# Procedures and Guidelines (PG)

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| **DIRECTIVE NO.** | 540-PG-8715.1.2C | **APPROVED BY Signature:** | Original signed by: |
| **EFFECTIVE DATE:** | 05/04/2010 | **NAME:** | Ken Hinkle |
| **EXPIRATION DATE:** | 05/04/2015 | **TITLE:** | Chief, Mechanical Systems Division |

**COMPLIANCE IS MANDATORY**

**Responsible Office:** 540.0/MSD Safety Lead

**Title:** Mechanical Systems Division Safety Manual

## PREFACE

### P.1 PURPOSE

The Mechanical Systems Division (MSD) Safety Manual is intended to establish the policies, procedures, and requirements for each of the facilities within the MSD, and to provide GSFC personnel contacts. This manual is a supplement to 500-PG-8715.1.2, *Applied Engineering and Technology Directorate* (*AETD) Safety Manual*. It summarizes the required safety information needed to conduct activities in the MSD facilities. This Manual lists the pertinent NASA, GSFC, and Occupational Safety and Health Act (OSHA) requirements documents. It is not intended to replace any of the above documents. For more detailed information, the reference documents listed in each section must be consulted.

### P.2 APPLICABILITY

This Manual applies to all GSFC organizational elements, contractors, commercial projects, and personnel from other Government agencies while in MSD facilities. The Manual sets the minimum requirements needed to conduct safe operations.

### P.3 AUTHORITY

NPR 8715.3, NASA Safety Manual
OSHA 29 CFR 1910, Occupational Safety and Health Standards
500-PG-8715.1.1, AETD Safety Plan
500-PG-8715.1.2, AETD Safety Manual

### P.4 REFERENCES

Each section lists the unique reference documents applicable for that section. Sections of the AETD Safety Manual are referred to within this document. The AETD Safety Manual lists the general safety requirements to be followed throughout the Directorate.

### P.5 CANCELLATION

540-PG-8715.1.1, MSD Safety Manual-Volume I

## P.6 SAFETY

This Manual describes safety issues associated with specific facilities or process areas within MSD. This Manual sets forth the requirements for conducting safe operations within the Mechanical Systems Division (MSD), Goddard Space Flight Center (GSFC), Greenbelt, Maryland and Wallops Flight Facility (WFF), Virginia. In general this includes activities in the follow areas: Buildings 4, 5, 7, 10, 15, 29, 30, 84, 302, 303, 304, and 305 and WFF D-101, E109, F-7, N-159, V-45/50/55, X-35, and X-55.

Although this Manual does not specifically list the NPR 8715.3, *NASA Safety Manual* in each section of the Manual, it is understood that NPR 8715.3 sets the requirements for the overall safety program, which will always be followed. Cross-referenced section numbers, which point to more detailed information on a subject within the document, are enclosed in parentheses. Those referring to sections of the AETD Safety Manual shall be noted as AETD SM with the applicable section number.

## P.7 TRAINING

Any required training is listed in the applicable section.

## P.8 RECORDS

| Record Title | Record Custodian |
|---|---|
| Non-ionizing Radiation Systems, forms GSFC 23-6RF, 23-28RF, 23-35RF, 23-6L, 23-28L, 23-67A/B, and 23-35LU | GSFC Radiation Protection Office |
| Ionizing Radiation Systems, forms GSFC 23-6I, 23-28I, 23-35IP, 23-6ID and 23-28ID | GSFC Radiation Protection Office |
| Flight Weight Pressure Systems Formal Certification Report | Appropriate Branch Head |
| Medium Weight Pressure Systems Formal Certification Report | Appropriate Branch Head |
| Hot Work Permit forms GSFC 23-4 and 23-4A and Utility Outage Request Form | Issuing Organization |
| Confined Space Entry Permit form GSFC 23-52 | Issuing Organization |
| Hazardous Waste Disposal form GSFC 23-54 | Hazardous Waste Environmental Office |
| Material Safety Data Sheets (MSDS) | Appropriate Branch Head or Safety Representative |

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|---|---|
| Incident Reporting Information System (IRIS) at web site https://nasa.ex3host.com/Iris/newmenu/login.asp or NASA Mishap Report Form 1627A | Issuing Organization |

## P.9 MEASUREMENT/VERIFICATION

None

## PROCEDURES

In this document, a requirement is identified by "shall" or "must," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive materials by "is."

# Table Of Contents

# 1.0 Introduction

This Manual is designed to provide the specific safety requirements for the facilities within MSD. The first ten sections of 500-PG-8715.1.2, *AETD Safety Manual* are designed to complement the MSD System, Subsystem, or Equipment Evaluation Form (Work Instruction 09-PC-WI71, Safety Evaluation Process on web site http://mscweb.gsfc.nasa.gov/549web/). As a further aid, Figure A-1 in Appendix A provides a cross-reference of Evaluation Form checklist items to the AETD Safety Manual's corresponding Section Numbers. This manual describes the safety issues encountered in each of the various test facilities and labs found in MSD.

The evaluation process is described in detail in 09-PC-WI71. This Manual and the AETD Safety Manual may be used by the project or group to help determine what safeguards/requirements are required for processing/testing, and by the Project Support Team Lead (PSL) to determine if these requirements have been met. Any remaining questions as to the safety of the test article shall be directed toward the Code 302 Safety Engineers, MSD Safety Lead, AETD Safety Manager, or S&ED. Hazardous situations not resolved, or extremely hazardous situations, shall be brought to the attention of the applicable Branch Head. Problem areas not resolved shall call for immediate stoppage of all work.

The PSL are responsible for overseeing the safety aspects of items being processed in the MSD facilities. The person responsible may be different depending on the facility in which the work is taking place. PSL could be the Section Head or Lead Engineer or another designated person.

# 2.0 Facilities Requirements

## 2.1 Acoustic Chamber

### 2.1.1 Scope

This section covers the acoustic reverberation chamber and its subsystems, located in Buildings 7/10.

### 2.1.2 General

Facilities and subsystems covered in this section are:

1. Acoustic Reverberation Chamber: The 40,000 $ft^3$ (1,100 $m^3$) reverberation chamber located adjacent to the Building 7 truck lock and Building 10 High Bay.
2. $GN_2$ Supply for the Acoustic Horns: The $GN_2$ storage system located on the Building 7 parking lot, which supplies the $GN_2$ needed to drive the acoustic generators and horns inside the acoustic chamber.
3. Chamber Air Handling System: The chamber air handling system either recirculates Building 10 conditioned air within the chamber, or exhausts nitrogen-rich chamber air to the outside atmosphere atop the chamber.

### 2.1.3 Specific Facility Requirements

The purpose of acoustic testing is to verify that test articles can withstand sound pressure levels up to 149 dB overall, in the frequency range of 25 Hz to 10 kHz. These noise levels are high enough to cause damage to equipment and personnel. Acoustic generators that drive the horns in the reverberation chamber are electro-pneumatically activated. The generators modulate nitrogen gas, which vents through the horns into the chamber. Nitrogen gas depletes oxygen inside the chamber, so special procedures are necessary to protect personnel who enter the chamber.

If necessary, the chamber can be cleaned and maintained as a Class 100 K (M6.5) cleanroom environment. Also, the chamber can be used as a controlled access facility for conducting deployment and shock separation testing. This shock testing requires the handling and firing of electro-explosive ordnance devices.

Special procedures for this facility are as follows:

1. Acoustic control system operators shall be trained by the facility engineer. The facility supervisor shall approve each operator's demonstrated ability to operate the acoustic control system satisfactorily. The facility supervisor shall maintain records showing the completion of the training and the demonstrated ability.
2. A Storm Warning Condition Status 3 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and Project Representative.
3. Authorized personnel shall enter the reverberation chamber either through the personnel door located in the anteroom in the Building 7 truck lock, or through the main doors located in Building 10 (when they are unlocked). Before entering, each person must notify the facility engineer of the intent and purpose of the visit. This ensures that personnel do not walk into hazardous situations.
4. Extra ventilation/air flow may be required to remove contaminants.
5. The facility engineer shall determine the appropriate opened or closed configuration of the chamber's two main access doors, and what other access controls and rope cordons are needed, depending on individual test circumstances.
6. During setup operations, visitors shall not be permitted inside the chamber unless they have been authorized by the facility engineer. Visitors shall observe all posted signs and comply with all access controls, such as roped off areas.
7. No one shall be allowed to enter the chamber while the red flashing warning lights are on. The console operator shall be the last person to check the chamber before he/she locks the chamber personnel door. As a fail-safe measure, the console operator shall keep the key to the chamber door in his/her possession at all times during the acoustic test so that no one else has the means to enter the chamber. This ensures that personnel are not exposed to high noise levels and possible oxygen deficient atmospheres. The payload doors shall be secured with a piece of powered industrial equipment (forklift or aerial lift) parked such the doors cannot be opened when hazards are present.

8. The console operator shall sound the klaxon warning horn three times before starting the test and inform the personnel working in the Building 7 truck lock, truck lock offices, and the Building 10 High Bay that testing is about to begin and to expect high noise. Upon such notification, personnel in the Building 7 truck lock and truck lock offices shall vacate the area for the duration of the acoustic test.
9. After the test is concluded, no one shall be allowed to enter the chamber until its atmosphere has been checked for a safe oxygen level. During testing operations, nitrogen gas enters the chamber through the horns, depleting the oxygen content inside the chamber. Simultaneously, the air circulating system intake fan supplies Building 10 conditioned air to the chamber, while the exhaust fan vents nitrogen-rich chamber air to the outside atmosphere atop the chamber. When the test is completed and the nitrogen flow is shut off, the air circulating system shall run for at least five minutes to purge nitrogen-rich air from the chamber. After five minutes, the red flashing warning lights will shut off. Then the console operator, with a buddy, shall unlock the chamber personnel door and check the oxygen level with a calibrated oxygen monitor. No one shall enter the chamber until its atmosphere contains at least 19.5% oxygen.
10. The buddy system shall be used when performing maintenance on the horn servicing platform or nitrogen supply system.
11. Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms or powered industrial trucks. Others may be given a waiver approved by the Code 549 Branch Head. No one shall be allowed to work beneath a suspended load. If the load is to remain suspended for acoustics or pyro-shock testing, personnel shall not be allowed in the chamber unless a certified LDE operator is manning the crane controls. No one is allowed inside the chamber during acoustic or pyro-shock testing. When a load is suspended on a hook, the chamber shall be locked to prevent access, and the key shall be controlled by the test coordinator. The key shall be accessible in case of emergency.
12. The S&ED conducted a noise survey of the acoustic facility in March of 2006 (Appendix D). When the facility was operating, the ambient noise levels surrounding the outside of the chamber walls and doors measured a maximum of 119 dBA for one minute approximately one foot from the doors. The levels dropped to 110 dBA at a distance of 25 feet from the doors. Per NASA Specifications, personnel must use hearing protection when exposed to environments where noise is at or above 85 dBA. Most GSFC/MSD acoustic tests last no longer than three minutes per run. The MSD provides ear defenders or plugs to personnel and recommends their use by experimenters who must monitor equipment set up in the vicinity of the chamber. Refer to AETD SM Section 2.9.3 Tables 2 and 3 for a listing of NASA permissible noise exposure limits.
13. Special procedures are required for deployment and shock separation testing that requires the handling and firing of electro-explosive ordnance devices. The Project is responsible for providing procedures for lifting/crane operations and firing the electro-explosive devices. The Project's test plan and operating procedures shall be approved by the MSD Project Support Team Lead before setup or testing is permitted. (See Section 2.2 in AETD SM for ordnance handling and operational requirements.)

### 2.1.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manger: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.1.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.179, *Overhead and Gantry Cranes*

OSHA 29 CFR Part 1910.212 and Part 1910.27, *Mechanical Equipment*

OSHA 29 CFR Part 1910.95, *Occupational Noise Exposure*

NPR 1820.1, *Hearing Conservation*

CGA P-14-1983, CGA P-12-1987, CGA P-1, and ASHRAE 15-89, *Gaseous Nitrogen*

## 2.2 Cleanrooms

### 2.2.1 Scope

This section covers safety issues related to all MSD cleanrooms, cleantents, and support areas. The cleanrooms include the SSDIF (Spacecraft Systems Development and Integration Facility), SCA (Spacecraft Checkout Area) and RFI room (Radio Frequency Interference). The Solar Environment Simulator anteroom is considered a clean area.

### 2.2.2 General

All of the cleanrooms and cleantents listed above are typically operated and maintained as Class 10,000 (M5.5) environments. They are used primarily for the integration and testing of space flight hardware. As such, strict rules govern the activities within these facilities. Besides the safety issues addressed in this section, clean facilities may also harbor potentially hazardous systems.

### 2.2.3 Specific Facility Requirements

All personnel who enter a clean facility shall wear cleanroom garments including coverall, hood, boots, gloves, and mask. Due to the nature of these garments, certain inherent risks occur with their use. The primary way to avoid an accident when wearing cleanroom garments is to execute work activities in a slow, deliberate manner.

1. Visibility limitations: The hood and mask may restrict an individual's peripheral vision. The hood shall be secured firmly to the face by using the adjustable snaps to achieve a snug fit. The face mask shall be fastened by placing the elastic band behind the head and adjusting the mask so that it does not ride up into the eyes or protrude away from the face a great distance. The hood and mask should not move or shift when the head is turned.
2. Bulkiness: Cleanroom garments are cut full by the manufacturer to allow space for the user's clothes. This extra bulk means the wearer should exercise caution when working around equipment or passing by obstructions, so as not to snag the garments on these items.
3. Boot hazard: Cleanroom boots are made to envelop the wearer's shoes, so they have a larger footprint than ordinary shoes. The boot straps that surround the instep and Achilles heel area fasten the boot to the foot, but only loosely, and have free-hanging ends several inches long that can dangle freely. Also, the polyurethane soles are somewhat slippery. Personnel who wear these boots are advised to fasten them as tightly as possible, snap down the dangling ends, and check them for a snug fit in the anteroom before entering the clean facility. Exercise extreme caution when climbing ladders or walking on scaffolding. Personnel who walk on the overhead crane bridge in the SSDIF cleanroom are exempt from wearing cleanroom boots.
4. Garment breathability: Garment material used in the cleanroom facilities is tightly woven polyester. The tight weave of the fabric prohibits most particles from passing through, resulting in a high quality barrier of protection to the environment. However, the tight weave characteristics of the garments can be uncomfortable or potentially hazardous to the wearer. Heat and moisture are not dissipated readily, and it is possible for a worker to experience heat exhaustion or fatigue when performing strenuous activities.

5. Garment flammability: The polyester fabric cleanroom garments are not treated with flame retarding agents. If exposed to extreme heat, the fabric will melt and possibly ignite. Molten or burning polyester emits toxic vapors and will cause severe burns upon contact with the skin. Personnel shall keep sources of heat a safe distance away from their cleanroom garments.
6. Work area congestion: The level of work activity in a clean facility can be extremely high, with many people moving about, working on separate projects simultaneously. Personnel could potentially stray into the path of moving hardware, or trip over cables, tubing, and other hardware lying on the floor, and possibly interfere with another worker's activities. Cleanroom workers shall be aware of their own and other worker's activities. Working and moving cautiously and deliberately are key to avoiding accidents.
7. Emergency evacuation: In the event of a fire drill or emergency requiring immediate evacuation, cleanroom workers shall leave the clean facility immediately through the nearest exit, then leave the building quickly. Workers shall not remove their cleanroom garments until they are out of the building, nor shall they sign out on the entry Log if applicable. Individuals who were working in a facility in which they signed in shall report immediately to the nearest fire warden to make their presence known. The first person leaving the cleanroom shall take the Log with him/her and present it to the fire warden. The fire warden in charge of an area having a cleanroom sign-in Log shall account for all personnel not signed out of the cleanroom.
8. Training: Personnel who need to work in the SCA or SSDIF must first undergo cleanroom training that familiarizes them with entry and clean operating procedures as well as safety procedures required for work in the area. This course is: GSFC Code 540 Cleanroom Certification Training and is located on SATERN.
9. Cranes, MAP, and PIT: Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms or powered industrial trucks. Others may be given a waiver approved by the Code 549 Branch Head.
10. Mechanical and electrical rooms: These rooms contain systems that service the cleanroom facilities. They may contain electrical service panels, mechanical air handling equipment (fans, blowers, filters, and ducts), hot water pumps, steam pressure regulating stations, chilled water circulating systems, and central vacuum cleaning machinery. General requirements are applicable in these rooms, as well as the following:

    All personnel working in these rooms shall use the buddy system. Individual personnel may enter to perform visual checks only.

    Use portable light sources to illuminate the work area. Check the area for wasps, birds, or other animals that might startle an employee.

    Systems may have high voltage/current, high temperature steam and hot water, chilled water and refrigeration systems, high air velocities and air pressure differentials, hydraulic systems, house-supplied air and gaseous nitrogen supplies, and vacuum equipment. Fans, blowers, pumps, and other machinery may be driven by large electrical motors with direct-drive gearing, belt drives, and other coupling mechanisms that present potential hazards. Plumbing systems may have non-insulated pipes that condense water

and drip to form puddles. Floors may be slippery from condensates, oils, and other machine fluids. Clean up or rope off any hazardous areas immediately.

Always exercise caution when entering or exiting doors in these rooms because of potential air differentials caused by blowers and high velocity air currents. Some doors must be opened forcibly and held tightly to prevent them from slamming shut on parts of the body. This same precaution holds for panel coverings, machine doors/openings, baffles, etc., that may slam shut.

Before working on pipe insulation or other insulating materials, verify that no asbestos is present. If asbestos is present, or if you are not sure of the contents, contact the S&ED.

### 2.2.4 GSFC Contacts

Support Contractor Cleanroom Operations Office: (301) 286-6547

S&ED: (310) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.2.5 Reference Documents Unique to this Section

OSHA 3067, *Concepts and Techniques of Machine Safeguarding*

OSHA 29 CFR Part 1910.242, *Hand and Portable Powered Tools and Equipment*

OSHA 29 CFR Part 1910.243, *Guarding of Portable Powered Tools*

## 2.3 Composite Materials Shop

### 2.3.1 Scope

This section covers the composite materials shop and its subsystems, located in Building 5A.

### 2.3.2 General

The composite materials shop is designed for process development, prototyping, and spacecraft hardware production in composite materials, primarily fiber-reinforced plastics. Graphite, glass, and Kevlar fibers are the most commonly used reinforcement, with epoxies and cynate-esters as matrices. The raw materials are laid up on a mold and cured with heat and pressure to near-net shape. Then the molded item is machine-finished and the surface is prepared for bonding, usually adhesive bonding with supplementary mechanical fasteners. The shop contains special purpose facilities, which are described under specific facility requirements below.

### 2.3.3 Specific Facility Requirements

Special procedures for this shop are as follows:

1. Shop personnel shall be trained in composite materials handling and fabrication techniques by senior technicians. The shop supervisor shall approve each fabricator's demonstrated ability to perform satisfactorily.
2. Personnel who operate special purpose facilities, such as the Autoclave pressure chamber and General Signal Blue M electric oven, shall have been trained by the equipment manufacturer or a senior technician. The shop supervisor shall approve each operator's demonstrated ability to operate the particular facility satisfactorily.
3. All shop equipment guards shall be installed before operating any equipment. (See AETD SM Section 3.3.4 Item 8 for guard information.)
4. When operating machinery, personnel shall wear approved eye protection, such as safety glasses, goggles, or full face shield with glasses/goggles, as well as ear defenders or plugs as necessary, and safety shoes. If necessary, respirators fitted with the appropriate filter cartridges shall be worn when working with vapor emitting materials. (See AETD SM Section 3.6 for PPE requirements.)
5. Cranes, MAP, and PIT: Only certified operators shall operate cranes, mobile aerial platforms or powered industrial trucks.
6. When handling Passa Gel 105 acid, clear the area of nonessential personnel, and wear a respirator with an acid filter cartridge, as well as rubber gloves, long sleeves, protective apron, and goggles or face shield.

7. Personnel handling pre-preg materials shall wear disposable, powder-free latex gloves for protection. The gloves minimize the possibility of allergic skin reactions and keep body oils from contaminating the materials being handled.
8. Avoid having liquid epoxies and adhesives contact the skin or eyes. In the event of skin or eye contact, rinse the affected areas with water for 15 minutes. The shop contains a permanent eyewash station at the wall near the exit door, by the fume hood.
9. When first opening or handling vapor-emitting materials, work directly in front of the fume hood and allow vapors to exhaust outside. (Section 2.5.4 in AETD SM for fume hood information.)
10. Use caution, and gloves as appropriate, when handling or surface-finishing shaped items to avoid being injured by rough and jagged edges of fibers and cured cements and epoxies.
11. Non-hazardous waste materials, except for metal waste, can be discarded in the standard GSFC dumpsters. All metal wastes are recycled. Usually, byproducts from the fabrication process that have been fully cured are non-hazardous.
12. Hazardous wastes, such as uncured materials, epoxies, solvents, etc., shall be disposed of by placing in the Satellite Accumulation Area and calling the Hazardous Waste Environmental Specialist (x6-9233) for removal service.
13. Shop personnel using the appropriate PPE shall clean debris and waste materials from surfaces on and around machinery. The senior technician shall direct custodial personnel to clean floor and office areas, but as a safety precaution, shall not allow them to clean near machines or facilities which present a potential hazard.
14. Autoclave pressure chamber operation:

    The pressure chamber is used to cure fiber-reinforced epoxy composites. It is capable of controlled heating of a mold and laminate in a pressurized atmosphere.

    Heat is generated at temperatures up to 350 °F (177 °C) during the epoxy curing process. Upon opening the chamber, the operator shall allow sufficient time for the item to cool before handling it.

