true, accurate, and complete.

As to **[the/those identified portion(s)]** of this **[type of submission]** for which I cannot personally verify **[its/their]** accuracy, I certify under penalty of law that this **[type of submission]** and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature : _____

Name : _____

Title : _____

XIV. DELAY IN PERFORMANCE/STIPULATED PENALTIES

1. Unless there has been a written modification of a compliance date by EPA, or excusable delay as defined below in Section XVII, "FORCE MAJEURE AND EXCUSABLE DELAY," in the event that NASA fails to comply with any requirement set forth in this Consent Agreement, NASA shall pay stipulated penalties, as set forth below, upon receipt of written demand by EPA. Compliance by NASA shall include commencement or completion, as appropriate, of any activity, plan, study or report required by this Consent Agreement in an acceptable manner and within the specified time schedules in and approved under this Consent Agreement. Stipulated penalties shall accrue as follows:

   a. For failure to commence, perform or complete work as prescribed in this Consent Agreement: $1,500 per day for one to seven days or part thereof of noncompliance, and $3,000 per day for each day of noncompliance, or part thereof, thereafter;

   b. For failure to submit any draft or final Workplan, plans, or reports as required by this Consent Agreement: $1,000 per day for one to seven days or part thereof of noncompliance, and $2,500 per day for each day of noncompliance, or part thereof, thereafter;

c. For failure to submit progress reports as required by this Consent Agreement: $500 per day for one to seven days or part thereof of noncompliance, and $1,000 per day for each day of noncompliance, or part thereof, thereafter;

d. For failure to comply with the provisions of this Consent Agreement after receipt of notice of noncompliance by EPA: $2,000 per day for one to seven days or part thereof of noncompliance, and $3,500 per day for each day of noncompliance, or part thereof, thereafter; in addition to any stipulated penalties imposed for the underlying noncompliance;

e. For any failure to comply with this Consent Agreement not described in subparagraphs a through d above: $1,000 per day for one to seven days or part thereof of noncompliance, and $2,000 per day for each day of noncompliance, or part thereof, thereafter.

2. All penalties shall begin to accrue on the date that complete performance is due or a violation occurs, and shall continue to accrue through the final day of or correction of the violation. Nothing herein shall prevent the simultaneous accrual of separate stipulated penalties for separate violations of this Consent Agreement.

3. All penalties owed to EPA under this Section XIV shall be due within thirty (30) calendar days of receipt of a demand for payment unless NASA invokes the dispute resolution procedures under Section XV, below. Such notification shall describe the noncompliance and shall indicate the amount of penalties due.

4. All penalty payments shall be made by certified or cashier's check payable to the Treasurer of the United States of America and shall be remitted to:

Regional Hearing Clerk
U.S. Environmental Protection Agency
Region III
P.O. Box 360515
Pittsburgh, Pennsylvania 15251-6515

All payments shall reference the name of the Main Base and Wallops Island Parcels, NASA's name and address, and the EPA Docket Number of this Consent Agreement. Copies of the transmittal of payment shall be sent simultaneously to the EPA Project Coordinator and the Regional Hearing Clerk (3RC00), U.S. Environmental Protection Agency, Region III, 1650 Arch Street, Philadelphia, Pennsylvania 19103-2029.

5. NASA may dispute EPA's demand for payment of stipulated penalties for any alleged violation of this Consent Agreement by invoking the dispute resolution procedures below under Section XV, "DISPUTE RESOLUTION." Stipulated penalties shall continue to accrue, but need not be paid, for any alleged noncompliance which is the subject of dispute resolution during the period of such dispute resolution. To the extent that NASA does not prevail upon resolution of the dispute, NASA shall remit to EPA within seven (7) calendar days of receipt of such resolution any outstanding penalty payment, in the manner described above in Paragraph 4 of this Section XIV. EPA may, in its sole discretion not subject to dispute resolution, reduce or waive any outstanding penalty payment. To the extent NASA prevails upon resolution of the dispute, no penalties shall be payable.

6. Neither the filing of a petition to resolve a dispute nor the payment of penalties shall alter in any way NASA's obligation to comply with the requirements of this Consent Agreement.

7. The stipulated penalties set forth in this Section XIV shall not preclude EPA from pursuing any other remedies or sanctions which may be available to EPA by reason of NASA's failure to comply with any of the requirements of this Consent Agreement.

8. Nothing in this Section is intended to limit NASA's ability to request an extension of a deadline or schedule as otherwise permitted under this Consent Agreement.

XV. DISPUTE RESOLUTION

1. Except as specifically set forth elsewhere in this Agreement, if a dispute arises under this Agreement, the procedures of this Section shall apply. The Parties to this Agreement shall make reasonable efforts to informally resolve disputes at the Project Coordinator or immediate supervisor level. If resolution cannot be achieved informally, the procedures of this Section shall be implemented to resolve a dispute.

2. Within thirty (30) calendar days after any action which leads to or generates a dispute, the disputing party shall submit to EPA a written statement of dispute setting forth the nature of the dispute, the work affected by the dispute, the disputing party's position with respect to the dispute and the information relied upon to support such position.

3. Upon receipt of the written statement of dispute, EPA and NASA shall engage in informal dispute resolution among the Project Coordinators and/or their immediate supervisors. They shall have fourteen (14) business days to resolve the dispute. During this informal dispute resolution period, EPA and NASA shall confer as many times as are

necessary to discuss and attempt resolution of the dispute. If at the conclusion of the fourteen (14) business day period EPA and NASA cannot resolve the dispute, either side shall have ten (10) business days from the conclusion of the fourteen (14) business day dispute resolution period to present the dispute to the Dispute Resolution Committee as set forth in paragraph XV.4., immediately below. If neither EPA nor NASA elevates the dispute within the ten (10) business day period, NASA shall be deemed to have agreed with EPA's position with respect to the dispute.

4. The Dispute Resolution Committee ("DRC") will serve as a forum for resolution of disputes for which agreement has not been reached through informal dispute resolution. The Parties shall each designate one individual and an alternate to serve on the DRC. The individuals designated to serve on the DRC shall be employed at the policy level or be delegated the authority to participate on the DRC for the purposes of dispute resolution under this Agreement. The EPA's representative on the DRC is the Waste and Chemicals Management Division Director of EPA Region III. NASA's designated member is the Chief of the Goddard Space Flight Center Safety and Environmental Division. Written notice of any delegation of authority from the Party's designated representative on the DRC shall be provided to the other Party.

5. Following elevation of a dispute to the DRC, the DRC shall have twenty-one (21) calendar days to unanimously resolve the dispute and issue a written decision signed by all Parties. If the DRC is unable to unanimously resolve the dispute within this twenty-one (21) day period, the written statement of dispute shall be forwarded to the Senior Executive Committee ("SEC") for resolution.

6. The SEC will serve as the forum for resolution of disputes for which agreement has not been reached by the DRC. The EPA's representative on the SEC is the Regional Administrator of EPA Region III. NASA's representative on the SEC is the Assistant Administrator for Institutional and Corporate Management. The SEC members shall, as appropriate, confer, meet and exert their best efforts to resolve the dispute and issue a unanimous written decision signed by all parties. If unanimous resolution of the dispute is not reached within twenty-one (21) calendar days, the EPA Regional Administrator shall issue a written position on the dispute. The NASA Assistant Administrator may, within twenty-one (21) calendar days of the Regional Administrator's issuance of EPA's position, issue a written notice elevating the dispute to the Administrator of U.S. EPA for resolution in accordance with all applicable laws and procedures. In the event that the NASA Assistant Administrator elects not to elevate the dispute to the EPA Administrator within the designated twenty-one (21) day escalation period, the decision will become final and the work will proceed in accordance with the Regional Administrator's written position with respect to the dispute.

7. Upon escalation of a dispute to the Administrator of EPA pursuant to Section XV.6 above, the Administrator will review and resolve the dispute within twenty-one (21) calendar days. Upon request, and prior to resolving the dispute, the EPA Administrator shall meet and confer with the NASA Administrator to discuss the issue(s) under dispute. Upon resolution, the EPA Administrator shall provide the Parties with a written final decision setting forth resolution of the dispute. The duties of the EPA Administrator set forth in this Section shall not be delegated.

8. The pendency of any dispute under this Section shall not affect NASA's responsibility for timely performance of the work required by this Agreement, except that the time period for completion of work affected by such dispute may be extended for a period of time usually not to exceed the actual time taken to resolve any good faith dispute in accordance with the procedures specified herein. All elements of the work required by this Agreement, which are not affected by the dispute, shall continue to be completed in accordance with the applicable schedule.

9. When dispute resolution is in progress, work affected by the dispute will be discontinued if the Waste and Chemicals Management Division Director for EPA Region III directs, in writing, that work related to the dispute be stopped because, in EPA's opinion, such work, among other things, is inadequate or defective. To the extent possible, EPA shall consult with NASA prior to initiating a work stoppage. After stoppage of work, if NASA believes that the work stoppage is inappropriate or may have potential significant adverse impacts, NASA may meet with the EPA to discuss the work stoppage. Following this meeting, and further consideration of the issues, the EPA Division Director will issue, in writing, a final decision with respect to the work stoppage. The final written decision of the U.S. EPA Waste and Chemicals Management Division Director may immediately be subjected to formal dispute resolution. Such dispute may be brought directly to either the DRC or the SEC, at the discretion of NASA.

10. Within twenty-one (21) calendar days of resolution of a dispute pursuant to the procedures specified in this Section, NASA shall incorporate the resolution and final determination into the appropriate plan, schedule or procedures and proceed to implement this Agreement according to the amended plan, schedule or procedures.

11. Resolution of a dispute pursuant to this Section of the Agreement constitutes a final resolution to any dispute arising under this Agreement. All Parties shall abide by all terms and conditions of any final resolution of dispute obtained pursuant to this Section of this Agreement.

XVI. ENFORCEABILITY

1. Violation of this Agreement, or failure or refusal to comply with this Agreement, may subject NASA to a citizens suit under RCRA for civil penalties of up to six thousand five hundred dollars ($6,500) for each day the violation occurs, as provided in Section 7003(b) of RCRA, 42 U.S.C. § 6973(b).

2. This Agreement, including its provisions related to statutory requirements, Early Actions, and Remedial Actions, record keeping, reporting and schedules of compliance, shall be enforceable under citizen suits pursuant to 42 U.S.C. Section 6972.

3. In the event of any action filed under section 7002 of RCRA, alleging any violation of this Agreement, it shall be presumed that this Agreement, including those provisions which address record keeping, reporting and schedules of compliance, are requirements, standards, and conditions, and are thus enforceable under Section 7002 of RCRA.

4. Nothing in this Agreement shall be deemed as authorizing any person(s) to seek judicial review of any action or work where such review is barred by CERCLA, including but not limited to Section 113 (h), 42 U.S.C. Section 9613(h).

XVII. FORCE MAJEURE AND EXCUSABLE DELAY

1. NASA shall perform the requirements of this Consent Agreement in the manner and within the time limits set forth herein, unless the performance is prevented or delayed by events which constitute a force majeure. NASA shall have the burden of proving such a force majeure. A force majeure is defined as any event arising from causes not reasonably foreseeable and beyond the control of NASA, which cannot be overcome by due diligence and which delays or prevents performance in the manner or by a date required by this Consent Agreement. Such events do not include increased costs of performance, changed economic circumstances, reasonably foreseeable weather conditions or weather conditions which could have been overcome by due diligence, or failure to obtain federal, state, or local permits.

2. NASA shall notify EPA, in writing, within seven (7) calendar days after it becomes or should have become aware of any event which NASA claims constitutes a force majeure. Such notice shall estimate the anticipated length of delay, including necessary demobilization and remobilization, its cause, measures taken or to be taken to prevent or minimize the delay, and an estimated timetable for implementation of these measures. Failure to comply with the notice provision of this Section XVII shall constitute a waiver of NASA's right to assert a force majeure claim with respect to such event. In addition to

the above notification requirements, NASA shall undertake all reasonable actions to prevent or to minimize any delay in achieving compliance with any requirement of this Consent Agreement after it becomes or should have become aware of any event which may delay such compliance.

3. If EPA determines that there is excusable delay because the failure to comply or delay has been or will be caused by a force majeure, the time for performance of that requirement of this Consent Agreement may be extended, upon EPA approval, for a period equal to the delay resulting from such force majeure. This shall be accomplished through an amendment to this Consent Agreement pursuant to Section XXIII, "SUBSEQUENT MODIFICATION." Such an extension shall not alter the schedule for performance or completion of any other tasks required by this Consent Agreement, unless these tasks are also specifically altered by amendment of the Consent Agreement. In the event that EPA and NASA cannot agree that any delay or failure has been or will be caused by a force majeure, or if there is no agreement on the length of the extension, NASA may invoke the dispute resolution procedures set forth in Section XV, "DISPUTE RESOLUTION."

XVIII. FUNDING

1. It is the expectation of the Parties to this Agreement that all obligations of NASA arising under this Agreement will be fully funded. NASA agrees to seek sufficient funding through its budgetary process to fulfill its obligations under this Agreement.

2. NASA shall include in its submission in its annual report to Congress the specific cost estimates and budgetary proposals associated with the implementation of this Agreement.

3. Any requirement for the payment or obligation of funds, including stipulated penalties, by NASA established by the terms of this Agreement shall be subject to the availability of appropriated funds. No provision herein shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, 31 U.S.C. Section 1341.

4. If appropriated funds are not available to fulfill NASA's obligations under this Agreement, EPA reserves the right to initiate an action against any other person, or to take any response action, which would be appropriate. However, should the appropriated funds be inadequate in any year to meet the requirements of this Agreement, NASA will, in consultation with EPA, prioritize and allocate that year's appropriated funds, considering legal requirements pertaining to each site under this Consent Agreement, relative risks to human health and the environment, and other relevant factors.

XIX. RESERVATION OF RIGHTS

1. EPA expressly reserves all rights and defenses that it may have, including the right both to disapprove of work performed by NASA pursuant to this Consent Agreement, to require that NASA correct and/or reperform any work disapproved by EPA, and to request that NASA perform tasks in addition to those stated in the relevant EPA guidance documents, workplan(s), reports(s) and/or this Consent Agreement.

2. EPA hereby reserves all of its statutory and regulatory powers, authorities, rights and remedies, both legal and equitable, including any which may pertain to NASA's failure to comply with any of the requirements of this Consent Agreement. This Consent Agreement shall not be construed as a covenant not to sue, or as a release, waiver or limitation of any rights, remedies, powers and/or authorities, civil or criminal, which EPA has under RCRA, CERCLA, or any other statutory, regulatory or common law authority.

3. Compliance by NASA with the terms of this Consent Agreement shall not relieve NASA of its obligations to comply with RCRA or any other applicable local, state, or federal laws and regulations.

4. The signing of this Consent Agreement and NASA's consent to comply shall not limit or otherwise preclude EPA from taking additional enforcement action pursuant to Section 7003 of RCRA, 42 U.S.C. Section 6973, or any other authority, should EPA determine that such action is warranted.

5. This Consent Agreement is not intended to be, nor shall it be construed as, a permit. This Consent Agreement does not relieve NASA of any obligation to obtain and comply with any local, state, or federal permit or approval except as otherwise provided for in CERCLA Section 121(e)(1).

6. EPA reserves the right to perform any portion of the work consented to herein or any additional Site characterization, feasibility study, and response/remedial actions it deems necessary to protect public health or welfare or the environment. EPA may exercise its authority under RCRA, CERCLA or any other authority to undertake or require the performance of response actions at any time. EPA reserves the right to seek reimbursement from NASA for costs incurred by the EPA in connection with any such response actions. Notwithstanding compliance with the terms of this Consent Agreement, NASA is not released from liability, if any, for the costs of any response actions taken by EPA.

7. EPA reserves whatever rights it may have under CERCLA or any other law, or in equity, to recover from NASA any costs incurred by EPA in overseeing the implementation of

this Consent Agreement.

8.

XX. OTHER CLAIMS

Nothing in this Consent Agreement shall constitute or be construed as a release from any claim, cause of action or demand in law or equity against any person, firm, partnership, or corporation, or other entity for any liability it may have arising out of or relating in any way to the generation, storage, treatment, handling, transportation, release, or disposal of any solid waste, hazardous constituents, hazardous substances, hazardous wastes, pollutants, or contaminants found at, taken to, or taken from the Main Base and/or Wallops Island Parcels.

XXI. OTHER APPLICABLE LAWS

All actions required to be taken pursuant to this Consent Agreement shall be undertaken in accordance with the requirements of all applicable local, state, and federal laws and regulations. The Parties recognize that under Section 121(e)(1) of CERCLA and the NCP, portions of the response actions called for by this Agreement and conducted entirely on site, where such response actions are selected and carried out in accordance with CERCLA, are exempt from the requirement to obtain Federal, Commonwealth, or local permits. All activities must, however, comply with the applicable or relevant and appropriate Federal and Commonwealth standards, requirements, criteria, or limitations that would have been included in any such permit. Except as otherwise provided in CERCLA Section 121(e)(1), NASA shall obtain or require its authorized representatives to obtain all permits and approvals necessary under such laws and regulations.

XXII. NOTICE OF NON-LIABILITY OF EPA

EPA shall not be deemed a party to any contract involving NASA and relating to activities at the Main Base and/or Wallops Island Parcels and shall not be liable for any claim or cause of action arising from or on account of any act, or the omission of NASA, its officers, employees, contractors, receivers, trustees, agents or assigns, in carrying out the activities required by this Consent Agreement.

XXIII. SUBSEQUENT MODIFICATION

1. Except as provided in Paragraph 2 of this Section XXIII, below, this Consent Agreement

may be amended only by mutual agreement of EPA and NASA. Any such amendment shall be in writing, shall be signed by an authorized representative of each party, shall have as its effective date the date on which it is signed by EPA, and shall be incorporated into this Consent Agreement.

2. Minor modifications in the studies, techniques, procedures, designs or schedules utilized in carrying out this Consent Agreement and necessary for the completion of the project may be made by written agreement of the Project Coordinators. Such modifications shall have as an effective date the date on which the agreement is signed by the EPA Project Coordinator.

3. No informal advice, guidance, suggestions, or comments by EPA regarding reports, plans, specifications, schedules, and any other writing submitted by NASA shall be construed as relieving NASA of its obligation to obtain written approval, if and when required by this Consent Agreement.

XXIV. SEVERABILITY

If any provision or authority of this Consent Agreement or the application of this Consent Agreement to any party or circumstance is held by any judicial or administrative authority to be invalid, the application of such provision to other parties or circumstances and the remainder of this Consent Agreement shall not be affected thereby and shall remain in full force.

XXV. TERMINATION AND SATISFACTION

The provisions of this Consent Agreement shall be deemed satisfied upon NASA's receipt of written notice from EPA that NASA has demonstrated, to the satisfaction of EPA, that the terms of this Consent Agreement, including any additional tasks determined by EPA to be required pursuant to this Consent Agreement, have been satisfactorily completed. This notice shall not, however, terminate NASA's obligation to comply with any continuing obligations hereunder including, but not limited to, Sections XI ("RECORD PRESERVATION"), XIX ("RESERVATION OF RIGHTS"), XX ("OTHER CLAIMS") and XXI ("OTHER APPLICABLE LAWS").

XXVI. ATTORNEYS' FEES

NASA shall bear its own costs and attorneys' fees.

XXVII. EFFECTIVE DATE

The effective date of this Consent Agreement shall be the date on which NASA receives a true and correct copy of the fully executed Consent Agreement or a true and correct copy of the fully executed modified Consent Agreement as provided in Section VIII ("PUBLIC COMMENT AND REVIEW OF Agreement").

