Procedures and Guidelines

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PREFACE

P.1 PURPOSE

The Mechanical Systems Division (MSD) Safety Manual Volume II is intended to establish the policies, procedures, and requirements for each of the facilities within the MSD, and to provide GSFC personnel contacts. 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

NPG 8715.3, NASA Safety Manual
OSHA 29 CFR 1910, Occupational Safety and Health Standards

P.4 REFERENCES

Each section list the unique reference documents applicable for that section. Each listing of information found in Volume I may be found in 540-PG-8715.1.1, Mechanical Systems Division Safety Manual – Volume I.

P.5 CANCELLATION

5405-048-98, Mechanical Systems Center Safety Manual, Volume II

P.6 SAFETY

This Volume describes safety issues associated with specific facilities or process areas within MSD. Detailed safety requirements are addressed in Volume 1 of this Manual and will only be referenced in this Volume.
The Project Support Leads discussed 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. It could be the Section Head or Lead Engineer or another designated person.

P.7 TRAINING

Any required training is listed in the applicable section.

P.8 RECORDS

Volume I of this manual list all required records.

P.9 METRICS

None

P.10 DEFINITIONS

Ω	ohm
µ	micro
ac or AC	alternating-current
ACGIH	American Conference of Governmental Industrial Hygienists
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
°C	degrees Celsius
CFM	cubic feet per minute
CG or cg	center of gravity
c	centi
CMAA	Crane Manufacturer's Association of America, Inc.
CPR	cardiopulmonary resuscitation
CTD	cumulative trauma disorder
CTS	carpal tunnel syndrome
dB	decibel
dc or DC	direct-current
DOT	Department of Transportation
EDM	electrical discharge machine
EED	electro-explosive device
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ESD	electrostatic discharge
ETU	engineering test unit
°F	degrees Fahrenheit
FMD	Facilities Management Division
FMEA	failure modes and effects analysis
FOM	Facility Operations Manager
ft	feet
g	gram
g	unit of acceleration (9.81 m/sec^2)
GERT	Goddard Emergency Response Team
GFCI	ground fault circuit interrupter
GHB	Goddard Handbook
GHz	gigahertz
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
Hz	Hertz (cycles per second)
IDLH	Immediately Dangerous to Life or Health
IEEE	Institute of Electrical and Electronic Engineers
IR	infrared radiation
ISI	inservice inspection
k	kilo
K	degrees Kelvin
kpa	kilopascal
lb	pound
lb/ft^2	pound/square foot
LDE	lifting devices and equipment
LEV	local exhaust ventilation
LFL	lower flammable limit
LN_2	liquid nitrogen
m	milli or meter
M	mega
MAWP	maximum allowable working pressure
MDP	maximum design pressure
MGSE	mechanical ground support equipment
MIL STD	Military Standard
MOI	moment of inertia
MSD	Mechanical Systems Division
MSDS	Material Safety Data Sheet
n	nano
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
pa	Pascal
PEL	permissible exposure limit
PETS	payload environmental transport system
psi	pounds per square inch
psig	pounds per square inch gauge
PPE	personal protective equipment
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&EB	Safety and Environmental Branch
SCA	Spacecraft Checkout Area
SED	stored energy device
SES	Space Environment Simulation
SLM	sound level meter
SMTF	Spacecraft Magnetic Test Facility
SO_2	sulfur dioxide
SPL	sound pressure level
SSDIF	Spacecraft Systems Development and Integration Facility
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
UL	Underwriter's Laboratories
UV	ultraviolet
VDT	video display terminal
w	watt

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4.0 Facilities

4.1 Acoustic Chamber

4.1.1 Scope

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

4.1.2 Acronyms/Definitions

1. dB—Decibel.
2. SPL—Sound pressure level.

4.1.3 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.

4.1.4 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.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Code 540 Section 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 will 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 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.
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 and the Building 10 High Bay that testing is about to begin and to expect high noise.
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. Simultan-eously, 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 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 working on ladders at heights above 4 ft (1.2 m) or when performing maintenance on the horn servicing platform or nitrogen supply system. Requirements for working on a ladder or at unprotected heights are found in Section 3.1 in Volume 1.
11. 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 overhead crane shall be bagged with plastic to prevent any crane oil from leaking, which could possibly damage critical hardware.

13. The S&EB conducted a noise survey of the acoustic facility in 1997. When the facility was operating, the ambient noise levels surrounding the outside of the chamber walls and doors measured a maximum of 147 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 Section 2.9.3 Tables 2 and 3 for a listing of NASA permissible noise exposure limits.
14. 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 must be approved by the MSD Project Support Team Lead before setup or testing is permitted. (See Section 2.2 in Volume 1 for ordnance handling and operational requirements.)