    The chamber uses $GN_2$ at 210 psi (1.45 Mpa) which is supplied from pressurized bottles. (See Section 2.3 in Volume 1 for $GN_2$ handling information.)

    The chamber fumes are vented to the outside roof.
15. General Signal Blue M electric oven operation:

    The oven is used to dry fiber-reinforced epoxy composites that are curing, and to warm pre-preg materials to ambient temperature.

    The oven can operate at temperatures up to 800 °F (427 °C) but is nominally operated up to 400 °F (204 °C). Upon opening the oven, the operator shall allow sufficient time for the item to cool before handling it.

    Oven fumes are vented to the outside roof.
16. Fume hood operation (see Section 2.5.4 in AETD SM):

    Fumes are exhausted to the roof.

Small quantities of acetone, alcohol, and compatible vapor-emitting materials for immediate use are stored on the shelf inside the fume hood. Store larger quantities or not-for-immediate-use vapor-emitting materials in the flammable storage cabinet.

Use the fume hood for etching operations, and when applying methyl-ethyl-ketone (MEK) for epoxy priming or mold release.

The permanent eyewash station is located by the exit door, next to the fume hood.

17. Harford freezer:

This walk-in freezer is used to store and cool b-staged pre-preg materials, epoxies, and film adhesives at temperatures as low as -10°F (-23°C).

Press the manual push button on the inside of the exit door to exit the freezer.

18. Layout room:

Rolls of sheet materials such as Teflon, nylon, and polyester, which are stored in this room do not present a hazard. Exercise normal care when unrolling and handling them.

Cutting and layout operations require sharp tools, razor knives, scissors, etc. When performing these operations, exercise caution, wear protective gloves, and always cut in a direction away from the body.

### 2.3.4 GSFC Contacts

Composites and Rapid Prototyping Group Leader: (301) 286-5217

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (301) 286-9660

Support Contract Safety: (301) 286-2601

### 2.3.5 Reference Documents Unique to this Section

N/A

## 2.4 Electromagnetic Compatibility

### 2.4.1 Scope

This section covers the EMC facilities and their subsystems. The Small EMC Test Facility is located in Building 7, Room 8—shielded enclosures 8A, 8B, and 8C. The Large EMC Test Facility is located in Building 7, Rooms N113, N115, N117, and 108A.

### 2.4.2 General

The shielded enclosures are designed to provide isolated environments for performing radiated and conducted emissions and susceptibility testing. Isolation methods provide quiet electromagnetic environments for the test article, and protect personnel from potentially harmful radiation. The isolation methods include using sandwiched steel walls, with the inner wall covered with special ferrite tiles. Eccosorb impregnated urethane foam is used as an anechoic material on the walls of the Small Facility and at selected critical locations on large, moveable panels in the Large Facility. Section 2.4.4, Item 5.a. below contains specifications regarding the shielding effectiveness of the enclosures.

### 2.4.3 Specific Facility Requirements

Summary of Potential EMC Testing Hazards—Radiated susceptibility test signals can result in exposure to fields marginally equivalent to the maximum safe levels prescribed by ANSI C95.1-1999 IEEE Standard for *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.* Also, field levels during operation of test item transmitters vary widely, and could conceivably exceed safe exposure levels by a substantial margin.

Special procedures for this facility are as follows:

1. The facility engineer shall train EMC control system operators. The facility supervisor shall approve each operator's demonstrated ability to operate the control system satisfactorily.
2. Personnel involved in performing EMC tests shall comply with the requirements specified in IEEE C95.1-1999.
3. A Storm Warning Code Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee—this may be the lead Project Test Engineer) and the Project Representative.
4. Personnel shall use caution when working inside the Small EMC enclosure to avoid damaging the urethane foam that protrudes from the inner walls. A moderate bump against it can dislodge pieces of foam, especially the protruding tips of the foam. Also use caution to avoid damaging the foam when sliding the inner wall payload entry doors open or closed.

5. The facility engineer is responsible for ensuring that all EMC testing be conducted according to the *Code 549.3 revised safety requirements for testing in the EMI shielded enclosures*, effective date April 22, 1998 (or a more recent update, as applicable.) A summary of these requirements follows:
   a. Completely Shielded RF Enclosure: All tests involving electromagnetic radiation shall be performed inside a shielded enclosure. The shielded enclosures provide typically 80–100 dB shielding effectiveness at frequencies from 100 kHz to 10 GHz, and reduced effectiveness from 10–100 kHz and 10–18 GHz. All access doors to the test enclosure shall be closed before radiated tests are performed. The sliding anechoic panels in the Small EMC room and the large swinging panels in the Large EMC room shall be closed during all radiated tests.

      It is possible for low frequency magnetic fields (below 10 kHz) radiated in the enclosure to result in a hazardous environment for personnel with specific medical conditions even when the enclosure doors are closed. The responsible EMC test engineer shall notify the Project test personnel of this potential hazard to implanted medical devices whenever low frequency magnetic fields are radiated within the enclosure.
   b. Fire/Smoke Safety Systems: The retractable sprinklers, smoke detectors, and fire alarm in the Small EMC enclosure shall be operational during all tests. In the event of fire, personnel shall evacuate immediately. The ventilation system will automatically convert to a closed loop system with potentially noxious fumes exhausting directly outside.

      The Large EMC enclosure fire alarm shall be activated and the sprinkler system operational during all tests. The EMC test engineer shall be cognizant of the fact that high power RF transmissions can falsely trigger the fire alarm. The engineer shall notify the emergency console operator of this possibility whenever such transmissions may occur.

      When personnel are present in the Large EMC, the portable emergency light shall be placed such that adequate lighting is provided for all personnel to locate the exits. The emergency light shall be checked weekly when personnel are working in the room to verify it is functioning properly.
   c. Test Area Ban and Hazardous Warning Posting: The EMC test engineer shall ensure that no personnel are inside the test area during radiated susceptibility testing without specific approval from Code 549.3. Radiation Hazard signs and/or warning lights shall be posted or illuminated, designating the proper safe or hazard situation.
   d. Closed Circuit Television (CCTV) Monitoring System: During potentially hazardous EMC testing, CCTV systems shall be monitored (for facilities so equipped) to ensure that no personnel are in the test area.
   e. Unauthorized Operation of Test Item Transmitters: No radiated operation of any test item transmitters is allowed in the test area without the written approval of Code 549.3 and S&ED. If permission is granted to operate transmitters into dummy loads or other devices, the EMC test engineer shall ensure safe termination of the transmitter signals. The RF level shall be monitored to verify that testing is conducted safely within specified limits.
   f. Monitoring of Enclosure Ambient RF Levels: For all EMC operations where it is possible to transmit RF signals at power levels exceeding 0.5 watt, the ambient level in the enclosure shall be monitored using a broad-band triaxial probe. The monitoring circuit shall be alarmed for 10

volt/meter. Code 549.3 shall be notified in the event the alarm is triggered by unintentional radiation.

The EMC test engineer shall notify Project personnel that a General Microwave Model 484 Radiation Hazard Meter is available for their use in the event of any concern regarding radiation levels.

### 2.4.4 GSFC Contacts

Electromagnetic Test Engineering Group, Lead: (301) 286-9948

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-2601

### 2.4.5 Reference Documents Unique to this Section

IEEE Standard C95.1-1999, IEEE Standard for *Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*

GPR 1860.2, *Radiation Safety Radio-Frequency*

## 2.5 High Capacity Centrifuge

### 2.5.1 Scope

This section covers the High Capacity Centrifuge and its subsystems, located in Building 15.

### 2.5.2 General

Facilities and subsystems covered in this section are:

1. High Capacity Centrifuge (HCC): The 120 ft (36.6 m) diameter centrifuge, located in the Building 15 Rotunda, with test chamber at one end and test platform on the opposite end. The test platform contains a motorized, adjustable tilt fixture for mounting test articles.
2. Centrifuge DC Drive Motors and Motor Generator Set: Two 1250 horsepower (0.93 Mw) DC motors located in the pit area beneath the centrifuge pedestal drive arm. The motor generator set, located in the Building 15 Mechanical Equipment Room, provides the DC power to the drive motors.
3. $GN_2$ Supply for the Load Balance Water Transfer System and Instrumentation Racks: The $GN_2$ storage system, located on the Building 15 parking lot, supplies the $GN_2$ needed to fill the centrifuge's on-board storage bottles.
4. HCC Pit and Drive Motor Air Handling System: The air handling fans circulate ambient air through either the centrifuge's drive motors or throughout the HCC pit area.
5. HCC End Cap Loading Vehicle: This vehicle is specially designed for handling, replacing, and removing the HCC chamber end cap. It has systems capable of precisely positioning and aligning the 18,000-lb (8,165 kg) end cap so that it can be bolted and unbolted from the chamber.

### 2.5.3 Specific Facility Requirements

The HCC simulates launch and landing loads up to 30 g steady state acceleration, depending on payload weight, center of gravity, and test configuration. Test articles are usually mounted on the platform end of the arm using the overhead crane or forklift. On a very infrequent basis, it may be necessary to mount a payload inside the chamber at the other end. The end cap loading vehicle is used to handle and mount the payload inside the chamber.
Special procedures for this facility are as follows:

1. HCC control system operators and end cap loading vehicle operators shall be trained by the facility engineer. The facility supervisor shall approve each operator's demonstrated ability to operate the centrifuge control system and/or end cap loading vehicle satisfactorily. Training shall be updated at least every 4 years.
2. A Storm Warning Code Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and Project Representative.

3. The GSFC power plant shall be notified prior to running the centrifuge arm because of the HCC's high consumption of electrical power and the plant's concerns about peak energy usage on the center.
4. During pre-test preparations, visitors shall obtain approval from the facility engineer before walking on the centrifuge arm.
5. Maximum centrifuge arm speed: The HCC has been stress analyzed and proof tested to the maximum arm speed of 38.3 RPM (March 1997). All permanent fixtures on the arm have been qualified to this speed. In the event that future testing requires a higher arm speed, the facility engineer shall verify that all on-board systems have been stress analyzed and approved for the higher speed. This holds true for the low riding platform, adjustable tilt fixture, and counterbalance structure particularly, because these items have never been qualified at speeds greater than 38.3 RPM.
6. End cap loading vehicle operations: The buddy system shall be used to assist the operator in driving and operating the loading vehicle. The operator's line of sight is somewhat limited by the bulk of the vehicle itself. Use caution when driving through the rotunda doorway, as it is a close clearance. Be aware that the Building 15 High Bay area often has extraneous materials and equipment, which could be stored in the vehicle's pathway. The hydraulic systems on the vehicle are prone to minor leaking. Wipe up oil spills immediately to minimize slipping hazards on the smooth floors in the handling areas. Verify the pressure systems are currently certified prior to using the vehicle.
7. Test platform preparations: The platform's removable personnel guard railings shall be installed during platform preparations. If the railings are removed, or personnel are working at unprotected heights, fall protection equipment shall be worn. If the handrails are not in place and personnel are not wearing fall protection, a spotter shall be provided to warn personnel when approaching the platform edge. Permanent structures and the adjustable tilt fixture on board the test platform present tripping and bumping hazards. Personnel shall exercise caution when working near the test article and be aware that instrumentation cabling, routed from the payload to junction terminals, may be underfoot or overhead. Often, string potentiometer displacement transducers have fine wires strung at various levels on the platform. Ribbon tapes shall be attached to these wires to alert personnel of their presence.
8. Weight bucket and weight pit: Personnel working in or around the weight bucket and weight pit shall use the buddy system, wear the appropriate PPE (see Section 3.6 in AETD SM), and comply with the mechanical handling requirements of Section 2.1 in AETD SM. Removable portable ladders should be used to climb into the weight bucket and weight pit. It is helpful to use the motorized personnel lifts to access the weight bucket from the exterior of the arm instead of from the arm's topside walkway. If personnel must work at unprotected heights, fall protection equipment shall be worn.
9. Operations prior to centrifuge arm running: The facility engineer and control operator shall conduct a rotunda and centrifuge arm walkdown prior to running the HCC. Items to be verified include: all payload-specific hardware and instrumentation are secured, crane is stowed with its hook at the highest elevation and crane runway cover plates are secured, platform personnel guard railings are removed, tilt table motor is removed, no extraneous items remain on-board, instrumentation racks are floating, arm access ladder is stowed in the up position, chamber hatch bolted is securely in

place, and the rotunda monitor is on station to prevent personnel from entering the rotunda and restricted high bay areas.

10. Operations while the centrifuge arm is running: Closed circuit television cameras and VCRs shall be used to monitor the payload and rotunda area when the arm is running. The control operator shall be trained in the alternate methods of "fast" and "emergency" stopping of the centrifuge arm. Static load balance shall be verified at 3 RPM. Testing shall be accomplished in increments up to the 100% level. As a safeguard to prevent arm speed runaway, no individual increment shall exceed 6 RPM.
11. During operations, a test team monitor shall be stationed at the rotunda entrance doors to keep all personnel out of the rotunda and away from restricted areas in the Building 15 High Bay and adjacent rooms. While the centrifuge is running, visitors and experimenters shall remain in the Building 15 hallway and view operations on the video monitors or through the control room observation window. Test team personnel that need to be inside the control room shall obtain the facility engineer's approval.
12. The pit area is a controlled area. Prior to entry call the number listed on the sign posted at the entrance for access. The drive motor blowers shall be turned on. During operations when no rotunda floor deck plates have been removed for increased air circulation, an approved confined space entry permit and use of the buddy system are required to enter the pit. The pit atmosphere shall be tested with a calibrated oxygen monitor upon entering, and one person shall keep the instrument at the work site to continually monitor the atmosphere while the work is in progress.
13. During times when a rotunda floor deck plate has been removed for increased air circulation, the drive motor blowers may be switched to circulate air throughout the pit instead of through the drive motors. In this case, personnel do not need a confined space entry permit to work in the pit, but they shall use the buddy system.
14. The buddy system is mandatory in certain areas and while performing certain activities in the facility, including the following:

    Operations involving moving or operating the loading vehicle.

    Working in the pit, rotunda attic, or inside the centrifuge chamber.

    Operations involving handling counterbalance weights.

    Working at heights above 4 ft (1.2 m).

    Servicing or repairing electrical equipment or electronic systems with energized circuits.

    Any non-recurring activity deemed hazardous by the facility supervisor.
15. Personnel should use ear defenders or plugs, at their option, when turning on the lubrication system pumps in the pit or the motor generator set in the Mechanical Equipment Room. There is no need for personnel to remain in these areas for longer than the one to two minutes necessary to verify that the systems are operating properly upon startup. The noise levels at these sites are less than 110 dBA (see Section 2.9.3 Tables 2 and 3 in AETD SM for NASA permissible noise exposure limits).
16. Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms or powered industrial trucks. Other may be given a waiver approved by the Code 549 Branch Head.

17. $GN_2$ is drawn from the Building 15 storage supply to fill the centrifuge's on-board storage bottles. The $GN_2$ provides the pressurized medium for transferring water on the centrifuge load balance system, and for floating the on-board instrumentation racks. The volume of $GN_2$ handled and stored within the facility is insufficient to present an oxygen depletion hazard. In the past, $GN_2$ flowed inside the chamber, but those systems were removed, so there is no longer a danger of depleting the oxygen inside the chamber.
18. Structural attachments and test fixturing for the HCC shall be stress analyzed before installation and proof tested as required. All hardware shall meet the safety factor or waiver requirements of the ISO document, *09-PC-PP01, Steady State Acceleration Testing*. All hardware not meeting a minimum safety factor of 3.0 on yield, and 5.0 on ultimate strength, shall require a waiver according to ISO Document No.09-PC-PP01.

### 2.5.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.5.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212, *General Requirements for all machines*
OSHA 29 CFR Part 1910.27, *Fixed Ladders*
09-PC-PP01, *Steady State Acceleration Testing*
CGA P-14-2000, CGA P-12-1993, CGA P-1, and ASHRAE 15-89, *Gaseous Nitrogen*

## 2.6 Mechanical Integration

### 2.6.1 Scope

This section covers the unique safety considerations associated with the mechanical integration disciplines.

### 2.6.2 General

Mechanical integration disciplines within the integration and test complex include flight hardware fabrication, assembly, and handling tasks associated with a particular payload. Unsafe actions must be avoided, and personnel safety shall never be jeopardized in order to meet or accelerate schedules or to minimize work requirements. Personnel and payload safety needs can be met by carefully planned and properly scheduled tasks.

### 2.6.3 Design/Operational Requirements

1. Always wear PPE appropriate for the task at hand and wear it correctly. When handling or working around critical flight hardware, personnel should not wear hardhats unless there is a possibility of head injury. (See AETD SM, section 3.6.4 for more information.) Care must be taken to wear PPE in a manner appropriate for the conditions. PPE must be kept in good condition. A hardhat with a broken liner, or safety shoes with protruding steel inserts, can result in damage to flight hardware.
2. Do not use an overhead crane to handle flight hardware during Code 3 or 5 Storm Warning conditions. The risk of power failure is higher than normal, and the resultant loss of crane response could leave the payload in an unacceptable position. Upon request of Project personnel, this restriction may be waived (see Section 3.3 in AETD SM).
3. Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms of powered industrial trucks. Other may be given a waiver approved by the Code 549 Branch Head.
4. Payload security at a minimum requires the area around flight hardware to be barricaded to prevent unauthorized access. If the payload is powered up in a potentially hazardous state or requires a security clearance, there may be a requirement for more positive barriers or for monitors to guard the area. Proper security will minimize the chance of personnel injury and payload damage; restricted areas must be honored.
5. Falling tools and other objects present a hazard to flight hardware and personnel positioned below. When working over payloads, all tools, radios, cameras, personal items, and other objects must be tethered or constrained in a positive manner. Of special concern is the widespread use of honeycomb panels on flight structures and their susceptibility to damage from dropped tools or a misplaced elbow or foot. Their location should be noted and, whenever possible, they should be protected with a piece of foam rubber or similar material.
6. Electrostatic discharge may result in damage to flight hardware instruments during movement through the test and integration facilities or during handling. Instrument, lifting device hook, and personnel grounding methods may be established. Abide by established requirements.
7. When working on or handling flight hardware, make sure the steps necessary to secure the payload under building evacuation conditions are completely understood. Leaving the flight hardware in a secure mode is critical, but at no time supersedes the priority of personnel safety.

### 2.6.4 GSFC Contacts

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.6.5 Reference Documents Unique to this Section

NASA-STD-8719.9, *NASA Standard for Lifting Devices and Equipment*

OSHA 29 CFR Part 1910.212, *General Requirements for all machines*

## 2.7 Advanced Manufacturing

### 2.7.1 Scope

This section covers the specialized equipment in the Advanced Manufacturing Branch machine shops located in and around the Building 5 High Bay and Mezzanine areas. (See Section 3.3 in the AETD SM for information on general machine shop safety.)

### 2.7.2 General

The specialized equipment include: NC machining centers, electrical discharge machines, and coordinate measuring machines.

Goddard has unique capabilities in the computer-aided manufacturing area. Very large parts can be machined automatically on the extremely precise NC machining centers. Machine operators use the ESDAPT interactive program to set up the tool path parameters for the NC machines.

### 2.7.3 Specific Facility Requirements

1. Personnel training: Building 5 Machine Shop technicians shall have been previously trained under an apprenticeship program and/or received on the job training. Shop technicians shall demonstrate their ability on each piece of equipment they run. Their supervisor shall approve their demonstrated performance.
2. NC machining centers: The following particular safety rules apply to NC machining centers:

   Only authorized, trained, and experienced personnel shall be permitted to maintain or operate the NC machining centers and related computer workstations.

   NC machines require skill and art in preparing a work piece for machining. Besides holding the work piece down and not letting the tools hit the clamps, the object is to minimize the operator's involvement once the machine is started. Double-check all settings, clamps, machining heads, etc. before starting.

   Each NC machine must have adequate clearance.
3. Electrical discharge machining: The following particular safety rules apply to the EDM machines:

   Only authorized and qualified electricians shall be allowed to hook up the electrical systems of EDM machines. The system electrical circuits, switches, and grounding shall comply with the NFPA 70, *National Electrical Code*.

   The operator shall be protected by a clear plastic safety shield on the work tank from accidentally brushing against the live electrode or platen when the machine is operating.

   The work piece in a Sinker type EDM machine is submerged in a synthetic hydrocarbon dielectric fluid. Avoid prolonged skin contact and wash hands with soap and water after contact.

   Maintain the dielectric fluid level above the highest portion of the electrode work piece's working gap. Adjust the safety float's switch to ensure that the fluid level is maintained.

   Dielectric fluids shall be handled and disposed of as hazardous waste. The fluids shall be collected in containers marked to identify their contents and set aside for pickup. Call the

Hazardous Waste Environmental Specialist (x6-9233) for pickup and disposal and for recommendations on how to handle and store the materials prior to pickup.

Since EDM is a heat-producing process, there must be adequate ventilation around an EDM machine. Often, building air conditioning systems must be augmented with local ventilation systems to ensure adequate capacity.

The operator must be aware of the possibility of machining discharge gases igniting. Operators should know how to smother an oil fire with a carbon dioxide foam fire extinguisher. All discharge gases are flammable: keep them away from sparks or flame. Be sure that ventilating systems in the area are operating properly before running EDM machines.

### 2.7.4 GSFC Contacts

Advanced Manufacturing Branch, Head: (301) 286-4336

Manufacturing Technology Group Leader: (301) 286-3956

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (301) 286-9660

Support Contractor Safety: (301) 286-2601

### 2.7.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910 Subpart O, *Machinery and Machinery Guarding*

OSHA 29 CFR Part 1910.242, *Hand and Portable Powered Tools and Equipment, General*

OSHA 3067, *Concepts and Techniques of Machine Safeguarding*

NFPA 70, *National Electrical Code*

NFPA 79, *Electrical Standard for Industrial Machinery*

## 2.8 Magnetics

### 2.8.1 Scope

This section covers the Magnetics Test Facilities and their subsystems, located at the Magnetics Test Site, Buildings 303, 304, and 305.