IT IS SO AGREED:

DATE: 9/28/04 BY: James J. Burke

JAMES J. BURKE
DIRECTOR OF THE WASTE AND CHEMICALS
MANAGEMENT DIVISION
UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY, REGION III

DATE: 9-30-04 BY: EJ Weiler

DR. EDWARD J. WEILER,
DIRECTOR
NASA GODDARD SPACE FLIGHT CENTER

Attachment 1
Index of Administrative Record

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
					1.0 Pre-Remedial				
01.01 Pre-Remedial Investigation Correspondence									
1	0001	01.01.00.0001	3/1/1986	131	Vol. 1, Environmental Audit Goddard Space flight Center Wallops Flight Facility	Letter	WFF	Fred C. Hart Associates, Inc.	National Aeronautics and Space Administration (NASA)
1	0002	01.01.00.0002	9/18/1989	17	Review of Removal Actions, Waste Oil Site End of Runway 17-35	Letter	WOD	M. Green, NASA	James A. Asne/EBASCO Services, Inc.
1	0003	01.01.00.0003	3/3/1993	6	Locations and Maps for Coordination of Environmental Sites	Letter	WFF	Teresa Spagnuolo/NASA, Environmental Branch	NASA, Fac. Eng. Br.; Fac. Mgm. Sec; Plant O&M Br.
3	0004	01.01.00.0004	6/2/2003	9	Response to Comments on draft Site Screening Document M-15 Photographic Tank Site	Letter	M15	Tetra Tech NUS, Inc.	NASA, EPA, VADEQ
01.02 Pre-Remedial Investigation Preliminary Assessment Documents									
2	0005	01.02.00.0001	1/1/1998	14	Preliminary Assessment Report for Wallops Flight Facility (WFF), National Aeronautics and Space Administration, Wallops Island, Virginia, undated	Report	WFF		
1	0006	01.02.00.0002	8/1/1994	371	Environmental Resources Document	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0007	01.02.00.0003	10/0/1999	381	Environmental Resource Document	Report	WFF	Occu-Health, Inc.	NASA
01.03 Pre-Remedial Investigation Site Investigation Documents									
1	0008	01.03.00.0001	2/1/1989	51	NASA Site Inspection for Goddard Space Flight Center and WFF, Statement of Work for Soil Borings and Well Installations	WP	WFF	EBASCO Services, Inc.	NASA
1	0009	01.03.00.0002	3/1/1989	61	Site Inspection Goddard Space Flight Center Field Sampling Plan	WP	WFF	EBASCO Services, Inc.	NASA
1	0010	01.03.00.0003	1/1/1990	155	Final Site Inspection NASA, Volumes I and II	Report	WFF	EBASCO Services, Inc.	
1	0011	01.03.00.0004	9/1/1990	28	Final Report Soil Gas and PCB Screen; Waste Oil Dump; Scrapyard; PCB Transformer	Report	WFF	EBASCO Services, Inc.	NASA
1	0012	01.03.00.0005	9/26/1991	44	Detection Limits/Analytical Methods for All Analyses: TCL Volatiles, semi-Volatiles, Pesticides/PCB's and TAL Metals and Cyanide	Letter	WFF	Teresa Spagnuolo/NASA	Jane Pillips/Medcalf & Eddy
1	0013	01.03.00.0006	5/1/1992	142	Quality Assurance/Quality Control Plan; Revision of Site Investigation	WP	WFF	Metcalf & Eddy, Inc.	NASA

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
1	0014	01.03.00.0007	5/1/1992	98	Field Sampling and Analysis Plan, Revision of Site Investigation	WP	WFF	Metcalf & Eddy, Inc.	NASA
1	0015	01.03.00.0008	8/1/1992	227	Final Report; Revision of Site Investigation Vol. I	Report	WFF	Metcalf & Eddy, Inc.	NASA
1	0016	01.03.00.0009	8/1/1992	330	Final Report; Revision of Site Investigation Vol. II - References	Report	WFF	Metcalf & Eddy, Inc.	NASA
1	0017	01.03.00.0010	8/1/1992	474	Final Report; Revision of Site Investigation Vol. IV - References	Report	WFF	Metcalf & Eddy, Inc.	NASA
1	0018	01.03.00.0011	8/22/1995	469	Final Site Inspection Work Plan	WP	WFF	Metcalf & Eddy, Inc.	NASA
2	0019	01.03.00.0012	5/1/1996	30	Aerial Photographic Analysis NASA - Wallops Flight Facility, Wallops Island, Virginia	Report	WFF	G. I. Martucci/Lockheed Environmental Systems & Technologies Co./EPA/ORD	EPA Hazardous Waste Mgm. Div. Reg. 3, Phila, PA/Office of Emergency and Remedial Response, Wash, DC
2	0020	01.03.00.0013	3/27/1996	512	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume I, Site Inspection Report	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0021	01.03.00.0014	3/27/1996	155	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume II, Preliminary Reports, Phases I-II, Field Surveys	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0022	01.03.00.0015	3/27/1996	407	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume III, Preliminary Reports, Phases III-IV, Field Sampling	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0023	01.03.00.0016	3/27/1996	180	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume IV, Preliminary Reports, HRS Scoring	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0024	01.03.00.0017	3/27/1996	435	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume V, Preliminary Reports, HRS PRECORE Output	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0025	01.03.00.0018	3/27/1996	1168	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume VI, Preliminary Report, HRS PRECORE Output	Report	WFF	Metcalf & Eddy, Inc.	NASA

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
2	0026	01.03.00.0019	3/27/1996	92	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume VII, Preliminary Report, EPA HRS PRESCORE Software and Manual	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0027	01.03.00.0020	3/27/1996	425	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume VIII, Preliminary Reports, References	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0028	01.03.00.0021	3/27/1996	699	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume IX, Preliminary Report, References	Report	WFF	Metcalf & Eddy, Inc.	NASA
2	0029	01.03.00.0022	3/27/1996	847	Site Inspection for Miscellaneous Sites at Wallops Flight Facility, Volume X, Preliminary Report, References	Report	WFF	Metcalf & Eddy, Inc.	NASA
3	0030	01.03.00.0023	11/1/2000	36	Wallops Flight Facility - Main Base GIS Based Historical Photographic Analysis 1938-1980	Report	WFF	U.S. Army Corps of Engineers, Norfolk District	NASA
3	0031	01.03.00.0024	7/31/2001	95	Site Investigation Report ADAS Facility Site 10	Report	10	Versar, Inc.	NASA
3	0032	01.03.00.0025	1/14/2003	12	Letter Work Plan for Supplemental Investigations Advanced Data Acquisition Support Facility (ADAS) NASA WFF, Wallops Main Base, NASA, WFF, Wallops Island, Virginia	Letter Report	10	Sue Fields/NASA	Mark Leeper/VADEP and Todd M. Richardson/USEPA
3	0033	01.03.00.0026	2/20/2003	7	Final letter Work Plan, Potable Water Supply Well Sampling	WP	WFF	Tetra Tech NUS, Inc. (TtNUS)	NASA
3	0034	01.03.00.0027	4/8/2003	151	Final Letter Report, Potable Water Supply Well Sampling	Letter Report	WFF	TtNUS	NASA
1	0035	01.03.00.0028	9/0/1990	206	Final Summary Report, Scrapyard, PCB Transformer, Photographic Tank, Waste Oil Dump	Report	WFF	EBASCO Services, Inc.	NASA
01.04 Pre-Remedial Investigation Expanded Site Investigation									
3	0036	01.04.00.0001	1/14/2003	100	Final Letter Work Plan, Background Soil and GW Investigation for the Main Base, NASA, WFF, Wallops Island, Virginia	WP	WFF	Sue Fields/NASA	Mark Leeper/VADEP and Todd M. Richardson/USEPA
3	0037	01.04.00.0002	7/10/2003	66	Summary Site Characterization Report for Wallops Island Fueling Station VADEQ Case No. PC# 93-0913 (Site 6, Building X-5 and X-10)	Report	WFF	TtNUS	NASA

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
01.05 Pre-Remedial Hazard Ranking System (HRS) Documents									
					2.0 Removal Response				
02.01 Removal Response Correspondence									
1	0038	02.01.00.0001	2/15/1995	2	Radiation Survey 'Walk-over' of Salvage Yard at Wallops Flight Facility (West Side of Building N-222)	Letter	N-222	Tad M. Blanchard, Senior Health Physics Technician, National Health Services, Inc.	Head, Safety and Health Branch, Terry Potterton/NASA
1	0039	02.01.00.0002	6/30/1995	1	Comments on Proposed Project Approach for Radiological Survey, Scrapyard, Wallops Flight Facility	Letter	N-222	Stacie M. Driscoll/EPA Region III	Ms. Teresa Spagnuolo/NASA
2	0040	02.01.00.0003	1/22/1996	5	Comments on NASA Goddard Space Flight Center Wallops Flight Facility, Scrapyard, Work Plan for Radiological Survey	Letter	N-222	Stacie M. Driscoll/EPA Region III	Ms. Teresa Spagnuolo/NASA
2	0041	02.01.00.0004	3/15/1996	14	Response to Comments on the Work Plan for Radiological Survey	Letter	N-222	Teresa Spagnuolo/NASA	Stacie Morekas-Driscoll/EPA, Region III
2	0042	02.01.00.0005	4/1/1996	1	Work Plan for Radiological Survey, Approval of Response to Comments	Letter	N-222	Stacie M. Driscoll/EPA, Region III	Ms. Teresa Spagnuolo/NASA
3	0043	02.01.00.0006	3/19/2003	2	Notification and Certification Requirements of 40 CFR Part 761.61	Letter	N-222	Sue Fields, NASA RPM	Donald S. Welsh, EPA/ R.G. Brumley DEQVA/K. Bull, Accomack County
02.02 Removal Response Reports									
1	0044	02.02.00.0001	6/9/1995	11	Proposed Approach for Radiological Survey for Scrapyard located at Wallops Flight Facility (WFF)	Letter	N-222	Teresa Spagnuolo/NASA	Stacie Morekas-Driscoll/EPA, Region III
2	0045	02.02.00.0002	10/10/1997	72	Final Scrapyard Area Radiological Survey Report	Report	N-222	Metcalf & Eddy	NASA
3	0046	02.02.00.0003	10/1/2002	59	Final Sampling and Analysis Plan and Radiological Field Survey for the N-222 Scrapyard and Area	Report	N-222	Weiss Associates	NASA
3	0047	02.02.00.0004	1/1/2003	73	Final Work Plan For The Removal Action At Site 005 and Site 012 Wallops Flight Facility	Report	5/12	Foster Wheeler Environmental Corporation	NASA
3	0048	02.02.00.0005	1/31/2003	162	Soil Sampling and Radiological Field Survey Data Gaps Report	Report	N-222	Weiss Associates	NASA

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

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3	0049	02.02.00.0006	3/14/2003	101	Removal Action Work Plan for The N-222 Scrapyard Area	Report	N-222	Weiss Associates	NASA
02.03 Removal Response CERCLA Removal Site Record									
3	0050	02.03.00.0001	2/0/2003	7	Action Memorandum for the NASA Goddard Space Flight Center's Non-time-critical Removal Action at the Paint Stain (Site 5) and Former Wind Tunnel (Site 12) Wallops Island, VA	Action Memo	5/12	William B. Bott/NASA	
3.0 Remedial Investigation (RI)									
03.01 Remedial Investigation Correspondence									
1	0051	03.01.00.0001	10/6/1992	14	Review of the draft Work Plan, Fire Training Area, Remedial Investigation/Feasibility Study for Wallops Flight Facility and the draft Field Operations Plan, Fire Training Area, Remedial Investigation/Feasibility Study for Wallops Flight Facility	Letter	FFTA	Stacie Morekas/USEPA	Mr. Terry M. Potterton/NASA
2	0052	03.01.00.0002	2/5/1997	13	Ecological Risk Assessment, Revisions to Work Plan for Sites 5, 12, 14, and 15	Letter	5/12 14/15	Mr. William H. Burton/Versar, Inc.	Coastal Resource Coordinator/National Oceanic and Atmospheric Administration
3	0053	03.01.00.0003	1/1/2002	2	VADEQ Comments on the December 2001 RI/FS for Sites 5 and 12, undated	Letter	5/12	VADEQ	NASA
3	0054	03.01.00.0004	2/25/2002	6	VADEQ Comments on the March 2001 RI/FS for Site 16	Letter	WOD	VADEQ	NASA
03.02 Remedial Investigation Sampling and Analysis Data - validated data and chain of custody forms are included in the AR by indicating their location and									
1	0055	03.02.00.0001	9/16/1993	586	Data Validation Narratives - Volume I	Report	WFF	Versar, Inc./Roy F. Weston, Inc.	NASA
2	0056	03.02.00.0002	5/14/1997	551	Data Validation Narratives - Volume II	Report	WFF	Versar, Inc.(Metcalf & Eddy/Roy F. Weston, Inc.)	NASA
03.03 Remedial Investigation Site Management Plan									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
03.04 Remedial Investigation Work Plans (including FSAP and QAPP), Progress Reports									
1	0057	03.04.00.0001	3/29/1993	225	Fire Training Area RI/Feasibility Final Work Plan	WP	FFTA	Metcalf & Eddy, Inc.	NASA
1	0058	03.04.00.000	3/0/1993	609	Fire Training Area RI/Feasibility Final Field Operations Plan	WP	FFTA	Metcalf & Eddy, Inc.	NASA
1	0059	03.04.00.0003	1/16/1995	373	Limited RI/Feasibility Study Final Work Plan Scrapyard	WP	N-222	Metcalf & Eddy, Inc.	NASA
2	0060	03.04.00.0004	5/2/1997	84	NASA Wallops island RI/FS Work Plan Sites 5, 12, 14, and 15	WP	5/12 14/15	Versar, Inc.	NASA
3	0061	03.04.00.0005	1/0/2003	800	Work Plan for Supplemental RI Activities at the Former Fire Fighting Training Area and Waste Oil Dump	WP	FFTA WOD	Tetra Tech NUS, Inc.	NASA
3	0094	03.04.00.0006	8/1/2003	123	Final Work Plan for the Supplemental RI at WFF Sites 005 and 012 (CD)	WP	WFF	Tetra Tech NUS, Inc.	NASA
03.05 Remedial Investigation Interagency or Federal Facility Agreements									
03.06 Remedial Investigation ARARs - if applicable									
03.07 Remedial Investigation (RI) Report									
1	0062	03.07.00.0001	8/28/1995	203	Limited RI Report for the Scrapyard Area	Report	N-222	Metcalf & Eddy	NASA
2	0063	03.07.00.0002	2/28/1996	370	Former Fire Training Area RI Final Report	Report	FFTA	Metcalf & Eddy	NASA
2	0064	03.07.00.0003	6/14/1999	757	RI/Feasibility Study Sites 14 and 15	Report	14/15	Versar, Inc.	NASA
3	0065	03.07.00.0004	12/6/2001	484	RI/Feasibility Study Sites 5 and 12, Volume I	Report	5/12	Versar, Inc.	NASA
3	0066	03.07.00.0005	12/6/2001	445	RI/Feasibility Study Sites 5 and 12, Volume II	Report	5/12	Versar, Inc.	NASA
3	0067	03.07.00.0006	3/13/2001	477	RI/Feasibility Study Site 16 Waste Oil Dump	Report	WOD	Versar, Inc.	NASA
3	0068	03.07.00.0007	10/6/2003	51	Final Site Screening Document M-15 Photographic Tank (Photo Tank) Site	Report	M15	Tetra Tech NUS, Inc.	NASA

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
03.08 Remedial Investigation Health Assessment - produced by ATSDR									
03.09 Remedial Investigation Endangerment/Risk Assessments									
3	0069	03.09.00.0001	12/8/2000	194	Risk Assessment Update Formar Fire Fighting Training Area	Report	FFTA	Versar, Inc.	NASA
4.0 Feasibility Study (FS)									
04.01 Feasibility Study (FS) Correspondence									
04.02 FS Sampling and Analysis Data -- if applicable									
04.03 FS Scopes of Work -- if applicable									
04.04 FS Work Plans -- if applicable									
04.05 FS ARARs - Initial Screening									
04.06 FS Treatability Studies/Site Characterizations -- if applicable									
04.07 Feasibility Study (FS) Report									
04.08 FS Proposed Plans for Selected Remedial Action									
5.0 Record of Decision									
05.01 Correspondence									
05.02 Responsiveness Summaries - Administrative Record									

7

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
05.03 Scopes of Work									
3	0070	05.03.00.0001	2/7/2002	4	Preliminary Identification, Commonwealth of Virginia, Applicable, Relevant & Appropriate Requirements (ARARs)	Letter	WFF	VADEQ	NASA
05.04 Work Plans									
05.05 Interagency or Federal Facility Agreements									
05.06 ARARs									
05.07 Records of Decision									
3	0071	05.07.00.0001	2/24/2003	69	Final Decision Document for Building N-161C PCB Transformer Pad Site NASA Wallops Flight Facility	Report	N-161	Tetra Tech NUS, Inc.	NASA
3	0095	05.07.00.0002	8/1/2002	156	Final Decision Document for Advance Data Acquisition Support Facility (ADAS) Site NASA Wallops Flight Facility	Report	N-161	Tetra Tech NUS, Inc.	NASA
6.0 Remedial Design									
06.01 Correspondence									
06.02 Sampling and Analysis Data									
06.03 Scopes of Work									
06.04 Work Plans and Progress Reports									
06.05 Cost Reports and Invoices									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
06.06 Interagency and Cooperative Agreements									
06.07 Applicable or Relevant and Appropriate Requirements (ARARs)									
06.08 Remedial Design Documents									
7.0 Remedial Action									
07.01 Correspondence									
07.02 Sampling and Analysis Data									
07.03 Scopes of Work									
07.04 Work Plans and Progressive Reports									
3	0072	07.04.00.0001	6/1/2003	38	Final Work Plan Addendum for the OE Removal Action at the N-222 Scrapyard Area WFF 2/03	Report	N-222	NASA	NASA
3	0073	07.04.00.0002	6/1/2003	59	Final Site Health and Safety Plan Addendum for the OE Removal Action at the N-222 Scrapyard Area, June 2003	Report	N-222	NASA	NASA
07.05 Cost Reports and Invoices									
07.06 Interagency and Cooperative Agreements									
07.07 ARARs									
07.08 Remedial Action Documents									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
8.0 Site Closeout (BRAC Documents)									
08.01 Correspondence									
08.02 Deletion from National Priorities List									
08.03 Operations and Maintenance									
08.04 Contractor Work Plans and Progress Reports									
08.05 Cost Reports and Invoices									
08.06 Long Term Responses									
9.0 State Coordination									
09.01Correspondence - documents of state involvement									
09.02 Federal Facility/State Contract/State Issued Permit -- if applicable									
09.03 State Memoranda of Agreement (SMOA) -- if applicable									
10.0 Enforcement									
10.01 Correspondence									
10.02 State Enforcement Records									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
10.03 Department of Justice (DOJ) - Referral Documents									
10.04 State Negotiations									
10.05 Federal Facility Negotiations									
10.06 EPA Administrative Order									
10.07 EPA Consent Order									
13.0 Community Relations									
13.01 Correspondence - all written comments from the public including factual data and Federal Agency responses									
13.02 Mailing List									
3	0074	13.02.00.0001	3/1/2003	6	Community Involvement Mailing List, Appendix A	List	WFF	Tetra Tech NUS, Inc.	NASA
13.03 Technical Review Committee									
13.04 Community Involvement Plan									
3	0075	13.04.00.0001	3/1/2003	47	Community Involvement Plan for NASA Wallops Flight Facility, Wallops Island, Virginia	Plan	WFF	Tetra Tech NUS, Inc.	NASA
13.05 Public Meetings-- transcripts with public comment, attendance list, agenda, and all public meetings									
3	0076	13.05.00.0001	12/28/2002	2	Public Notice for Sites 5/12 RI, Removal Work Plan, Action Memo, and Removal Action	PN	5/12	Gannett Publications	
13.06 Fact Sheets									
1	0077	13.06.00.0001	4/1/1991	1	Environmental Fact Sheet, Old Aviation Fuel Tank Farm	FSh	WFF	NASA, Public Affairs	
1	0078	13.06.00.0002	9/1/1991	2	Environmental Insight Fact Sheet, Old Aviation Fuel Tank Farm	FSh	WFF	NASA, Public Affairs	
1	0079	13.06.00.0003	9/1/1992	1	Environmental Insight Fact Sheet, Old Aviation Fuel Tank Farm	FSh	WFF	NASA, Public Affairs	