4.1.5 GSFC Contacts

Structural Dynamics Test Engineering Section, Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.1.6 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*

NPG 1820.1, *Hearing Conservation*

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

4.2 Cleanrooms

4.2.1 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 cleantents include the Big Top; the 150 Cleantent; the CRIF Cleantent; Chambers 225, 239, and 238 cleantents; and the Solar Environment Simulator anteroom.

4.2.2 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 that are addressed in other sections of this Safety Manual, including the following: cleaning solvents, scaffolding and ladders, lifting devices, high pressure gas systems, confined spaces, and cutting devices.

4.2.3 Specific Facility Requirements

All personnel who enter a clean facility must 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 must be secured firmly to the face by using the adjustable snaps to achieve a snug fit. The face mask must 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 must 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. Personnel must be in reasonable physical condition and must be aware of the restrictive nature of the cleanroom garments they are wearing.

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 must 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 must 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 should 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 fire warden in charge of an area having a cleanroom sign-in Log shall remove the Logbook from its designated location, carry it out of the building to the assigned gathering area, and personally 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 a cleanroom training orientation that familiarizes them with entry and clean operating procedures as well as safety procedures required for work in the area. This can be arranged by contacting the Support Contractor Cleanroom Operations training officer.
9. 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 stated throughout this Manual 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&EB.

4.2.4 GSFC Contacts

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

S&EB: (310) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.2.5 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 Equipment*

4.3 Composite Materials Shop

4.3.1 Scope

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

4.3.2 Acronyms/Definitions

1. Pre-preg—Pre-impregnated fiber materials.

4.3.3 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.

4.3.4 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 Section 4.7.4 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 Section 3.6 in Volume 1 for PPE requirements.)
5. 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.
6. 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.
7. 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.

8. 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 Volume 1 for fume hood information.)
9. 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.
10. Nonhazardous waste materials can be discarded in the standard GSFC dumpsters. Usually, byproducts from the fabrication process that have been fully cured are nonhazardous.
11. 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.
12. 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.
13. 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.
14. 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.
15. Fume hood operation (see Section 2.5.4 in Volume 1):

    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.
16. Grit blaster:

Wear safety glasses with side shields, goggles, or full face shields with glasses/goggles when operating the grit blaster.

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.

4.3.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Manager: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (301) 286-6453

Support Contractor Safety: (301) 286-1035

4.3.6 Reference Documents Unique to this Section

N/A

4.4 Electromagnetic Compatibility

4.4.1 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.

4.4.2 Acronyms/Definitions

N/A

4.4.3 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 4.4.4, Item 5.a. below contains specifications regarding the shielding effectiveness of the enclosures.

4.4.4 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 shall preclude testing unless a waiver has been signed by the Code 549.3 Section 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 must 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.

   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. 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.

4.4.5 GSFC Contacts

Electromagnetic Test Engineering Section, Head: (301) 286-6201

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.4.6 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*

GHB 1860.2, *Radiation Safety Radio Frequency*

4.5 High Capacity Centrifuge

4.5.1 Scope

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

4.5.2 Acronyms/Definitions

1. g—Unit of steady state acceleration.

4.5.3 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.

4.5.4 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. 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.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Code 549.3 Section 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.
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. 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 Volume 1), and comply with the mechanical handling requirements of Section 2.1 in Volume 1. 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 designated a confined space. Personnel who enter the pit shall be trained and certified in confined space entry procedures. 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 Volume 1 for NASA permissible noise exposure limits).
16. 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.

17. 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.

4.5.5 GSFC Contacts

Structural Dynamics Test Engineering Section Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.5.6 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212 and Part 1910.27, *Mechanical Equipment*
09-PC-PP01, *Steady State Acceleration Testing*
CGA P-14-1983, CGA P-12-1987, CGA P-1, and ASHRAE 15-89, *Gaseous Nitrogen*

4.6 Mechanical Integration

4.6.1 Scope

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

4.6.2 Acronyms/Definitions

N/A

4.6.3 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 must 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.

4.6.4 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 are not to wear hardhats unless there is a possibility of head injury. (See Volume I, section 3.6.4 of this manual for more information.) Care must be taken to wear PPE in a manner appropriate for the conditions. One example is to cinch the hardhat's chinstrap when working above payloads and other personnel. This will help prevent the hardhat from falling off and damaging hardware or injuring people. PPE must be kept in good condition. A hardhat with a defective chinstrap or 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 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 Volume 1).
3. Payload security at a minimum requires the area around flight hardware to be roped off with flagging ribbon 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.
4. Falling tools and other objects present a hazard to flight hardware and personnel positioned below. When working over payloads, all tools, 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.
5. Electrostatic discharge may result in damage to flight hardware instruments during movement through the test and integration facilities or during handling. Ensure that instrument, lifting device hook, and personnel grounding methods have been established, and abide by them.