### 2.8.2 General

The remotely located Magnetics Test Site contains two major coil systems used for magnetic testing of payloads and for calibrating torque coils and magnetometers in attitude control systems. The coils and their control consoles are isolated and are designed to provide a quiet electromagnetic environment for the coils. Special construction techniques substitute wood and other nonmagnetic materials for magnetic-field-producing metals as a means of reduceing the background magnetic environment in the facilities.

Facilities and subsystems covered in this section are:

1. Magnetic Field Component Test Facility (MFCTF): This facility in Building 303 contains a 22-ft (6.7 m) diameter, 3-axis Braunbek coil system. This coil is primarily for testing smaller satellites, performing dipole moment measurements, and for calibrating magnetometers.
2. Spacecraft Magnetic Test Facility (SMTF): This facility in Building 305 contains a 42-ft (12.8 m), 3-axis Braunbek coil system. It is used for magnetic testing of test articles ranging up to fully configured spacecraft. Smaller Hemholtz coils are available for perming and de-perming spacecraft, and for magnetically cleaning smaller test items.
3. Magnetic Facility Control Rooms: These separate rooms in Building 304 contain the necessary equipment to control the two coils. Their isolation from the coil buildings prevents the control systems from degrading the quiet magnetic environment of the coils.

### 2.8.3 Specific Facility Requirements

Special procedures for this facility are as follows:

1. The facility engineer or supervisor shall train and document magnetic control system operators. The facility supervisor shall approve each operator's demonstrated ability to operate the control system satisfactorily.
2. A Storm Warning Condition Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and the Project Representative.
3. Personnel shall notify the facility engineer of the intent and purpose of the visit before entering the coil buildings. A locked gate at the entrance to the Magnetics Test Site prevents unauthorized entry into the compound. Visitors can use the phone at the gate to call the Security Guard for access. The Security Guard can remotely open the motorized gate to allow authorized visitors to enter. Upon access to the compound, visitors shall sign in the Visitor's Logbook in Building 304 and notify the facility engineer of their presence.
4. For magnetic testing, the control operator may erect vehicle control barriers on the compound. Vehicles shall not be driven in the restricted areas because they could affect the magnetic background. Personnel shall obtain approval from the facility engineer before driving vehicles on the compound once testing has started.

5. No personnel shall be allowed inside the coil area during testing. This measure ensures that the quiet magnetic background being maintained within the coil is not degraded by movement, electronic equipment, or other means.
6. Sections surrounding the coil areas are constructed of slatted wooden flooring to reduce the amount of metal near the coils. Check with the facility engineer before moving items weighing more than 200 lb (91 kg) onto the wooden flooring so as not to exceed floor loading limits. Personnel shall be careful not to drop articles in the spaces between the wooden floorboards. Wear shoes with low, broad heels, and exercise caution when walking to keep from tripping on the wooden flooring.
7. Experimenters shall check with the facility engineer and set up their ground equipment in specially designated areas adjoining the coils. Sections of the floors surrounding the coils have been reinforced to support heavy ground equipment.
8. No personnel shall be allowed in close proximity to the small Hemholtz coils during perming and deperming operations. Check with the facility engineer for an approved area to set up and work.
9. The unique cranes and hoists in the coil buildings are specially designed to minimize unwanted magnetic fields, substituting wood and other nonmagnetic materials in the place of metals. Certified personnel, knowledgeable in the uniqueness of the cranes and hoists, shall be the only ones allowed to perform handling operations in the facilities.
10. Personnel calibrating or servicing the Building 305 spacecraft turntable shall be aware of the potential hazards of the rotating mechanisms, gears, and belt drive. Improper actions can lead to personnel being caught and injured in the moving mechanisms. Only authorized personnel shall be allowed to operate the turntable. Erect personnel control barriers and post signs to keep unauthorized personnel out of the area. Exercise caution so as not to have clothing, accessories, or parts of the body entrapped in any of the turntable moving parts. Follow the instructions in the current version of the Lockout/Tagout procedures to avoid personal injury.
11. Exercise caution and use the buddy system when working in or around cable trays, manholes, or basement areas beneath the coils. Facility personnel and visitors must be aware of the fact that snakes and other animals have been observed in some of the dark, warm, and protected recesses in these areas. Verify that out-of-the-way or dimly lit locations are clear of animals before stepping or reaching in with parts of the body.

### 2.8.4 GSFC Contacts

Electromagnetic Test Engineering Group, Lead: (301) 286-9948

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.8.5 Reference Documents Unique to this Section

GHB 1860.2, *Radiation Safety Radio Frequency*

## 2.9 Mass Properties

### 2.9.1 Scope

This section covers the Mass Properties Measurement Facility and its subsystems, located in Building 15.

### 2.9.2 General

Facilities and subsystems covered in this section are:

1. Mass Properties Measurement Facility: This facility is a portable Miller Table designed to measure the weight, CG, and MOI of test articles, and to balance payloads statically and dynamically. The table accepts payloads weighing up to 10,000 lb (4,536 kg) and has a moment measurement capability up to 30,000 in-lb (3,390 Newton-meter). The table can rotate at speeds up to 60 RPM, limited by payload physical characteristics and Project requirements.

### 2.9.3 Specific Facility Requirements

The Miller Table must be connected to a $GN_2$ supply to float the table freely during operation. During spinning operations, personnel shall be protected from the potential hazard of objects being ejected from the table.
Special procedures for this facility that shall be followed are:

1. Miller Table control system operators shall be trained by the facility engineer. The facility supervisor shall approve and document each operator's demonstrated ability to operate the control system satisfactorily.
2. A Storm Warning Code Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and the Project Representative.
3. Personnel shall notify the facility engineer of the intent and purpose of the visit before working on or around the Miller Table.
4. All unauthorized personnel shall be restricted from the area during mass properties testing. During table spinning operations, the facility engineer shall verify that the operator and experimenters are situated in safe zones (at least 7 feet from any rotating part) and protected from the potential danger of items being ejected from the table. The test item shall be inspected prior to the start of rotation to ensure there are no loose parts.
5. The facility engineer shall check with other personnel to ensure that other work in progress does not interfere with mass properties measurement testing, and vice versa.
6. When special tests require setting up and operating the Miller Table in cleanrooms or cleantents, personnel shall check with the facility engineer before entering the payload area, and observe the appropriate cleanroom working procedures.
7. An MSD-approved stress analysis is required for all fixturing needed to adapt a payload to the Miller Table. All of the facility's structural hardware shall have a minimum safety factor of 3.0 on yield and 5.0 on ultimate strength.
8. The pressure system shall meet the requirements stated in the AETD SM, Section 2.3. All pressure hoses and relief valves shall have current certifications.
9. Attach points on the top of the table may be used to lift the assembly when certified hoist rings are attached.

10. All covers shall be on the sides of the table when it is powered up.

### 2.9.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.9.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212, *General Requirements for All Machines*

## 2.10 Modal Survey

### 2.10.1 Scope

This section covers the Modal Survey Facility and its subsystems, located in Building 15.

### 2.10.2 General

Facilities and subsystems covered in this section are:

1. Modal Survey Facility: This facility is a structural steel framework designed for measuring dynamic response characteristics of structures up to shuttle-sized payloads. Electrodynamic vibration exciters apply dynamic forces to the test article. Multi-directional applied forces can be applied up to 220 lb (100 kg) in the frequency range of 2 Hz to 25 kHz, limited by individual exciter specifications.
2. Electrodynamic Vibration Exciters: Four exciters and their associated power amplifiers are available, ranging from 50 lb (23 kg) to 220 lb (100 kg) force.
3. Overhead Bridge Cranes: Three overhead bridge cranes, with capacities up to 1.0 ton (907 kg), provide a convenient means of supporting the vibration exciters in a variety of driving point configurations.

### 2.10.3 Specific Facility Requirements

The Modal Survey Facility contains large steel beams in its framework and trunnions mounted on a seismic block. These beams and trunnions can be moved so that test items can be mounted in the facility to simulate the desired constraint conditions. Exciters can either be suspended from cranes or hard mounted, to apply excitation forces at one or more points. Digital data acquisition systems monitor and record signals from force gages and response accelerometers.
Special procedures for this facility that shall be followed are:

1. Modal survey operators shall be trained by the facility engineer. The facility supervisor shall approve and document each operator's demonstrated ability to operate the exciter control systems satisfactorily. Certified crane operators are required to operate the cranes.
2. A Storm Warning Code Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and Project Representative.
3. Personnel shall notify the facility engineer of the intent and purpose of the visit before working on or around the Modal Survey Facility.
4. The immediate test area is fenced to keep personnel out when the exciters are running or items are hanging on the crane hooks. The fence shall be closed and locked when there are items on the hooks and the crane controls are not manned. The facility engineer shall check with personnel in the Building 15 High Bay area and High Capacity Centrifuge control room to ensure that other work in progress does not interfere with modal testing, and vice versa.
5. No one shall be allowed to work beneath a suspended load such as a suspended exciter. Personnel shall not be allowed near the load unless a certified LDE operator is manning the crane controls. Modal testing often necessitates having the exciters suspended from the overhead cranes and remaining in position overnight. The facility fence shall be closed and locked to prevent unauthorized access. The key shall be accessible in case of an emergency.

6. The Level-Tite baseplate in the modal facility contains slots that allow for a variety of fixturing and payload mounting configurations. Facility personnel shall be instructed as to the potential tripping hazard of these slots. Removable slot covers are available and can be installed as needed to minimize the tripping hazards.
7. An MSD-approved stress analysis is required for modal survey test fixturing. All structural hardware shall have a minimum safety factor of 3.0 on yield and 5.0 on ultimate strength.
8. The buddy system is mandatory while performing certain activities in the facility as follows:
   - Working at heights above 4 ft (1.2 m) when there is no protection (handrails) provided.
   - Handling beams and structural hardware necessary to set up or reconfigure the modal facility.

### 2.10.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.10.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.179, *Overhead and Gantry Cranes*

OSHA 29 CFR Part 1910.212, *General Requirements for All Machines*

## 2.11 Rapid Prototyping Facility

### 2.11.1 Scope

This section covers the plastics/wood/model shop and its subsystems, located in Building 5, Rooms E48 and E52. The plastics, wood, and modeling areas comprise the rapid prototyping capability. They share the same rooms and are operated by the same personnel.

### 2.11.2 General

The rapid prototyping facility provides assistance and technical information about plastics manufacturing technology, and fabricates models made of acrylic, Plexiglas, wood, metals, polyamide foams, and similar materials, as required. For example, the shop fabricates plastic scintillator wave guide assemblies, scale model and mockup assemblies of spacecraft and flight instruments, and mockup assemblies for routing cable harnesses. The shop is organized into machining, assembly, and storage areas. Typical equipment includes table and radial saws, miter and jig saws, lathe, joiner, planer, shaper, milling machine, drill press, bending and forming equipment, and sander. There is a vented fume hood for painting and for handling vapor-emitting materials. There is no crane in the area.

### 2.11.3 Specific Facility Requirements

Special procedures for this shop are as follows:

1. Shop personnel shall be trained to operate equipment and handle materials by senior technicians. The shop supervisor shall approve and document each fabricator's demonstrated ability to perform satisfactorily.
2. All shop equipment guards shall be installed before personnel operate the equipment. Special indicator lights have been added to certain shop equipment as a precaution to warn hearing impaired personnel when the motors are running. (See AETD SM Section 3.3.4 Item 8 for further safety guard information.)
3. Personnel shall wear the appropriate PPE for the job (see Section 3.6 in the AETD SM). When operating machinery, personnel shall wear approved eye protection such as safety glasses with sideshields, goggles, ear defenders or plugs as necessary, and safety shoes. Respirators, fitted with the appropriate filter cartridges, shall be worn when working with vapor-emitting materials.
4. House-supplied compressed air is available in the shop. Compressed air shall not be used for cleaning purposes except where reduced to less than 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use flexible compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from machinery. See AETD SM, Section 2.3 for pressure system requirements.)
5. Avoid having liquid epoxies and solvents contact the skin or eyes. In the event of skin or eye contact, rinse the affected areas with water for at least fifteen minutes. A permanent eyewash station is located immediately outside the shop doorway, along the wall in the Building 5 High Bay area.
6. The S&ED conducts an evaluation of the local exhaust ventilation systems (LEV) in Building 5, Room E48, on a machine-by-machine basis. Shop personnel shall comply with the hygienist's recommended procedures when operating the machines. For example, no more than two machines

shall be operated simultaneously, and the LEV flexible ducts shall be placed as close to the workpiece as practical.

7. Shop personnel shall open LEV blast gates when operating a piece of machinery, and close them when finished. For some machines, movable flexible ducts are positioned to capture dust and vapors. The senior technician checks the LEV tray filter collection system and empties waste materials approximately three to four times annually. Waste materials collected in the LEV are not classified as hazardous, so they are disposed of in the GSFC trash dumpsters.
8. Hazardous wastes such as uncured materials, epoxies, solvents, etc., shall be disposed of by calling the Hazardous Waste Environmental Specialist (x6-9233) for removal service. Typically, this shop uses epoxies, solvents, and paints in less than one gallon quantities at a time, so hazardous wastes are minimal. (See Section 2.5 in the AETD SM for Hazardous Materials requirements.)
9. Store flammable materials in the flammable storage cabinet, which is vented to the outside atmosphere.
10. When painting or handling vapor-emitting materials, work directly in front of the fume hood and allow the vapors to exhaust outside. (See Section 2.5.4 in the AETD SM for fume hood information.)
11. Use caution and gloves, as appropriate, when handling or surface finishing shaped items, to avoid being injured by rough and jagged edges of fibers and cured cements and epoxies.
12. Shop personnel shall clean debris and waste materials from surfaces on and around machinery. Use brushes, vacuum equipment, or special tools for removing chips—do not use hands. Machine operators shall direct custodial personnel to clean floor and office areas but, as a safety precaution, shall not allow them to clean near machines or facilities that present a potential hazard.

### 2.11.4 GSFC Contacts

Composites and Rapid Prototyping Group Leader: (301) 286-5175

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-9660

Support Contractor Safety: (301) 286-2601

### 2.11.5 Reference Documents Unique to this Section

See Section 3.3 in the AETD SM for Machine Shop reference documents.

## 2.12 Plating Facility

### 2.12.1 Scope

This section covers the electroplating facility and its subsystems, located in Building 5, Room E14 and surrounding areas.

### 2.12.2 General

The electroplating facility provides electro-chemical processing of spacecraft and instrument components, to guard against oxidation and to provide for requisite thermal and electrical conductivity and electrical resistivity. Baths for cleaning, iriditing, anodizing, and plating processes are maintained daily. Capabilities include gold, silver, copper, and nickel plating, as well as electroless nickel coating, black nickel coating, zincating, anodizing and iriditing. The plating analysis laboratory provides analysis of plating baths, thickness coating measurements, and thickness and sealing quality of anodic coatings.
The Building 5 plating facility is a complex consisting of the following areas:

1. Office Area: Contains desks, computer workstations, and a small conference table.
2. Chemical Storage Area: Contains four separate storage rooms including the following:

   Cyanide storage room.

   Oxidizer storage room.

   Acid storage room.

   Flammable storage room.

   All four rooms are vented to the outside atmosphere. Each has a floor grate with a chemically-resistant epoxy-coated floor beneath it. Each floor has a sump to collect any spilled chemicals.

   Each room is equipped with a chemical spill kit. The flammable storage room is designed with explosion-proof features, such as flammable storage cabinets and explosion-proof lighting with light switches located outside the room.
3. Buffing Room: Contains one large, two-wheeled, buffing lathe and one smaller, bench-mounted lathe. The large lathe is vented to an outside collection hopper. Storage for buffing compounds and wheels is present in the room.
4. Waste Treatment Area: This area is divided into two rooms. One room contains air scrubber columns. The second room contains the ion exchange columns and pH neutralization equipment needed to treat plating shop effluents. In addition, there are three sumps: a sump for heavy metal-bearing effluents, a second for cyanide-based effluents, and a third for acidic or basic effluents. Each sump is equipped with two pumps to transfer effluents throughout the waste treatment system.
5. Prototype Plating Facility: This facility, designed for testing new plating solutions, is equipped with a bank of small plating and rinsing tanks. Air from the area is vented directly to the outside atmosphere. This area, as well as the rest of the plating shop, is maintained under a slightly negative air pressure, a design feature which helps ensure that vapors are directed toward the proper ventilating systems.

6. Acid Polishing Facility: This facility is designed to etch and polish ceramic mirror blanks using a solution of sulfuric acid and hydrofluoric acid. The entire processing line is enclosed. Air from the facility is vented through the main plating shop exhaust system.
7. Gold Plating Facility: This facility contains two gold plating baths and rinse water tanks. Air vents through the main plating shop provide exhaust for the system.
8. Main Plating Facility: This facility contains five major processing lines including the following:

   Metal cleaning and etching line.

   Aluminum processing line.

   Heavy metals line.

   Electroless nickel line.

   Cyanide substitute line (copper and silver plating baths).

   The floor is coated with a chemically-resistant epoxy. Each line is situated over a floor trench which would route chemical spills to the appropriate waste treatment sump. Trenches can overflow into each other and into all of the pits.

### 2.12.3 Specific Facility Requirements

Special procedures for the plating facility are as follows:

1. Only authorized personnel wearing appropriate eye protection may enter any chemical area. Personnel performing operations must complete the courses listed below, review Chemical Hygiene Plan for the facility, and be approved by the Ship Lead or Branch Head

2 The plating group's analytical chemist shall track the personnel training records on a computer file and keep the information in the notebook in the plating facility office. All plating facility employees shall attend the following training classes:

   Hazardous communication (HAZCOM) training.

   Laboratory standard training.

   Goddard Hazardous Waste Management Training.

   Fire extinguisher training (initial half-day hands-on course, followed yearly by a 15-minute videotape course).

   Respirator training (initial class, with yearly respirator tests).

   Personal protective equipment (PPE) training (yearly 15-minute videotape).

   Waste Treatment Facility Operations.

   Specific Plating Lab Operations and Safety requirements.

3 The Plating Lab Chemical Hygiene Plan (CHP) shall be updated whenever a change is made in operations or at least every two years. All personnel working in the facility shall review the plan and sign off each applicable Process Hazard Analysis. The CHP shall include operating procedures for filling and draining the baths and operations of the Waste Treatment Facility (WTF). As part of the WTF operations, the neutralization equipment shall be checked at least twice a day to verify it is properly operating. If personnel notice the pH levels are not within specified levels, the system will immediately be shut down and Code 250 Environmental contacted.

4. Eyewash and shower facilities: There are eyewash stations and shower facilities located as follows:

   Building 5, Room 14D: Three eyewash stations and one shower facility.

   Building 5, Room 14F: One eyewash station and one shower facility.

5. Eye protection: Safety glasses with side shields are the mandatory minimum protection required for anyone working—or in the immediate vicinity of anyone performing work—in the plating laboratory and facilities, buffing room, or waste treatment area. A full face shield shall be worn when pouring or mixing corrosive chemicals such as strong acids and bases. Contact lenses shall not be worn in the plating analysis laboratory or facilities.

6. Gloves: When handling chemicals or processing parts in the plating areas, gloves shall be worn which are appropriate for the materials at hand. Typically, these are rubber or latex gloves. Gloves shall have no tears, holes, or discolorations. Do not lean on or touch tank equipment or areas without gloves due to the possibility of caustic material on work surfaces.

7. Aprons: Rubberized aprons shall be worn when handling chemicals or processing parts in the plating facilities. A minimum of a lab coat is required in the plating analysis laboratory.

8. Respirators: Respirators, with filter cartridges appropriate for the materials at hand, shall be worn when mixing powdered chemicals or working with volatile chemicals without benefit of a fume hood. For example, special cartridges are available for working with acids/bases, organics, and particulates. Cartridge-type respirators shall not be used for emergency or rescue operations. Only personnel specifically trained in rescue operations, and equipped to do so, shall conduct emergency actions in a hazardous area. The lab Chemical Hygiene Plan should discuss selection of filer cartridges.

9. Footwear: Safety shoes shall be worn when processing parts. Safety shoes are not required in the plating analysis laboratory, but high heels and open-toed footwear, such as sandals or cloth footwear, are not permitted outside the office area.

10. Buddy system: No one shall perform work in the plating analysis laboratory and plating facilities unless at least one other person is present in the complex and aware of the worker's location and activity.

11. Housekeeping: Plating facility personnel shall clean potentially hazardous areas. Senior plating shop personnel shall direct custodial personnel to clean floor and office areas but, as a safety precaution, shall not allow them to clean in areas which present a potential hazard. Other considerations are discussed below:

    Laboratory and plating facilities shall be kept clean and free of clutter.

    All containers shall be labeled to identify contents.

Solvent-laden rags shall be placed in labeled containers marked for that purpose and treated as hazardous waste for disposal purposes (see waste disposal instructions below).

When personal knowledge ensures there is no risk to personnel, small spills shall be cleaned up by donning the proper PPE and using the appropriate spill control kits located in the immediate area. The kit and waste material shall be disposed of as hazardous waste (see waste disposal instructions below). If unable to ascertain the nature of a spill, personnel shall cordon off the area and contact the Emergency Console (911).

Trash receptacles should be emptied daily.

12. Cranes: Only certified operators shall operate cranes.

13. Waste disposal instructions:

Hazardous chemicals scheduled for disposal shall be placed in containers marked as to their contents and class of waste (health hazard, corrosive, flammable).