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
1	0080	13.06.00.0004	10/1/1993	1	Environmental Insight Fact Sheet, Old Aviation Fuel Tank Farm	FSh	WFF	NASA, Public Affairs	
1	0081	13.06.00.0005	10/1/1994	2	Environmental Insight Fact Sheet, Old Aviation Fuel Tank Farm	FSh	WFF	NASA, Public Affairs	
3	0082	13.06.00.0006	12/1/2002	2	NASA Fact Sheet, NASA's Environmental Restoration Program at Wallops Flight Facility	FSh	WFF	NASA, Public Affairs	
3	0083.	13.06.00.0007	6/0/2002	2	Former Wind Tunnel (Site 12) Contaminated Soil, Fact Sheet	FSh	5/12	NASA, Env. Program	
14.0 Congressional Relations									
14.01 Correspondence -- if applicable									
14.02 Transcripts -- if applicable									
14.03 Testimonies -- if applicable									
14.04 Published Hearing Records -- if applicable									
16.0 Natural Resource Trustee									
16.01 Correspondence									
3	0084	16.01.00.0001	1/14/2003	5	Natural Resource Trustee Notification	Letter	WFF	Sue Fields/NASA	Robert M. Burr/US DOI
3	0085	16.01.00.0002	1/14/2003	5	Natural Resource Trustee Notification	Letter	WFF	Sue Fields/NASA	Russell Bellmar/NOAA
3	0086	16.01.00.0003	1/14/2003	5	Natural Resource Trustee Notification	Letter	WFF	Sue Fields/NASA	Honorable W. Tayloe Murphy,Jr./Secretary Natural Resources, Commonwealth of VA
16.02 Natural Resource Trustee Release									
16.03 Trustee Notification Form and Selection Guide									
16.04 Technical Issue Paper									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
18.0 Initial Remedial Measures (IRM)									
18.01 Correspondence									
18.02 IRM Response									
19.0 Resource Conservation and Recovery Act (RCRA) Records									
19.01 Correspondence									
19.02 Notification/Part A/Part B/Permit Mods									
19.03 RCRA Facility Assessment (RFA) Reports									
1	0087	19.03.00.0001	11/1/1992	147	Draft RFA Report	Report	WFF	Versar, Inc.	
19.04 RCRA Facility Inspection (RFI) Report									
19.05 RCRA Enforcement Action									
19.06 Quarterly Enforcement Action									
19.07 RCRA Corrective Measures Study (CSM)									
19.08 RCRA Statement of Basis									
19.09 RCRA Corrective Measure Implementation									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
19.40 RCRA Facility Inspection (RFI) Report									
19.41 Correspondence									
19.42 Sampling and Analysis Data									
19.43 Corrective Action MGMT Plan (CAMP)/Site MGMT Plan									
19.44 Work Plans									
19.45 Interagency/Federal Facility Agreements									
19.46 ARARs									
19.47 RCRA Facility Investigation (RFI) Report									
19.48 Health/Endangerment/Risk Assessments									
19.49 Interim Measures									
19.70 RCRA Corrective Measures Study (CMS)									
19.71 Correspondence									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
19.72 Sampling and Analysis Date									
19.73 Scopes of Work									
19.74 Work Plan									
19.75 ARARs – Initial Screening									
19.76 Treatability Studies/Site Characterization									
19.77 Corrective Measure Study (CMS) Report									
19.78 Proposed Plan for Selected Remedial Action									
19.79 RCRA Statement of Basis									
19.81 Correspondence									
19.82 Responsiveness Summaries									
19.83 Scope of Work									
19.84 Work Plans									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
19.85 Interagency or Federal Facility Agreements									
19.86 ARARs									
19.87 Statement of Basis									
19.90 RCRA Corrective Measures Implementation (CMI)									
19.91 Correspondance									
19.92 Sampling and Analysis Data									
19.93 Scopes of Work									
19.94 Work Plans/Progress Reports									
19.95 Cost Reports and Invoices									
19.96 Interagency and Cooperative Agreements									
19.97 ARARs									
19.98 Corrective Measure Design/Construction & Implementation									

ADMINISTRATIVE RECORD - WALLOPS FLIGHT FACILITY

CD	ID No.	EPA AR Category and Document Tracking Number	Date	No. of pages	Description of Document/Correspondence	Doc. Type	Site	Author/Author's Affiliation	Recipient/Recipient's Affiliation
21.0 Non-Specific/Oversight Activities									
21.01 Correspondence – if applicable									
21.02 RPM Meeting Minutes, Handouts, and Material									
3	0088	21.02.00.0001	10/23/2001	3	Remedial Project Managers Meeting Summary	Minutes	WFF	Sue Fields/NASA	Project Team
3	0089	21.02.00.0002	1/23/2002	2	Remedial Project Managers Meeting Summary	Minutes	WFF	Sue Fields/NASA	Project Team
3	0090	21.02.00.0003	4/30/2002	1	Remedial Project Managers Meeting Summary	Minutes	WFF	Sue Fields/NASA	Project Team
3	0091	21.02.00.0004	8/19/2002	1	Remedial Project Managers Meeting Summary	Minutes	WFF	Sue Fields/NASA	Project Team
3	0092	21.02.00.0005	12/4/2002	84	Remedial Project Managers Meeting Summary	Minutes	WFF	Sue Fields/Donna Sutherland/NASA	Project Team
3	0093	21.02.00.0006	3/6/2003	23	Final Remedial Project Managers Meeting Summary	Minutes	WFF	Donna Sutherland/NASA	Project Team
3	0096	21.02.00.0007	6/18/2003	7	Remedial Project Managers Meeting Summary	Minutes	WFF	Brenda Harris/Carolyn Turner	Project Team
50.0 Administrative Record Oversight Activities									
50.01 Internal Requests for AR Inclusion									
50.02 Repository Correspondence									

EXHIBIT IV.A-2: TOPGRAPHIC MAP OF CORRECTIVE ACTION UNIT

MODULE V - DETECTION MONITORING

V.A. HIGHLIGHTS – BACKGROUND

The Open Burn (OB) Area at the NASA Wallops Flight Facility (WFF) is located on the southwest end of Wallops Island and consists of four cylinders embedded in the ground and a single open burn pad assembly. NASA has been using the OB Area since 1972. In 1988, NASA submitted a RCRA Part B Permit Application and operated under interim status until the final Permit for Open Burning Treatment of Hazardous Waste was issued on September 20, 2005. Groundwater monitoring at the OB Area was conducted under a Detection Monitoring Program from permit issuance in 2005 until hazardous constituents related to the site were determined to be statistically significant above background concentrations in 2014. At the time of permit re-issuance, the facility is entering into compliance groundwater monitoring.

MODULE VI - GROUNDWATER COMPLIANCE MONITORING

VI.A. MODULE HIGHLIGHTS – BACKGROUND

The Open Burn (OB) Area at the NASA Wallops Flight Facility (WFF) is located on the southwest end of Wallops Island and consists of three cylinders embedded in the ground and a single open burn pad assembly.

NASA has been using the OB Area since 1972. In 1988, NASA submitted a RCRA Part B Permit Application and operated under interim status until the final Permit for Open Burning Treatment of Hazardous Waste was issued on September 20, 2005. Groundwater monitoring at the OB Area was conducted under a Detection Monitoring Program from permit issuance in 2005 until hazardous constituents related to the site were determined to be statistically significant above background concentrations in 2014. At the time of permit re-issuance, the facility is entering into compliance groundwater monitoring.

VI.B. COMPLIANCE MONITORING REQUIREMENTS

VI.B.1. The Compliance Monitoring Program requires monitoring at the upgradient monitoring well, and point of compliance wells at least semiannually. Static groundwater elevations will be measured at all wells during each sampling event.

a. Groundwater beneath the OB Area shall be monitored with one background groundwater monitoring well and at least three downgradient point of compliance wells located as specified on the map presented in Permit Attachment VI.A-9.

As a result of the major storm event of November 11 -13, 2009, the original background monitoring well MW-3 was damaged and was deemed inoperable. The Permittee submitted an Open Burn Area Proposed Background Well (MW-4) Analysis Report, dated February 9, 2010. The above Report proposed an original point-of-compliance well, MW-4, to serve as the new background monitoring well, replacing the damaged background well MW-3. In a letter dated April 5, 2010, the DEQ determined that MW-4 was a suitable replacement background well. On May 6, 2010, the Permittee requested a Class 2 permit modification to replace MW-3 with MW-4 as the facility background well. MW-4 was approved as the OB Area background well on August 3, 2010.

Monitoring well MW-4 is the background well for the OB Area and monitoring wells MW-1, MW-2, MW-5, MW-6, and MW-7 are the point of compliance wells.

b. The point of compliance wells and background well will be sampled in accordance with the Sampling and Analysis Plan (Permit Attachment VI.A) and the following schedule:

1. The background well and downgradient point of compliance wells specified in Permit Section VI.C.1. will be sampled semiannually for the constituents listed in Permit Attachment VI.B. Samples for each constituent will be collected using the methods specified in Permit Attachment VI.A and analyses shall be obtained using the EPA SW-846 Methods specified in Permit Attachment VI.B.

2. Alternate SW-846 methods may be approved by the Director, provided the request is in writing and submitted 30 days prior to the sampling event. Proposed alternate methods must achieve the same Limit of Quantitation (or lower) as the specified method.

3. The background well and downgradient point of compliance wells specified in Permit Section VI.B.1. will be sampled annually for the 40 CFR 264 Appendix IX constituents listed in Permit Attachment VI.D.

VI.C. WELL LOCATION, INSTALLATION, AND CONSTRUCTION

The Permittee shall maintain a ground water monitoring system as specified below:

VI.C.1. The Permittee shall maintain groundwater monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7 at the locations specified on the map presented in Permit Attachment VI.A-Figure II. If additional monitoring wells are required they shall be installed and sampled in accordance with the requirements of 40 CFR § 264.97:

a. Boring logs for monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7 are included as Permit Attachment VI.A-7.

b. Monitoring well design and construction details for monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7 are included as Exhibit VI.A-7.

VI.C.2. All groundwater monitoring wells required by this permit shall be maintained in conformance with the following:

a. The ground water monitoring system must yield samples in upgradient well(s) that represent the quality of the background ground water unaffected by leakage from the regulated unit, and, in downgradient wells, yield samples that represent the quality of groundwater passing the point of compliance.

b. The number and location of monitoring wells must be sufficient to identify and define all logical release pathways from the regulated units to the uppermost aquifer based on site specific hydrogeologic characterization.

VI.C.3. The Permittee shall maintain the monitoring wells identified in Permit Section VI.C.1, of the Permit in accordance with the plans and specifications presented in Exhibit VI.A-7.

VI.C.4. The Director must approve the addition or removal of all monitoring wells prior to installation or decommissioning.

a. The Permittee shall request approval for abandonment of all monitoring wells, observation wells, and remediation wells from the Department prior to implementing well abandonment activities. All wells that are to be abandoned shall be plugged and abandoned in general accordance with 12VAC 5-630-420 and 12VAC 5-630-450. Chlorination of each well is not required and an effort to remove the well casing and associated materials shall be made at each well prior to abandonment. A report including methods and certification will be submitted to the Department within thirty (30) days following the completion of abandonment. The Permittee may propose alternate methods for well abandonment and must obtain approval from the Department prior to implementing alternate methods for well abandonment activities."

b. All monitoring wells added to the existing groundwater monitoring system described in Permit Section VI.C.I, must be constructed in accordance with the requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) and approved by the Department (Exhibit VI.A-5).

VI.D. GROUND WATER PROTECTION STANDARD

VI.D.1. The Permittee shall monitor the groundwater to determine whether regulated units are in compliance with the Groundwater Protection Standard (GPS) under 40 CFR § 264.92. The GPS is based in part upon upgradient concentrations from the facility's initial background monitoring, EPA Maximum Contaminant Levels (MCLs), and Alternate Concentration Limits (ACLs). ACLs are health based standards calculated by DEQ. The hazardous constituents and their concentration limits listed in Permit Attachment VI.C comprise the GPS.

VI.D.2. The Permittee shall monitor all wells as described in Permit Sections VI.C.1 for all parameters and constituents specified in Permit Attachments VI.B.

VI.D.3. The compliance period, as defined by 40 CFR § 264.96, is the period during which the GPS applies is equal to the number of years equal to the active life of the waste

management area, including waste management activities conducted prior to permitting and the closure period. If the Permittee is conducting corrective action at the end of the compliance period specified, then the compliance period shall be extended until the Permittee demonstrates that the GPS has not been exceeded for three (3) consecutive years.

VI.E. SAMPLING AND ANALYSIS PROCEDURES

The Permittee shall use the following techniques and procedures when obtaining and analyzing samples from the ground water monitoring wells described in Permit Sections VI.C.

VI.E.1. Groundwater monitoring samples shall be collected using the techniques described in Attachment VI.A.

VI.E.2. Samples shall be preserved, packed, and shipped off-site for analysis in accordance with the procedures specified in Permit Attachment VI.A.

VI.E.3. Samples shall be analyzed in accordance with the procedures specified in Permit Attachment VI.A using the methods prescribed in Attachment VI.B.

VI.E.4. Samples shall be tracked and controlled using the chain-of-custody procedures specified in Attachment VI.A.

VI.E.5. The Permittee must determine the concentration of hazardous constituents and parameters in the ground water at upgradient and compliance point wells at least semiannually in accordance with VI.B.1 of this Permit.

VI.E.6. The Permittee must analyze samples from the background well and all point of compliance wells, for all constituents contained in Appendix IX to CFR part 264 at least annually for at least two years. At that time, the Facility may demonstrate that a subset of Appendix IX methods and/or parameters is appropriate for continued monitoring through a minor permit modification.

VI.F. ELEVATION OF THE GROUND WATER SURFACE

VI.F.1. The Permittee shall determine the groundwater surface elevation at each monitoring well (MW-1, MW-2, MW-4, MW-5, MW-6, and MW-7) each time groundwater is sampled in accordance with Attachment VI.A.

VI.F.2. The Permittee shall report the surveyed elevation of any additional or replacement monitoring well(s) when installed with as-built drawings. The total depth of wells and the elevation of the following shall be recorded: top of the casing, ground surface and/or apron elevation, and the top of the protective casing.

VI.G. STATISTICAL PROCEDURES

When evaluating the monitoring results in accordance with Permit Section VI.H., the Permittee shall determine whether there is statistically significant evidence of increased contamination for any hazardous constituent or parameters specified in the Groundwater Protection Standard VI.C. using the statistical procedures in Exhibit VI.A-6.

VI.G.1. The Permittee may elect to perform a simple empirical comparison of Point of Compliance data to the GPS instead of the statistical procedures specified in Permit Attachment VI.A-6.

VI.H. MONITORING PROGRAM AND DATA EVALUATION

The Permittee shall determine ground water quality as follows:

VI.H.1. The Permittee shall collect, preserve, and analyze ground water samples pursuant to Module VI.E of this Permit.

VI.H.2. The Permittee shall determine whether there is evidence of increased contamination for any chemical parameter or constituent when compared, either statistically or empirically, to established upgradient background concentrations, as specified in Permit Attachment VI.C. These determinations should be made at least semiannually.

VI.H.3. The Permittee shall determine the ground water flow rate and direction in the uppermost aquifer at least annually.

VI.H.4. The Permittee shall determine whether there is a statistically significant increase over the ground water protection standards listed in Permit Attachment VI.C each time ground water quality is determined at the point of compliance. In determining whether such an increase has occurred, the Permittee must compare the ground water quality at each monitoring well specified in Module VI.C.1 of this Permit, to the ground water protection standards listed in Permit Attachment VI.C, in accordance with the statistical procedures specified in Module VI.G. of this Permit.

VI.H.5. The Permittee shall analyze samples from all compliance point wells, for all constituents contained in Appendix IX to CFR Part 264 at least annually to determine whether additional hazardous constituents are present in the uppermost aquifer.

a. If the Permittee finds additional constituents present (i.e. not listed in Module VI.B of the Permit, the Permittee shall notify the Director within seven (7) days of the data being available from the laboratory. The Permittee may resample within thirty (30) days of receipt of original laboratory data, not to exceed sixty days (60) from date of original sample collection and repeat the analysis for the detected

Appendix IX to 40 CFR § 264 constituent(s). If resampling is intended, the Permittee shall include the proposed sampling date with the notification.

b. If the second analysis confirms the presence of new constituents, the Permittee shall report the concentration of these additional constituents to the Director in writing within seven (7) days after the data is available from the laboratory and add them to the Compliance Monitoring Program Constituent list.

c. If the Permittee chooses not to resample, then the Permittee shall report the concentrations of these additional constituents to the Director within seven (7) days after the data is available from the laboratory and add them to the Compliance Monitoring Program Constituent List.

d. As a result of detected Appendix IX to 40 CFR § 264 constituent(s), the Permittee may demonstrate that a source other than the Regulated Unit caused the detection pursuant to 40 CFR § 264.99(i). The Director shall be notified of the Permittee's intent to make the demonstration in conjunction with either the initial notification that a new constituent was detected or with the confirmation notice after the resampling. The results of the demonstration will be submitted to the Director within ninety (90) days of the notification.

VI.H.6. If the second analysis confirms the presence of new constituents, the Permittee shall establish the background values for each additional Appendix IX to CFR 264 constituent found in the ground water in accordance with the following procedures:

a. Background ground water quality for a monitoring parameter or constituent shall be based on data from at least quarterly sampling of the upgradient monitoring well (MW-4) for one year.

VI.H.7. For each additional confirmed Appendix IX to CFR 264 constituent, the EPA Safe Drinking Water Act MCL as listed in the Environmental Protection Agency's Drinking Water Regulations and Health Advisories, or the higher of the background value, a Health Based Risk Assessment ACL approved by the Director in accordance with VHWMR §§ 10.5.E.l.c. and 10.5.E.2., or the Practical Quantitation Limit (PQL) of the lowest Method Detection Limit (MDL) available for non-naturally occurring hazardous constituents where neither an ACL nor an MCL have been determined shall be utilized as the ground water protection standard under VHWMR § 10.5.C. The Permittee shall add each new constituent to the monitoring list contained in Permit Attachment VI.B. and the ground water protection standard listed in Permit Attachment VI.C.

VI.H.8. For each hazardous constituent identified in Attachment VI.C of this Permit, the Permittee shall determine whether there is a statistically significant evidence of increased contamination for any parameter or chemical constituent each time the

concentration of hazardous constituents is monitored in ground water at the compliance point; pursuant to Module VI.G of this Permit. In determining whether such an increase has occurred, the Permittee shall compare the ground water quality at each monitoring well specified in Module VI, Section C.1 of this Permit, to the GPS for that constituent, in accordance with the procedures specified in Module VI.G. of this Permit.

VI.H.9. The Permittee shall perform the statistical evaluation required by Module VI.G of this Permit within 30 days from when the analyses results are available from the laboratory performing the analyses. The Permittee shall report in writing all significant increases identified pursuant to Module VI, Section G of this Permit to the Director within seven (7) days from when the determination is made.

VI.I. COMPARISON TO GROUNDWATER PROTECTION STANDARDS

At least semiannually, the Permittee shall compare the groundwater concentration of each constituent contained in Permit Attachment VI.C from each Point of Compliance Well to the Groundwater Protection Standard (Permit Attachment VI.C) for that constituent. The following procedures shall be used.

VI.I.1. Methods of Comparison

a. If a single independent sample was collected at the monitoring well, the Permittee shall conduct a simple empirical comparison of the GPS and the measured value.

b. If multiple independent samples were collected from each monitoring well, a statistical comparison to the GPS, which has been approved by the Director, shall be conducted. Guidelines for method selection are contained in Permit Attachment A-6.

VI.I.2. For constituents that have not exceeded the Groundwater Protection Standard during previous sampling events, the Permittee shall submit written notification to the Director within seven (7) days of determining that the GPS has been exceeded. The notification shall include the following:

a. Concentration of the constituent(s) exceeding the GPS;

b. Identification of the monitoring well where the GPS was exceeded; and

c. Map showing the extent of the groundwater contaminant plume with concentrations mapped.

VI.I.3. The Permittee may make a demonstration that the groundwater protection standard as indicated in Permit Attachment VI.C was exceeded due to sources other than the unit; errors in sampling, analysis, and evaluation; or natural variation in the groundwater. The demonstration shall be conducted as follows:

a. The Permittee shall include in the notification to the Director in Permit Section VI.I.2., that the demonstration will be attempted.

b. Resampling must be conducted within thirty (30) days of receipt of original laboratory data, not to exceed sixty days (60) from date of original sample collection.

c. Four (4) independent samples shall be collected from the well for each constituent the Permittee includes in the demonstration. A statistical evaluation of the data shall be conducted using a statistical method approved by the Director.

d. The Permittee must submit a report to the Director within 90 days of the notification that demonstrates a source other than the regulated unit caused the groundwater protection standard to be exceeded or that the apparent noncompliance was a result of an error in sampling, analysis, or evaluation. The Permittee must also submit to the Director within 90 days of the notification in Permit Section VI.I.2. an application for a permit modification to make any appropriate changes in the Compliance Monitoring Program.

e. The Permittee must continue to monitor in accordance with the Compliance Monitoring Program established under 40 CFR § 264.99.

VI.I.4. The Permittee shall specify all Groundwater Protection Standard exceedances from the reported sampling event in the Semiannual Monitoring Report.