6. 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.

4.6.5 GSFC Contacts

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

4.6.6 Reference Documents Unique to this Section

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

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

4.7 Machine Shops

4.7.1 Scope

This section covers the MSD machine shops. The primary machine shops are located in and around the Building 5 High Bay and Mezzanine areas, but there are remotely located machine shops in Buildings 2, 5W, 10, and 33. Several MSD integration and testing facilities (mechanical integration, vibration lab, static test) have integral machine shops for fabricating quick response fixtures and hardware. This section presents safety guidelines and shop procedures common to all machine shops.

4.7.2 Acronyms/Definitions

1. APT—Computer language for programming numerically-controlled (NC) machines. ESDAPT is an interactive programming tool that provides syntax checks, menu-based geometry creation, and graphical tool path display.
2. EDM—Electrical discharge machine that uses an electrically charged moving wire to produce complex shapes in conductive metals.
3. NC—Numerically-controlled machining centers with computer control systems.

4.7.3 General

The MSD machine shops provide a complete manufacturing facility to meet GSFC's machining requirements. They contain a wide variety of conventional machining equipment and state-of-the-art NC machining centers. Typical examples include NC machining centers, electrical discharge machines, coordinate measuring machines, mills, lathes, drill presses, borers, saws, grinders, brakes, presses, rollers, punches, shears, metal shrinking and stretching machines, bending machines, etc. The general shop guidelines discussed below apply to this wide variety of machinery types. 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.

4.7.4 Specific Facility Requirements

Good housekeeping in the work area can help establish good work habits when operating machine tools. These two factors—good housekeeping and good habits—result in fewer accidents. Special procedures for the machine shops are as follows:

1. Personnel training: Building 5 Machine Shop operators shall be trained under an apprenticeship program and shall demonstrate their ability on each piece of equipment they run. Their supervisor shall approve their demonstrated performance. Likewise, operators in all of the other MSD machine shops shall demonstrate their ability to operate all equipment they run, and be approved by the area supervisor. No one shall be allowed to operate a piece of machine shop equipment unless they have been trained under the direction of lead personnel and approved by the area supervisor.
2. Safety talks: Monthly safety meetings should be held to keep shop personnel informed of safety topics and new developments in machining techniques.

3. PPE: When operating machinery, eye protection shall be worn. Eye protection with side shields—such as goggles or full-face shield with glasses/goggles—shall be worn if chips, dust, debris, or other materials can become airborne. Machine operators shall wear safety-toed shoes. Gloves can be used to protect the hands when handling rough or jagged materials but should be removed when operating rotating machinery where they are liable to get caught.
4. Hearing protection: Wear hearing protection such as ear plugs or ear defenders around noise-producing machinery. Refer to Section 2.9 in Volume 1 for permissible noise exposure limits. If in doubt as to noise levels, arrange to have the S&EB conduct noise level surveys and/or noise level dosimeter checks of the affected personnel.
5. Clothing/accessories: Do not wear loose-fitting garments, loose sleeves, lab coats, rings, necklaces, or other jewelry or accessories which could get caught in moving parts of the machinery. Keep hair secured to prevent it from being snagged.
6. Use splash guards, shields, PPE, and other means to minimize exposure of workers to cutting oils or cleaning solvents. Personnel should use barrier creams where appropriate and wash thoroughly to minimize skin irritations.
7. All machine shop equipment shall be installed with electrical circuits and switches that comply with the NFPA 70, *National Electrical Code* (see Section 2.8 in Volume 1). Other metalworking standards are in NFPA 79, *Electrical Standard for Industrial Machinery*. Each machine must have a disconnect switch that can be locked in the off position to isolate the machine from the power source.
8. All machine shop equipment shall have guard mechanisms that comply with OSHA 3067, *Concepts and Techniques of Machine Safeguarding*. Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. The point of operation of a machine that exposes the operator to injury shall be guarded. Do not operate the equipment without the guards in place and functioning properly. Never override a safety interlock, automatic kill switch, guard mechanism, or other device which is designed to protect the operator while the machine is running or to shut the system off in an emergency.
9. All non-portable machines shall be firmly secured to the floor, bench, or other properly designed workstand.
10. Only maintenance personnel who are authorized and experienced with the equipment shall perform maintenance on the machines. This includes changing cooling fluids, oils, dielectric fluids in EDM machines, etc. Lockout/Tagout/Blockout procedures shall be used when performing maintenance (see Section 3.8 in Volume 1).
11. Some machines have automatic dust collection systems. Before starting, verify that the exhaust ducts are unobstructed and venting properly, and that the collection bins have adequate capacity for the job at hand.
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. Metal chips shall be placed in the metal recycle bins. General dust and debris can be discarded in the standard GSFC dumpsters.