Only 45 gallons (170.3 liters) of waste shall be accumulated in one area at any given time. Only one pint (0.475 liter) of extremely hazardous material (e.g., cyanides) shall be accumulated. All spills/overflows into trenches/pits must be called into the Emergency Console (911).

When the above amounts are accumulated, or if no further accumulation is anticipated, call the Hazardous Waste Environmental Specialist (x6-9233) for removal service. Prepare a Hazardous Waste Disposal Inventory Form, NASA WI-1550, and submit it to the waste disposal personnel. Copies of the MSDSs for chemicals being disposed of shall be readily available.

### 2.12.4 Hazardous Chemicals Specific to the Plating Facility

The following describes chemicals used in the plating facilities and summarizes safety requirements for each:

1. Copper cyanide:

Hazard: Toxic, Eco Toxin

Ventilation: Local exhaust.

Respiratory protection: NIOSH-approved respirator if there is danger of inhaling dust or gas in a major spill.

PPE: Chemical safety goggles or face shield; rubber gloves for solution or cotton gloves for dry solid; and laboratory apron, coveralls, or lab coat.

Work/hygiene practices: Wash thoroughly after handling and before smoking or eating.

Handling/storage: Keep container closed and away from strong acids, weak alkalis, oxidizing agents, and food products. Store in a cool, dry place, 55-85°F (13-29°C).

2. Eccostrip 93 (paint stripper containing methylene chloride, phenol and formic acid):

Hazard: Toxic, Flammable, Caustic.

Ventilation: Fume hood.

Respiratory protection: NIOSH-approved respirator with combination acid/organic cartridges.

PPE: Goggles or minimum of safety glasses with side shields, rubber gloves, and rubber apron.

Work/hygiene practices: Keep Eccostrip 93 in closed container when not using. Wash off immediately if it contacts the skin. Never allow continued skin contact.

Handling/storage: Store in a cool, dry place. Keep container covered. Keep away from intense heat and open flames.

3. Hydrofluoric acid:

   Hazard: Caustic, Toxic.

   Ventilation: Local exhaust, fume hood.

   Respiratory protection: NIOSH-approved respirator with acid cartridge.

   PPE: Chemical goggles or face shield, rubber gloves, and rubber apron.

   Work/hygiene practices: When mixing acid and water, add acid to water. Acid comes to GSFC in polyethylene containers. This acid is difficult to contain, corrosive to glass, most metals, and other materials except lead, wax, polyethylene, and platinum.

   Handling/storage: Store in well-ventilated area. Store away from nitric and sulfuric acids, cyanides, and other incompatible materials.

4. Nitric acid:

   Hazard: Caustic, Toxic.

   Ventilation: Local exhaust, fume hood.

   Respiratory protection: NIOSH-approved respirator with acid cartridge.

   PPE: Chemical goggles or face shield, rubber gloves, and rubber apron.

   Work/hygiene practices: Transport acid bottles in a rubber basket. When mixing acid and water, add acid to water.

   Handling/storage: Protect against physical damage, separate from metallic powders, carbides, hydrogen sulfide, turpentine, organic acids; and all combustible, organic, or other readily oxidizable materials. Provide adequate ventilation and avoid direct sunlight.

5. Potassium cyanide:

   Hazard: Severe Poison, Corrosive, Eco Toxin.

   Ventilation: Local exhaust.

   Respiratory protection: NIOSH-approved respirator if there is a danger of inhaling dust or gas in a major spill.

   PPE: Chemical goggles or face shield; rubber gloves for solution or cotton gloves for dry solid; and laboratory apron, coveralls, or lab coat.

   Work/hygiene practices: Wash thoroughly after handling and before smoking or eating.

   Handling/storage: Keep container closed and away from strong acids, weak alkalis, oxidizing agents, and food products.

6. Potassium silver cyanide (silver sol-u-salts):

   Hazard: Oxidizer, Flammable, Toxic.

Ventilation: Local exhaust.

Respiratory protection: NIOSH-approved respirator if there is a danger of inhaling dust or gas in a major spill.

PPE: Chemical goggles or face shield; rubber gloves for solution or cotton gloves for dry solid; and laboratory apron, coveralls, or lab coat.

Work/hygiene practices: Wash thoroughly after handling and before smoking or eating.

Handling/storage: Keep container closed and away from strong acids, weak alkalis, oxidizing agents, and food products. Store in a cool, dry place, 55-85°F (13-29°C).

7. Sodium cyanide:

Hazard: Highly Toxic, Corrosive, Flammable.

Ventilation: Local exhaust.

Respiratory protection: NIOSH-approved respirator if there is a danger of inhaling dust or gas in a major spill.

PPE: Chemical goggles or face shield; rubber gloves for solution or cotton gloves for dry solid; and laboratory apron, coveralls, or lab coat.

Work/hygiene practices: Wash thoroughly after handling and before smoking or eating.

Handling/storage: Keep container closed and away from strong acids, weak alkalis, oxidizing agents, and food products. Store in a cool, dry place, 55-85°F (13-29°C).

8. Toluene:

Hazard: Flammable, Toxic, Corrosive.

Ventilation: Local exhaust.

Respiratory protection: NIOSH approved respirator with organic vapor cartridge.

PPE: Safety goggles, rubber gloves, rubber apron.

Work/hygiene practices: Wash thoroughly after handling and before smoking or eating.

Handling/storage: Store in standard flammable liquids storage room or cabinet. Keep separate from oxidizing materials.

### 2.12.5 GSFC Contacts

Plating Shop: Plating Group Leader: (301) 286-2620

Chemical Analyst: (301) 286-2258

Lead Technician: (301) 286-5708

Chemical Safety Officer: (301) 286-5708

Environmental Liaison: (301) 286-6464

Chemist: (301) 286-2258

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-9660

Support Contractor Safety: (301) 286-2601

S&ED: (301) 286-2281

### 2.12.6 Reference Documents Unique to this Section

GPR 1700.2, *Chemical Hygiene Program*

## 2.13 Precision Assembly Area

### 2.13.1 Scope

This section covers the precision assembly area and its subsystems, located in Building 5, east wing. This area includes the sheet metal shop.

### 2.13.2 General

The precision assembly area is used to assemble mechanisms, instruments, and structures up to shuttle-sized spacecraft. It consists of four main areas as follows:

1. Building 5, north end, 1st floor: Contains large manufacturing and assembly machines such as mill, lathe, drill press, roller, punch, ram press, notcher, brake, sander, and finishing machine.
2. Building 5, north end, 3rd floor: Contains smaller manufacturing and assembly machines which complement the machines on the 1st floor, listed above.
3. Building 5 High Bay: Contains four cast steel precision assembly tables with grid pattern of drilled and tapped holes for positioning and clamping flight components during mechanical assembly. This area has a Kern 3-dimensional, computerized measurement system which uses up to six theodolites to assist in aligning mechanical assemblies. The area is served by the two Building 5 High Bay bridge cranes.
4. Building 5, Precision Assembly Cleanroom: This limited access, controlled environment, Class 10,000 (M5.5) cleanroom is used for critical hardware assembly and functional testing.

### 2.13.3 Specific Facility Requirements

Special procedures for this assembly area are as follows:

1. Machine operators shall be trained by senior technicians. The shop supervisor shall approve each operator's demonstrated ability to perform satisfactorily.
2. Refer to Section 2.1 in Volume 1 for mechanical handling and operator certification requirements.
3. All shop equipment safety guards shall be in place and effective before operating the equipment. Various machines contain automatic light beam cutoff switches, cutoff pressure mats, and other interlock-type automatic cutoff controls. (See AETD SM Section 2.7.4, Item 8 for further safety guard information.)
4. When operating machinery, personnel shall wear approved eye protection, such as safety glasses, goggles, or full-face shield with goggles/glasses, as well as ear defenders or plugs as necessary, and safety shoes.
5. Wear protective gloves when handling materials that have sharp or jagged edges. De-burr jagged surfaces as soon as possible after a machining process.
6. Avoid having liquid epoxies and adhesives contact the skin or eyes. In the event of skin or eye contact, rinse the affected areas with water. A permanent eyewash station for the assembly area is located at the north end of the high bay, 1st floor, on the east wall.
7. Dust- and chip-generating machines have automatic dust and chip collection systems. The area generates non-hazardous waste materials which can be discarded in the standard GSFC dumpsters.

8. Hazardous wastes such as uncured materials, epoxies, solvents, etc., shall be disposed of by calling the Hazardous Waste Environmental (x6-9233) for removal. Typically, this area generates minimal hazardous wastes.
9. Shop personnel shall clean debris and waste materials from surfaces on and around machinery. Use brushes, vacuum equipment, or special tools for removing chips—do not use hands. Machine operators shall direct custodial personnel to clean floor and office areas but, as a safety precaution, shall not allow them to clean near machines or facilities, which present a potential hazard. Metal chips shall be placed in the metal recycle bins. General dust and debris can be discarded in the standard GSFC dumpsters.
10. Post signs and erect barrier tapes (or equivalent) to control unauthorized personnel access near the precision assembly tables when setting up and aligning mechanical structures. It is particularly critical to prevent unauthorized personnel from disturbing the Kern 3-dimensional measurement system because its theodolites are highly sensitive to motion.
11. Consult with the senior technician before entering the assembly area cleanroom. Wear cleanroom garments and observe procedures consistent with the cleanliness specification being maintained for the particular job.

### 2.13.4 GSFC Contacts

Hardware Development Group Leader: (301) 286-3956

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-9660

Support Contractor Safety: (301) 286-2601

### 2.13.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910 Subpart O, *Machinery and Machinery Guarding*

OSHA 29 CFR Part 1910.242, *Hand and Portable Powered Tools and Equipment, General*

OSHA 3067, *Concepts and Techniques of Machine Safeguarding*

NFPA 70, *National Electrical Code*

NFPA 79, *Electrical Standard for Industrial Machinery*

## 2.14 Static Test

### 2.14.1 Scope

This section covers the static test facilities and their subsystems, located in Buildings 15/29.

### 2.14.2 General

Facilities and subsystems covered in this section are:

1. Universal and Small Static Load Test Facilities: These facilities are structural steel frameworks, designed for applying static loads to test articles ranging from structural components to shuttle-sized payloads. Multi-directional loads can be applied up to 80,000 lb (36,288 kg).
2. Hydraulic Actuators: Piston-type hydraulic actuators for applying controlled loads to test articles.

### 2.14.3 Specific Facility Requirements

Static load test facilities contain large steel beams that can be configured to provide payload and load link mounting points. Hydraulic actuators, load links, and load monitoring devices are arranged so as to apply specified, multi-directional static loads to designated points on the payload. Digital data acquisition systems monitor and record signals from load cells, strain gages, and displacement transducers.
Special procedures for this facility are as follows:

1. Static load test control system operators shall be trained by the facility engineer. The facility supervisor shall approve and document each operator's demonstrated ability to operate the hydraulic actuator control system satisfactorily.
2. A Storm Warning Code Status 3 or 5 shall preclude testing unless a waiver has been signed by the Code 549 Branch Head (or designee) and Project Representative.
3. Personnel shall notify the facility engineer of the intent and purpose of the visit before working on or around the static test facilities.
4. A Section-approved stress analysis is required for conducting static load tests. All of the facility's structural hardware and fixturing shall have a minimum safety factor of 3.0 on yield and 5.0 on ultimate strength.
5. Personnel shall be aware of the potential for tripping or slipping when working on the elevated baseplates. Keep all unnecessary tools, hardware, etc., off the baseplates where personnel are liable to walk. Wipe up hydraulic oil and other spilled liquids immediately to minimize slipping hazards.
6. Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms or powered industrial trucks. Others may be given a waiver approved by Code 549 Branch Head.
7. Always be aware of the location of the center of gravity of a load, and verify that it will not topple, tilt, swing, or react in an unexpected way. This is especially important when dismounting and reconfiguring the massive structural beams of the facilities. (See Section 2.1 Mechanical Handling in AETD SM.)
8. Use appropriate gloves and protective gear to handle materials that have rough or sharp edges or surfaces.

9. All unauthorized personnel shall be restricted from the area during load testing. The facility engineer shall verify that hydraulic actuator operators and experimenters are situated in safe zones and protected from potential harm before the load is applied to the test item.
10. Hydraulic systems shall have current certifications. (See AETD SM, Section 2.3 for requirements.)
11. The buddy system is mandatory while performing certain activities in the facility, including the following:
    - Working at heights above 4 ft (1.2 m) when no fall protection (handrailing) is provided.
    - Handling beams and structural hardware necessary to set up or reconfigure the static load facility.

### 2.14.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.14.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212 and Part 1910.27, *Mechanical Equipment*

# 2.15 Thermal Vacuum

## 2.15.1 Scope

This section covers thermal vacuum chambers, rapid pumpdown systems, temperature humidity chambers, portable thermal systems, portable solar simulators, liquid nitrogen vaporizers, and emergency power generators. Temperature/Humidity (T/H) chambers consist of Facilities 204 and 232, located in Building 7. Thermal vacuum (T/V) test chambers consist of Building 7 Facilities 225, 237, 238, 239, 240, 241, 245, 281, Building 10 Facility 290 and WFF Building F7. Thermal conditioning units (TCUs) consist of Facilities 201, 205, 206, and 207. Emergency generators consist of Facility 222 (350 kVA), Facility 253 (250 kVA), and Facility 254 (500 kVA).

## 2.15.2 General

Facilities and subsystems covered in this section are:

1. T/V Chambers: These chambers range from small, cylindrical bell jars (2 ft x 2 ft, 0.61 m x 0.61 m) to large, walk-in chambers (27 ft x 40 ft, 8.2 m x 12.2 m), and are used for T/V and thermal balance testing, and baking out test items. Personnel can enter the larger chambers to perform pre- and post-test handling operations. Electric heater arrays, solar lamps, cryopumps, and thermal shroud systems are used to provide temperature cycling.
2. Vacuum Pumping Systems: Chambers use turbo pump diffusion pumping and/or cryopumping systems to achieve and maintain high vacuum. All mechanical pumps "rough down" the chamber, then the high vacuum pumps achieve the ultimate vacuum pressure.
3. Cryogenic Systems: Temperature cycling systems inside the chambers use $GN_2/LN_2$ and LHe. Facility 290 uses a permanent helium system. All other chambers use portable helium systems. LHe systems can achieve cryogenic temperatures to within a few degrees of absolute zero.
4. Portable Thermal Systems: These systems can achieve temperatures ranging from -220 to +284°F (-140 to +140°C) by using electric heater arrays, $GN_2$ transfer systems, and $LN_2$ systems. Portable TCUs can be set up and used at each T/V facility as needed.
5. Portable Solar Simulators: Solar simulators are used to illuminate test items with intensities ranging from 0.5 to 25 solar constants. These portable units are designed to be set up outside a T/V chamber and project the solar beam through a quartz window to illuminate the test item inside the chamber. A typical unit contains a lamp housing with optical projection system, de-ionized water cooling system for the lamp electrodes, power supply, and control console.
6. T/H Chambers: These chambers range from 2 $ft^3$ to 64 $ft^3$ (0.06 $m^3$ x 1.81 $m^3$) chambers, and are used for thermal conditioning of test items. Electrical heaters warm (and a cascade refrigeration system cools) the air stream. A cooling unit provides dehumidification, and an electrically heated vapor generator provides humidification.
7. $LN_2$ Vaporizers: These systems convert $LN_2$ to $GN_2$ for use as the heat transfer medium in T/V facilities. The vaporizer's high pressure pump increases the nitrogen liquid pressure to 2,000 psig (13.8 Mpa), then the liquid is evaporated in the heat exchanger and transferred to storage bottles. The nitrogen gas is withdrawn for use after a two-stage pressure reduction to 350 and 100 psig (2.4 and 0.69 Mpa), respectively.

8. Emergency Power Generators: T/V facilities are backed up by emergency power generators in the event of commercial power failure. In Facilities 253 and 254, diesel-powered generators start up and transfer automatically when commercial power is interrupted for longer than approximately 15 seconds. In Facility 232, the diesel-powered generator must be manually started. Generator capacity ranges from 250 kVA to 500 kVA, 480 VAC, 3-phase, 60 Hz.

### 2.15.3 Specific Facility Requirements

1. General Requirements for T/H chambers and vacuum chambers:

   As a class, all T/V test facilities involve potential exposure to vacuum, cryogenic, high temperature, slip (water), pneumatic, electric, and confined space hazards. Information about these topics can be found in Section 2.0 in the AETD SM. Some chambers also involve working at heights (see Section 3.1 in AETD SM). In addition, all of the T/V chambers have equipment that is started by remote control.

   The pumps, motors, and other associated equipment are not rated for hazardous materials.

   Quartz view ports are normally shielded with Plexiglas. In spite of this protection, care must be taken to ensure that the quartz is not subjected to impact, particularly while under vacuum. The catastrophic failure of a quartz window will cause sufficient air flow that nearby personnel may be injured or killed. The risk of damage to the test vehicle is also high.

   Most chambers have external ion gages. These gages are glass bulbs that enclose a filament structure that gives off visible light. While these gages are protected by an expanded metal guard, the bulb could still be struck, potentially causing injury to personnel and equipment.

   Loading platforms and carts shall be analyzed and load tested per the requirements of AETD SM, Section 2.1. Only certified operators shall operate cranes. Load platforms shall have stops for payload carts to prevent unintended movement. Platforms with cantilevered rails shall be analyzed and tested for stability when the payload/cart is on the cantilevered section or provisions made to maintain stability of the cart.

   All chamber pressure systems shall comply with AETD SM, Section 2.3. LN2 exhaust shall be located so as to prevent creating hazards, such as possible contact of cold materials or oxygen deficient areas.

2. Facility 225:

   This facility has a loading table that is supported by air bearings during positioning activities. Excessive air pressure can result in the loading table becoming unstable. This instability is primarily a vertical oscillation with some horizontal displacement occurring during each bounce. Handrails must be installed on the loading table.

   Personnel must not work above the pumping header or on top of the chamber when standard handrails are not installed, unless fall protection is used. (See Section 3.1 in AETD SM for details on fall protection.)

3. Facility 237 and Facility 239:

   A wheeled cart supported on rails is used to load this chamber. The cart must be locked to the support structure whenever a load is being placed on, or removed from, the loading cart. To protect the payload, the cart should be locked in place when it is positioned inside the chamber.

Handrails and chains must be installed on the loading cart whenever personnel are on the cart.

A quartz view-port exists on the chamber entrance door.

4. Facility 238:

   The top of the chamber is accessed from a platform that surrounds the removable lid. This platform has a load rating of 125 lb/ft$^2$ (610 kg/m$^2$). If platform handrails are temporarily removed or the dome open, non-essential personnel must be cleared from the area, a pre-task briefing held discussing the fall hazard, and personnel on the upper level must stay at least 6 ft (1.8 m) from the open edge or fall protection must be used (harness and lanyard or spotter) when in the taped area. The handrails must be reinstalled or dome closed immediately after the item passes the interference area.

   After opening the dome, install safety blocks to keep the dome from lowering farther than expected.

   A quartz view-port exists on the north side on the main floor.

5. Facility 240:

   A vertical discharge burst disk is located near the back, on the east side of the chamber, close to the stairway. Be aware that activation of the burst disk creates a loud noise. Use caution.

6. Facility 241:

   A vertical discharge burst disk is located near the back, on the east side of the chamber. Be aware that activation of the burst disk creates a loud noise. Use caution.

7. Facility 281:

   A thermal system vent is located above the stairway to the basement.

8. Facility 290:

   This is the largest T/V test chamber at Goddard. Because of its size, it is important that all personnel be accounted for prior to closing the chamber for any reason. In addition, access to the chamber bilge, the space below the chamber working floor, and the area behind the shroud is considered a confined space (see AETD SM Section 2.11). The rescue of an injured person from the bilge (or from between the shrouds and the chamber wall) is a difficult and potentially dangerous task.

   Access to the chamber itself is through an airlock. This entry is a trip hazard. Occupancy inside the chamber is limited to no more than 10 people at a time. Equipment/materials left in the anteroom shall not be placed in such a manner to restrict egress. An egress route of at least 36 inches wide shall be maintained at all time.

   All loading and unloading activities for this chamber require the use of a crane. The Building 10 overhead crane is operated by a hand-held remote control. All personnel directly involved with the crane operations shall maintain radio contact with each other. Immediately cease crane operations if communications are interrupted. Some lifts may be blind, depending upon whether the crane operator can follow the payload at all times with the hand-held remote control. The operator shall ensure that no personnel are beneath the suspended load, particularly those persons who must remain inside the chamber during the loading process.

The chamber is surrounded by a deck plate on both the first floor and basement levels. The load rating of this deck plate is 75 lb/ft$^2$ (366 kg/m$^2$).

Two high pressure, 160 psig (1.1 Mpa), pneumatic tanks that provide reserve power to close the main valves, are located in the basement next to the chamber on the north side. These tanks are just to the west of the helium skid.

The helium skid can produce temperatures as low as -263 °C (-442 °F). The helium skid has a sound attenuating enclosure around the compressor section. This enclosure must remain in place during operation.

9. Facility 232 (T/H):

This facility operates in the temperature range of -73 to 100°C (-100 to 212°F) at atmospheric pressures. The facility has an $LN_2$ connection to provide additional cooling capacity. When the $LN_2$ boost is enabled, -196°C (-320°F) gas will vent through a gas phase eliminator located to the rear and above the chamber. Gas at the operating temperature may be vented through a vent port located on top of the chamber near the front door at the latch side. Under extreme conditions, this gas could vent from horizontal operating ports located approximately five feet above floor level. The chamber may be set to generate low pressure (2 to 4 psig, 13.8 to 27.6 kpa) steam. In normal operation, the $GN_2$ will be contained within the machine area and the test chamber.