VI.J. REPORTING AND RECORDKEEPING

VI.J.1. The Permittee shall enter all monitoring, testing, and analytical data obtained pursuant to Permit Module VI into the operating record. The data packages must include all computations, calculated means, variances, t-statistic values, and t-test results or the calculations and results of statistical tests that the Department has determined to be equivalent as appropriate. Reports containing the information shall be submitted in accordance with Permit Condition I.I.2.

VI.J.2. The permittee shall submit reports semiannually, with the annual report containing the required information for the previous calendar year being submitted no later than March 1st of each year.

VI.J.3. Pursuant to Permit Section V.I., if the Permittee determines there is a statistically significant evidence of increased contamination above the concentration limits specified in Permit Attachment VI.C for the constituents specified in Permit Attachment VI.C (indicating that the groundwater protection standard is being exceeded), at any monitoring well at the point of compliance, the Permittee shall notify the Director in writing within seven (7) days

VI.K. ASSURANCE OF COMPLIANCE

The Permittee shall demonstrate to the Director that groundwater monitoring and corrective action measures necessary to achieve compliance with the groundwater protection standard under 40 CFR § 264.92 are taken during the term of the Permit.

VI.L. SPECIAL REQUIREMENTS IF SIGNIFICANT INCREASES OCCUR IN VALUES FOR PARAMETERS OR CONSTITUENTS

VI.L.1. The Permittee must notify the Director in writing within seven (7) days if the groundwater protection standard (Permit Attachment VI.C) has been exceeded at any well for any constituent contained in Permit Attachment VI.C pursuant to Permit Section V.G. The notification must indicate specifically which GPSs have been exceeded.

VI.L.2. The Permittee must submit to the Director a permit modification to establish a corrective action program that meets requirements 40 CFR § 264.100 within 180 days, or within 90 days if the Permittee has previously submitted an engineering feasibility study.

VI.L.3. The Permittee may make a demonstration that the ground water protection standard as indicated in Permit Attachment VI.C was exceeded due to sources other than a regulated unit or errors in sampling, analysis, evaluation, or natural variation in the ground water as specified in VI.I.3.

VI.M. REQUESTS FOR PERMIT MODIFICATION

VI.M.1. If the Permittee or the Director determines the groundwater protection standard presented in Permit Attachment VI.C is being exceeded, the Permittee shall submit to the Director an application for a permit modification to establish a Corrective Action Program that meet the requirements of 40 CFR § 264.100 within 180 days of receipt of the Director's determination that corrective action is required.

VI.M.2. If the Permittee or the Director determines the Compliance Monitoring Program no longer satisfies the requirements of 40 CFR § 264.99, then within 90 days the Permittee must submit an application for a permit modification to make any appropriate changes.

LIST OF ATTACHMENTS

The following Attachments are incorporated, in their entirety, by reference into this Permit. These incorporated attachments are enforceable conditions of this Permit. Some of the documents contain excerpts from the Permittee's Hazardous Waste Permit Application. The Department has, as deemed necessary, modified specific language excerpted from the Permit application. Additional modifications are prescribed in the Permit Conditions (Modules I through IV), and thereby supersede the language of the attachments. Facility operations shall be in accordance with the contents of the Attachments and this Permit.

Attachment VI.A - Groundwater Monitoring Program: Sampling and Analysis Plan

Attachment VI.B – Compliance Groundwater Monitoring List

Attachment VI.C – Groundwater Protection Standards

Attachment VI.D – Groundwater Monitoring Constituents

ATTACHMENT VI.A

GROUNDWATER MONITORING PROGRAM
SAMPLING AND ANALYSIS PLAN

ATTACHMENT VI.A - GROUNDWATER MONITORING PROGRAM: SAMPLING AND ANALYSIS PLAN

TABLE OF CONTENTS

I.A. INTRODUCTION VI.A-3
I.B. SAMPLING FREQUENCY VI.A-3
I.C. FIELD METHODS VI.A-3
I.C.1. Measurement of Static Water Level Elevations: VI.A-4
I.C.2. Calculation of Static Water Volume: VI.A-4
I.C.3. (Reserved) VI.A-4
I.C.4. Well Purging VI.A-5
I.C.5. Groundwater Sampling Equipment: VI.A-5
I.C.6. Decontamination: VI.A-6
I.C.7. Groundwater Sample Collection VI.A-7
I.D. Field AND LABORATORY QA/QC Program VI.A-8
I.D.1. Field QA/QC VI.A-9
I.D.2. Laboratory QA/QC Program VI.A-9
I.D.3. Field Instrument Calibration VI.A-9
I.E. Sample Handling AND CHAIN-OF-CUSTODY VI.A-10
I.F. Field Logbook VI.A-11
II. LABORATORY ANALYSIS VI.A-11
II.A INTRODUCTION VI.A-11
II.B LABORATORY QA/QC VI.A-11
II.B.1. Internal quality control: VI.A-11
II.B.2. Calibration: VI.A-12
II.B.3. Duplicate samples: VI.A-12
III. DATA EVALUATION VI.A-12
III.A ANALYTICAL DATA REVIEW VI.A-12
III.B STATISTICAL EVALUATION VI.A-12
III.C DATA QUALITY OBJECTIVE VI.A-12
IV. RECORD KEEPING AND REPORTING VI.A-13

IV.A. INTRODUCTION.....VI.A-13

IV.B. GROUNDWATER MONITORING RESULTS.....VI.A-13

IV.C. ANNUAL REPORT.....VI.A-13

EXHIBIT VI.A-1: GROUNDWATER LOG EXAMPLE VI.A-1
EXHIBIT VI.A-2: CALCULATIONS OF PURGE VOLUME VI.A-1
EXHIBIT VI.A-3: EXAMPLE CHAIN OF CUSTODY RECORD VI.A-1
EXHIBIT VI.A-4: SAMPLE CONTAINERS AND PRESERVATIVES VI.A-1
EXHIBIT VI.A-5: MONITORING WELL CONSTRUCTION DIAGRAM VI.A-1
EXHIBIT VI.A-6: STATISTICAL PROCEDURES VI.A-1
EXHIBIT VI.A-7: MONITORING WELL ABANDONMENT PROCEDURES VI.A-1
EXHIBIT VI.A-8: BORING LOGS AND WELL CONSTRUCTION DIAGRAMS VI.A-1
EXHIBIT VI.A-9: INVESTIGATIVE DERIVED WASTE POLICY VI.A-14
EXHIBIT VI.A-10: GROUNDWATER MONITORING WELL LOCATIONS VI.A-1

NASA WALLOPS FLIGHT FACILITY OPEN BURN AREA, GROUNDWATER MONITORING SAMPLING AND ANALYSIS PLAN

I.A. INTRODUCTION

Federal regulations at 40 CFR§270.14(c)(5), § 270.14(c)(6)(iv), and § 270.14(c)(7)(vi) require a description of the sampling, analysis, and statistical comparison procedures proposed for evaluating groundwater monitoring data. In addition, §§264.97(d) and 264.97(e) outline minimum procedures and techniques for groundwater monitoring programs implemented pursuant to 40 CFR Part 264 Subpart F. These regulations require that groundwater monitoring programs include measurement, sampling, and analytical methods that accurately assess groundwater quality, and that provide early detection of hazardous constituents released to groundwater.

Groundwater beneath the OB Area will be monitored with one background monitoring well and six downgradient compliance point monitoring wells located as specified on the map presented in Figure II.A-4. Monitoring well MW-4 is the background well. Monitoring wells MW-1, MW-2, MW-5, MW-6, and MW-7 are the point of compliance wells for the unit.

The NASA Wallops Flight Facility Open Burn Area Groundwater Monitoring Sampling and Analysis Plan (GMP) is an essential part of the Compliance Monitoring Program in that it stipulates the field sampling, laboratory analysis and annual reporting methods to be utilized throughout the post-closure period. The GMP addresses the Compliance Monitoring Program requirements prescribed in the VHWMR, 9 VAC 20-60 § 264.99 and as described in the Operating Permit.

I.B. SAMPLING FREQUENCY

Groundwater samples will be collected and analyzed semi-annually at each point of compliance well for all the constituents listed in Attachment VI.B. Permit Attachment VI.B lists the parameters, constituents, and test methods required for the Detection Monitoring Program. The Permittee may resample for any statistically significant detection within 30 days to confirm or refute the detection.

I.C. FIELD METHODS

The following activities should be performed prior to collecting ground-water samples for analysis:

- Measurement of static water level elevation;

- Detection and sampling of immiscible layers; and
- Well purging.

I.C.1. Measurement of Static Water Level Elevations:

Prior to purging each well, both the static water level (SWL) and the depth to the bottom of the well shall be measured to ±0.01 foot. Well measurements will be made using an electronic water level probe, referenced to a predetermined mark at the top of the well casing. The elevation of the top of the well casing (with locking cap removed) will be established to an elevation ±0.01 foot, in relation to the existing landfill datum, which will be established from a National Geodetic Vertical Datum.

The static ground water surface elevations obtained prior to each sampling event shall be used to create potentiometric maps to determine whether the requirements for locating the monitoring wells continues to be satisfied. If the potentiometric maps reveal that the depths, location, or number of wells is insufficient to monitor hazardous waste constituents migrating from the waste management area, new well locations and depths will be submitted to the Department for their approval and subsequent installation and monitoring. Any new wells will be installed prior to the next regularly scheduled groundwater sampling event.

Background wells and wells where constituents have not historically been noted will be measured first, followed by wells where constituents have been noted. All measurements for each well will be recorded in the Groundwater Log. Measurements that do not correlate with the previous trends will be verified in the field with different measurement technology, if necessary.

I.C.2. Calculation of Static Water Volume:

The static water level and total depth will be used to calculate the volume of stagnant water in the well and provide a check on the integrity of the well (e.g., identify siltation problems), as well as characterize changes in hydraulic conditions that may occur over time. The static water level measuring device used will be constructed of inert materials and thoroughly decontaminated prior to each use to prevent cross contamination from one well to another. The meter will be decontaminated by washing with non-phosphate detergent and rinsing three times with deionized water prior to air-drying. Decontamination fluid will be containerized and disposed of in an on-site wastewater treatment system if available or a publicly owned treatment facility with approval. Sampling members will wear clean gloves during sampling and shall change gloves between sampling each well at a minimum.

I.C.3. (Reserved)

I.C.4. Well Purging

The volume of stagnant water in each well will be determined prior to well evacuation based on the static water level, well depth, well diameter, filter pack length, and borehole diameter. Three volumes of the pore space of the screen filter pack and three volumes of the well casing will be purged prior to sampling if possible. The volume of stagnant water to be purged shall be calculated according to the formulae presented in Exhibit VI.A-2 of this Attachment. Purge volume calculations will be recorded in the Groundwater Log shown in Exhibit VI.A-1, or volume purged shall be sufficient when pH, temperature, and conductivity have stabilized.

a. If the wells prove to be low yield, wells will be evacuated to dryness once and will be purged at a rate which will not cause recharge water to be excessively agitated. Dry and low recharge rates will be noted in the field observations.

b. All purge water will be containerized and disposed of in an on-site wastewater treatment system if available or a publicly owned treatment facility with approval.

Stabilization parameters pH, temperature, conductivity, and turbidity will be measured at the start and end of sampling as a check on the stability of the water samples over time. Four (4) replicate measurements of pH and specific conductivity will be recorded in the Groundwater Log shown in Attachment 1 for each groundwater sample. In addition to the start and end measurements, additional measurements will be taken for each well volume. All purging equipment that has been or will be in contact with ground water should be decontaminated prior to use (See Section I.C.6.). Decontamination water should be stored in appropriate containers and disposed of per I.C.4.b and Exhibit VI.A-9.

I.C.5. Groundwater Sampling Equipment:

The Department prefers that all sampling equipment be dedicated to a particular well. The following recommendations apply to the selection of sampling equipment:

- Sampling equipment should be chosen based on the analytes of interest and the characteristics and depth of the saturated zone from which the sample is withdrawn. For example, the choice of sampling equipment should reflect consideration of the potential for LNAPLs and DNAPLs.

- Sampling equipment should be constructed of inert material. Sample collection equipment should not alter analyte concentrations, cause loss of analytes via sorption, or cause gain of analytes via desorption, degradation, or corrosion.

- Sampling equipment should be designed such that Viton®, Tygon®, silicone, or neoprene components do not come into contact with the ground-water sample.

- Sampling equipment should cause minimal sample agitation and should be selected to reduce/eliminate sample contact with the atmosphere during sample transfer. Sampling equipment should not allow volatilization or aeration of samples to the extent that analyte concentrations are altered.

I.C.6. Decontamination:

When dedicated equipment is not used for sampling (or well purging) or when dedicated equipment is stored outside of the well, it will be thoroughly decontaminated between wells by disassembling and washing with (non-phosphate) detergent, thoroughly rinsed with de-ionized water, and air dried. All equipment coming in contact with media suspected of being contaminated will be decontaminated before it contacts a media which is likely to be less contaminated or uncontaminated.

All non-dedicated ground water sampling equipment will be cleaned over a decontamination pad after each use in the following manner:

- Rinse with tap water.

- Wash with a non-phosphate laboratory detergent and tap water.

- Rinse with distilled water

- Wash with laboratory-grade methanol or isopropanol

- Triple rinse with de-ionized, distilled water

- Allow to air dry.

If the equipment is not to be used again immediately, it should be packaged and properly stored to protect it from dust and dirt. Equipment may be wrapped in aluminum foil (shiny side on the outside) and placed in a plastic bag. A label should be affixed to the outside wrapping summarizing the decontamination procedure and stating the date of decontamination. Decontaminated sampling equipment should not be placed on the ground or on other contaminated surfaces prior to insertion in the well.

The decontamination pad will be lined with polyethylene sheeting and sloped to promote drainage towards one corner into an in-ground container. This will facilitate

removal of any potentially contaminated decontamination fluids. The fluids will be collected, contained, labeled, and stored in U.S. Department of Transportation (DOT)-approved 55 gal drums. All decontamination fluids will be managed and disposed of in accordance with the DEQ Investigation-Derived Waste Policy (Appendix 9). Disposable items will be disposed of as solid waste in an approved, permitted landfill.

I.C.7. Groundwater Sample Collection

Monitoring well sampling should always progress from a well that is the least contaminated to the well that is the most contaminated, to minimize the potential for cross-contamination of samples that may result from inadequate decontamination of sampling equipment. Samples should be collected and containerized according to the volatility of the target analytes. The preferred collection order for some of the more common groundwater analytes is as follows:

- Volatile organics and total organic halogens
- Dissolved gases and total organic carbon
- Semi-Volatile Organics
- Pesticides/herbicides
- PCBs
- Metals and cyanide
- Total Phenols
- Major water quality cations and anions (sulfate, chloride, etc.)
- Nitrate

A sample collecting bottle kit should be prepared from the sample parameter list in accordance with approved sample analysis methods (see Appendix 4). The sample kit should be stored in clean coolers for transport to the site. To preserve sample integrity, all samples should be collected in pre-cleaned containers, preserved when required, and stored at the appropriate temperature. The containers shall be shipped with caps that are securely fastened. Samples shall be transferred directly from the sampling device to the sample containers.

The following recommendations apply to the use and operation of groundwater sampling equipment:

- Check valves should be designed and inspected to ensure that fouling problems do not reduce delivery capabilities or result in aeration of samples.

- Sampling equipment should never be dropped into the well, as this will cause degassing of the water upon impact.

- Contents of the sampling device should be transferred to sample containers in a controlled manner that will minimize sample agitation and aeration.

- Decontaminated sampling equipment should not be allowed to come into contact with the ground or other contaminated surfaces prior to insertion into the well.

- Groundwater samples should be collected as soon as possible after the well is purged. Water that has remained in the well casing for more than about 2 hours has had the opportunity to exchange gases with the atmosphere and to interact with the well casing material.

- The rate at which a well is sampled should not exceed the rate at which the well was purged. Low sampling rates, approximately 0.1 L/min, are suggested. Pumps should be operated at rates less than 0.1 L/min when collecting samples for volatile organics analysis.

- Pump lines should be cleared at a rate of 0.1 L/min or less before collecting samples for volatiles analysis so that the samples collected will not be from the period of time when the pump was operating more rapidly.

- Pumps should be operated in a continuous, non-pulsating manner so that they do not produce samples that are aerated in the return tube or upon discharge.

- When sampling wells that contain LNAPLs, a stilling tube should be inserted in the well. Groundwater samples should be collected from the screened interval of the well below the base of the tube.

- Groundwater samples collected for analysis for organic constituents or parameters should not be filtered in the field.

I.D. FIELD AND LABORATORY QA/QC PROGRAM

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of blanks to verify that the sample collection and handling process has not

affected the quality of the samples. Both field and laboratory QC samples should be prepared during the sampling event. It is recommended that the following samples be analyzed with each batch of samples (a batch may not exceed 20 samples):

- One field duplicate;
- One equipment rinsate (required only when non-disposable equipment is being used);
- One matrix spike (when appropriate for the method); and
- One duplicate sample (either a matrix duplicate or a matrix spike duplicate).

A trip blank should be prepared and analyzed when samples are being analyzed for volatile organic analytes. A trip blank should be submitted with samples each day that samples are collected.

I.D.1. Field QA/QC

All field QC samples should be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The concentrations of any contaminants found in blank samples should not be used to correct the groundwater data. The contaminant concentrations in blanks should be documented, and if the concentrations are more than an order of magnitude greater than the field sample results, the Permittee should resample the ground water. Other QA/QC practices such as sampling equipment calibration, equipment decontamination procedures, and chain-of-custody procedures are discussed in other sections of this Attachment.

I.D.2. Laboratory QA/QC Program

The permittee's laboratory should provide for the use of control samples. The Permittee should use appropriate statistical procedures to monitor and document performance and to implement an effective program to resolve testing problems (e.g., instrument maintenance, operator training). Data from control samples (e.g., spiked samples, duplicates, and blanks) should be used as a measure of performance or as an indicator of potential sources of cross-contamination. All QC data should be submitted to the Department with the groundwater monitoring sample results.

I.D.3. Field Instrument Calibration

At a minimum, all field instruments should be calibrated at the beginning of each use and in accordance with the frequency suggested by the manufacturer. Field instruments should be calibrated using at least two calibration standards spanning the

range of results anticipated during the sampling event. For example, if groundwater pH is expected to be near pH 7, the two standards used to calibrate the pH meter should be pH 4 and pH 10, respectively.

I.E. SAMPLE HANDLING AND CHAIN-OF-CUSTODY

Sample handling will be strictly controlled to prevent sample contamination. Chain-of-Custody control for all samples will consist of the following:

1. Labels will be placed on individual sample containers while sampling indicating the sampler's name, date and time of sample collection, place of collection, and preservation method used for the sample.

2. A custody seal should be placed on the shipping container or on the individual sample bottles. Custody seals provide prevention or easy detection of sample tampering. The custody seal should bear the signature of the collector and the date signed. The custody seal can be placed on the front and back of a cooler, around the opening of a polyethylene overpack bag or on the lid of each sample container.

3. No sample should be brought back to the laboratory for preservation. It is recommended that two polyethylene overpack bags be used in shipping. The first will contain the sample bottles, the second the ice needed to keep the samples at 4o C. A temperature history of the samples should be maintained as a quality control measure. Upon receipt of the shipment, the laboratory should record the temperature on the chain-of-custody record. Holding time refers to the period that begins when the sample is collected from the well and ends with its extraction or analysis.

4. A chain-of-custody record should be completed and should accompany every sample shipment. The chain-of-custody record should contain enough copies so that each person possessing the shipment receives his/her own and should be designed to allow the Permittee to reconstruct how and under what circumstances a sample was collected, including any problems encountered. An example of a chain-of-custody form that includes the necessary information is included as Appendix 3.

5. Samples will be packaged and labeled for shipment in compliance with current U.S. Department of Transportation regulations. All samples will be shipped priority/overnight via commercial carrier or hand delivered to the lab.

6. Samples will arrive at the laboratory via the overnight delivery service or hand delivery. Upon delivery to the laboratory, the ice chests will be checked for intact custody seals and the samples will be unpacked and the information on the

accompanying chain of custody records will be examined. If the samples shipped match those described on the chain-of-custody form, the laboratory sample coordinator will sign the form and assume responsibility for the samples. If problems are found with the sample shipment, the laboratory sample custodian will sign the form and record the problems in the "remarks" section.

7. Any missing samples, missing sample tags, broken sample bottles, or unpreserved samples will be noted on the chain-of-custody record. If there are problems with individual samples, the sample custodian will inform the laboratory coordinator of such problems. The laboratory custodian will then contact the Permittee to determine a viable solution to the problem.

8. All information relevant to the sample will be secured at the end of each business day. All samples will be stored in a designated sample storage refrigerator, access to which will be limited to laboratory employees.