13. House-supplied compressed air is available in the shops. 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. Vacuum equipment is preferred for removing dust and debris from machinery. Air shall not be used to clean personnel.
14. Fire extinguishers are located on the east and west walls at about the midpoint of the Building 5 High Bay. The large capacity, portable fire extinguisher for metals—MET-L-X, 150-B—can be moved to wherever it is needed in the high bay, using its built-in wheels. All MSD machine shops shall have fire extinguishers in the immediate area.
15. Permanent eyewash stations are located at the Building 5 second floor mezzanine shop area, and the high bay east wall between Rooms E-42 and E-48 (just outside the welding shop entrance curtains).
16. Personnel who operate equipment in any of the MSD machine shops shall familiarize themselves with the locations of the nearest eyewash stations, fire extinguishers, emergency rescue equipment, and first aid kits. Personnel must be trained in the use of fire extinguishers.
17. Safety rules for operating machine tools:

    Establish and maintain safe working procedures; do not take short cuts. Devote full-time attention to the work in progress. Do not be distracted by onlookers. Do not leave machine tools running unattended unless the machine has been designed to do so.

    Operators should read the operations manual and understand all the precautions before setting up or running a machine tool. Observe all precautions and warning labels affixed to the machines.

    Inspect each tool before use to be sure it has all its parts and that they are in good working order. Do not use blades, bits, heads, etc. that have visual defects such as cracks, chips, pitting, or warping. Follow the manufacturer's instructions for using the tool, including sharpening and changing blades, bits, heads, etc. Verify that all chucks, bits, workpiece securing devices, etc., are tightened to manufacturer's specifications before running the machine.

    Clamp work securely to prevent its movement while drilling, milling, etc. Verify that no part of the machine tool will hit the clamps or any part of the workpiece not intended to be machined.

    Do not operate the machine at higher speeds than specified for the blade, bit, head, etc.

    Where possible, use autofeed drive mechanisms to minimize the need for manual feeding of the workpiece. Set autofeed limits according to the manufacturer's specifications and verify them before starting the machine.

    Verify that there is adequate clearance around the machine for the workpiece to move as it is being machined. Provide supports for overhanging workpieces, and ensure that sections of the workpiece that are to be cut off do not present a hazard as they separate from the main piece.

    Keep onlookers away from the immediate area around a running machine tool. If necessary, post warning signs and use barrier tape cordons to prevent unauthorized personnel access, but do not erect physical barriers that impede aisles, emergency exit routes, or doors leading away from the machine.

    Do not startle or surprise the operator while the machine is running. Wait until the machine is turned off before addressing the operator.

Keep tools properly lubricated and free of dirt and grime. Keep cooling fluids and cooling systems clean and flowing properly.

Do not manually adjust and gauge work while the machine is running.

Understand the differences in machining ferrous and non-ferrous metals, and know the health or fire hazards of working with these metals. Consult an MSDS for accurate information about materials if in doubt as to their properties and potential hazards. Special machining procedures, over and above those required for aluminum and steel, are required when working with exotic materials such as beryllium, magnesium, and titanium used in the aerospace industry. There may be prohibitions or special regulations on machining exotic materials at GSFC. When in doubt, check with the S&EB or area safety representatives to obtain the latest regulations on exotic materials.

Select the proper hand tools where necessary, and use them for their intended purpose. Do not improvise an operation with an improper tool.

Keep the body in proper balance with firm footing to avoid falling into or bumping the workpiece. Do not stretch arms or place hands in awkward positions. Use appropriate clamping jigs, push rods, etc., to avoid placing parts of the body near the machining heads.

18. 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 center computer workstations. Configuration control shall be maintained so that no unauthorized personnel can modify the ESDAPT program or enter parameters into any of the NC machines.

NC machines require skill and art in preparing a workpiece for machining. Besides holding the workpiece 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. If possible, conduct a tryout before cutting metal by using a mockup that simulates the machining operation.

A significant potential hazard with NC machines is the abrupt machine motion and extent of travel. The operator shall verify that there are no possible interferences to machine travel, and that personnel are excluded from the work zone. Each NC machine must have adequate clearance, with safety yellow perimeter lines around its working zone, to exclude personnel and equipment.

19. 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 workpiece in an EDM machine is submerged in a dielectric fluid. Most fluids are petrochemical oils, while some are water-based. When the machine is running, the fluid is hot and contains very fine metal particles and oxides in it. Do not allow the fluid to contact the skin; if it does, cleanse the affected areas with massive doses of water for at least 15 minutes. Handle

workpieces with non-porous gloves such as rubber latex (not leather or fabric). Replace gloves if they have cuts or tears, and replace rubber gloves frequently because the fluid breaks down the rubber over time.