10. Temperature Conditioning Units (TCUs) requirements:

These facilities are small and portable. The largest, Facilities 201 and 206, are on wheels. Electrical power connections are made using a flexible cord and plugs. Voltages range from 120 VAC for the 207 units to 480 VAC for the 201s. All of these facilities are connected to an energy source using a temporary, flexible connection. Containment failure could result in the release of gas or liquid at a temperature of -196°C (-320°F). The TCU control system has sensing systems that automatically shut the TCU off if an anomalous condition occurs. If the automatic system were to fail, the operator must turn off the $LN_2$ supply at the input to the TCU.

Transportation of the 201 units is difficult, requiring a minimum of two people to move the unit.

The 201 Facilities have a rupture disk that is constrained to a vertical discharge by a pipe mounted in the center of the facility.

Any water on the floor near electrical units shall be cleaned up immediately to prevent a shock hazard.

Facilities 205 and 207 are single-pass systems that exhaust nitrogen to the atmosphere. The temperature of the exhaust can range between -140° and +140°C (-220° and +284°F). The use of these facilities in confined spaces requires the use of an oxygen monitor.

11. Emergency Generators:

Entry into any of these facilities requires the use of the buddy system.

Each of these systems is located inside a trailer. Access to and around both the generator and the diesel engine is restricted. Eye protection must be used when working around the batteries that provide starting power. Facilities 253 and 254 may be set to start automatically when a power failure occurs. Facility 222 is operated manually.

During operation the following protective equipment/hazards exist for all three generators. Hearing protection is required due to the high sound levels that exist within the generator trailers. Eye protection is required to protect against foreign matter carried by high velocity air. Hot manifold and exhaust surfaces exist with the trailers.

Facility 222 (Building 10, Facility 290, GSE Emergency Generator):

The rear doors must be opened and latched prior to starting the generator. Exercise care when opening the side door.

Facility 253 (Building 7 Emergency Generator):

High pressure (160 psig, 1.1 Mpa) $GN_2$ may be present in a pressure vessel located within the generator trailer. This gas is used for a manually operated, gas-driven starter.

Facilities 253 and 254 (Buildings 7 and 10 Emergency Generator):

Entrance doors must be latched open prior to entering these trailers. Serious injury may result from the doors being slammed closed by rushing air during generator operation. In addition, the pressure difference between the outside and inside is sufficient to prevent a person from exiting the trailer.

12. $LN_2$ Vaporizers:

These consist of Facility 258 (Building 7) and Facility 263 (Building 10)

Low pressure (25 to 30 psig, 172 to 207 kpa) $LN_2$ is transferred from a storage tank to a 500-gallon (1,893 liters) tank where the pressure is increased to 75 psig (517 kpa). Both the transfer and system start-up require precooling of components. This precooling process vents cold $GN_2$ to the atmosphere at near ground level. The temperature of the vented gas will approach -196°C (-320°F). The 500-gallon (1,893 liters) tanks have a burst disk located at the top of the tank, in addition to relief and pressure control valves located near ground level.

All piping is close to the ground. During operation, the piping between the pumps and the heat exchanger contains $LN_2$ at pressures up to 2,000 psig (13.8 Mpa). Piping between the heat exchanger and the storage bottles contains $GN_2$ at a pressure of 2,000 psig (13.8 Mpa).

Slippery conditions are common in the immediate vicinity of this equipment. Ice and/or water are byproducts of the vaporizing process.

High noise conditions will exist during the cool down period. Hearing protection is required during all high noise operations.

### 2.15.4 GSFC Contacts

Test Facilities in Buildings 7/10:
Space Simulation Test Engineering Group, Lead: (301) 286-6058

Test Facilities in Building 5 (Welding Shop and Composite Materials Shop):
Advanced Manufacturing Branch, Head: (301) 286-4336

Test Facilities at WFF Mechanical Systems Branch: (757) 824-1314

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Building 5 Safety Committee Head: (310) 286-9660

Buildings 7/10 Support Contractor Safety: (301) 286-2601

### 2.15.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212, *General Requirements for All Machines*

OSHA 29 CFR Part 1910.27, *Fixed Ladders*

GPR 8710.5, *Certification and Recertification of Ground-Based Pressure Vessels and Pressurized Systems*

CGA P-14-1983, CGA P-12-1987, CGA P-1

ASHRAE 15-89

## 2.16 Vibration Laboratory

### 2.16.1 Scope

This section covers the Vibration Laboratory and its subsystems, located in Buildings 7/10.

### 2.16.2 General

Facilities and subsystems covered in this section are:

1. Vibration Exciters: Electrodynamic exciters rated up to 35,000 lb (156 k-Newton) force.
2. Exciter Power Amplifiers and Hydraulic Power Supply: Amplifiers for electrodynamic exciters rated up to 240 kVA.
3. Lateral Tables: Slip tables connected to the lateral exciters with hydrostatic, bi-directional support bearings.
4. Subbasement Equipment Room: Service area beneath the vibration test cells containing hydraulic power supply equipment and exciter cooling systems.
5. Amplifier Equipment Room: Service area above the vibration test cells containing power amplifiers for the electrodynamic exciters.
6. Gyrex Centrifuge in Building 7 Transducer Calibration Lab: Small dual table centrifuge with a 10-inch (25.4 cm) radius for calibrating accelerometers.

### 2.16.3 Specific Facility Requirements

The Vibration Laboratory contains four electrodynamic exciters, lateral slip tables, and fixturing for conducting shock and vibration testing on flight test articles. Sine, random, sine burst, and shock testing are conducted up to g levels, limited by the power ratings specified above. Typical sine and random testing is in the frequency range of 5 Hz to 2 kHz, with shock testing up to 10 kHz.
Vibration testing causes high noise levels, which are potentially harmful to personnel.
Special procedures for this facility are as follows:

1. Vibration control system operators shall be trained by the facility engineer. The facility supervisor shall approve and document each operator's demonstrated ability to operate the vibration control system satisfactorily.
2. A Storm Warning Condition Status 3 or 5 shall preclude testing, unless a waiver has been signed by the Code 549 Branch Head (or designee) and the Project Representative.
3. Visitors shall notify the facility engineer of the intent and purpose of the visit before entering any of the vibration test cells.
4. The facility engineer shall conduct a walkdown of the test article, exciter, fixturing, and test cell, and close the test cell doors, including the doors on the building 10 floor, before starting the test, to verify that all items are secure. Upper doors shall be secured when a test item contains hazardous systems.
5. No personnel are allowed to remain inside the test cell if hazardous conditions exist. For example, the payload might contain pressurized containers or ordnance. The facility engineer shall consult the Safety Evaluation Form for hazard information and restrict personnel from remaining inside the test cell when hazards are present.

6. Under normal circumstances when non-hazardous conditions exist, personnel may remain inside the test cell during the test, but this is not encouraged. All personnel shall obtain the facility engineer's approval to remain inside, and shall wear ear defenders or plugs during noise-producing tests. (Noise levels were measured up to 118 dBA per four-minute test.) Sine sweeps create pure sine tones and random tests create broadband noise that can damage the ear. (See AETD SM Section 2.9.3 Tables 2 and 3 for NASA permissible noise exposure limits and Section 2.16 for PPE use and training requirements.)
7. The buddy system is mandatory in certain areas and while performing certain activities in the facility as follows:
   - Working in the subbasement equipment room.
   - Working at heights above 4 ft (1.2 m).
   - Servicing or repairing electrical equipment or electronic systems with energized circuits.
8. Use the buddy system to enter the subbasement area and exercise caution to keep from bumping the head on the low clearance pipes and ceiling appurtenances. Hardhats are optional. Personnel shall obey signs on the exciter cooling system that warn of remotely-started pumps. Do not touch or service any systems unless they have been locked and tagged out. (See Section 3.8 Lockout/Tagout in AETD SM.)
9. Do not store flammable materials in the subbasement.
10. The Team hydraulic exciter and lateral table bearings use hydraulic pumping systems, which are located in the subbasement. Only vibration technicians shall service the hydraulic systems. (See AETD SM Section 2.3 Pressure & Vacuum Systems for pressure system requirements.)
11. For new or modified fixturing, a Group Lead-approved stress analysis shall be prepared. All fixturing and attachment hardware shall have a minimum safety factor of 3.0 on yield and 5.0 on ultimate strength. Customers should be aware of their fixture dynamics in addition to the structural requirements. All fixturing shall be reviewed the Section Engineering prior to use.
12. The trench plates in the test cells are rated for a maximum rating of 12,000 $lb/ft^2$.
13. The laboratory has a small machine shop for customizing vibration fixturing. Personnel shall comply with the applicable machine shop requirements listed in AETD SM Section 3.3 when operating this machinery.
14. No drilling or grinding shall be performed on magnesium or beryllium fixtures. These fixtures shall be sent to an outside vendor when modifications are necessary.
15. All operators of the Gyrex Centrifuge shall be trained and approved in their performance by the facility supervisor. The following guidelines shall be observed when operating the centrifuge:

    The centrifuge shall be operated in accordance with the procedure in the manufacturer's operating manual.

    All test items shall be securely attached to the applicable centrifuge table, and the connecting wires shall be tied or taped down firmly.

    Before applying power, always manually rotate the centrifuge arm one complete revolution and verify that there is no interference with the setup.

Close the access lid and clasp, and leave it in the closed position throughout the centrifuge spinning operation. Wait until the arm has coasted to a complete stop before reopening the lid.

In an emergency, turn off the power toggle switch located on the top, right-hand side of the centrifuge console to quickly stop the arm.

16. Only certified operators from Code 549 and 540.5 shall operate crane, mobile aerial platforms or powered industrial trucks. Others may be given a waiver approved by Code 549 Branch Head.
17. When test articles are suspended on the crane for pyro-shock testing, the crane shall be locked out, the key controlled by the task coordinator, all personnel evacuated from the area, and all test cell doors secured/locked (both upper and lower.) The key shall be accessible in case of an emergency. If entry into the test cell is required while the load is suspended, a certified LDE operator shall man the crane controls.
18. Reference NSI document 14-11-218 "Building 10 Columns Stress Analysis Report" and NSI Memorandum dated Nov. 23, 1990. In summation, "it is recommended that a restriction be imposed prohibiting the simultaneous loading of the building (# 10 Crane 10-1) and vibration lab (Crane 7-4 & 7-6) cranes". This restriction addresses the application of simultaneous loading of the cantilevered sections of either of the two Vibration Cell Cranes and the positioning of Crane 10-1 into the column area 16-EX through 16-HX.

### 2.16.4 GSFC Contacts

Structural Dynamics Test Engineering Group, Lead: (301) 286-6480

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.16.5 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.179, Overhead and Gantry Cranes
OSHA 29 CFR Part 1910.212, General Requirements for All Machines

# 2.17 Welding Shop

## 2.17.1 Scope

This section covers the welding shop and its subsystems, located in Building 5, Rooms E42 and E10.

## 2.17.2 General

The welding shop maintains a capability to perform metal joining and heat treating services. Metal joining for spacecraft applications consists of manual and automatic gas-tungsten arc welding, manual and vacuum brazing, and soldering. Most of the welding is performed within the shop; however, welding services can be provided elsewhere by using portable equipment. The welded and/or brazed materials include steel, stainless steel, aluminum, copper, titanium, magnesium, etc. Contained within the shop are special purpose welding facilities, which are described under specific facility requirements below.

## 2.17.3 Specific Facility Requirements

Special procedures for this shop are as follows:

1. The welders shall be trained and certified to the qualification requirements of MIL Std 1595 and OSHA 1910.251 through 1910.257. Their work product shall pass an independent quality assurance inspection to MIL Std 1595 specifications on a yearly basis.
2. Personnel who operate the special purpose facilities, such as the inert gas welding chamber and vacuum furnace, shall have been trained by the equipment manufacturer or a senior technician. The shop supervisor shall approve each operator's demonstrated ability to operate the particular facility satisfactorily.
3. Cranes: Only certified operators shall operate cranes.
4. All welding shop equipment safety guards shall be installed before operating the equipment. (See AETD SM Section 3.3.4 Item 8 for safety guard information.)
5. Argon and helium gases, obtained from individual pressurized bottles, are consumed in some welding processes. Refer to Section 2.3 in AETD AM for information on handling these gases.
6. Hot work permits are not required for welding operations conducted wholly within the welding shop. However, a hot work permit is required prior to performing any welding operations outside the welding shop. (See Section 3.4.4 Item 16 in the AETD SM for how to obtain a hot work permit.)
7. Arc, gas, and laser welding equipment produce infrared, ultraviolet, and visible light in concentrations that can be harmful to operators and onlookers in the immediate vicinity. Eye damage from radiation is the principal hazard. Typically, welders in the shop wear a #10 shield, all-purpose face welding helmet to protect against eye damage. The welder shall be responsible for posting signs and erecting appropriate welding curtains or equivalent guards to protect non-welders from inadvertent exposure to harmful light. For this purpose, signs are posted and dark protective curtains can be drawn at the entrance to the welding shop. Warning signs and portable curtains or equivalent shields shall be erected at job sites outside the welding shop.
8. A permanent eyewash station for the shop is located immediately outside the entrance curtains on the Building 5 High Bay east wall.

9. Welders shall wear the PPE appropriate for the job at hand. This includes eye, face, and respiratory protection and, when appropriate, other protective clothing prescribed for the operation in progress. Specialty items may include smocks, leather gloves, and tongs for handling hot work. Filter cartridges for respirators, appropriate for the material at hand, are obtained from S&ED.
10. The welding shop floors are concrete to reduce the possibility of flying sparks or heated particles causing fires. For jobs outside the shop, use welding blankets or equivalent means to prevent fire hazards.
11. The shop contains fire extinguishers appropriate for the jobs at hand and an overhead sprinkler system. For jobs outside the shop, the welder shall ensure that appropriate fire extinguishers are readily available for immediate use at the site.
12. Welding operations emit metal vapors that shall be vented to the outside atmosphere. The shop's ventilation system has flexible ducts, which shall be placed near the welding job to vent metal vapors outside. The Industrial Hygiene Office shall verify the ventilation system is adequate on an annual basis.
13. The shop has oil and water baths for cooling hot work. Use leather gloves and tongs, or equivalent means, when handling and cooling hot work.
14. Nonhazardous waste materials can be discarded in the standard GSFC dumpsters. The shop has a recycle bin for scrap metals.
15. Hazardous wastes such as acids, solvents, etc., shall be disposed of by calling the Hazardous Waste Environmental (x6-9233) for removal. Environmental also can recommend the proper methods of storing and handling materials such as the hydrochloric acid used in the brazing process. All chemicals shall be properly stored. (See AETD SM, Section 2.5 for hazardous material requirements.)
16. The welder shall clean debris and waste materials from surfaces near welding job sites. The welder shall direct custodial personnel to clean floor and office areas but, as a safety precaution, shall not allow them to clean near facilities which present a potential hazard.
17. Inert gas welding chamber operation:

    This aluminum chamber is designed for welding materials that cannot be welded in normal atmosphere, such as titanium. It is equipped with vacuum pumps, electric dryers, and recorders for measuring vacuum and dewpoint readings.

    The operator works through glove ports and views the work through the windows that have dark welding glass for eye protection.

    Chamber is evacuated with the vacuum pump and backfilled with an inert gas of either argon or helium to one atmosphere.

    Chamber fumes are vented to the outside atmosphere.

18. Vacuum furnace operation:

    This furnace is a horizontal chamber containing a vacuum heat zone shrouded with a water jacket. Its purpose is to vacuum braze components or instruments to provide greater metallic reinforcement or bonding.

The furnace has an inert gas supply, heat exchanger, vacuum pumping system, and electrical control cabinet.

The furnace can operate at temperatures up to 2,400°F (1,315°C). The inert gas supply is used for gas quenching when heat treating various metals. The heat exchanger circulates the inert gas and cools the heat zone to room temperature.

Furnace fumes are vented to the outside atmosphere.

19. Astro Arc automatic tube welder and Jetline seam welder operation:

These two machines are designed for special purpose welding applications. The Astro Arc's welding head has a tungsten electrode which rotates inside the head and around the tube joint to be welded. It has a 100-ampere electrical power supply. The Jetline can longitudinally weld piece parts such as flat sheets, plates, cylinders, and cones. Its tungsten inert gas torch is mounted on a side beam carriage and is motor driven down a track assembly on its positioner. It has a 300-ampere power supply.

20. LASAG laser welder operation:

Refer to Section 2.6 in AETD SM for laser technology regulations.

This machine uses laser technology for welding. It is housed in its own dedicated room, Building 5, Room E10.

Prior to operating this system, the welding shop supervisor shall consult with the S&ED and follow their recommendations concerning laser operations. Some items to be addressed are listed below.

Operators shall be trained and certified by the manufacturer, or equivalent source, and undergo periodic recertification.

Operators shall undergo periodic eye and health exams.

Room E10 shall be set up to comply with GSFC regulations concerning personnel access controls, warning signs, fail-safe methods to protect personnel during laser operations, and emergency procedures. The room will have posted signs warning of visible and/or invisible laser radiation, and flashing red lights to alert personnel of the potential hazard.

### 2.17.4 GSFC Contacts

Welding Shop: Hardware Development Group Leader: (301) 286-3956

Lead Technician: (301) 286-2103

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-9660

Support Contractor Safety: (301) 286-2601

### 2.17.5 Reference Documents Unique to this Section

MIL Standard 1595, *Qualification of Aircraft, Missiles, and Aerospace Fusion Welders*

See other welding references in Section 3.4 Welding, Brazing, and Cutting (see AETD SM).

# 2.18 Computer Aided Design (CAD) Computer Facilities

## 2.18.1 Scope

This section covers the Computer-Aided Design (CAD) Computer Facility. From a safety stand point this facility requires the same safety considerations as general purpose offices.

## 2.18.2 General

This section covers the following facilities:

1. CAD Computer Facility—This facility's equipment is housed in Building 5, Rooms W205 and W076J and in Building 7, Room 272B. The equipment includes CAD computer workstations, plotters, Design Jet printer, NASTRAN server, MSD Mail and Web Server, and MSD Domain Controller. Bulk paper and computer and plotter supplies are handled and stored within the facility.

## 2.18.3 Specific Facility Requirements

Personnel working in these facilities should read and comply with the requirements for office safety described in Section 3.7 in the AETD SM, particularly with respect to computer setup and operations.

Boxes of paper, toner cartridges, digital tapes, etc., shall be stored so as not to interfere with doorways, electrical panels, and fire extinguishers. In particular, allow at least 3' (0.9 m) clearance around the electrical service panels on the wall adjoining the hallway in Building 7, Room 272B. Boxes of paper and other items shall not be stored on top of cabinets where they are likely to fall and injure personnel.

To the extent possible, toner cartridges should be recycled rather than discarded. For removal of hazardous waste, contact the Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in AETD SM). Follow instructions included with the toner cartridges when handling and replacing them. Some toner materials can be harmful to the skin upon prolonged exposure. After handling toner, thoroughly rinse affected areas of skin with clean water.

Lead personnel in computer-sensitive areas should implement precautions, such as requiring passwords, establishing personal accounts for tracking computer access, and developing read-only access mechanisms to protect sensitive computer files. Original software media should be kept in storage areas that can be secured from unauthorized access.

### 2.18.4 GSFC Contacts

Mechanical Engineering Branch, Head: (301) 286-6003 CAD Computer Facilities

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

### 2.18.5 Reference Documents Unique to this Section

See references listed in Section 3.7.6 in the AETD SM.

## 2.19 Electronic Test and Assembly Laboratory

### 2.19.1 Scope

This section covers the Electronic Test and Assembly Laboratory located in Building 5, Rooms W006, W006A–E, and C062B.

### 2.19.2 General

This laboratory performs electronic fabrication, breadboarding, assembly, and testing activities in support of flight spacecraft projects. Types of equipment and facilities located throughout the multi-room laboratory include electronic fabrication stations, low-powered lasers, pneumatically-floated granite block testing tables, solder stations, dehumidifier/dry keeper, thermal cycling chambers, Class 100 clean benches, vacuum chamber, and other specialized equipment for working with electronic equipment.

### 2.19.3 Specific Facility Requirements

1. Personnel who operate or work around Class II or lower laser equipment shall read and comply with the safety requirements described in Section 2.6 in Volume 1 of this Manual.
2. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information and Section 2.6 for specific eye protection requirements for laser operations).
3. All personnel shall use ESD controls when handling electronic hardware that is sensitive to electrostatic discharge.
4. Only authorized and trained operators shall operate specialized facilities, such as the lasers, thermal cycling and vacuum chambers, Dewars, etc. During potentially hazardous operations, the operators shall post warning signs and erect personnel control barriers to prevent inadvertent access.
5. Liquefied and pressurized gases shall be supplied in standard cylinders/canisters, and handled per the safety requirements in Section 2.3 in AETD SM. $GN_2$ supplied in standard cylinders is used to float the granite block tables. $LN_2$ supplied in standard canisters is used as the cooling medium in the thermal cycling and vacuum chamber.
6. Fume filters or extractors shall be placed as near to vapor producing activities as possible, particularly when performing soldering activities while using solder pots.
7. Alcohol, acetone, and other volatile materials shall be stored in the flammable storage cabinets provided for the purpose.
8. House-supplied compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use flexible compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
9. Small machine tools are provided for minor fabrication activities (see AETD SM Sections 3.2 and 3.3 for tool and machine shop safety requirements).
10. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in AETD SM).

11. The standard refrigerator in Room W006E is used for storing dry cell batteries and photographic film. Do not store food in this refrigerator.