I.F. FIELD LOGBOOK

Field technician(s) will keep an up-to-date field logbook documenting information pertaining to field activities. Appendix 1 of this Attachment provides an example of a Groundwater Log that includes the necessary information that must be completed for each monitoring well sampled.

II. LABORATORY ANALYSIS

II.A INTRODUCTION

The groundwater parameters and constituents to be analyzed include organic and inorganic constituents which have been used at the facility or have been detected in the facility's waste, sludge, and/or groundwater (Attachment VI.B). Attachment VI.B also lists analytical methods that must be used in the analysis of groundwater samples.

II.B LABORATORY QA/QC

QA/QC procedures will be used at all times. The laboratory shall assure the accuracy and precision of all analytical determinations.

II.B.1. Internal quality control:

Internal quality control checks shall be undertaken regularly to assess the precision and accuracy of analytical procedures. Internal quality control checks shall include use of calibration standards, standard references, duplicates and spiked/fortified samples.

II.B.2. Calibration:

Calibration standards shall be verified against standard reference from an outside source. Calibration curves shall be comprised of a minimum of one blank and three standards. Samples shall be diluted if necessary to ensure analytical measurements fall on the linear portion of the calibration curve.

II.B.3. Duplicate samples:

Duplicate samples shall be processed at an average frequency of ten percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked/fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of analysis. During the course of analysis, quality control data and sample data shall be reviewed to identify questionable data.

III. DATA EVALUATION

III.A ANALYTICAL DATA REVIEW

The Permittee and/or its representative will review and validate the analytical data to ensure that the laboratory followed proper analytical protocols. The data review will be performed in general accordance with the following United States EPA guidance documents:

Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, April 1993, and

Region III Modifications to National Functional Guidelines for Organic Data Review Multi-Media, Multi-Concentration, September 1994.

III.B STATISTICAL EVALUATION

Statistical evaluations will be performed in general accordance with Appendix 6 to Attachment VI.A-6.

III.C DATA QUALITY OBJECTIVE

High-quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for in the permit) to meet the program objectives. It is the Permittee's responsibility to report sufficient valid analytical results for each monitoring event. Reported data will, at a minimum, be of such quality to immediately detect a release

from the regulated unit. Laboratory methods will be selected to yield reporting limits (Limit of quantitation, or LOQ) values that are equal to or below human health-based standards for the target analytes. The human health-based standards are established as: Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act; Alternate Concentration Limits (ACLs) whenever MCLs are not available; or as EPA Region III Tap Water Risk Based Concentrations when MCLs or ACLs are not available. ACLs are calculated by VURAM using a residential ground water ingestion-modeling scenario by VADEQ.

IV. RECORD KEEPING AND REPORTING

IV.A. INTRODUCTION

Copies of all groundwater analytical results, groundwater semiannual reports, groundwater annual reports, groundwater level elevations, Groundwater Sampling and Analysis Plan, Facility Operating Permit, etc. shall be maintained at the Wallops Island site throughout the active life of the facility and post-closure care period. The Permittee shall report the groundwater monitoring information to the Director described in Sections IV.B and IV.C below.

IV.B. GROUNDWATER MONITORING RESULTS

The Permittee shall report concentrations or values of the parameters and constituents listed in Permit Attachment V.B for each required groundwater monitoring well within 30 days after completing each analysis.

IV.C. ANNUAL REPORT

The Permittee shall submit an Annual Groundwater Monitoring Report to the Virginia Department of Environmental Quality by March 1st of the following year for the year beginning January 1st and ending December 31st containing:

1. Static groundwater level elevations;

2. Potentiometric surface maps reflecting each sampling event;

3. Groundwater flow rate and direction in the uppermost aquifer calculated after each sampling event;

4. Statistical evaluations of the concentrations or values of the parameters and constituents listed in Attachment VI.B;

5. The calculated or measured rate of migration of hazardous waste or hazardous waste constituents in the groundwater; and

2. 6. Results of the evaluations of groundwater surface evaluations to determine whether the requirements for locating the monitoring wells continue to meet the criteria set forth in 40 CFR § 264.97.

EXHIBIT VI.A-1: GROUNDWATER LOG EXAMPLE

SAMPLING EVENT: _____
LOCATION: _____
WELL NO.: _____ DATE: _____
WEATHER: _____ TEMPERATURE: _____

MEASUREMENT TEAM: _____
TIME WELL CASING UNLOCKED _____
DEPTH TO WATER FROM TOP OF OUTER CASING _____FT
DEPTH OF WELL FROM TOP OUTER CASING _____FT
STATIC WASTER LEVEL _____FT

MEASUREMENT TECHNIQUE: [ ] WATER LEVEL INDICATOR
[ ] OTHER/EXPLAIN _____

FORMULAS FOR DETERMINING PURGE VOLUME **TWD =**

Water Level above Sand Pack: [ ]

$3 \times [(\pi r_b^2 h_s - \pi r_c^2 h_s) \times 0.3 + (\pi r_c^2 h_w)]$

Water Level below Sand Pack: [ ]

$3 \times [\pi r_b^2 h_w - \pi r_c^2 h_w) \times 0.3 + (\pi r_c^2 h_w)]$

where:
r_b = radius of boring =
r_c = radius of casing =
h_s = height of sand =
h_w = height of water =

IMMISCIBLE LAYERS: [ ] YES [ ]NO
DETECTION METHOD: [ ] VISUAL [ ] OTHER_____
COLLECTION METHOD: [ ] BEAKER [ ] OTHER_____

SAMPLE IDENTIFICATION: _____

PURGE TEAM: _____

PURGE PROCEDURE/EQUIPMENT: [ ]TEFLON BAILER
[ ]WELL PUMP

PURGE TIME: _____ PURGE VOLUME: _____

PURGE APPEARANCE: _____

Exhibit VI.A-1 (cont'd)

COMMENTS: _____
_____

SAMPLING EVENT: _____
LOCATION:_____
WELL:_____ DATE: _____

SAMPLING PROCEDURE/EQUIPMENT: [ ]TEFLON BAILER
[ ]WELL PUMP

SAMPLING TIME:_____

pH METER CALIBRATED WITH BUFFERS: [ ]4 [ ]7 [ ]10
pH METER CALIBRATED BY: _____
CONDUCTIVITY METER CALIBRATED WITH STANDARD SOLUTION OF: _____
CONDUCTIVITY METER CALIBRATED BY: _____

pH(S.U.): _____

TEMP (^oC):_____

COND (µS): _____

SAMPLE COLLECTION TIME: CONTAINER*/PRESERVATIVE

(1)_____	VOC(G/NONE)	(2)_____	TOX(A/HNO_3)
(3)_____	TOC(A/H_2SO_4)	(4)_____	COD(A/H_2SO_4)
(5)_____	O&G/TPH(A/HCL)	(6)_____	PHEN(A/H_2SO_4)
(7)_____	N(/)	(8)_____	PHOS(A/H_2SO_2)
(9)_____	SO(/)	(10)_____	TMET(P/HNO_3)
(11)_____	DMET(P/NONE)	(12)_____	pH,COND(P/NONE)
(13)_____	CHLORIDE(P/NONE)	(14)_____	SMLLTST(P/NONE)
(15)_____	CN^- (P/NONE)	(16)_____	(P/NONE)

FINAL pH (S.U.):_____ FINAL TEMPERATURE (^oC):_____
FINAL CONDUCTIVITY (µS):_____

LOCKED WELL AT:_____

COMMENTS _____
_____

NOTES:

1. G = GLASS, A=AMBER GLASS BOTTLE, P=PLASTIC(POLYETHYLENE)

2. Shipping containers (cooling chest with ice or ice pack) should be certified as to the 4° C temperature at time of sample placement into these containers. Preservation of samples requires that the temperature of collected samples be adjusted to the 4° C immediately after collection. Shipping coolers must be at 4° C and maintained at 4° C upon placement of sample and during shipment. Chain-of-custody forms will have Shipping/Receiving (max/min) temperature boxes for recording data and verification.

3. IDW: Collect all used decontamination solutions and rinses; store in a labeled 55 gallon drum for no more than 90 days in accordance with DEQ's IDW Policy.

4. SILTATION: If the level of siltation is higher than 1 foot above the base of the screen, the well will need to be redeveloped. Note whether the level of siltation is greater than 1 foot in the comments section.

EXHIBIT VI.A-2: CALCULATIONS OF PURGE VOLUME

Determine purge volume as follows:

Water Level above sand pack:

$3 \times [(\Pi\ rb2\ hs - \Pi\ rc2\ hs) \times 0.3 + (\Pi\ rc2\ hw)]$

Water Level below sand pack

$3 \times [(\Pi\ rb2\ hw - \Pi\ rc2\ hw) \times 0.3 + (\Pi\ rc2\ hw)]$

Where:

rb = radius of boring
rc = radius of casing
hs = height of sand
hw = height of water

This calculation must be based upon 30% filter pack volume. Once the volume to be purged is known, purging can begin. The purge water will be collected, containerized and disposed of in accordance with local, state and federal regulations and laws.

EXHIBIT VI.A-3: EXAMPLE CHAIN OF CUSTODY RECORD

Phone:
Fax:

Chain of Custody Record

Date: _____ Page: _____ of _____

Contact Name | Phone Number | Fax Number

Company Name

Street Address

City, State, Zip

Project Name | Site Location

Sample ID	Date Collected	Time	Matrix	Lab ID	Preservation Code	Number of Containers	Rush	Container Size	Analysis Request							Comments

Preservation Code
1 = 4°C
2 = HNO_3
3 = HCl
4 = H_2SO_4
5 = NaOH
6 = Other

Special Instructions / Comments	(1) Relinquished By	(2) Relinquished By	Sampler Initials:
	(1) Date / Time	(2) Date / Time	Method of Shipment
	(1) Company	(2) Company	HAND CARRY USPS FEDX UPS
	(1) Received By	(2) Received By	CoC
Route Results Through: Circle: Fax Email	(1) Date / Time	(2) Date / Time	Seal Intact?
Email address:	(1) Company	(2) Company	Yes No

EXHIBIT VI.A-4: SAMPLE CONTAINERS AND PRESERVATIVES

Analyte	SW-846 Analysis Numbers	Container	Preservative	Holding Time (days)
pH	9040C/ Field	T, HDPE or glass	None	Analyze immediately
Specific Conductance	9050A/Field	T, HDPE or glass	None	Analyze immediately
Temperature	Field	T, HDPE or glass	None	Analyze immediately
Turbidity	Field	T, HDPE or glass	None	Analyze immediately
Nitrates	9056	T, HDPE or glass	H2SO4 4o C	2
Nitrites	9056	T, HDPE or glass	4o C	28
Ammonia	SM4500-NH3-C	HDPE	H2SO4 4o C	28
Total Lead	6020/6010C	HDPE	HNO3 to pH<2, 4o C	6 months
Perchlorate	6850	HDPE	4o C	28
Phenols	9065	Amber glass, Teflon cap	H2SO4 4o C	28
Total Cyanide	9010/9014/9012B	HDPE	NaOH 4o C	14 days
Chlorobenzene	8260	Amber glass, Teflon cap	4o C	40 days
Arsenic	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Barium	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Cadmium	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Chromium	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Copper	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
SIlver	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Vandium	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months
Zinc	6010/6020/6010C	T, HDPE or glass	HNO3 to pH<2, 4o C	6 months

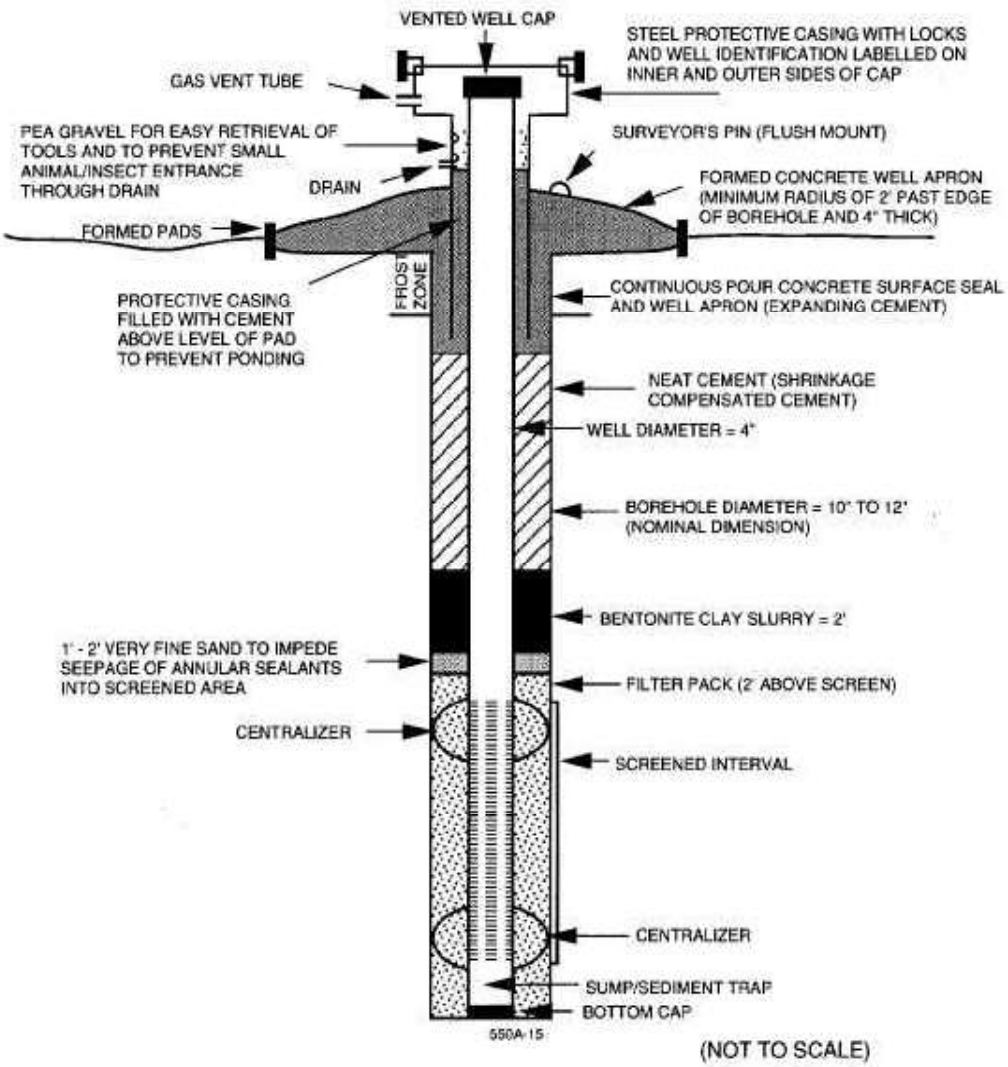
NOTES:

1. References:
   Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (3rd edition).
   Methods for Chemical analysis of Water and Wastes, EPA-600/4-79-020.
   Standard Methods for the Examination of Water and Wastewater, 22th edition (2011).

2. Container Types:
   HDPE = Plastic (polyethylene)
   T = Fluorocarbon resins (PTFE, Teflon8. FEP, PFA, etc.)

EXHIBIT VI.A-5: MONITORING WELL CONSTRUCTION DIAGRAM

(from EPA Technical Enforcement Guidance Document, 1986)



CROSS-SECTION OF TYPICAL MONITORING WELL

EXHIBIT VI.A-6: STATISTICAL PROCEDURES

A. Highlights

In accordance with 40 CFR § 264.97(g), the permittee will collect an appropriate number of samples from upgradient well(s) and an appropriate number of samples from each of the point of compliance wells specified in Permit Section IV.C.1. Appropriate background sample sizes for the preferred method of statistical analysis will be collected prior to the scheduled date of the statistical analysis.

Statistical analysis of the groundwater data will include the following:

1. Outliers
2. Testing of normality
3. Missing data
4. Evaluation of data below detection limits or quantitation limits
5. Selection of statistical method
6. Verification sampling strategy (optional)

B. Outliers

An outlier refers to a data point which is an inconsistently large or small value. An outlier can be observed due to sampling, laboratory, transportation, or transcription errors. To remove the possibility of including data with this type of error, the historical data should be screened for each well and constituent for the existence of outliers (USEPA 1992 section 6.2) using the method described by Dixon (1953) or another method approved by the VADEQ. Background observations, which are considered to be outliers, should not be included in the statistical analysis. If an extreme value occurs in a point-of-compliance well or during a compliance sampling event, the facility should collect a re-sample during the compliance period of the initial sample. Any elimination of an outlier must be approved by the Department.

C. Testing Normality of Data Distribution

The Permittee shall verify that the distribution of monitoring data for the Hazardous Constituents is consistent with the assumptions of the selected statistical test method. A multiple group version of the Shapiro-Wilk test shall be applied to determine if the distribution of the data is normal or lognormal. To test for log normality, the natural

logarithms of original data are taken and if the distribution of the transformed concentrations is normal then the data are considered to be log-normally distributed. The permittee may use any other appropriate method for testing the distributional assumptions (see Gibbons 1994a for a review, also see USEPA 1992). However, the permittee shall demonstrate that the alternative method can detect deviations from normality with similar power as the Shapiro-Wilk and Shapiro-Francia methods. No testing of normality is required when the percentage of non-detects or non-quantified values are greater than 50%. Once the distribution of the data is determined, the permittee should apply statistical tests as follows:

When the detection frequency is less than 50% and/or transformation fails to bring about normality, a non-parametric method should be used.

When the detection frequency is between 50%-75%, a parametric test can be performed with an adjustment for non-detects. Aitcheson's or Cohen's adjustments are recommended. Determination of the appropriate adjustment to be applied should be based on the properties of the data set (USEPA, 1992, section 2.2).

When the detection frequency is 75% or greater, an appropriate parametric test may be applied without adjusting for non-detects. Non-detects should be analyzed using one half the laboratory limit of detection or quantitation.

D. Missing Data

If a sampling event results in a missing data value, an attempt to resample for the missing value shall be made within two weeks.

E. Data Below Detection Limits

For data where the non-detects or non-quantified values are less than 25 percent, the Permittee shall replace the non-detects or non-quantified values with one half the laboratory limit of detection or quantitation. However, when the percentage of non-detects or non-quantified values is greater than 25 percent and less than 50 percent the mean and standard deviation should be adjusted using Atchison's method (USEPA 1992 section 2.2.2 and Aitchison, 1955). An acceptable alternative to Aitchison's method is Cohen's maximum likelihood estimator (Cohen, 1961). Extensive tables and computational details are also provided in Gibbons, 1994a. The approach for selection between the two methods is described in USEPA (1992) section 2.2.1.

F. Selection of Statistical Method

The Permittee shall use an appropriate statistical method consistent with the Virginia Hazardous Waste Management Regulations. As specified in these regulations, the level of significance for individual well comparison shall be no less than 0.01 and no

less than 0.05 for multiple comparisons. However, these performance standards do not apply for prediction intervals, tolerance intervals and control charts. The false positive rate for these interval methods or control charts can depend on the number of data points available from the background wells at the time of statistical comparison. A larger number of background data points can decrease the false positive rate for these tests. In the event the Permittee has decided to use an interval or other statistical method, and if the selected method requires additional samples, the Permittee shall collect the additional samples prior to the date specified in this permit for conducting appropriate statistical analysis. The statistical comparison shall not be delayed due to collection of an inadequate number of samples. The false positive rate for a single constituent/well comparison shall not be lower than .01 unless the Permittee can demonstrate that an alternative false positive rate will provide at least 50% power to detect a 3 standard deviation increase above background levels and 80% power to detect a 4 standard deviation increase above background levels.

1. Interval Method

   If the Permittee uses an interval method and the percentage of detects is greater than 50%, the Permittee shall test the data from the background wells for normality. If the background well data are normally or log-normally distributed the permittee shall use a parametric interval method. Table 1 provides the suggested minimum number of samples for calculation of parametric interval methods that are acceptable to VADEQ. In the event the background data are not normally or log-normally distributed the permittee shall use a non-parametric interval method. Suggested test methods and recommended minimum sample size requirements are provided in Table 1. However, a statistical analysis can be conducted with a smaller dataset than the suggested size at any time. Please note that these methods can lead to higher false positive or false negative rates with smaller samples sizes. For each sampling event, the permittee shall calculate the appropriate interval for the background data set based on the method selected, and compare each data point from the compliance well to the upper limit. If the Compliance well data exceeds the upper limit, the permittee shall report that there has been a statistical increase of contaminants in the groundwater.