Maintain the dielectric fluid level above the highest portion of the electrode workpiece'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.

4.7.5 GSFC Contacts

Advanced Machining Branch, Head: (301) 286-8374

Manufacturing Technology Group Leader: (301) 286-7093

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.7.6 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*

4.8 Magnetics

4.8.1 Scope

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

4.8.2 Acronyms/Definitions

N/A

4.8.3 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.

4.8.4 Specific Facility Requirements

Special procedures for this facility are as follows:

1. The facility engineer or supervisor shall train magnetic control system operators. The facility supervisor shall approve each operator's demonstrated ability to operate the control system satisfactorily.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Section 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.

4.8.5 GSFC Contacts

Electromagnetic Test Engineering Section, Head: (301) 286-6201

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.8.6 Reference Documents Unique to this Section

GHB 1860.2, *Radiation Safety Radio Frequency*

4.9 Mass Properties

4.9.1 Scope

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

4.9.2 Acronyms/Definitions

1. CG or cg—Center of gravity.
2. MOI—Moment of inertia.

4.9.3 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.

4.9.4 Specific Facility Requirements

The Miller Table must be connected to a GN_2 supply to float the table freely during operation. The small amount of nitrogen used does not present a health or safety hazard to personnel, except that they must exercise the normal precautions of working with pressures of 160 psi (1,103 kpa). (See Section 2.3 Pressure and Vacuum Systems in Volume 1.) During spinning operations, personnel must be protected from the potential hazard of objects being ejected from the table.
Special procedures for this facility are as follows:

1. Miller Table control system operators shall be trained by the facility engineer. The facility supervisor shall approve each operator's demonstrated ability to operate the control system satisfactorily.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Section 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 and protected from the potential danger of items being ejected from the table.
5. 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 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.

4.9.5 GSFC Contacts

Structural Dynamics Test Engineering Section, Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

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Support Contractor Safety: (301) 286-1035

4.9.6 Reference Documents Unique to this Section

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

4.10 Modal Survey

4.10.1 Scope

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

4.10.2 Acronyms/Definitions

N/A

4.10.3 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.

4.10.4 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 are as follows:

1. Modal survey operators shall be trained by the facility engineer. The facility supervisor shall approve each operator's demonstrated ability to operate the exciter control systems satisfactorily.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Code 549.3 Section 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 shall be cordoned off with barrier tape to keep personnel out when the exciters are running. 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 shall be fenced off 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.

4.10.5 GSFC Contacts

Structural Dynamics Test Engineering Section, Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.10.6 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*

4.11 Rapid Prototyping Facility

4.11.1 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.

4.11.2 Acronyms/Definitions

1. LEV—Local exhaust ventilation system for exhausting dust from shop equipment.
2. Blast gate—Manual damper inside the LEV which turns the air exhaust on and off.

4.11.3 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.

4.11.4 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 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 Section 4.7.4 Item 8 for further safety guard information.)
3. Personnel shall wear the appropriate PPE for the job (see Section 3.6 in Volume 1). When operating machinery, personnel shall wear approved eye protection such as safety glasses, 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. Vacuum equipment is preferred for removing dust and debris from machinery.
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&EB 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 Volume 1 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 Volume 1 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.

4.11.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.11.6 Reference Documents Unique to this Section

See Section 4.7 for Machine Shop reference documents.

4.12 Plating Facility

4.12.1 Scope

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

4.12.2 Acronyms/Definitions

1. Anodize—Apply a protective oxide film by an electrolytic process.
2. Iridite—Apply a protective oxide film by an electrolytic process.
3. pH—Symbol to indicate acidity or alkalinity: pH values from 0 to 7 indicate acidity, and values from 7 to 14 indicate alkalinity.

4.12.3 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.

Note: The Maryland Department of the Environment conducted stack evaluation tests on the GSFC air scrubber equipment and determined that airborne concentrations of pollution were below harmful threshold limits. Based on the evaluation results, the GSFC air scrubber equipment is not on-line as of this publication date.

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.

4.12.4 Specific Facility Requirements

Special procedures for the plating facility are as follows:

1. The section analytical chemist shall track the personnel training records on a computer file and keep the information in the GHB 1790.1A GSFC Chemical Hygiene Plan binder notebook on file in the plating facility office. All plating facility employees shall attend the following training classes:

   Hazardous communication (HAZCOM) training.

   Laboratory standard 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).
2. 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.
3. 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.

4. 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.
5. 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.
6. 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. Consult the GHB 1790.1A, *GSFC Chemical Hygiene Plan,* Appendix B for filter cartridge selection criteria. 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.
7. 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.
8. 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.
9. 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 lidded 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 Goddard Emergency Response Team (GERT) by dialing extension 112.