### 2.19.4 GSFC Contacts

Electromechanical Systems Branch, Head: (301) 286-3637

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

### 2.19.5 Reference Documents Unique to this Section

GPR 1860.3, *Radiation Safety—Laser*

See AETD SM Section 2.3 references for pressurized vessel information.

See AETD SM Section 2.6 references for additional laser information.

See AETD SM Section 2.8 references for electrical systems information.

## 2.20 Mechanical Assembly Laboratory

### 2.20.1 Scope

This section covers the Mechanical Assembly Laboratory located in Building 5, Rooms W022, W022A, and C062A.

### 2.20.2 General

This laboratory contains facilities, equipment, and services needed for assembling mechanical structures and spacecraft hardware. There are machine tools, cleanrooms and clean benches, leveling tables, vacuum Dewars, a thermal cycling and vacuum chamber, a dehumidifier/dry keeper, and a freezer for epoxy storage.

### 2.20.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see Section 3.6 in Volume 1 for PPE information).
2. Only authorized and trained operators shall operate specialized facilities such as the machine tools, vacuum Dewars, thermal and vacuum chambers, etc. During potentially hazardous operations, the operators shall post warning signs and erect personnel control barriers to prevent inadvertent access.
3. $GN_2$ and $LN_2$ are used as cryogenic fluids in the vacuum Dewars. Liquefied and pressurized gases shall be supplied in standard cylinders/Dewars, and handled per the safety requirements in Section 2.3 in AETD SM. (See Section 2.15 in this Manual for thermal vacuum operations information.) Pressurized vessels, pressurized systems, and components shall be certified prior to use.
4. Alcohol, acetone, and other volatile materials shall be stored in the flammable storage cabinets provided for the purpose.
5. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in AETD SM).
6. House-supplied compressed air, needed for running machine tools, shall be regulated to the tool manufacturer's specified pressure rating. Compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use flexible compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
7. Mechanical structures sensitive to contamination shall be assembled in the cleanroom (Class 10,000), or in front of a clean bench (Class 100). Wear cleanroom garments and observe working procedures appropriate to the cleanliness level being maintained.
8. Hand and machine tools are provided for fabrication activities (see AETD SM Sections 3.2 and Section 3.3 for hand tool and machine shop safety requirements).
9. The freezer for storing epoxy is rated for -94°F (-70°C). Do not store food or other incompatible items with the epoxy.

### 2.20.4 GSFC Contacts

Electromechanical Systems Branch, Head: (301) 286-3637

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.20.5 Reference Documents Unique to this Section

See AETD SM Section 2.1 references for mechanical handling information.

See AETD SM Section 2.3 references for pressurized vessel information.

See AETD SM Section 3.3 references for machine shop information.

# 2.21 Thermal Coating Characterization and Environmental Testing Facility

## 2.21.1 Scope

This section covers the Thermal Coating Characterization and Environmental Testing Facility and subsystems, located in Building 7, Room 12, inner room. It also covers the Thermal Coatings Optical Measurements Laboratory, which is located in Room 12, outer room.

## 2.21.2 General

The inner room laboratory contains a variety of highly specialized facilities for measuring thermal coating degradation. These facilities include solar simulators, a solar wind facility, an electrostatic facility, a calorimetric emittance facility, and a Multi-Seeds ultraviolet degradation chamber. These specialized facilities are used to expose thermal coatings to ultraviolet radiation and to bombard them with low energy protons and electrons.

The outer room contains a variety of highly specialized electronic equipment for optically measuring thermal coatings, including: spectrometer, infrared spectra-photometer, infrared reflectometer, and spectra-reflectometer.

## 2.21.3 Specific Facility Requirements

1. Personnel who operate or work around solar simulator equipment shall read and comply with the safety requirements described in Section 2.6 in the AETD SM. In Room 12, inner room, there are black curtains that can be drawn around the solar simulators to block outside illumination, and to protect personnel from inadvertent ultraviolet radiation exposure. All personnel in the area of the solar simulators shall wear goggles rated for ultraviolet radiation protection and shall wear appropriate long-sleeved clothing for protecting the skin from ultraviolet exposure. There are warning signs and warning lights installed outside the entrance door to Room 12 to warn personnel not to enter the facility when potentially hazardous operations are in progress.
2. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information). Ear defenders are provided for working in the area when the vacuum pumps are running (see AETD SM Section 2.9 for noise information).
3. Only authorized and trained operators shall operate the specialized facilities described in Section 2.21.3 above. During potentially hazardous operations, the operators shall post warning signs and erect barriers to prevent inadvertent access by unauthorized personnel.
4. The electrostatic facility chamber and the calorimetric emittance facility use $LN_2$ as a cooling medium. The $LN_2$ is house-supplied via lines from the Building 7 thermal vacuum test area. These facilities also use liquid helium, which is supplied in standard 100-liter Dewars. Other house-supplied service lines include $GN_2$, compressed air, and water. Liquefied and pressurized gases shall be handled and used per the safety requirements of AETD SM Section 2.3.
5. Gases used in these facilities have the potential for displacing oxygen in Room 12. There is a portable oxygen monitor with an alarm available. The room's ventilating system capacity has been increased to provide sufficient airflow for maintaining normal atmospheric conditions when the facilities are running.
6. Pressurized vessels, systems, and components shall be certified prior to use.

7. Ventilation ducts are connected to the solar simulators to exhaust ozone vapors to the outside of the Building 7 roof.
8. House-supplied compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use flexible compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
9. A flammable storage cabinet is provided for storing alcohol, acetone, and other volatile materials.
10. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in AETD SM).
11. The electronic measuring equipment, described in Section 2.21.3 above, to be located in Room 12, outer room, requires authorized, trained operating personnel. However, this equipment does not present potential hazards similar to the facilities in the inner room. The only service needed for this measuring equipment is 110 VAC, and there are no harmful vapors or hazardous wastes produced.

### 2.21.4 GSFC Contacts

Contamination and Coatings Engineering Branch, Head: (301) 286-4708

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.21.5 Reference Documents Unique to this Section

GPR 1860.4, *Radiation Safety—Ultraviolet and High Intensity Light*

See AETD SM Section 2.3 references for pressurized vessel information.

See AETD SM Section 2.6 references for non-ionizing radiation information.

## 2.22 Thermal Technology Development Facility

### 2.22.1 Scope

This section covers the Thermal Technology Development Facility and subsystems, located in Building 4, Room 183A–F.

### 2.22.2 General

This laboratory contains a variety of specialized facilities for developing and testing new thermal systems for flight spacecraft. It contains systems for storing and handling anhydrous ammonia, which is used in flight thermal transfer systems such as Capillary Pumped Loop and Loop Heat Pipes. Other facilities include three thermal vacuum chambers, bake-out ovens, chillers, ammonia charging station, small machine shop, 1-ton (907 kg) bridge crane, and 1-ton (907 kg) gantry crane. The roof (i.e., ceiling) above some of the lab and office areas in Room 183 has been designated as a storage area.

### 2.22.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information).
2. Personnel who work with or around anhydrous ammonia shall read and comply with the requirements of the AETD SM Section 2.5, Hazardous Materials and Hazardous Waste, paragraph 2.5.4.
3. Only authorized and trained personnel shall operate the ammonia charging station. During potentially hazardous ammonia handling activities, the operator shall post warning signs and erect personnel control barriers to keep unauthorized personnel out of harm's way. The laboratory has ammonia sensors with automatic alarms. In the event of a leak, the ventilating system can be configured for optimal air flow, with the inner door closed and the outer door opened, to vent ammonia rapidly.
4. Local exhaust ventilation (LEV) systems can be placed near vapor-producing activities to vent unwanted vapors to the outside. Curtains can be drawn around certain facilities for further controlling the atmosphere and localized environment.
5. Only authorized and trained operators shall operate the vacuum chambers, ovens, and other special facilities. During potentially hazardous activities, the operator shall post warning signs and erect personnel control barriers to keep unauthorized personnel out of harm's way. (See Section 2.15 for thermal vacuum chamber operations information.)
6. A variety of gases and liquids are used in the laboratory. The thermal vacuum chambers use $LN_2$ as a cooling medium. The $LN_2$ is house-supplied via lines from the Building 4 outside supply tank. These facilities also use gaseous helium which is supplied in standard bottles. Other house-supplied service lines include compressed air and water. Some thermal experiments require argon and krypton gases, which are supplied in standard cylinders. Liquefied and pressurized gases/systems shall be handled and used per the safety requirements of Section 2.3 in AETD SM. Pressurized vessels, systems and components shall be certified.

7. House-supplied compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
8. Chiller equipment that contains either ethylene glycol or DC200 refrigerants is used to cool thermal transfer systems and experiments (see Section 2.3 in AETD SM for pressurized systems information).
9. Two vented (to outside) flammable storage cabinets are provided for storing alcohol, acetone, and other volatile materials. A separate vented (to outside) flammable storage cabinet is provided for ammonia.
10. The 1-ton (907 kg) gantry crane has a manual traverse and electric-driven hoist. Use extreme caution if the gantry must be operated. Because of the cramped overhead ceiling space, parts of the gantry structure are straddled by building utility lines and pipes. Check for adequate clearances before moving the gantry structure. Only certified operators shall operate cranes.
11. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in AETD SM).
12. Items to be stored in the designated areas above the ceiling in parts of Room 183 shall not exceed the capacity rating of 30 lb/ft$^2$ (146 kg/m$^2$). Note that this capacity is much lower than a typical floor storage area.
13. One area is reserved for assembly, fabrication, repair, and storage of electronics equipment (see Section 2.8 in AETD SM for Electrical Systems and Equipment).
14. Room 183B contains a fabrication/checkout area which can be operated as a controlled cleanroom. Observe posted cleanroom entry and working procedures applicable to the current cleanliness level being maintained.
15. Room 183E contains an emergency eyewash station.
16. Room 183G contains a small machine shop (see AETD SM Section 3.3 for Machine Shop safety requirements).

### 2.22.4 GSFC Contacts

Thermal Engineering Branch, Head: (301) 286-5115

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.22.5 Reference Documents Unique to this Section

NSI Document 01-05-120, *Anhydrous Ammonia Safety Operating Procedure*

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See AETD SM Section 3.3 references for machine shop information.

See Section 2.15 references for thermal vacuum operations information.

## 2.23 Thin Film Deposition Facility

### 2.23.1 Scope

This section covers the Thin Film Deposition Facility and its subsystems, located in Building 4, Room 195A–B.

### 2.23.2 General

This laboratory contains a variety of specialized facilities for depositing thin films on items such as astronaut visors. It contains vacuum deposition and thermal cycling chambers that use resistive heating, and $GN_2$ and $LN_2$ cryogens. Other facilities are the distilled water system, chemical mixing area, vacuum drying oven, and clean bench.

### 2.23.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 PPE information).
2. A local exhaust ventilation (LEV) system over the sink exhausts vapors produced when mixing chemicals needed for the deposition process. The distilled water system provides clean water for mixing chemicals, cleaning, and rinsing items to be processed with thin films.
3. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see AETD SM Section 2.5).
4. Only authorized and trained operators shall operate the vacuum deposition chambers, vacuum drying oven, and other special facilities. During potentially hazardous activities, the operator shall post warning signs and erect personnel control barriers to keep unauthorized personnel out of harm's way. (See Section 2.15 for thermal vacuum testing information.)
5. A variety of gases and liquids are used in the laboratory. The vacuum chambers use $LN_2$ as a cooling medium. The $LN_2$ is house-supplied via lines from the Building 4 outside supply tank. Gaseous oxygen and nitrogen are supplied in standard cylinders. Other house-supplied service lines include compressed air and water. Liquefied and pressurized gases shall be handled and used per the safety requirements of AETD SM Section 2.3.
6. House-supplied compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use compressed air hoses unless they are certified. Pressurized vessels, systems, and components shall be certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
7. Room 195B contains a clean bench and plastic enclosure for handling astronaut visors. Observe posted cleanroom working procedures when handling the visors.
8. The chamber hoist mechanism used on the HVEC Vapor Deposition Chamber has been determined by RECERT to not be a crane.

### 2.23.4 GSFC Contacts

Contamination and Coatings Engineering Branch, Head: (301) 286-4708

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.23.5 Reference Documents Unique to this Section

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See Section 2.15 references for thermal vacuum operations information.

## 2.24 Thermal Coatings Application Facility

### 2.24.1 Scope

This section covers the Thermal Coatings Applications Facility and its subsystems, located in Building 4, Rooms 195A and 195C.

### 2.24.2 General

This laboratory contains two commercially-supplied spray booths in which thermal coatings are sprayed onto flight hardware. The small Binks spray booth, located in Room 195A, contains a dehumidifier and is used primarily for spraying silicone paints. The large JBI spray booth, located in Room 195C, is used for spraying thermal coatings other than silicone paints. The thermal coatings can be various paints, lacquers, polyurethanes, etc.
Other facilities in the laboratory are the air purifier system for the respirator masks, electric oven, thermal vacuum oven, freezer, mixing station with fume hood, and carbon monoxide monitoring equipment.

### 2.24.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information). When spraying polyurethane paints containing isocyanates, the operator shall wear a respirator. The respirator shall be connected to the Catalite air purifier system, which supplies a continually renewing positive flow of fresh air to the wearer.
2. Only authorized and trained operators shall operate the spray booths, Catalite compressed air purifier, thermal vacuum oven, and other special facilities. During potentially hazardous activities, the operator shall post warning signs and erect personnel control barriers to keep unauthorized personnel out of harm's way.
3. Laboratory personnel shall monitor the condition of the air filters in the paint spray booths and replace them as required. These furnace-type, roughing filters trap airborne contaminants and paint sediments before they are exhausted to the outside.
4. House-supplied compressed air is provided for the paint sprayers. Regulate the air pressure for each sprayer per the manufacturer's specifications. Compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
5. The laboratory contains a carbon monoxide (CO) monitoring system, which sounds an audible alarm whenever a harmful CO concentration is detected. All personnel shall evacuate the facility when the alarm sounds.
6. A permanent eyewash station is located in Room 195C.
7. A fume hood is provided for mixing paints and volatile materials. (See AETD SM Section 2.5.4 for fume hood operational information).
8. Four flammable storage cabinets are provided for storing paints and solvents. One storage cabinet is provided for storing non-flammable materials.
9. Store silicone paints in the freezer in Room 195A. Do not store food in this freezer.

10. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see AETD SM Section 2.5).

### 2.24.4 GSFC Contacts

Contamination and Coatings Engineering Branch, Head: (301) 286-4708

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.24.5 Reference Documents Unique to this Section

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See Section 2.15 references for thermal vacuum information.

# 2.25 Molecular Kinetics Facility

## 2.25.1 Scope

This section covers the Molecular Kinetics Facility and its subsystems, located in Building 4, Rooms 193A–B.

## 2.25.2 General

This laboratory contains thermal vacuum chambers and special equipment necessary to measure outgassed products during vacuum bake-out testing. Room 193A is a Class 10,000 cleanroom with flowhoods with access to a 2.5' diameter x 5' long (0.76 m x 1.52 m) horizontal vacuum chamber located in Room 193B for performing bake-outs. Room 193B contains a Molecular Kinetics (MOLEKIT) vacuum facility with two vacuum bell jars connected to a common pumping system. The MOLEKIT is used for precision measurement of outgassed materials per ASTM E-1559-00 "Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials". Quartz crystal microbalance sensors inside the vacuum chambers measure the outgassed materials.

## 2.25.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see Section 3.6 in Volume 1 for PPE information). Wear cleanroom garments appropriate for the cleanliness level being maintained in the cleanroom staging area at the entrance to the large horizontal vacuum chamber.
2. Only authorized and trained operators shall operate the vacuum chambers and other special facilities. (See Section 2.15 for thermal vacuum operations information.)
3. Use extreme caution when handling and cleaning Thermoelectric Quartz Crystal Microbalance (TQCM) sensors. The QCM systems measure and record condensable masses which deposit on a piezoelectric crystal. The crystal is very susceptible to damage from excessive force, so handle and clean the sensors as gently as possible. Precision measurements in the laboratory depend on having reliable QCMs in good working order.
4. Liquid and gaseous nitrogen used in the vacuum chambers are usually supplied in standard Dewars/cylinders, although $LN_2$ may be supplied by lines from the tank outside Building 4. Liquefied and pressurized gases shall be handled per the requirements of Section 2.3 in Volume 1. Pressurized vessels, systems, and components shall be certified.
5. A vacuum oven is used for baking out epoxies. (See Section 2.5 in Volume 1 for hazardous materials and waste information.) For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see Section 2.5 in Volume 1).
6. House-supplied, compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use compressed air hoses unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.

### 2.25.4 GSFC Contacts

Contamination and Coatings Engineering Branch, Head: (301) 286-4708

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

### 2.25.5 Reference Documents Unique to this Section

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See AETD SM Section 2.15 references for thermal vacuum information.

## 2.26 Contamination Engineering Analysis Facility

### 2.26.1 Scope

This section covers the Contamination Engineering Analysis Facility and its subsystems, located in Building 84.

### 2.26.2 General

This facility is equipped with a variety of optical devices, which are used to measure contamination on flight hardware. Building 84 houses a medium-sized, Class 10,000 cleanroom containing an optical bench, laser systems, and automatic scanning microscopes. The optical bench has low-powered lasers and detectors designed for making light-scattering measurements from contaminated optical and reflective surfaces.

The outer staging area for the cleanroom contains subsystems, which support the optical measurement systems inside the cleanroom. One subsystem is the carbon dioxide/snow equipment used for cleaning hardware. A part of the outer room has been designated a temporary storage area for various equipment (e.g., a small, out-of-service vacuum chamber) destined for installation in other buildings on the Goddard complex.

### 2.26.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information). Cleanroom garments required for Class 10,000 conditions must be worn in the cleanroom.
2. Only authorized and trained operators shall operate the optical bench, laser systems, and scanning microscopes. Personnel who operate or work around laser equipment shall read and comply with the safety requirements of AETD SM Section 2.6. Operators shall wear eye protection appropriate for the type of laser operations being conducted. Building 84 has laser warning signs posted at its entrance, and at the entrance to the cleanroom. All personnel shall obey all laser warning signs, and must not enter areas where potentially hazardous laser operations are in progress.
3. The cleanroom contains two pass-through windows with alcoves in one wall. Computers, monitors, and printers are placed in the alcove openings, away from the scanning microscopes and optical devices. This protective measure helps to keep contaminants produced by the computer equipment and operator from affecting sensitive optical measuring operations.
4. There is an emergency exit door with a push bar leading directly from the cleanroom to the outside of Building 84. After an emergency exit, it may be necessary to call the GSFC guard to reenter Building 84 if the key card was left in the cleanroom's garment changing room.
5. The carbon dioxide ($CO_2$) required by the $CO_2$ /snow cleaning system is supplied in standard cylinders. Liquefied and pressurized gases shall be handled per the requirements of AETD SM Section 2.3.
6. House-supplied, compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Do not use compressed air hoese unless they are certified. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.

7. Solvents and other flammables are stored in the flammable storage cabinet beneath the fume hood. The fume hood is provided for cleaning activities and for working with volatile materials. (See AETD SM Section 2.5.4 for fume hood operational information.)
8. A permanent eyewash and shower station are located adjacent to the fume hood in the staging area.
9. For removal of hazardous waste, contact Hazardous Waste Environmental, telephone x6-9233 (see AETD SM Section 2.5).

### 2.26.4 GSFC Contacts

Contamination and Coatings Engineering Branch, Head: (301) 286-4708

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.26.5 Reference Documents Unique to this Section

GPR 1860.3, *Radiation Safety—Laser*

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See AETD SM Section 2.6 references for additional laser information.

## 2.27 Recertification (RECERT) Laboratories

### 2.27.1 Scope

This section covers the Recertification (RECERT) Laboratories supporting the Pressure Vessel and Pressurized Systems (PV/S) and Lifting Devices and Equipment (LDE) Program elements. The PV/S Lab is located in Building 302; the Nondestructive Testing (NDT) Lab is located in Building 10, Room 130; and the LDE Sling Test Lab is located on the balcony of the Building 7/10 Truck Lock.

### 2.27.2 General

1. Only authorized and trained/certified personnel shall operate facility equipment.
2. The RECERT PV/S Lab contains facilities for performing pneumatic and hydrostatic pressure testing of pressure systems and components. The primary site for conducting pressure testing is at the remotely located Building 302. Whenever practical, equipment is brought to the Lab for testing. Where it is impractical to remove equipment from a facility, field tests are conducted at the facility using portable testing equipment. Examples of articles tested include relief valves, piping systems and components, flexible hoses, pressure vessels, Dewars, vacuum chambers, structural hardware, and flight hardware. Test equipment certified for ultra-pure service is available for pneumatic testing.
3. The NDT Lab is located in Building 10, Room 130. Surface inspections are performed using the Liquid Penetrant and Magnetic Particle NDT methods. Both visible and fluorescent techniques are employed for each method. For items too large for the NDT Lab to accommodate, field NDT is performed using portable equipment.
4. The RECERT LDE Group performs tensile strength and proof testing of slings, straps, cables, and structural hardware using the Roberton/Schwartz horizontal Sling Test Lab in the Building 7/10 Truck Lock.

### 2.27.3 General Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see Section 3.6 for PPE information). Eye protection requirements vary with the different types of activities, for example, welding/brazing, grinding, fluorescent inspections using UV-A sources, and hydrostatic and pneumatic pressure testing. Hearing protection shall be worn when testing pressure relief valves. Latex or rubber nitrile gloves, and disposable coveralls are required when handling potentially hazardous materials.
2. Only certified personnel shall weld or braze. Hot work permits shall be obtained for all welding or brazing operations. See AETD SM Section 3.4 for additional welding information, and Section 3.4.4, Item 15, for hot work permit information.
3. Solvents and other flammables are stored in the flammable storage cabinets in each of the lab areas.
4. The PV/S, NDT, and LDE Labs generate a variety of hazardous waste materials. PV/S and LDE testing and NDT processes produce contaminated rags and garments, empty aerosol cans and solvent bottles, hydraulic fluids, and other materials that shall be handled and disposed of as hazardous waste. Empty containers and soiled rags are kept in separate waste disposal cans until picked up and

disposed of. There is a spill control station, with Polysorb packages, for controlling minor fluid spills such as hydraulic oil. Hazardous Waste Environmental (x6-9233) removes all wastes.