2. Other Methods

   In the event the Permittee has selected any other method listed in the Virginia Hazardous Waste Management Regulations, the Permittee shall collect the appropriate number of samples and shall maintain the appropriate level of significance specified above.

G. Verification Sampling (Optional)

Verification resampling can be an integral part of the statistical methodology (USEPA, 1992 section 5); however, it should be considered as a part of the statistical test and based on the site-specific condition. Since the probability of an initial exceedance is very high for the site as a whole (considering only test wise false positive rates), the verification sample is considered as a part of the evaluation to conclude a statistically significant exceedance. A pre-planned verification sample can be incorporated into the calculation of the statistical limits to calculate an upper limit using a smaller false positive rate. Without verification resampling, an attempt to minimize the false positive rates will lead to very large prediction limits. This will increase the false negative rates and decrease the power of the test to detect a release from the facility. All verification samples must be collected at the earliest time possible (prior to next scheduled sampling event) or as approved by the DEQ or as specified in this permit. Note that the Department must be informed of any planned verification resampling in advance.

Verification resampling can involve one or two samples. DEQ's preferred strategy includes passing one verification resample or passing one of two verification resamples. Statistical analyses which incorporate verification samples must provide at least 50% power to detect a 3 standard deviation increase above background levels and 80% power to detect a 4 standard deviation increase above background levels.

H. Comparison of Point of Compliance Well Data to a Standard During Compliance or Corrective Action

In accordance with the Virginia Hazardous Waste Management Regulations the point of compliance data shall be compared to the GWPS. If a maximum contaminant level (MCL) is promulgated or alternate concentration limit (ACL) is established for a constituent, and the ACL or MCL is greater than the background limit (or statistically determined background level), the ACL or MCL is the groundwater protection standard. All new concentrations in the point of compliance wells should be compared to the standard (i.e., ACL or MCL) using the lower 95% confidence limit computed from the last four sampling values (collected during the last 12 months).

If an upper limit based on a tolerance or prediction limit calculated from naturally occurring background data exceeds the MCL or ACL, then the background limit will be the groundwater protection standard. If the groundwater protection standard is based on a tolerance or prediction limit, the point of compliance samples shall be compared to the GWPS using a point comparison. If the point of compliance sample exceeds the background based GWPS, a statistical exceedance above the GWPS shall be reported to the Department.

However, for all constituents analyzed, if the established groundwater protection standard is less than the Department accepted Limit of Quantitation (LOQ) then the

LOQ becomes the standard, and the new point of compliance well data will be compared to the LOQ.

Comparisons of point of compliance well data to a groundwater protection standard based on a MCL or ACL should be performed by a parametric or non-parametric confidence interval. If data are normally or log-normally distributed a 95% lower confidence limit on the last four samples (collected during the last 12 months) can be calculated for comparison to the MCL or ACL. If data are not normally or log-normally distributed the minimum concentration from the last four samples (collected during the last 12 months) should be compared to the groundwater protection standard (based on a MCL or ACL). Alternative statistical methods for comparing lower limits of Compliance well data to a groundwater protection standard based on a MCL or ACL should be approved by the Department prior to implementation. If the lower confidence limit or minimum concentration exceeds the groundwater protection standard based on a MCL or ACL then the permittee has shown a statistical exceedance above the ground water protection standard.

Please note that a point comparison (non-statistical) to the GWPS (based on a MCL or ACL) may be performed if only one data point exists for a sampling event. If the point comparison indicates that the given data point is above the groundwater protection standard, and the GWPS is based on a MCL or ACL, and the facility chooses not to use data from the previous three sampling events, then additional samples (at least three additional samples will be required to calculate a confidence interval) may be collected within the next 3 months and a statistical comparison to the GWPS (based on a MCL or ACL) may be performed.

I. References

1. Aitchison, J. On the distribution of a positive random variable having discrete probability mass at the origin, Journal of American Statistical Association, 50(272), 901-908 (1955).

2. Cohen, A.C. Tables for maximum likelihood estimates: Singly truncated and singly censored samples, Technometrics, 3, 535-541 (1961).

3. Gibbons, R.D. Statistical Methods for Groundwater Monitoring, John Wiley and Sons, Inc., 1994.

4. Gibbons, R.D. Some conceptual and statistical issues in analysis of groundwater monitoring data, Environmetrics, 7, 185-199 (1996).

5. USEPA, Statistical analysis of groundwater monitoring data at RCRA facilities. Addendum to Interim Final Guidance. Office of Solid Waste, July 1992.

6. USEPA, Statistical analysis of groundwater monitoring data at RCRA facilities - Interim Final guidance (April 1989).
Table 1

Suggested Minimum Samples*			
	Parametric	Non-Parametric	Non-Parametric Interval %Confidence
CABF T-test	4	NA	NA
Wilcoxon Rank Sum	NA	5	NA
Confidence Interval	4	NA	NA
Tolerance Interval	8	19	95%
Prediction Interval	8	13	99%#
Shewhart CUSUM Chart+	8	NA	NA

* The above tests can be used with fewer samples; however it will increase the false positive rate.

Includes one verification re-sample, use 19 samples for a 95% Prediction Interval with no verification re-samples.

+ For Intra-well testing only.

NA Not Applicable.

EXHIBIT VI.A-7: MONITORING WELL ABANDONMENT PROCEDURES

NOTE: Approval from the Director must be granted before any monitoring well may be abandoned.

A. Monitoring wells and/or piezometers will be abandoned by pressure grouting methods. Surface installations (protective covers or manholes) will be removed and an attempt to pull the casing string with the rig will be made. Once this has either been accomplished or has failed, grouting operations will commence as described below.

A.1. Monitoring well abandonment will be accomplished by lowering a tremie pipe to the bottom of the borehole.

A.2. Portland cement/bentonite grout will then be pumped down the tremie pipe until an even flow of consistent grout returns at the surface.

A.3. The tremie pipe will be removed from the borehole on completion of grouting operations and a minimum four inch thick and six foot diameter concrete cap will be constructed over the grouted borehole.

B. Removed casings will be steam cleaned, cut up into manageable sections, and disposed of as refuse.

C. All tremie rods and other downhole equipment will be steam cleaned prior to introduction into the hole or well.

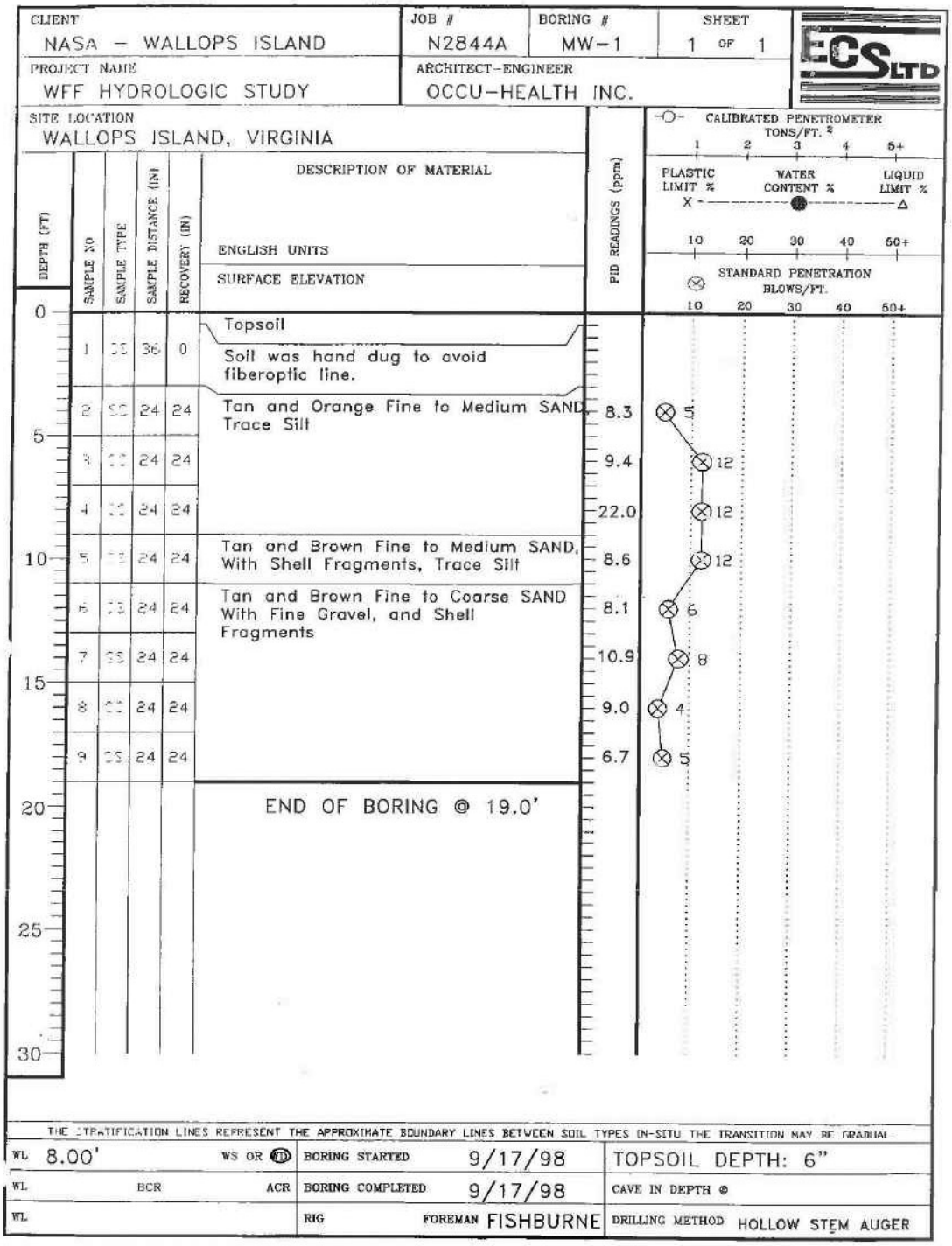
D. All decontamination fluid will be containerized and handled pursuant to decontamination fluid handling procedures contained in Exhibit V.A-9.

EXHIBIT VI.A-8: BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

Boring logs and well construction diagrams for groundwater monitoring wells are included as appendices to this Attachment.

Well MW-1
Well MW-2
Well MW-4
Well MW-5
Well MW-6
Well MW-7

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-1



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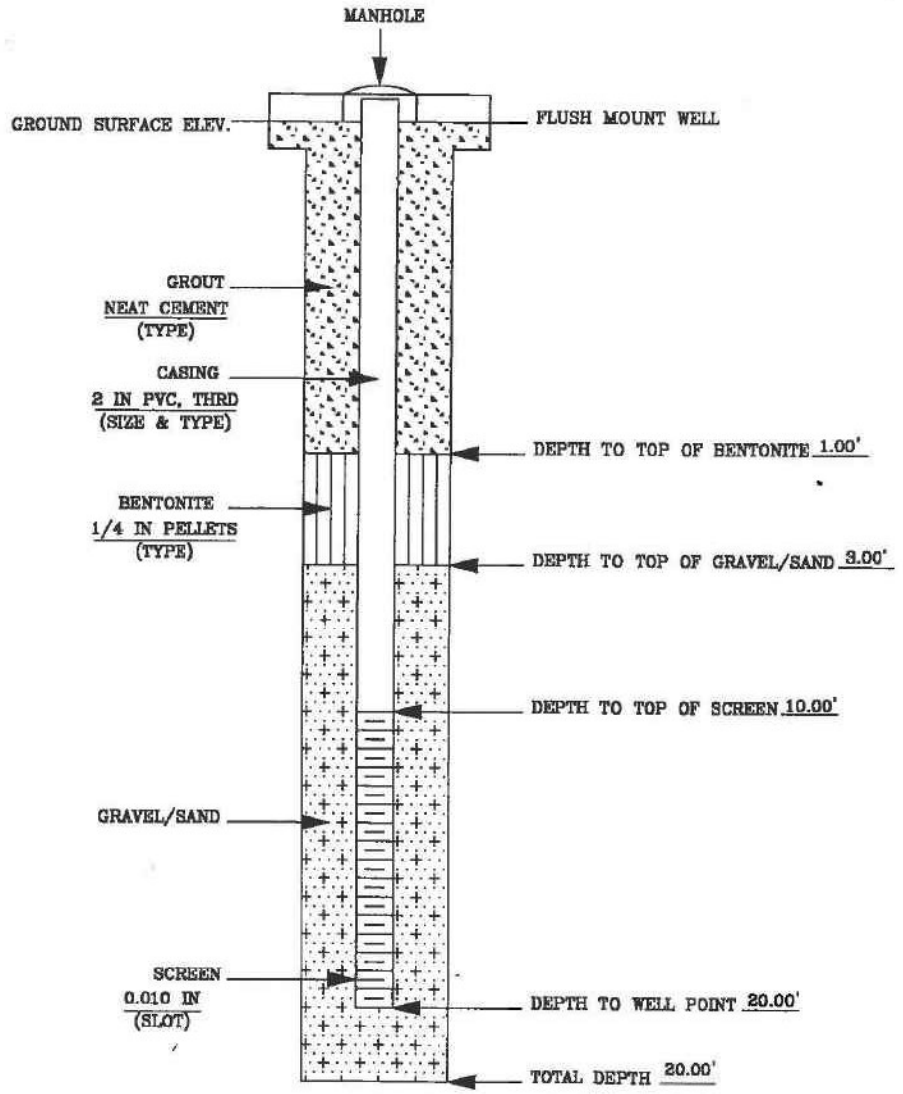
MONITORING WELL SCHEMATIC

WELL NO. MW-1
DATE COMPLETED 9/17/98
PROJECT NO. N2844A

O.D. OF CASING 4.50"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-2

CLIENT	JOB #	BORING #	SHEET
NASA – WALLOPS ISLAND	N2844A	MW–2	1 OF 1

PROJECT NAME: WFF HYDROLOGIC STUDY
ARCHITECT–ENGINEER: OCCU–HEALTH INC.
SITE LOCATION: WALLOPS ISLAND, VIRGINIA

CALIBRATED PENETROMETER TONS/FT.^{2} (1, 2, 3, 4, 5+)
PLASTIC LIMIT % X — WATER CONTENT % ● — LIQUID LIMIT % Δ
STANDARD PENETRATION BLOWS/FT. (10, 20, 30, 40, 50+)

DEPTH (FT)	SAMPLE NO	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL (ENGLISH UNITS; SURFACE ELEVATION)	PID READINGS (ppm)	STANDARD PENETRATION BLOWS/FT.
0	1		36	0	Topsoil Hand dug to avoid fiberoptic line		
	2		24	24	Tan Fine to Medium SAND, Trace Silt	12.9	12
5	3		24	24		16.7	20
	4		24	24		10.9	7
10	5		24	24	Tan Fine to Medium SAND, Trace Silt, With Shell Fragments	8.9	8
					END OF BORING @ 11.0'		
15							
20							
25							
30							

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 8 WS OR WD	BORING STARTED 9/17/98	TOPSOIL DEPTH: 6"
WL BCR ACR	BORING COMPLETED 9/17/98	CAVE IN DEPTH @
WL	RIG FOREMAN FISHBURNE	DRILLING METHOD HOLLOW STEM AUGER

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-3

(The boring log and well construction diagram for MW-3 was removed from the Permit by permit modification, dated August 3, 2010. As a result of the major storm event of November 11 -13, 2009, the original background monitoring well MW-3 was damaged and was deemed inoperable. The Permittee submitted a Open Burn Area Proposed Background Well (MW-4) Analysis Report, dated February 9, 2010. The above Report proposed an original point-of-compliance well, MW-4, to serve as the new background monitoring well, replacing the damaged background well MW-3. In a letter dated April 5, 2010, the DEQ determined that MW-4 was a suitable replacement background well. On May 6, 2010, the Permittee requested a Class 2 permit modification to replace MW-3 with MW-4 as the OB/OD unit background well. Monitoring well MW-3 was subsequently abandoned in accordance with procedures approved by the DEQ in correspondence, dated July 27, 2010.)

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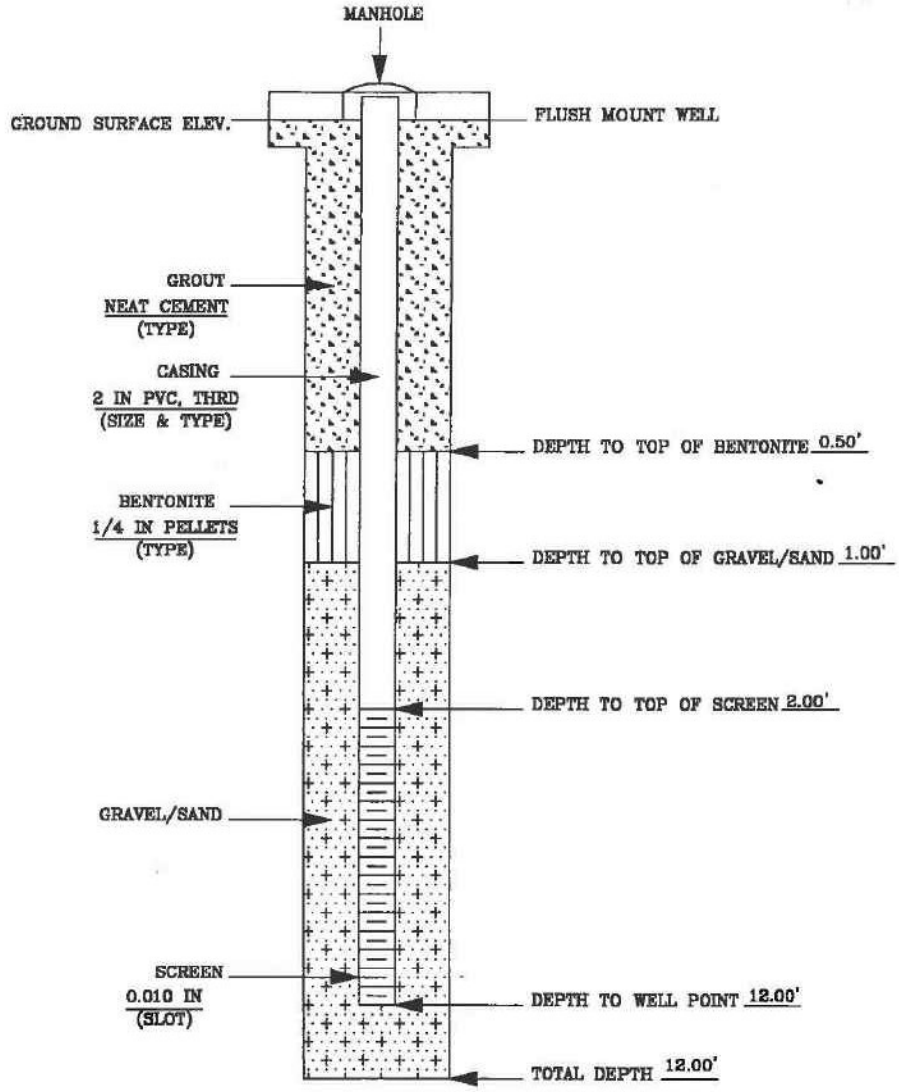
MONITORING WELL SCHEMATIC