    Trash receptacles should be emptied daily.

10. 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 55 gallons (208 liters) of waste shall be accumulated in one area at any given time. Only one quart (0.95 liter) of extremely hazardous material (e.g., cyanides) shall be accumulated.

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.

4.12.5 Hazardous Chemicals Specific to the Plating Facility

Consult the GPG 1700.2, *Chemical Hygiene Program* for additional information on laboratory work practices and handling and storage of specific chemicals. The following describes chemicals used in the plating facilities and summarizes safety requirements for each:

1. Copper cyanide:

   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):

   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.

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

3. Hydrofluoric acid:

   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:

   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:

   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):

   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:

   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:

   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.

4.12.6 GSFC Contacts

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

Chemical Analyst: x6-2258

Lead Technician: x6-5708

Chemical Safety Officer: x6-5708

Environmental Liaison: x6-6464

Chemist: x6-2258

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

S&EB: (301) 286-2281

Support Contractor Safety: (301) 286-1035

4.12.7 Reference Documents Unique to this Section

GPG 1700.2, *Chemical Hygiene Program*

4.13 Precision Assembly Area

4.13.1 Scope

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

4.13.2 Acronyms/Definitions

N/A

4.13.3 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.

4.13.4 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 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 Section 4.7.4, 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 nonhazardous 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 Specialist (x6-9233) for removal service. 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.

4.13.5 GSFC Contacts

Precision Assembly Group Leader: (301) 286-3956

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.13.6 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*

4.14 Static Test

4.14.1 Scope

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

4.14.2 Acronyms/Definitions

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

4.14.3 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.

4.14.4 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 each operator's demonstrated ability to operate the hydraulic actuator control system satisfactorily.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Section 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. 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 Volume 1.)

7. Use appropriate gloves and protective gear to handle materials that have rough or sharp edges or surfaces.
8. 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.
9. 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.

4.14.5 GSFC Contacts

Structural Dynamics Test Engineering Section, Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.14.6 Reference Documents Unique to this Section

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

4.15 Thermal Vacuum

4.15.1 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, 243, 244, 281, and Building 10 Facility 290. 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).

4.15.2 Acronyms/Definitions

1. GN_2—Gaseous nitrogen.
2. LHe—Liquid helium.
3. LN_2—Liquid nitrogen.
4. T—Temperature.
5. TCU—Thermal conditioning unit.
6. T/H—Temperature/humidity.
7. T/V—Thermal vacuum.

4.15.3 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 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, diesel-powered generator must be manually started. Generator capacity ranges from 250 kVA to 500 kVA, 480 VAC, 3-phase, 60 Hz.

4.15.4 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 Volume 1. Some chambers also involve working at heights (see Section 3.1 in Volume 1). 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.

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 Volume 1 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. Special attention must be given whenever people are, or may be, between the chamber wall and the thermal shroud. 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 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.

   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.

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), 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.

4.15.5 GSFC Contacts

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

Test Facilities in Building 5 (Welding Shop and Composite Materials Shop):
Fabrication Engineering Branch, Head: (301)286-6381

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Building 5 Safety Committee Head: (310) 286-6453

4.15.6 Reference Documents Unique to this Section

OSHA 29 CFR Part 1910.212 and Part 1910.27

GMI 1710.4, *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

4.16 Trailers

4.16.1 Scope

This section covers trailer fire protection and safety.

4.16.2 Acronyms/Definitions

1. Trailer—Mobile electronics, instrumentation test/evaluation trailers, containers, or vans, either self-propelled or towed, and all trailers or vans being used to satisfy a requirement for office, laboratory, technical facility, conference room, shop, storage, construction, or other space that would ordinarily be replaced by either permanent or temporary construction.
2. Mobile trailer—A trailer or container which is not located in a fixed position for greater than six months.

4.16.3 General

Trailers and mobile trailers under the authority of the MSD must comply with the requirements specified in the latest revision of GMI 1710.3, *Trailer Fire Protection and Safety*. Examples are: trailers used for office space, storage space, or construction activities; trailers and instrumentation vans which are parked outside the MSD buildings in support of flight project integration and testing programs; and the emergency generator facilities that provide backup electrical power during commercial power outages.