### 2.27.4 Specific PV/S Lab Requirements

1. A safety feature of the RECERT PV/S Laboratory is its isolated location in Building 302 at the GSFC Magnetic Test Site (MTS). To gain entry into the MTS compound, personnel shall insert an authorized keycard to open the motorized gate before driving onto the grounds or call Security from the phone provided next to the gate. The red, flashing warning light above the lab entrance shall be activated whenever potentially hazardous activities are in progress.
2. Instructions shall be posted on the lab door for obtaining emergency access to the lab.
3. Only authorized and trained operators shall operate pressure testing equipment.
4. The pressure testing systems have Haskel pressure intensifiers that can achieve pneumatic ($GN_2$) pressures up to 35,000 psi (242 Mpa) and hydrostatic (water) pressures up to 50,000 psi (345 Mpa). $GN_2$ is supplied in standard DOT compressed gas cylinders with pressure ratings of 2,640 psi (18.2 Mpa) and 6,000 psi (41.4 Mpa). There is a permanent rack for storing these cylinders outside Building 302 along the north wall. Pressurized gases shall be handled per the safety requirements of AETD SM Section 2.3.
5. The high pressure intensifier/system and/or high hazard lab equipment shall not be left unattended while energized.
6. The primary pressure testing enclosure, 3.0’ x 2.5’ x 2.5’ (0.91 m x 0.76 m x 0.76 m) is designed to completely surround an article undergoing pressure testing. The enclosure is rated for pressure testing up to 50,000 psi (345 Mpa). The test article is installed in the enclosure through its hinged Lexan lid, and the lid is closed securely. If the article fails while undergoing pressure testing, the Lexan enclosure will prevent ejected pieces from injuring operating personnel.
7. The Lab’s portable testing systems can be taken into the field for on-site pressure testing. Operators shall post warning signs and erect barrier tapes or shields to protect area personnel from injury. As a safety precaution, potentially hazardous testing activities may be scheduled for after normal working hours to limit the number of people in the area.
8. Pressure vessels, systems, and components shall be certified.
9. PV/S inspectors test pressurized flight systems that either have contained, or may eventually contain, hazardous materials such as ammonia or hydrazine. The test requestor shall verify that these systems have been drained of all hazardous materials, purged, and cleaned thoroughly before they are brought to the lab for testing. A flight project Quality Assurance representative shall be allowed to be present for all testing. Exercise extreme caution to keep test process materials from contaminating the item(s) under test.
10. There is a Padlock Control Center cabinet in Building 302, Room 115. Sign for and obtain security devices for performing Lockout/Tagout procedures from this cabinet.
11. There is a storage area located in the basement of Building 302, in Room 10, as well as a small out-building at the northwest corner of Building 302 for storing gages, valves, piping, and spare plumbing parts.
12. There is a portable eyewash station located at the doorway of Building 302, Room 115.

### 2.27.5 Specific NDT Lab Requirements

1. Some NDT methods may create potentially hazardous conditions for the operator. Several liquid penetrant techniques produce fumes, which should not be inhaled. A local exhaust ventilating (LEV) system is provided in the NDT Lab. (See AETD SM Section 2.5.4 for fume hood operational information.) In the event the LEV cannot sufficiently remove hazardous fumes, the NDT inspectors shall wear respiratory protection suitable for the task. Forced air respirators which keep a positive flow of fresh, purified air flowing to the mouth and nose via a portable fresh air pumping system are also available. The dry powder magnetic particle testing technique employs a non-toxic iron powder. This powder can, through repeated use, degrade into a fine, dry dust. This condition must not be allowed to occur because if the dust exceeds the minimum explosive concentration, a dust explosion could occur in the presence of an ignition source. Therefore, at the conclusion of each test, residual iron powder must be cleaned up, preferably with a vacuum cleaner. NDT operators using the dry powder magnetic particle technique should wear a dust mask and safety goggles to protect the mucus membranes and eyes from irritation.
2. Only qualified and authorized operators shall operate the M2000 magnetic particle test equipment. This equipment can develop low-voltage currents up to 2,000 amperes. (See AETD SM Section 2.8 for electrical system information.)
3. Personnel who operate the ultraviolet black light equipment shall read and comply with the non-ionizing radiation safety requirements of Section 2.6 in Volume 1 of this Manual.
4. There is a permanent eye wash station located in Building 10, Room 130.
5. There is a storage area located in Building 10, Room 130A.

### 2.27.6 Specific LDE Sling Test Lab Requirements

The RECERT LDE Group operates the Roberton/Schwartz horizontal break and proof testing machine, located in the Building 7/10 Truck Lock. Only trained and authorized operators shall operate the Roberton/Schwartz facility. The following safety considerations apply to this facility:

1. Do not exceed the balcony's floor loading capacity of 150 lb/ft$^2$ (732 kg/m$^2$).
2. Use the 500-lb (227 kg) monorail jib crane for lifting articles from the truck lock floor to the balcony.
3. Only certified operators shall operate the crane.
4. A sign shall be posted at the vertical ladder and stairs warning that access to the lab is for authorized personnel only. Contact the RECERT group leader for permission to enter.
5. The break and proof testing machine has a hydraulic pumping system capable of applying loads up to 150,000 lb (68,000 kg). Only authorized and trained personnel shall operate the machine. Follow the step-by-step procedure printed on the inside cover of the operator's console. Always close and secure the hinged steel safety gate before applying loads, to protect personnel from being injured by ejected pieces.
6. Due to the configuration of the equipment and limited floor space, good housekeeping must be maintained.
7. There is a portable eyewash station near the operator's console.

### 2.27.7 GSFC Contacts

RECERT Manager: (301) 286-4209

RECERT Support Function, Manager: (301) 286-5183

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-2601

### 2.27.8 Reference Documents Unique to this Section

See AETD SM Section 2.3 references for pressurized systems information.

See AETD SM Section 2.5 references for hazardous materials and waste information.

See AETD SM Section 2.6 references for ultraviolet radiation information.

# 2.28 W045 Mechanical Assembly Laboratory, W51 Integration and Test Facility, and W27 Advanced Development Facility

## 2.28.1 Scope

This section covers the Mechanical Assembly, Integration, and Test facilities for the Mechanical Engineering Branch located in Building 5. The Mechanical Engineering Branch is responsible for the mechanical design, buildup, testing, and checkout of spacecraft and instrument structures and deployment systems.

## 2.28.2 General

The Mechanical Assembly Laboratory, Rooms W045 and W069, is used for the mechanical buildup, testing, and checkout of spacecraft and instrument structures and small deployment systems. It is also used for storage of flight hardware, GSE, tools, miscellaneous parts, materials and supplies, and light assembly work.

The Integration and Test Facility, Rooms W047 and W051, is used for assembly, checkout and test of flight hardware. Mechanical activities on contamination sensitive hardware is performed in the 500 ft^s Class 10,000 cleantent located within Room W051 of the facility. Room W047 is primarily used to set up GSE but may also be used for light assembly and/or integration work.

The Advanced Development Laboratory, Room W027, is used for structures and deployment systems development work and flight assembly. This includes fit-checking models, fit checking and applying thermal blankets, deploying solar panels and other moving devices, evaluating dynamic mechanisms, etc. Electro-explosive devices (EEDs) and other release devices are sometimes actuated to deploy dynamic systems.

### 2.28.3 Specific Facility Requirements

1. All personnel shall wear PPE appropriate for the activity at hand (see AETD SM Section 3.6 for PPE information).
2. Only authorized and trained operators shall operate specialized facilities such as the machine tools, etc. Only certified operators shall operate the cranes and the monorail hoists in Rooms W027, W045 and W051. During potentially hazardous operations, the operators shall post warning signs and erect personnel control barriers to prevent inadvertent access.
3. Store alcohol, acetone, and other volatile materials in the flammable storage cabinets provided for the purpose.
4. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see AETD SM Section 2.5).
5. $GN_2$ is used for purging and epoxy application. LN2 is used for transferring and temporary storage of pre-mixed epoxies. Liquefied and pressurized gases shall be supplied in standard cylinders/Dewars and handled per the safety requirements in Section 2.3 in Volume 1. Pressurized vessels, systems, and components shall be certified.
6. Hand tools are provided for fabrication activities (see AETD SM Section 3.2 for hand tools).

7. The freezer in Room W45 for storing epoxy is rated for -94°F (-70°C). Do not store food or other incompatible items with the epoxy.
8. Personnel who actuate EEDs, or work around hardware containing EEDs, shall read and comply with the safety requirements described in AETD SM Section 2.
9. There is an electrical ground plate on the east wall of W27 near the deployment apparatus for achieving effective grounding of sensitive hardware and EED circuits.
10. Two house-supplied lines of pressurized air are located on the east wall of W27. These lines can supply the air pads used for payload handling activities. Compressed air shall not be used for cleaning except where reduced to 30 psi (207 kpa), and then only with effective chip guarding and proper PPE. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.

### 2.28.4 GSFC Contacts

Mechanical Engineering Branch, Head: (301) 286-6003

Lead Mechanical: (301) 286-8116

S&ED: (301) 286-2281

AETD Safety Manager: (301) 286-1035

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-9660

Support Contractor Safety: (301) 286-2601

### 2.28.5 Reference Documents Unique to this Section

See AETD SM Section 2.1 references for mechanical handling information.

See AETD SM Section 2.2 references for ordnance information.

See AETD SM Section 2.3 references for pressurized vessel information.

See AETD SM Section 3.2 references for hand tool information.

## 2.29 Materials Engineering Branch Facilities

### 2.29.1 Scope

This section covers the facilities, laboratories, and subsystems of the Materials Engineering Branch, Code 541, located in Building 30. For reference, these facilities have been listed below, by room number, according to their general function:

| **Chemical Analysis Laboratories** | |
|---|---|
| 104 | Thermal Analysis & FTIR Spectroscopy |
| 110 | Mass Spectroscopy, GC/MS |
| 114 | Scanning Electron Microscopy |
| 123 | Detector Development SEM |
| 124 | X-Ray Photoelectron Spectroscopy |
| 126 | X-Ray Diffraction |
| 130 | Optical Emission Spectroscopy |

| **Physical Analysis Laboratories** | |
|---|---|
| 111 | Vacuum |
| 125 | Mechanical Testing |
| 136 | Outgassing Test Facility |
| 171 | Nondestructive Evaluation |
| 177 | Metallography |
| 193 | Physics & Optics |
| 197 | Instrumentation |
| Bsmnt* | Immersion Ultrasonic Facility |

| **Processing Laboratories** | |
|---|---|
| 103 | Cryogenics |
| 105 | Ceramics Processing |
| 131 | Machine Shop |
| 139 | Heat Treatment |
| 140 | Polymer Processing |
| 148 | Parylene Processing |
| 158 | Tribology |
| ---- | Cleanrooms (146, 148A, 158A) |

| **Miscellaneous** | |
|---|---|
| 164 | Bonded Storage |
| 166 | Chemical Storage |
| Bsmnt | Chemical Storage |
| Bsmnt | Cabinet Storage (Non-chemical) |

(Bsmnt*= Basement of Building 30)

### 2.29.2 General

The Materials Engineering Branch (MEB) is an integral part of the Mechanical Systems Center. The MEB conducts laboratory investigations to solve material problems, and conducts applied research activities in materials technology and development in support of future needs of the GSFC spacecraft, instrument, and technology programs. In providing this support, the MEB maintains and operates a significant number of sophisticated analytical instruments. The MEB Website (http://code541.gsfc.nasa.gov/) a comprehensive description of the MEB capabilities. The topics presented in Volume 1 of this Safety Manual address many of the potential hazards associated with the special and often unusual equipment used in the MEB. Some potential hazards in Building 30 (with Volume 1 Section References) are as follows:

- Pressurized systems (AETD SM Section 2.3.1).
- Processes using hazardous chemicals and solvents (AETD SM Section 2.5).
- Cryogenic systems (AETD SM Section 2.5.4.15–16).
- Radiation sources (lasers, x-ray, infrared, ultraviolet, AETD SM Sections 2.6 and 2.7).
- High voltage electrical systems (AETD SM Section 2.8).

- Mechanical energy-producing machinery (AETD SM Section 3.2).
- High temperature furnaces and thermal-cycling ovens (AETD SM Section 3.9).

MEB personnel should identify potential hazards in their operations, consult the appropriate Sections of the AETD Safety Manual, and follow the requirements therein. The remainder of this section presents particulars that apply directly to the Building 30 operations.

### 2.29.3 Specific Facility Requirements

#### A. General Safety Design Features for Building 30

In addition to typical building services and emergency systems (e.g., automatic sprinklers and smoke detectors), Building 30 contains the following safety design features:

1. All laboratory entrance doors are held open via an electromagnetic mechanism. In the event of a building emergency, the doors will automatically close for the purpose of fire control.
2. Visual beacon and audible alarm warning system in hallways detect the presence of hazardous gases or vapors. The three gases being monitored are hydrofluoric, phosphine, and silane. The alarm system is connected to the GSFC emergency console (x8080), which is alerted automatically whenever a warning or evacuation alarm sounds. The yellow warning beacon and audible alarm will activate when the 50% threshold level of any of the three gases is detected. Any personnel in Building 30 may contact the Code 553.0 Detector Development Lab FOM (pager # 1-877-330-6101) who will investigate the problem, recommend further actions, and determine whether building evacuation is necessary while in the warning condition. The red evacuation beacon and audible alarm will activate when a hazardous vapor concentration is confirmed at the 100% threshold level. It is mandatory that all personnel shall evacuate the building when the red beacon illuminates and the audible evacuation alarm sounds.
3. Argon and liquid nitrogen (LN2), storage tanks, and vaporizer are located outside of Building 30, south side. A liquid nitrogen fill station is located in room 103 for dewars used in various labs. Refer to the operational and control requirements for hazardous and cryogenic materials described in Section 2.5 in Volume 1. Also, the vaporizer creates a high noise environment requiring the use of ear protection according to the requirements of Section 2.9 in Volume 1. Permanent plumbing lines supply the argon, GN2, and LN2 directly to various laboratories inside the building where needed. Permanent vent lines leading to the Building 30 roof exhaust vapors from the equipment using these gases.
4. Pressurized vessels, systems, and components shall be certified prior to use.
5. MSA 5300 oxygen monitoring system has a warning beeper, klaxon horn, and automatic valve that shuts off the nitrogen supply if the room's oxygen level falls below 19.5% and fans for external venting. The warning beeper sounds if the oxygen level approaches 19.5%. Oxygen sensors are located in Room 103 (two each), Room 105 (one each), and Room 197 (one each.) This is a local monitoring system that is not connected to the GSFC emergency console (x8080.)
6. There are separate rooms dedicated for the storage of hazardous chemicals (see Paragraph D below.)

7. The facility also has a MQUAL laboratory acid neutralization wastewater treatment system. All laboratory sinks and wastewater outlets on the north side of the building drain into this automatic treatment system, located in the basement. All labs on the southern half of the building have individual acid neutralization systems. The wastewater is treated with a solution to neutralize it before being discharged into the sanitary sewer system.

### B. Personal Protective Equipment (PPE)

MEB personnel shall wear and/or use the appropriate PPE when performing hazardous tasks such as handling/using cryogenic liquids and pressurized systems, mixing hazardous chemicals, operating lasers and x-ray machines, handling specimens in and around thermal ovens, operating machinery, etc. Guidelines describing when and how to use PPE, and the training requirements, are contained in AETD SM Section 3.6.

### C. Chemical Spill Kits and Chemical Wastes

MEB personnel shall wear and/or use the appropriate PPE when performing hazardous tasks such as handling/using cryogenic liquids and pressurized systems, mixing hazardous chemicals, operating lasers and x-ray machines, handling specimens in and around thermal ovens, operating machinery, etc. Guidelines describing when and how to use PPE, and the training requirements, are contained in AETD SM Section 3.6.

### D. Chemical Storage (Rooms 166 and Basement 5)

Refer to AETD SM Section 2.5.1 and follow guidelines described in the AETD Hazard Communication Program. Building 30 contains two dedicated chemical storage rooms that have the following safety and health features:

1. Locked doors with controlled access and a sign-in/sign-out log for storing and obtaining materials.
2. Posted signs directing personnel to MSDS Pro at http://msds where material safety data sheets (MSDSs) are on file and readily accessible to all personnel.
3. Personal protective equipment dedicated to the room.
4. Explosion proof electrical equipment that meets the National Electrical Code Division 1, Class 2 requirements.
5. Permanent eyewash and shower.
6. Dumbwaiter elevator connecting first floor (Room 166) with basement (Room 5), so chemicals do not have to be carried up the stairs.
7. Clearly marked dedicated shelving for segregating dissimilar materials.
8. Spill kits for aggressive and non-aggressive fluids.
9. Epoxy flooring with raised sills for containing spilled materials.
10. Outer walls designed to blast outward.
11. Dedicated air ventilating systems (Room 166 has specially marked emergency switches inside and outside the entrance door, for activating/resetting the roof exhaust fan.)
12. Specially designed protective containers for transporting hazardous materials in glass bottles.
13. Flammable storage cabinets with integral VAP-R activated charcoal filters for absorbing fumes.

### E. Ozone Depleting Chemical Storage

Quantities of oxygen depleting chemicals such as Freon are stored in the basement chemical storage

area.

### F. Safety Guards and Interlocks

Unique equipment and instruments in the MEB have built-in safety mechanisms designed to protect personnel and equipment. For example, some equipment items have protective shields and covers, interlocked to the control system, that must be closed and secured before operating them. This is especially true for various instruments that use x-ray tubes and laser light sources, the argon plasma source in the Fisons Instruments Optical Emissions Spectrometer, and/or rotating machinery. (See Paragraphs K and L below for radiation systems training and use requirements.) Typically, if the protective shield or cover is opened during operation, the power is shut off to the source of the potential hazard. Personnel shall inspect these protective shields and interlocks to verify that they are correctly installed and in proper working order before operating equipment. Also, personnel shall never disable or override any safety guards or interlocks.

Extractors in room 140 and water purification systems in rooms 104 and 130 have systems to detect leaks and close valves if a leak is detected.

Certain facility subsystems, such as thermal-cycling ovens and vacuum diffusion pumps, require house-supplied chilled water for cooling. In such cases, the chilled water supply lines are interlocked to the control system for overheat protection. If the chilled water flow is interrupted, the interlock sensor automatically shuts off the power to the heat producing equipment. Thermal cycling ovens have over and under temperature detectors, which shut systems down if temperature excursions are detected.

### G. Fume Hoods and Local Exhaust Ventilating Systems

All laboratories that handle or use chemicals have permanent fume hoods with powered ventilating exhausts leading to the roof. Hoods should be evaluated prior to use and annually thereafter by the GSFC Industrial Hygiene personnel to verify adequate air flow. When used, front closures must be positioned to optimize performance. Some laboratories also contain local exhaust ventilating systems with flexible ducts. The flexible ducts should be positioned as close as practical to the job at hand for maximum effectiveness.

### H. Eyewash and Shower Stations

All laboratories that handle or use chemicals have permanent eyewash and shower stations located within 100 feet of the lab.

### I. Liquid Nitrogen Fill Station (Room 103)

Personnel use the Room 103 fill station to transfer LN2 from the house supply lines to 150-liter Dewars. Once filled, the portable Dewars are rolled on their casters into other laboratories for use at facilities not supplied by permanent house lines. Personnel who perform the filling operations shall use the appropriate PPE and be trained in the handling/use of cryogenic liquids and compressed gases, with annual refresher training. (See Paragraph A.4 for information on oxygen deficiency monitoring.)

### J. Cleanrooms (Rooms 146, 148A)

The MEB maintains and operates two cleanrooms at the cleanliness level of Class 10,000 (M5.5). Contained within the main cleanrooms are flow benches maintained to Class 100 (M3.5), fume hoods, and eyewash/shower stations. See Section 2.2 for cleanroom operating requirements and garment specifications.

### K. Radiation Source (Room 130)

(Refer to AETD SM Section 2.7.4 for training and use requirements for radiation systems.) The x-

ray fluorescence (XRF) system uses a combination of detectors and radioactive sources to perform elemental analysis of bulk specimens. Personnel who operate the XRF system shall lock the sealed x-ray sensor probes in the designated cabinet when not in use, and control access to them while in operation. The locked cabinet shall be clearly labeled with Radiation Warning signs. The Safety & Environmental Division (S&ED) shall leak test and inspect the sealed probes quarterly, at a minimum.

### L. Lead-Lined X-Ray Room (Room 171A, 171B)

(Refer to AETD SM Section 2.7.4 for training and use requirements for radiation systems.) These lead-lined room contains three facilities that use x-ray tubes. The Film Radiographic facility uses a 200-kV tube head, the Digital Radiography facility uses a 210-kV x-ray source, and the CZT characterization facility uses a 160 kV source. Safety features of the lead-lined room are as follows:

14. Posted signs in the area clearly warning of hazardous x-ray operations, and warning lights that illuminate during operations.
15. Complete room coverage with initial design lead thickness as follows: door and floor 9.525 mm; walls and ceiling 6.350 mm. Based upon an on-site leak test after initial installation, certain surfaces of the room near the x-ray sources were beefed up with additional lead thickness to comply with OSHA and NASA standards.
16. RaySafe Alarm Panel installed by the manufacturer, Technical Equipment Marketing, with clearly written safety and emergency procedures.
17. Closed circuit television system monitors the room to ensure no personnel are inside before starting x-ray operations, and to monitor the test specimens.
18. No personnel are allowed inside the room during operation of the x-ray sources. The room is designed so that personnel cannot be locked inside the room. Emergency exit is always available.
19. Emergency stop switches for both systems located conveniently inside the room.
20. The room access door is interlocked with the control system so that the x-ray source cannot be actuated unless the door is closed. If the door is inadvertently opened during operation, the power is automatically shut off to the x-ray sources.