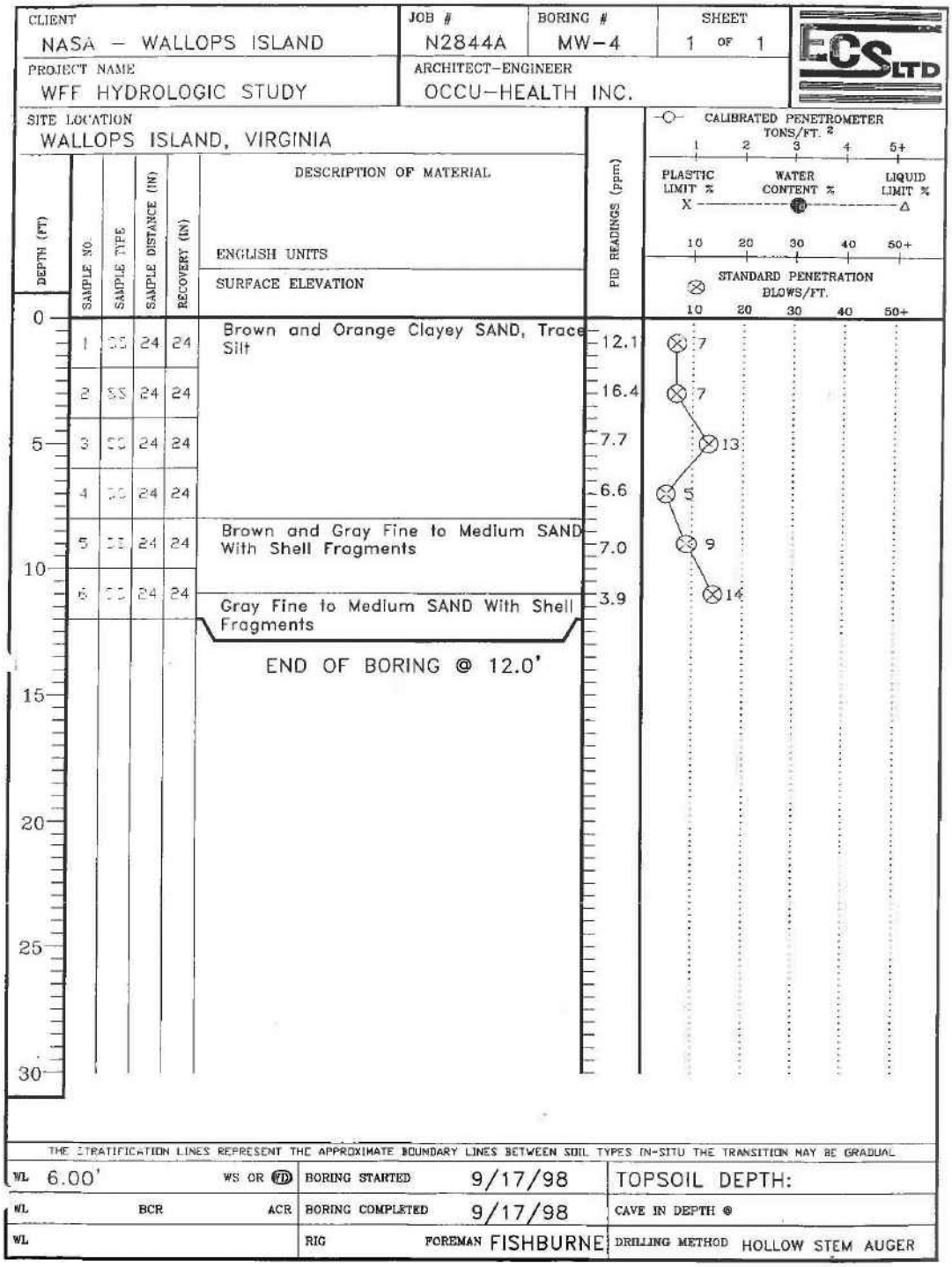
WELL NO. MW-2
DATE COMPLETED 9/17/98
PROJECT NO. N2844A

O.D. OF CASING 2.375"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-4



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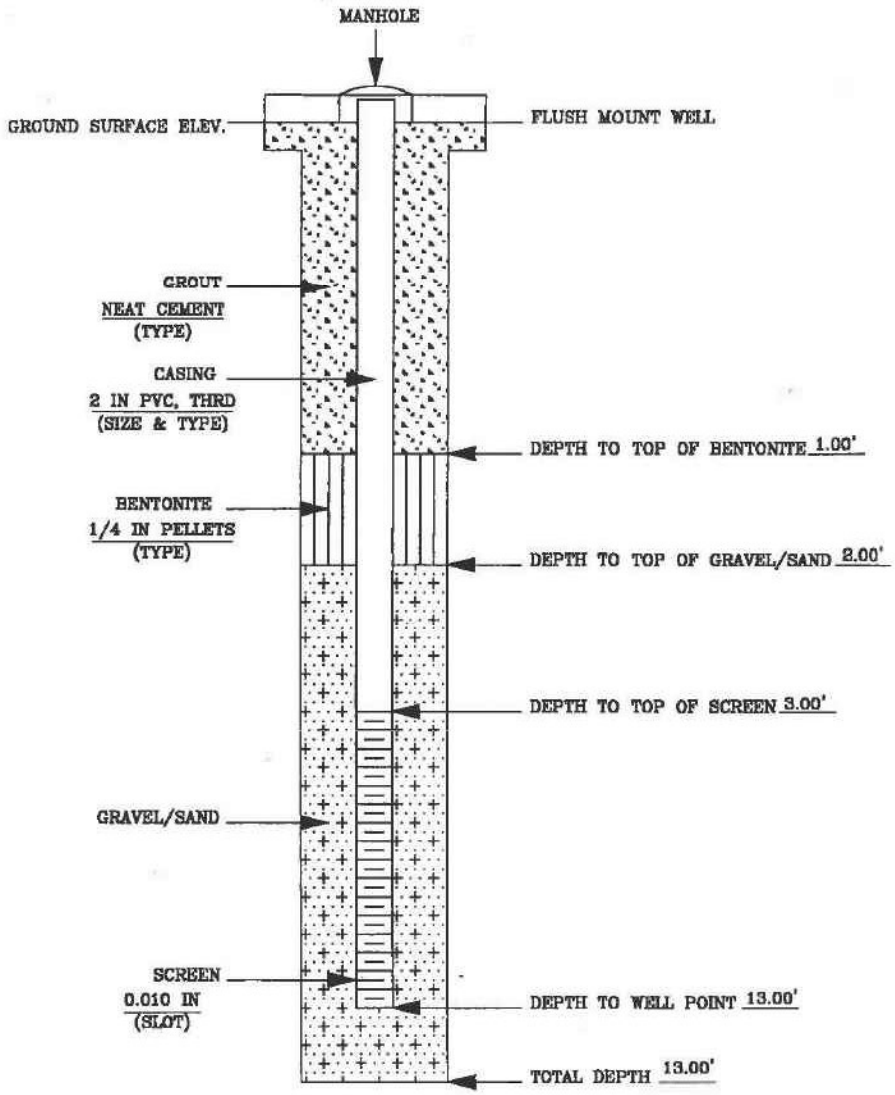
MONITORING WELL SCHEMATIC

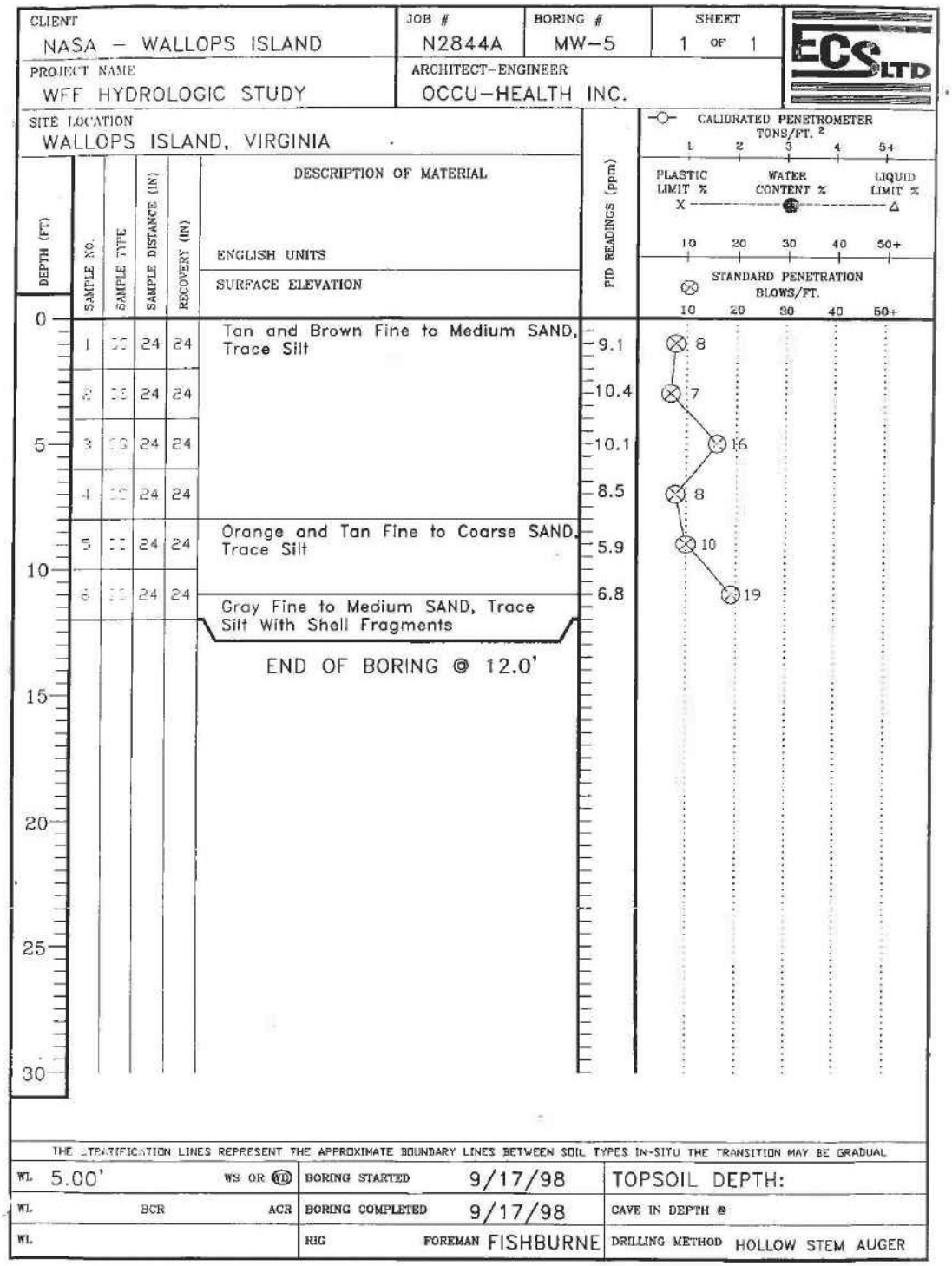
WELL NO. MW-4
DATE COMPLETED 9/17/98
PROJECT NO. N2644A

O.D. OF CASING 2.375"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-5



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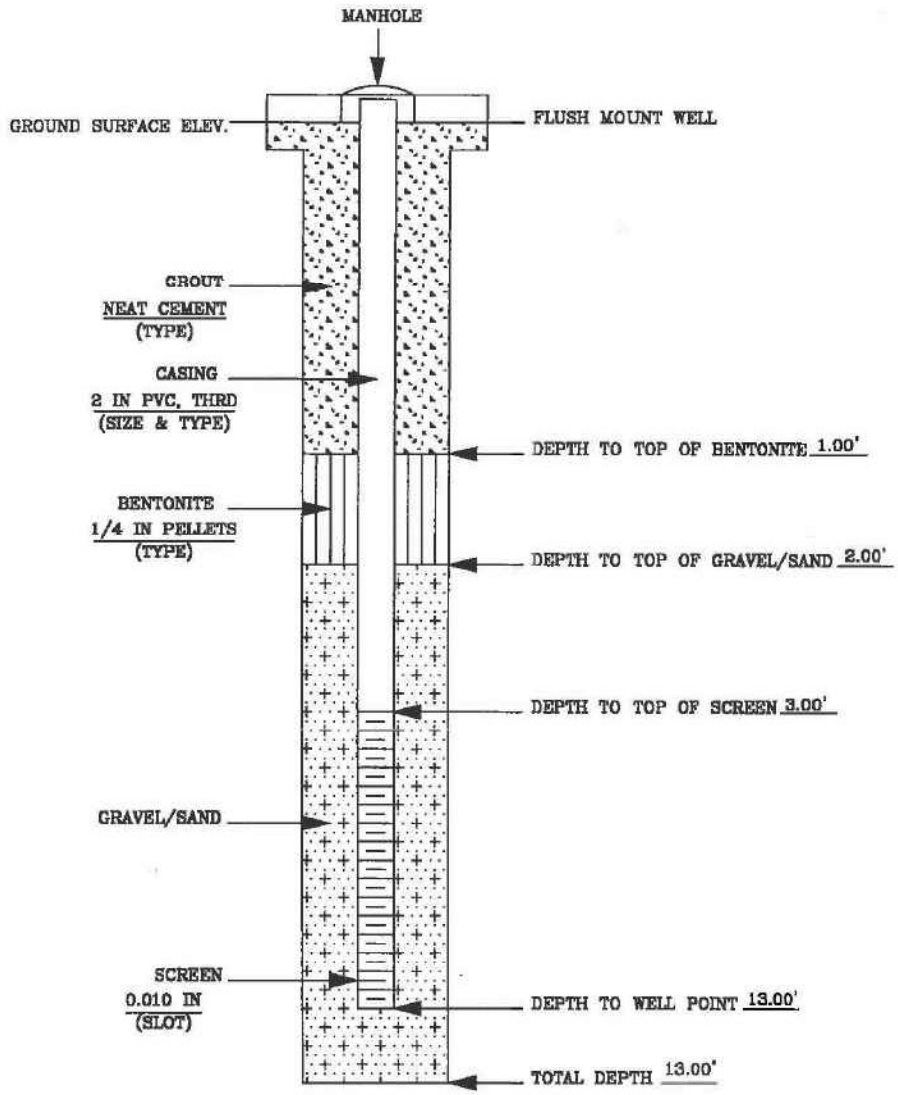
MONITORING WELL SCHEMATIC

WELL NO. MW-5
DATE COMPLETED 9/17/98
PROJECT NO. N2844A

O.D. OF CASING 2.375"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-6

CLIENT	JOB #	BORING #	SHEET
NASA – WALLOPS ISLAND	N2844A	MW–6	1 OF 1
PROJECT NAME: WFF HYDROLOGIC STUDY	ARCHITECT–ENGINEER: OCCU–HEALTH INC.		
SITE LOCATION: WALLOPS ISLAND, VIRGINIA			

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CALIBRATED PENETROMETER TONS/FT.^{2} (1, 2, 3, 4, 5+)
PLASTIC LIMIT % X — WATER CONTENT % ● — LIQUID LIMIT % Δ
STANDARD PENETRATION BLOWS/FT. (10, 20, 30, 40, 50+)

ENGLISH UNITS
SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	PID READINGS (ppm)	STANDARD PENETRATION BLOWS/FT.
0	1	SS	24	24	Tan Fine to Medium SAND, Trace Silt	16.1	8
	2	SS	24	24		8.7	15
5	3	SS	24	24	Tan Fine to Coarse SAND, Trace Silt	4.3	13
	4	SS	24	24		12.8	3
	5	SS	24	24	Gray Fine to Coarse SAND, Trace Silt	11.6	9
10	6	SS	24	24		10.9	16
					END OF BORING @ 12.0'		
15							
20							
25							
30							

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 5.00' WS OR PD	BORING STARTED 9/17/98	TOPSOIL DEPTH:
WL BCR ACR	BORING COMPLETED 9/17/98	CAVE IN DEPTH ●
WL	RIG FOREMAN FISHBURNE	DRILLING METHOD HOLLOW STEM AUGER

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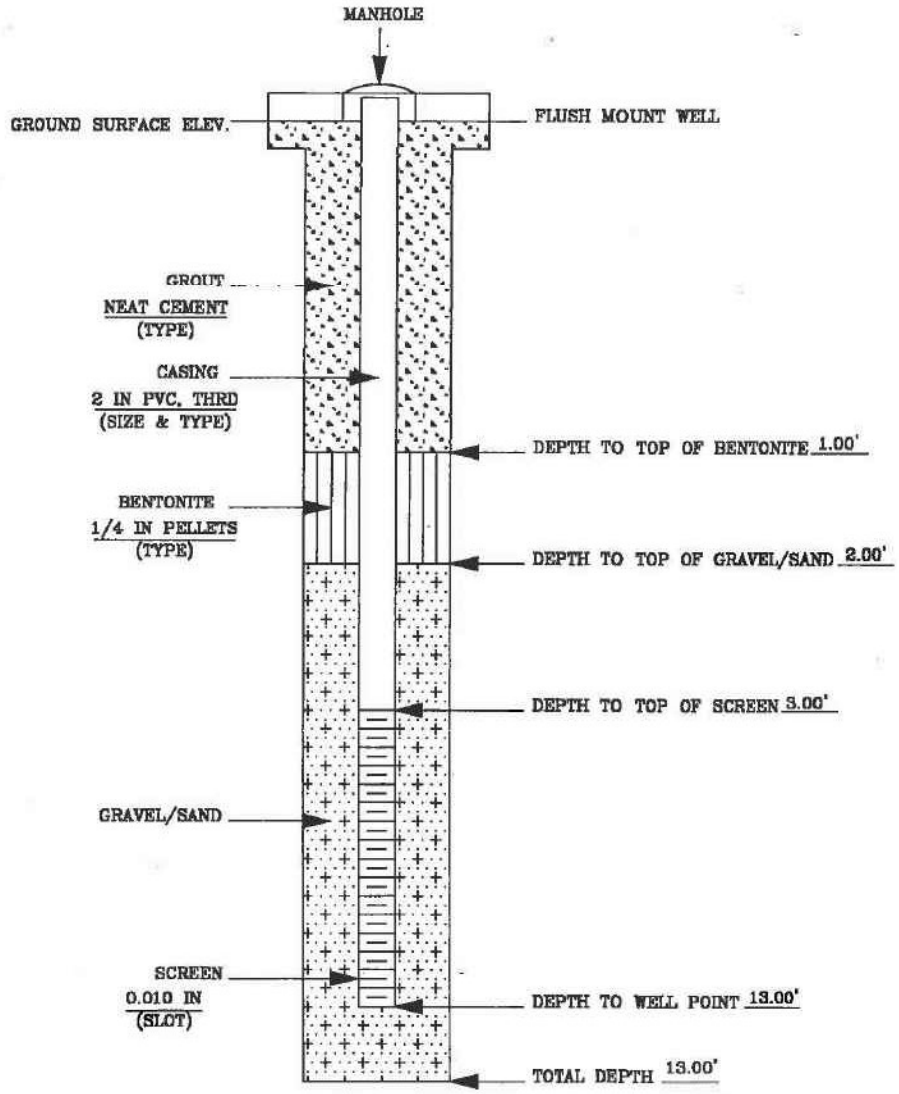
MONITORING WELL SCHEMATIC

WELL NO. MW-6
DATE COMPLETED 9/17/98
PROJECT NO. N2844A

O.D. OF CASING 2.375"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

BORING LOG AND WELL CONSTRUCTION DIAGRAM FOR MW-7

CLIENT	JOB #	BORING #	SHEET
NASA – WALLOPS ISLAND	N2844A	MW-7	1 OF 1

PROJECT NAME: WFF HYDROLOGIC STUDY
ARCHITECT-ENGINEER: OCCU-HEALTH INC.
SITE LOCATION: WALLOPS ISLAND, VIRGINIA

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CALIBRATED PENETROMETER TONS/FT.² (1, 2, 3, 4, 5+)
PLASTIC LIMIT % X — WATER CONTENT % ● — LIQUID LIMIT % △
STANDARD PENETRATION BLOWS/FT. ⊗ (10, 20, 30, 40, 50+)

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL (ENGLISH UNITS)	PID READINGS (ppm)	STANDARD PENETRATION BLOWS/FT.
0	1	SS	24	24	Tan and Brown Fine to Medium SAND, Trace Silt	17.0	4
	2	SS	24	24		10.3	3
5	3	SS	24	24		14.3	WOH
	4	SS	24	24		11.4	7
	5	SS	24	24	Brown and Tan Fine to Coarse SAND, Trace Silt	17.6	9
10	6	SS	24	24		9.3	10
					END OF BORING @ 12.0'		
15							
20							
25							
30							

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WL 5.00' WS OR PD	BORING STARTED 9/17/98	TOPSOIL DEPTH:
WL BCR ACR	BORING COMPLETED 9/17/98	CAVE IN DEPTH @
WL	RIG FOREMAN FISHBURNE	DRILLING METHOD HOLLOW STEM AUGER