4.16.4 Specific Facility Requirements

MSD personnel must coordinate trailer operational requirements with the S&EB. The following information summarizes GMI 1710.3 regulations:

1. For MSD trailers not associated with a major building, a Facilities Operation Manager (FOM) will be appointed to monitor and enforce GMI 1710.3 regulations.
2. As part of their annual safety inspections, safety survey teams shall inspect all trailers in their areas of responsibility. For trailers not associated with a major building, separate surveys shall be scheduled.
3. Trailer parking will be restricted to designated permanent trailer pads where trailer service is provided. All permanent trailer pads must be provided with utility services to include fire protection and security alarm connections. Trailer pads must be sized for the full dimensions of the trailer.
4. Mobile trailers are exempted from pad requirements, provided they are not located within 40 feet (12 m) of a building.
5. Specifications and proposed locations for trailers must be reviewed and approved by the S&EB. Trailer information must be provided to the Facilities Management Division so they can prepare site location maps and provide the necessary engineering services.
6. A reliable and unobstructed means of access to all trailers shall be maintained for vehicles and equipment responding to emergencies.
7. Stairs, landings, and handrails shall meet OSHA and NFPA 101 requirements. Stairs shall be firmly attached to the trailer but shall not be supported by the trailer. The FOMs shall inspect the stairs and

appurtenances annually. Mobile trailers shall provide stairs engineered to best reflect provisions of the same codes, within their operational constraints.

8. All trailers shall be anchored unless they are actively used as mobile trailers.
9. All trailers must have suitably sized fire extinguishers, compatible with the occupancy being protected. Coordinate other fire protection requirements, such as smoke detectors, automatic alarms, fire suppression systems, etc., with S&EB. The comprehensiveness of fire protection apparatus will be determined based on variables such as life safety, dollar value, mission importance, etc.
10. Handling, use, and storage of flammable and combustible liquids shall be in accordance with NFPA 30 and approved by S&EB.
11. Trailers containing potentially hazardous liquids should have spill containment dikes around them. For example, in the event of a spill, diesel fuel in an emergency power generator should be contained by dikes.
12. The most prominent hazards of each trailer must be identified in accordance with NFPA 704.
13. Personnel contact information shall be posted near the main entrance to each trailer. Emergency procedures shall be developed for occupied trailers.
14. Requests for waivers to GMI 1710.3 requirements shall be routed through S&EB review, and approved either by S&EB or Goddard Headquarters (NPG 8715.3, Section 1.19), as applicable.

4.16.5 GSFC Contacts

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.16.6 Reference Documents Unique to this Section

GMI 1710.3D, *Trailer Fire Protection and Safety*

NFPA 30 and 704

4.17 Vibration Laboratory

4.17.1 Scope

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

4.17.2 Acronyms/Definitions

1. g—Unit of acceleration (9.81 m/sec^2).

4.17.3 General

Facilities and subsystems covered in this section are:

1. Vibration Exciters: Electrodynamic exciters rated up to 35,000 lb (156 k-Newton) force. Hydraulic exciter rated up to 22,700 lb (101 k-Newton) force.
2. Exciter Power Amplifiers and Hydraulic Power Supply: Amplifiers for electrodynamic exciters rated up to 192 kVA, and hydraulic exciter power supply rated at 150 horsepower (0.11 Mw).
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.

4.17.4 Specific Facility Requirements

The Vibration Laboratory contains one hydraulic and 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 each operator's demonstrated ability to operate the vibration control system satisfactorily.
2. A Storm Warning Code Status 3 shall preclude testing unless a waiver has been signed by the Section 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 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 Project Test Plan 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 Section 2.9.3 Tables 2 and 3 in Volume 1 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 Volume 1.)
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 Section 2.3 Pressure & Vacuum Systems in Volume 1.)
11. For new or modified fixturing, a Section Head-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. It is recommended that design be reviewed by the Section prior to manufacture.
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 Section 4.7 when operating this machinery.
14. No drilling or grinding shall be performed on magnesium or beryllium fixtures. These fixtures shall be sent to the Building 5 Machine Shop 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. 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.

4.17.5 GSFC Contacts

Structural Dynamics Test Engineering Section, Head: (301) 286-6480

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.17.6 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*

4.18 Welding Shop

4.18.1 Scope

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

4.18.2 Acronyms/Definitions

1. TIG—Tungsten inert gas welding.

4.18.3 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.

4.18.4 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. All welding shop equipment safety guards shall be installed before operating the equipment. (See Section 4.7.4 Item 8 for safety guard information.)
4. Argon and helium gases, obtained from individual pressurized bottles, are consumed in some welding processes. Refer to Section 2.3 in Volume 1 for information on handling these gases.
5. 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 Volume 1 for how to obtain a hot work permit.)
6. 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.

7. A permanent eyewash station for the shop is located immediately outside the entrance curtains on the Building 5 High Bay east wall.
8. 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&EB.
9. 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.
10. 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.
11. Welding operations emit metal vapors that must 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.
12. 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.
13. Nonhazardous waste materials can be discarded in the standard GSFC dumpsters. The shop has a recycle bin for scrap metals.
14. Hazardous wastes such as acids, solvents, etc., shall be disposed of by calling the Hazardous Waste Environmental Specialist (x6-9233) for removal service. The Environmental Specialist also can recommend the proper methods of storing and handling materials such as the hydrochloric acid used in the brazing process.
15. 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.
16. 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.