### M. Electrostatic Discharge Station (Room 146, 177B)

Separate areas in Rooms 146 and 177B have been set up with equipment and materials for personnel to use when handling or working on flight electronics. Handling procedures and detection systems have been developed to avoid the buildup of electrostatic charges that can damage sensitive flight electronics.

### N. Laser Dilatometer (Room 193)

Significant amounts of liquid helium are used to cool the dilatometer chamber and as such the lab has been designated as having an oxygen Deficiency Hazard Rating of "1." The lab is equipped with a oxygen sensor and audible and flashing light warning.. No personnel shall have a permanent desk located in this laboratory.

### O. Immersion Ultrasonic Inspection System (Basement G-5)

This facility has been set up in room B-9 located in the basement. It contains a mechanical ultrasonic scanner and a large water immersion tank, 72" x 40" x 40" (183 cm x 102 cm x 102 cm.) The facility is convenient to water supply and drain lines, and can be set up for unattended operation for long duration testing (up to periods of 8 hours.) For safety, there is minimal personnel traffic in

the area, and the surrounding cage can be locked to prevent unauthorized or inadvertent personnel access during unattended operations.

### 2.29.4 GSFC Contacts

Materials Engineering Branch, Head: (301) 286-6882
Materials Engineering Branch, Secretary: (301) 286-6882

### 2.29.5 Reference Documents Unique to this Section

69. See AETD SM, Sections 2.0 and 3.0 references by safety topic as applicable to the MEB.

# 2.30 WFF Facilities

## 2.30.1 Scope

Primarily the work associated with the Mechanical Systems Branch (MSB), Code 548 consists of supporting Suborbital and Special Orbital Projects Directorate (Code 800) missions and technology development activities. Facilities include office spaces, integration and assembly shops, lab facilities, specialized testing facilities and machine shop areas.

## 2.30.2 General

MSB office area is primarily located in Building E-109. Engineering, analysis, drafting, meetings and other activities are conducted in a general office setting. Matrixed employees reside with project personnel in similar office settings in Buildings X-55. Refer to Section 3.7 in AETD SM for Office Safety requirements.

In general, MSB personnel should identify potential hazards in their operations, consult the appropriate AETD SM Sections of the Safety Manual, and follow the requirements therein. General requirements that apply to all MSB work areas are identified below.

## 2.30.3 General Facility Requirements

1. MSB personnel shall wear and/or use the appropriate PPE when performing hazardous tasks such as handling/using cryogenic liquids and pressurized systems, mixing hazardous chemicals, handling specimens in and around thermal ovens, operating machinery, etc. Guidelines describing when and how to use PPE, and the training requirements, are contained in the AETD SM section 3.6, cryogenics in section 2.5, and pressure systems in section 2.3. In general, wear safety goggles and/or face shields for working with cryogenics and pressurized systems which are not sealed, or mixing hazardous chemicals, wear gloves when handling hot items, safety glasses/goggles when performing machine shop operations.
2. Only authorized and trained operators shall operate specialized facilities such as the machine tools, cranes, etc. During potentially hazardous operations, the operators shall post warning signs and erect personnel control barriers to prevent inadvertent access. Requirements for cranes and slings are covered in AETD SM section 2.1 and machine guarding in sections 3.2 and 3.3. Certified operators shall use canes and slings using currently certified lifting equipment. All points rotating or moving parts on machine tools, except the point of operation shall be guarded to prevent personnel injury.
3. Properly label and store alcohol, acetone, and other volatile materials and store in the flammable storage cabinets provided for the purpose. Labels must have the chemical name and hazard listed.
4. Specially marked waste containers shall be used to collect waste materials. The designated MSB representative for a given work area shall coordinate pickup of hazardous wastes with the Hazardous Waste Environmental Specialist as required (see AETD SM Section 2.5). The phone number for WFF Hazardous Waste is (757) 824-1718.

5. Except for certain areas of Building F-7, liquefied and pressurized gases shall be supplied in standard cylinders/dewars and handled per the safety requirements in Section 2.3. An oxygen monitoring system is installed near the Thermal Vacuum chamber to ensure a safe area. When the alarm sounds (at 19.5% oxygen), personnel shall clear until told the area is safe by WFF Safety. The oxygen monitoring systems shall have a current calibration. Pressure systems shall be inspected by the WFF RECERT Group prior to being used and shall be maintained within certification date.
6. All laboratories that handle or use chemicals shall have a permanent eyewash station. These are inspected weekly.

## 2.30.4 Specific Facility Requirements

### 2.30.4.1 Multi-Payload Processing Facility (Building F-7)

The Multi-Payload Processing Facility (MPPF), Building F-7, houses multiple areas for small spacecraft and other flight test article processing, off-line subsystem and experimenter integration activities. Two high bays at the east and west ends of the building are available for payload processing. The West High Bay has dual trolley cranes, and is intended for "non-clean" applications. The East High Bay is designed as a Class 100,000 clean room and is equipped with a bridge crane and ESD floor. The building also houses several specialized work areas: a thermal vacuum test area, a materials testing lab (controlled by Code 820), a small prototyping machine shop, hardware storage, and a "battery lab" equipped with a fume hood and freezer. The following requirements apply to the appropriate areas referenced above:

1. The Battery Processing Lab has a permanent fume hoods with powered ventilating exhausts leading to the roof. Hoods shall be evaluated prior to use and annually thereafter by the GSFC Industrial Hygiene personnel to verify adequate air flow. When used, front closures must be closed as much as possible to improve performance.
2. The freezer located in the Battery Processing Lab is for storing epoxy and is rated for -94°F (-70°C). Do not store food or other incompatible items with the epoxy.
3. An external storage tank supplies the Materials Testing Lab and the Thermal Vac Chamber with liquid and gaseous $N_2$. Personnel handling cryogenics shall have training on the hazards and wear proper PPE (cryogenic gloves and faceshield).Multiple calibrated oxygen monitors are mounted in this area of the building. They are not connected to an external alarm notification system. When alarms sound, evacuate the area until it is verified safe to re-enter by Safety.
4. Thermal Vacuum (TV) Chamber – The hazards associated with TV Chambers are pressure systems, electrical systems, possible confined spaces, cryogenics, and lifting/handling/movement critical hardware. The pumps and motors associated with the chamber are not rated for hazardous materials. Do not enter the chamber unless the oxygen content has been verified. The pressure system must be within certification prior to use. The handling cart shall be load tested and analyzed to determine the loads it can handle. The test

date of the cart shall be verified within date prior to use. The electrical systems shall not have exposed electrical circuits.

5. Integration Areas shall comply with the requirements in Section 2.6 Mechanical Integration. Tool tethers shall be used when working above flight hardware where a dropped item can cause damage. ESD controls shall be used when the hardware is sensitive to electrostatic discharge. Crane and industrial trucks shall be rated for critical operations when used to handle critical hardware.
6. The small Prototyping Machine Shop shall comply with the requirements in AETD SM Section 3.3 Machine Shops. Ensure personnel operating machine shop equipment are properly trained/experienced. Wear proper PPE (impact resistant faceshield and glasses with side shields/goggles, safety-toed shoes, leather or cotton gloves when handling rough or jagged materials and hearing protection when noise levels are above 85 bdA.) Ensure machine guards are in place and properly adjusted prior to using equipment. Non-portable machines shall be secured to prevent movement. Only maintenance personnel are allowed to perform maintenance on equipment.

### 2.30.4.2 AETD Engineering Building (Building E-109)

The AETD Engineering building, while primarily housing office areas for AETD branch personnel and their contractors, also includes several lab areas that are controlled by Code 548. A small High Bay with a trolley crane is used for integration activities for subsystem development. A Mechanical Lab is a general work area used for assembly, integration and testing of hardware associated with projects, such as the High Gain Antenna System for GPM. A Prototype Fabrication Area houses small machine shop equipment and sheet metal fabrication work areas. The following requirements apply to the appropriate areas referenced above:

1. Integration Areas shall comply with the requirements in Section 2.6 Mechanical Integration. Tool tethers shall be used when working above flight hardware where a dropped item can cause damage. ESD controls shall be used when the hardware is sensitive to electrostatic discharge. Crane and industrial trucks shall be rated for critical operations when used to handle critical hardware.
2. The Prototype Fabrication Area shall comply with the requirements in AETD SM Section 3.3 Machine Shops. Ensure personnel operating machine shop equipment are properly trained/experienced. Wear proper PPE (impact resistant faceshield and glasses with side shields/goggles, safety-toed shoes, leather or cotton gloves when handling rough or jagged materials and hearing protection when noise levels are above 85 bdA.) Ensure machine guards are in place and properly adjusted prior to using equipment. Non-portable machines shall be secured to prevent movement. Only maintenance personnel are allowed to perform maintenance on equipment.

### 2.30.7 WFF Contacts

Mechanical Systems Branch, Head: (757) 824-1314

Lead Mechanical: (757) 824-1310

MSB Facilities Safety Rep: (757) 824-1255

MSB Employee Safety Committee Rep: (757) 824-1255

Support Contractor Safety (Thermal Vac. Area, F-7): (757) 824-3200

WFF Institutional Safety: (757) 824-1498

WFF RECERT: (757) 824-1359

WFF RECERT Support Contractor: (757) 824-1797

### 2.30.8 Reference Documents Unique to this Section

GPR 8715.2, Aviation Safety Program

Wallops Safety Manual (WSM-2005) for Wallops Flight Facility

Additionally, the following list applicable references specified in 540-PG-8715.1.1, AETD SM.

Section 2.1 references for mechanical handling information.

Section 2.3 references for pressurized vessel information.

Section 2.5 references for operational and control requirements for hazardous and cryogenic materials.

Section 2.9 references the use of ear protection in high noise environments.

Section 3.2 references for hand tool information.

## 2.31.0 Storm Conditions

### 2.31.1 Scope

This section covers the storm condition warning system..

### 2.31.2 Acronyms/Definitions

| | |
|---|---|
| Condition 1 (Alert) (White) | Prepare for weather disturbance that could affect commercial power, such as thunderstorms, high winds, and freezing or frozen precipitation that could accumulate on wires or trees. |
| Condition 2 (Warning) (Blue) | Storms approaching the area, 2-hours from GSFC. |
| Condition 2C (Confirmation) (Yellow) | Thunderstorm/wind confirmation 1-hour prior to the storm hitting immediate area of GSFC. Freezing precipitation build-up on trees/wires in progress and expected to continue. |
| Condition 3 (Action) (Red) | Storm within 30 minutes of GSFC – lighting/rain/high winds trees and wires loaded to possible breaking point. |
| Condition 4 (All Clear) | Storm out of range or diminished. |

(Green)

### 2.31.3 General

Certain critical MSD facilities and computer areas could be affected by weather conditions that might interrupt electrical service. Such disruptions are typically momentary, so critical systems should be protected using Uninterruptable Power Supplies equipped with surge protection to the greatest extent practical. Several facilities have operating procedures that mandate approved waivers before operations are allowed under a storm 3 condition. The MSD has arranged with the GSFC Emergency Console (x6-8080) to contact specific areas within MSD, on a 24-hour-per-day basis, whenever there is a weather alert.

### 2.31.4 Design/Operational Requirements

1. The GSFC Emergency Console (x6-8080) obtains weather alerts from a contracted Weather Service. When the alert is received, the Emergency Console transmits the weather condition status to critical areas via the phone mail message system. Designated personnel in the I&T complex, Code 549 (e.g., shift leader in thermal vacuum facility) receive storm condition updates from the contracted weather service directly, and notify the appropriate personnel of the weather status.
2. Color-coded, illuminated, weather condition displays have been installed in some facilities so that all personnel in the area can obtain the current weather conditions at a glance.
3. MSD managers and supervisors shall conduct surveys of their areas of responsibility to determine which facilities and equipment would be affected by adverse weather conditions. They shall arrange to have the appropriate personnel notified of any changes in status of the weather conditions. Examples of areas that could be affected by storms are: vibration lab, thermal vacuum facilities, clean rooms, computer operations, magnetic test site, crane handling operations, ordnance operations, etc.
4. Maintenance and operating procedures for critical facilities and equipment shall include a section that specifies the appropriate action to be taken for the different weather conditions. In some cases, testing would be precluded unless an approved waiver is in place, as described below. Procedures shall describe emergency actions necessary to secure equipment when the weather condition status changes while a test is in progress, such as during a long-term thermal vacuum test.
5. Procedures shall specify the weather condition circumstances under which a waiver is required to conduct operations or perform testing Condition 3 or 5). The waivers shall be signed by the applicable manager (or designee) and project representative. The project representative shall be the Product Design Lead for tests at the subsystem, or box level, and the I&T manager or designee for tests at the instrument or spacecraft level. Project managers are encouraged to provide the names of personnel authorized to approve waivers for their project.
6. Building FOMs shall be responsible for surveying equipment and materials on the grounds outside the buildings. They shall take steps necessary to ensure that equipment and materials are protected from rain, sleet, hail, snow, lightning, etc. These items may have to be shielded from the elements with protective coverings or secured from the dangers of high winds by restraining mechanisms.

7. Mobile crane operations shall not be conducted during storm 3 conditions. Ordnance operations shall be suspended during storm code 3 or 5 conditions. The following operations require a waiver to continue operations during storm code 3 or 5 conditions: vibration, EMC/EMI, acoustics, HCC, and critical lifting operations within the buildings. Thermal vacuum operations continue during condition 3 or 5, but MSD recommends that Projects place their spacecraft in a secure mode.

### 2.31.5 GSFC Contacts

Emergency Console: (301) 286-8080
S&ED: (301) 286-2281
AETD Safety Manager: (301) 286-1035
MSD Safety Lead: (301) 286-710

## Appendix A – Definitions

Ω - Ohm

µ - Micro

Anhydrous Ammonia – Anhydrous (having no water) ammonia is shipped as a liquefied gas under its own vapor pressure. At ambient conditions, ammonia is a colorless gas with a sharp, pungent odor. The odor is easily detectable by humans, even at very low concentrations in the atmosphere.

Anodize – Apply a protective oxide film by an electrolytic process.

APT – Computer language for programming numerically-controlled (NC) machines. ESDAPT is an interactive programming tool that provides syntax checks, menu-based geometry creation, an graphical tool path display.

Blast Gate – Manual damper inside the LEV, which turns the air exhaust on and off.

ºC – Degrees Celcius

c - Centi

dB – Decibel

EDM – Electrical discharge machine that uses an electrically charged moving wire to produce complex shapes in conductive metals.

ºF – Degrees Fahrenheit

ft - Feet

g – Unit of steady state acceleration (9.81 $m/sec^2$).

g - Gram

$GN_2$ – Gaseous Nitrogen

Hz – Hertz (cycles per second)

Incident - Any situation which has caused, or potentially could have caused injury, damaged critical hardware, or resulted in AETD property damage.

Iridite – Apply a protective oxide film by an electrolytic process.

k – Kilo

K – Kelvin

kpa – Kilopascal

lb – Pound

$lb/ft^2$ – Pounds per Square Foot

LEV – Local exhaust ventilation system for exhausting dust form shop equipment.

LHe – Liquid Helium

$LN_2$ – Liquid Nitrogen

Load – Controlled force applied to a test article measured in lb or kg, usually via a hydraulic actuator.

m – Milli or Meter

M – Mega

n - Nano

NC – Numerically-controlled machining center with computer control systems.

pa - Pascal

pH – Symbol to indicate acidity or alkalinity: pH values from 0 to 7 indicate acidity, and values from 7 to 14 indicate alkalinity.

Pre-Preg – Pre-impregnated fiber materials.

psi – Pounds per Square Inch

TIG – Tungsten Inert Gas welding.

w – Watt

## Appendix B – Acronyms

| | |
|---|---|
| ac or AC | Alternating-Current |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| AETD | Applied Engineering and Technology Directorate |
| AGMA | American Gear Manufacturer's Association |
| Amu | Atomic Mass Units |
| ANSI | American National Standards Institute |
| APT | Automatically Programmed Tool |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing Materials |
| AWS | American Welding Society |
| CFM | Cubic Feet per Minute |
| CG or cg | Center of Gravity |
| CMAA | Crane Manufacturer's Association of America, Inc. |
| CPR | CardioPulmonary Resuscitation |
| CTD | Cumulative Trauma Disorder |
| CTS | Carpal Tunnel Syndrome |
| dc or DC | Direct-Current |
| DOT | Department of Transportation |
| EDM | Electrical Discharge Machine |
| EED | Electro-Explosive Eevice |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| ESD | ElectroStatic Discharge |
| ETU | Engineering Test Unit |
| FMD | Facilities Management Division |
| FMEA | Failure Modes and Effects Analysis |
| FOM | Facility Operations Manager |
| GERT | Goddard Emergency Response Team |
| GFCI | Ground Fault Circuit Interrupter |
| GHB | Goddard Handbook |
| GMI | Goddard Management Instruction |
| $GN_2$ | Gaseous Nitrogen |
| GND | Ground |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| HCC | High Capacity Centrifuge |
| HOPs | Hazardous Operating Procedures |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IDLH | Immediately Dangerous to Life or Health |
| IEEE | Institute of Electrical and Electronic Engineers |
| IR | Infrared Radiation |
| ISI | In Service Inspection |
| LDE | Lifting Devices and Equipment |
| LEV | Local Exhaust Ventilation |
| LFL | Lower Flammable Limit |
| $LN_2$ | Liquid Nitrogen |
| MAWP | Maximum Allowable Working Pressure |
| MDP | Maximum Design Pressure |
| MGSE | Mechanical Ground Support Equipment |
| MIL STD | MILitary STandarD |
| MOI | Moment Of Inertia |
| MOLEKIT | MOLEcular KIneTics |
| MSB | Mechanical Systems Branch |
| MSD | Mechanical Systems Division |
| MSDS | Material Safety Data Sheet |
| NC | Numerically Controlled |
| NDT | NonDestructive Testing |
| NEC | National Electrical Code |
| NFPA | National Fire Protection Association |
| Ni-Cd | Nickel-Cadmium |
| NIOSH | National Institute for Occupational Safety and Health |
| NHB | NASA Handbook |
| NSS | NASA Safety Standard |

| | |
|---|---|
| OEM | Original Equipment Manufacturer |
| OHA | Operating Hazard Analysis |
| OSHA | Occupational Safety and Health Act |
| PEL | Permissible Exposure Limit |
| PETS | Payload Environmental Transport System |
| PPE | Personal Protective Equipment |
| PSL | Project Support Lead |
| PSTL | Project Support Team Lead |
| PV/S | Pressure Vessels and Systems |
| RBO | Regulator BurnOut |
| RECERT | RECERTification program |
| RF | Radio Frequency |
| RFI | Radio Frequency Interference |
| RMSS | Remote Manipulator System Simulator |
| RPO | Radiation Protection Officer |
| RWA | Reaction Wheel Assembly |
| S&ED | Safety and Environmental Division |
| SCA | Spacecraft Checkout Area |
| SED | Stored Energy Device |
| SES | Space Environment Simulation |
| SLM | Sound Level Meter |
| SM | Safety Manual |
| SMTF | Spacecraft Magnetic Test Facility |
| SPL | Sound Pressure Level |
| SSDIF | Spacecraft Systems Development and Integration Facility |
| TQCM | Thermoelectric Quartz Crystal Microbalance |
| T | Temperature |
| T/H | Temperature Humidity |
| T/V | Thermal Vacuum |
| TCU | Thermal Conditioning Unit |
| TIG | Tungsten Inert Gas |
| TLV | Threshold Limit Value |
| TLV-C | Threshold Limit Value—Ceiling |
| TLV-STEL | Threshold Limit Value—Short-Term Exposure Limit |
| TLV-TWA | Threshold Limit Value—Time-Weighted Average |
| TQCM | Thermoelectric Quartz Crystal Microbalance |
| UL | Underwriter’s Laboratories |
| UV | UltraViolet |
| VDT | Video Display Terminal |

## CHANGE HISTORY LOG

| Revision | Effective Date | Description of Changes |
|---|---|---|
| Baseline | 03/20/2004 | Initial Release |
| A | 02/23/2005 | Updated to include ISO wording requirements, updated Acoustic Chamber information, updated documents reference throughout, removed confined space requirement from HCC pit, added Mass Properties safety requirements, changed quantities of hazardous waste allowed in SAA, in Thermal Vacuum section added platform requirements for Chamber 238 and WFF facility requirements. |
| B | 12/5/2006 | Updated to include a section for Wallops Flight Facility, delete references to 540-PG-8715.1.1, remove sections placed in 500-PG-8715.1.2, and added sections deleted from Volume I that are applicable to 540-PG-8715.1.2. Deleted 540-PG-8715.1.1 references, added storm codes section, moved sections on trailer and machine shops to 500-PG-8715.1.2, changed phone numbers where applicable, added references to Safety Evaluation Form. Added METRICS section and Appendix B and C Document reviewed and updated with new Appendix C. METRICS section removed (now included in AETD SM 500-PG-8715.1.2). |
| C | 05/04/2010 | Document was reformatted to the current template. Section 2.31 was updated to address changes to the storm condition system. Clerical references were updated throughout the document. |
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