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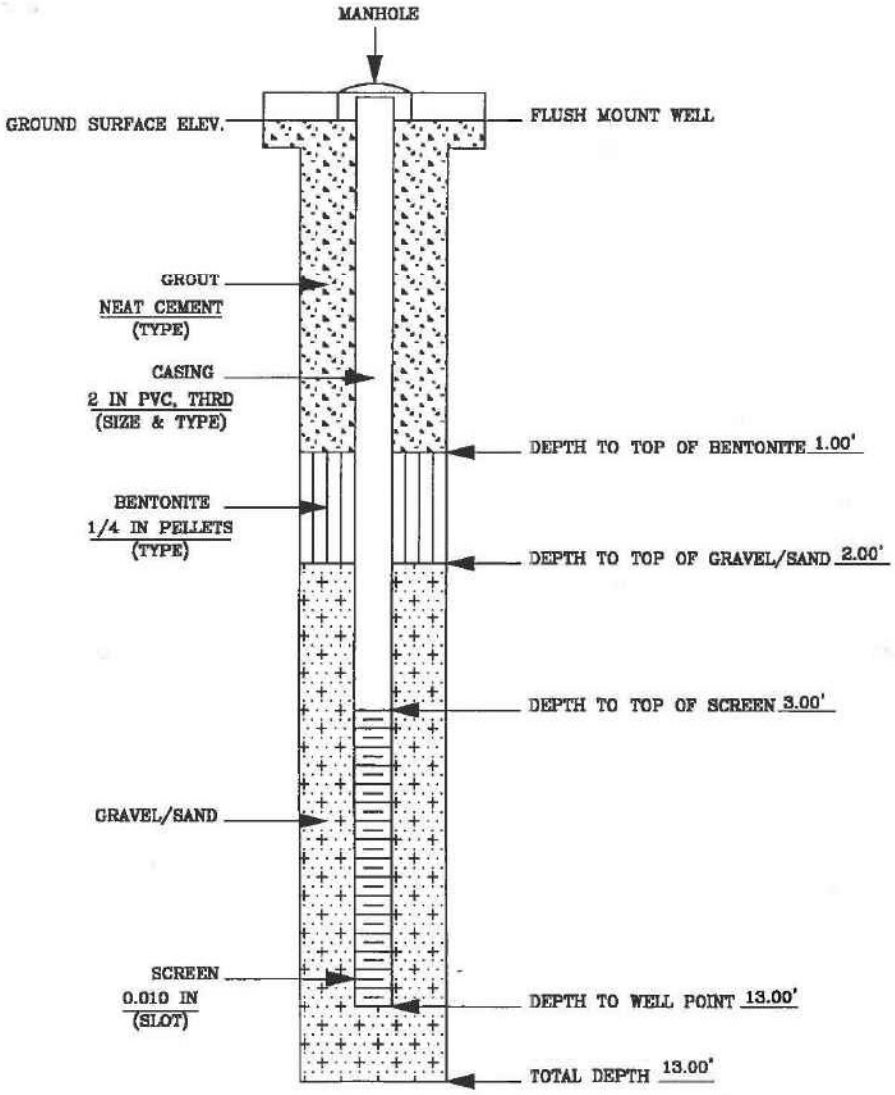
PHONE (757) 366-5100
FAX (757) 366-5203

MONITORING WELL SCHEMATIC

WELL NO. MW-7
DATE COMPLETED 9/17/98
PROJECT NO. N2844A

O.D. OF CASING 2.375"
LENGTH OF SCREEN 10.0'
SCREEN OPENING SIZE 0.010"



NOTE: ALL DEPTHS REFERENCED FROM GROUND SURFACE

EXHIBIT VI.A-9: INVESTIGATIVE DERIVED WASTE POLICY

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Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Management of Investigation Derived Waste**

Effective Date: July 3, 2014 | **Number:** SESDPROC-202-R3

Authors

Name: Art Masters
Title: Environmental Scientist, Regional Expert
Signature: Date: 7/2/14

Approvals

Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature: Date: 7/2/14

Name: Mike Bowden
Title: Acting Chief, Ecological Assessment Branch
Signature: Date: 7/2/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 7/2/14

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Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-202-R3, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R2. **General:** Corrected typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	July 3, 2014
SESDPROC-202-R2, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R1.	October 15, 2010
SESDPROC-202-R1, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R0.	November 1, 2007
SESDPROC-202-R0, Management of Investigation Derived Waste, Original Issue	February 05, 2007

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TABLE OF CONTENTS

1 General Information 4
1.1 Purpose 4
1.2 Scope/Application 4
1.3 Documentation/Verification 4
1.4 References 4
1.5 General Precautions 5
1.5.1 Safety 5
1.5.2 Procedural Precautions 5
2 Types of Investigation Derived Waste 6
3 Management of Non-Hazardous IDW 7
4 Management of Hazardous IDW 8

TABLES

Table 1: Disposal of IDW 9

COPY

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

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1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when managing IDW. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

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2 Types of Investigation Derived Waste

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for mud or water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvents and wash water.
- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

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3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

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4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

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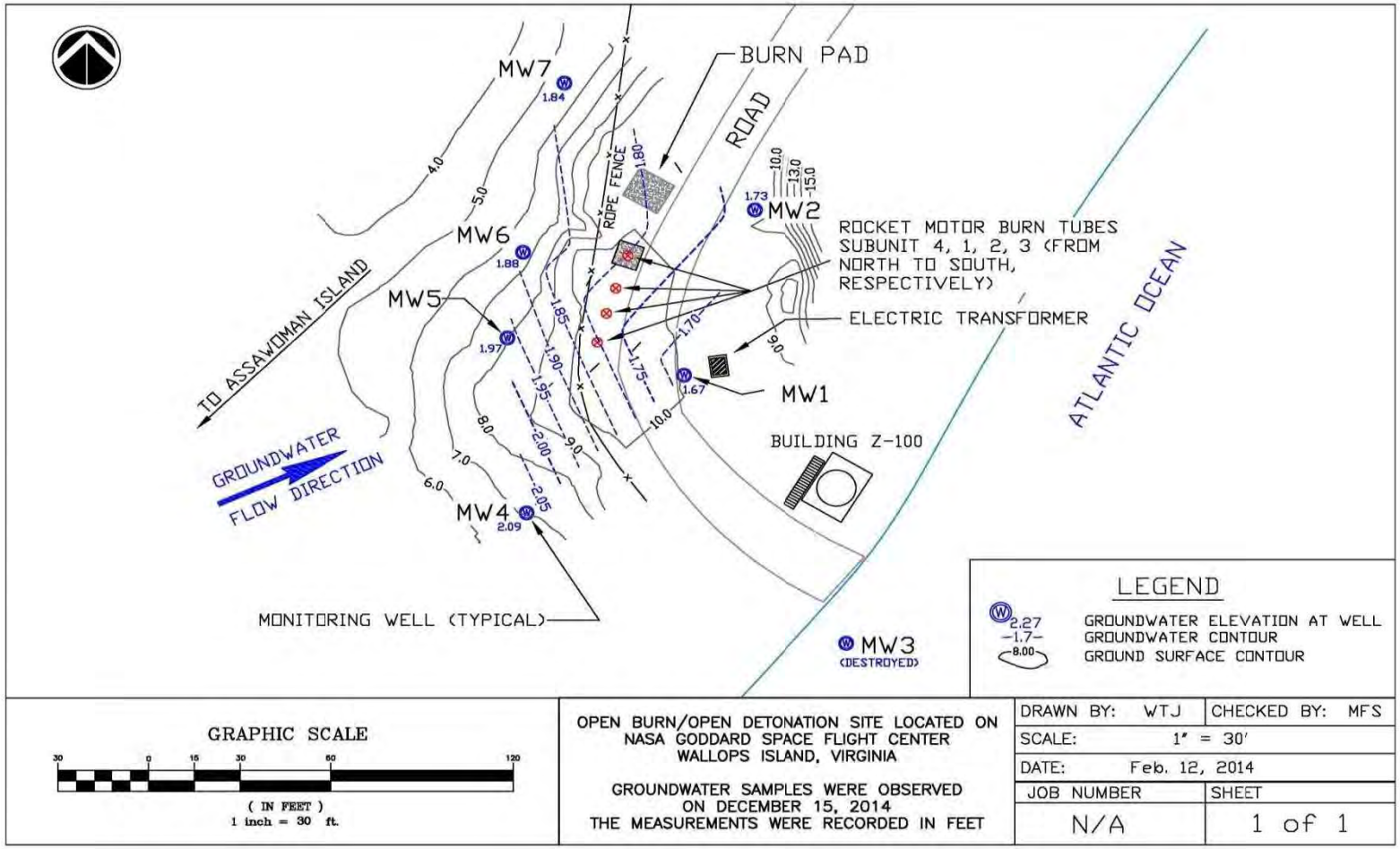
Table 1: Disposal of IDW

TYPE	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

**** These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.**

EXHIBIT VI.A-10: GROUNDWATER MONITORING WELL LOCATIONS



ATTACHMENT VI.B

GROUND WATER MONITORING LIST

ATTACHMENT VI.B - COMPLIANCE GROUND WATER MONITORING LIST

Constituents	**Analytical Method**	MDL (ug/L)	PQL (RL) (ug/L)
Indicator Parameters			
pH	Field	NA	NA
Specific Conductivity	Field	NA	NA
Temperature	Field	NA	NA
Turbidity	Field	NA	NA
Groundwater Protection Standard Constituents			
Nitrate	9056	33	250
Nitrite	9056	33	250
Ammonia	SM4500-NH3-C	100	300
Total Lead	6020/6010C low	0.375	1.25
Perchlorate	6850	0.5	2
Phenols	9065	0.02	0.1
Total Cyanide	9010/9014/9012B	5	20
Chlorobenzene	8260	0.25	1.00
Arsenic	6010/6020/6010C	0.75	2.5
Barium	6010/6020/6010C	1.25	10
Cadmium	6010/6020/6010C	0.25	1.25
Chromium	6010/6020/6010C	0.5	2.5
Copper	6010/6020/6010C	1.0	2.5
Silver	6010/6020/6010C	0.25	2.5
Vanadium	6010/6020/6010C	1.25	3.125
Zinc	6010/6020/6010C	1.25	5

Note:
Alternate SW-846 Methods may be approved by the Department if the request is in writing and submitted at least 30 days prior to the sample collection event. Proposed alternative methods must achieve the appropriate Data Quality Objective (i.e. at least a Department approved health-based concentration limit).

ATTACHMENT VI.C - GROUNDWATER PROTECTION STANDARDS

Constituents	**Background Concentrations**	**Groundwater Protection Standards (mg/L)**	**Source**
Nitrate	2.2	10	MCL
Nitrite	0.046	1	MCL
Ammonia	0.3	0.3	Background
Total Lead	0.0089	0.015	MCL
Perchlorate	0.000355	0.015	MCL
Phenols	0.092	5.8	ACL
Total Cyanide	0.064	0.2	MCL
		GPS (ug/L)	
Chlorobenzene	NE	100	MCL
Arsenic	NE	10	MCL
Barium	NE	2000	MCL
Cadmium	NE	5	MCL
Chromium	NE	100	MCL
Copper	NE	1300	MCL
Silver	NE	94	ACL
Vanadium	NE	86	ACL
Zinc	NE	6000	ACL

Notes:

1. The 95% Upper Tolerance Limit (UTL) Background Values for the constituents of concern (COCs) listed in the table above with the exception of perchlorate were calculated by the DEQ using the data from MW-4 from November 2005, through 2009. See DEQ correspondence to Permittee, dated April 5, 2010.

2. The 95% Upper Tolerance Limit (UTL) Background Value for perchlorate was calculated using data from MW4 from 2012 to 2015. See DEQ correspondence to Permittee, dated February 11, 2016.

3. NE – Background Concentrations Not Established at the time of permit issuance

4. The GPS should reflect the most recently published MCL and/or ACL at the time of comparison. The MCLs and ACLs listed as placeholders are those published June 2017 (MCL) and November 2017 (ACL).

ATTACHMENT VI.D - GROUNDWATER MONITORING CONSTITUENTS
(FROM APPENDIX IX to 40 CFR § 264 AND ANALYTICAL METHODS LIST)

PARAMETERS	**ANALYTICAL METHODS SW-846, 3RD EDITION**
acenaphthene	8270C
acenaphthylene	8270C
acetone	8260B
acetophenone	8270C
acetonitrile	8015B 8260B
2-acetylaminofluorene	8270C
acrolein	8260B
acrylonitrile	8260B 8316
aldrin	8081A
allyl chloride	8260B
4-aminobiphenyl	8270C
aniline	8270C
anthracene	8270C 8310
antimony	6010B 6020A 7041
aramite	8270C
arsenic	6010B 6020A
barium	6010B 6020A 7081
benzene	8260B
benzo[a]anthracene	8270C/8310
benzo[b]fluoranthene	8270C/8310
benzo[k]fluoranthene	8270C/8310
benzo[ghi]perylene	8270C/8310
benzo[a]pyrene	8270C/8310
benzyl alcohol	8270C
beryllium	6010B 6020A 7091
BHC-alpha	8081A

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
BHC-beta	8081A
BHC-delta	8081A
BHC-gamma; Lindane	8081A
bis(2-chlorethoxy)methane	8270C
bis(2-chloroethyl)ether	8270C
bis(2-chloro-1-methylethyl)ether	8270C
bis(2-ethylhexyl)phthalate	8270C
bromodichloromethane	8021B 8260B
bromoform; tribromomethane	8260B
4-bromophenyl phenyl ether	8270C
butyl benzyl phthalate	8061 8270C
cadmium	6020A 7131A
carbon disulfide	8260B
carbon tetrachloride	8021B 8260B
chlordane	8081A
p-chloroaniline	8270C
chlorobenzene	8021B 8260B
chlorobenzilate	8270C
p-chloro-m-cresol	8041 8270C
chloroethane; ethyl chloride	8021B 8260B
chloroform; trichloromethane	8021B 8260B
2-chloronaphthalene	8121 8270C
2-chlorophenol	8041 8270C
4-chlorophenyl phenyl ether	8111 8270C
chloroprene	8260B
chromium	6020A 7191

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
chrysene	8270C 8310
cobalt	6010B 6020A 7201
copper	6010B 6020A 7211
m-cresol	8270C
o-cresol	8270C
p-cresol	8270C
cyanide	9010B 9012A
2,4-D; 2,4-dichlorophenoxy acetic acid	8151A
4,4'-DDD	8081A 8270C
4,4'-DDE	8081A
4,4'-DDT	8081A
diallate	8270C
dibenz(a,h)anthracene	8310
dibenzofuran	8270C
dibromochloromethane	8021B 8260B
1,2-dibromo-3-chloropropane; DBCP	8011
1,2-dibromoethane; ethylene dibromide	8011
di-n-butyl phthalate	8061 8270C
di-n-octyl phthalate	8270C
o-dichlorobenzene; benzene, 1,2-dicholoro-	8021B 8121 8260B 8270C
m-dichlorobenzene; benzene, 1,3-dicholoro-	8021B 8270C
p-dichlorobenzene; benzene, 1,4-dicholoro-	8021B 8121 8260B

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
	8270C
3,3'-dichlorobenzidine	8270C
trans-1,4-dichloro-2-butene	8260B
dichlorodifluoromethane	8021B 8260B
1,1-dichloroethane	8021B 8260B
1,2-dichloroethane	8021B 8260B
1,1-dichloroethylene	8021B 8260B
trans-1,2-dichloroethylene	8021B 8260B
2,4-dichlorophenol	8041 8270C
2,6-dichlorophenol	8270C
1,2-dichloropropane	8021B 8260B
cis-1,3-dichloropropene	8260B
trans-1,3-dichloropropene	8260B
dieldrin	8081A
diethyl phthalate	8061 8081A
O,O-diethyl O-2-pyrazinylphosphorothioate	8141 8270C
dimethoate	8141 8270C
p-dimethylaminoazobenzene	8270C
7,12-dimethylbenz(a)anthracene	8270C
3,3'-dimethylbenzidine	8270C
alpha, alpha-dimethyl phenethylamine	8270C
2,4-dimethylphenol	8041 8270C
dimethyl phthalate	8061 8270C
m-dinitrobenzene; benzene, 1,3-dinitro-	8270C
4,6-dinitro-o-cresol	8041 8270C
2,4-dinitrophenol	8041

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
	8270C
2,4-dinitrotoluene	8091 8270C
2,6-dinitrotoluene	8091 8270C
2-sec-butyl-4,6-dinitrophenol; Dinoseb; DNBP	8151A
di-n-octyl phthalate	8061 8270C
1,4-dioxane	8015B
diphenylamine	8270C
disulfoton	8141A 8270C
Endosulfan I	8081A
Endosulfan II	8081A
Endosulfan sulfate	8081A
Endrin	8081A
Endrin aldehyde	8081A
ethylbenzene	8021B 8260B
ethyl methacrylate	8015B 82B0B 8270C
ethyl methanesulfonate	8270C
ethyl parathion	8141
famphur	8270C
fluoranthene	8270C 8310
fluorene	8270C 8310
heptachlor	8081A
heptachlor epoxide	8081A
hexachlorobenzene	8121
hexachlorobutadiene	8021B 8121 8260B
hexachlorocyclopentadiene	8121 8270C
hexachloroethane	8121
hexachlorophene	8270C

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
hexachloropropene	8270C
2-hexanone	8260B
indeno(1,2,3-cd)pyrene	8310
isobutyl alcohol	8015B 8260B
isodrin	8270C
isophorone	8091 8270C
isosafrole	8270C
kepone	8081A 8270
lead	6020A 7421
Lindane	8081A
mercury	7470A 7471A
methacrylonitrile	8015B
methapyrilene	8270C
methoxychlor	8081A 8270C
methyl bromide; bromomethane	8260B
methyl chloride; chloromethane	8021B 8260B
3-methylcholanthrene	8270C
methylene bromide	8021B 8260B
methylene chloride; dichloromethane	8021B 8260B
methyl ethyl ketone; MEK; 2-butanone	8015B 8260B
methyl iodide; iodomethane	8260B
methyl methacrylate	8015B 8260B
methyl methanesulfonate	8270C
2 methylnaphthalene	8270C
methyl parathion	8141A 8270C
4-methyl-2-pentanone;	8015B

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
MIBK	8260B
methylene bromide; dibromomethane	8260B
2-methylnaphthalene	8270C
naphthalene	8021B 8260B
1,4-naphthoquinone	8270C
1-naphthylamine	8270C
2-naphthylamine	8270C
nickel	6010B 6020A
o-nitroaniline	8270C
m-nitroaniline	8270C
p-nitroaniline	8270C
nitrobenzene	8091 8270C
o-nitrophenol	8041 8270C
p-nitrophenol	8041 8270C
4-nitroquinoline-1-oxide	8270C
n-nitrosodi-n-butylamine	8270C
n-nitrosodiethylamine	8270C
n-nitrosodimethylamine	8070A 8270C
n-nitrosodiphenylamine	8070A 8270C
n-nitrosodi-n-propylamine; di-n-propylnitrosamine	8070A 8270C
n-nitrosomethylethylamine	8270C
n-nitrosomorpholine	8270C
n-nitrosopiperidine	8270C
n-nitrosopyrrolidine	8270C
5-nitro-o-toluidine	8270C
Parathion	8270C
polychlorinated biphenyls; PCB's	8081A 8270C
polychlorinated dibenzofurans; PCDFs	8280A/8290
pentachlorobenzene	8270C

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
pentachloroethane	8260B 8270C
pentachloronitrobenzene	8270C
pentachlorophenol	8041
phenacetin	8270C
phenanthrene	8270C 8310
phenol	8041 8270C
phenols (total)	9066A 9067A
p-phenylenediamine	8270C
phorate	8141A 8270C
2-picoline	8260B 8270C
polychlorinated biphenyls (1242)	8081A
polychlorinated dibenzo-p-dioxins; PCDDs	8280A/8290
polychlorinated dibenzofurans; PCDFs	8280A/8290
potassium	6010B 7610
pronamide	8270C
propionitrile	8015B 8260B
pyrene	8270C 8310
pyridine	8260B 8270C
safrole	8270C
selenium	7740 7741A
silver	6010B 7761
Silvex; 2,4,5-TP	8151A
styrene	8021B 8260B
sulfide	9030A
1,2,4,5-tetrachlorobenzene	8270C

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
2,3,7,8-tetrachlorodibenzo-p-dioxin	8280A/8290
1,1,1,2-tetrachloroethane	8021B 8260B
1,1,2,2-tetrachloroethane	8021B 8260B
tetrachloroethylene; PCE; tetrachloroethene	8260B
2,3,4,6-tetrachlorophenol	8270C
tetraethyl dithiopyrophosphate; Sulfotep	8141
thallium	6020A 7841
tin	6010B 7871
toluene	8021B 8260B
o-toluidine	8270C
Toxaphene	8081A
1,2,4-trichlorobenzene	8021B 8121 8260B
1,1,1-trichloroethane	8021B 8260B
1,1,2-trichloroethane	8260B
trichloroethylene; trichloroethene	8021B 8260B
trichlorofluoromethane	8021B 8260B
2,4,5-trichlorophenol	8270C
2,4,6-trichlorophenol	8041A 8270C
2,4,5-trichlorophenoxyacetic acid; 2,4,5-T	8151A
1,2,3-trichloropropane	8021B 8260B
O,O,O-triethyl phosphorothioate	8270C
1,3,5-trinitrobenzene	8270C
vanadium	6010B 7911
vinyl acetate	8260B
vinyl chloride	8021B

PARAMETERS	ANALYTICAL METHODS SW-846, 3RD EDITION
	8260B
xylene (total)	8021B 8260B
zinc	6010B 6020A 7950 7951