17. 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.

18. 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.

19. LASAG laser welder operation:

Refer to Section 2.6 in Volume 1 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&EB 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.

4.18.5 GSFC Contacts

Welding Shop: Spacecraft Assembly Section Group Leader: (301) 286-3956

Lead Technician: (301) 286-2103

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.18.6 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 Volume 1).

4.19 Mechanical Drawing Reproduction, CAD, and VAX Computer Facilities

4.19.1 Scope

This section covers the Mechanical Drawing Reproduction Facility, Computer-Aided Design (CAD) Computer Facility, and VAX Computer Facility. These three areas are being grouped in this section because their office areas and equipment are similar in nature. From a safety viewpoint, their building areas and facilities require the same safety considerations as general purpose offices.

4.19.2 Acronyms/Definitions

N/A

4.19.3 General

This section covers the following facilities:

1. Mechanical Drawing Reproduction Facility—This facility's primary equipment is housed in Building 5, Room W205, and has a small storage area in a portion of Room W209. Documents and drawings of various sizes and color are reproduced, using equipment such as scanners, printers, and copiers. Bulk paper and toner cartridges are handled and stored within the facility.
2. CAD Computer Facility—This facility's equipment is housed in Building 5, Rooms W214A and W214B. The equipment includes CAD computer workstations, plotters, DesignJet 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.
3. VAX Computer Facility—The Thermal Engineering Branch maintains VAX computers and subsystems in Building 7, Rooms 258A–F and Rooms 272B–F. Also, there are storage areas and personnel offices in these rooms.

4.19.4 Specific Facility Requirements

1. Personnel working in these facilities should read and comply with the requirements for office safety described in Section 3.7 in Volume 1 of this Manual, particularly with respect to computer setup and operations.
2. Boxes of paper, toner cartridges, digital tapes, etc., should 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 should not be stored on top of cabinets where they are likely to fall and injure personnel.
3. To the extent possible, toner cartridges should be recycled rather than discarded. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1). 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.

4. 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.

4.19.5 GSFC Contacts

Mechanical Engineering Branch, Head: (301) 286-6003 for Mechanical Drawing Reproduction and CAD Computer Facilities

Thermal Engineering Branch, Head: (301) 286-5115 for VAX Facilities in Building 7

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.19.6 Reference Documents Unique to this Section

See references listed in Section 3.7.6.

4.20 Advanced Development Laboratory

4.20.1 Scope

This section covers the Advanced Development Laboratory and subsystems, located in Building 5, Room W27.

4.20.2 Acronyms/Definitions

N/A

4.20.3 General

This laboratory is set up to perform a variety of spacecraft development activities. These include fit-checking models, fit checking and applying thermal blankets, deploying solar panels and other moving devices, evaluating dynamic mechanisms on newly-designed flight hardware, etc. Electro-explosive devices (EEDs) are sometimes actuated to deploy dynamic systems.

4.20.4 Specific Facility Requirements

1. Personnel who actuate EEDs, or work around hardware containing EEDs, shall read and comply with the safety requirements described in Section 2.2 in Volume 1 of this Manual.
2. All personnel shall wear PPE appropriate for the activity at hand (see Section 3.6 in Volume 1).
3. There is an electrical ground plate on the east wall near the deployment apparatus for achieving effective grounding of sensitive hardware and EED circuits.
4. Only authorized and trained personnel shall operate the 1,000-lb (454 kg) monorail hoist. The hoist operator uses manual chains for the lifting and traversing functions.
5. Two house-supplied lines of pressurized air are located on the east wall. 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.
6. A drill press and other small machine tools are provided for hardware fabrication (see Section 4.7 for machine shop safety requirements).
7. The access doors to Room W27 have been heightened, and the aisle-ways leading to the nearest Building 5 west exit door have been widened. These modifications facilitate the movement of large payloads into and out of the laboratory.

4.20.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.20.6 Reference Documents Unique to this Section

GHB 1720.1, *GSFC Explosives and Pyrotechnic Safety*

See Section 2.1 references for mechanical handling information (see Volume 1).

See Section 4.7 references for machine shop information.

4.21 Electronic Test and Assembly Laboratory

4.21.1 Scope

This section covers the Electronic Test and Assembly Laboratory located in Building 5, Rooms W6, W6A–E, and C62B.

4.21.2 Acronyms/Definitions

1. LEV—Local exhaust ventilating.

4.21.3 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 pots, local exhaust ventilating (LEV) systems, hot/cold chambers, Class 100 clean benches, vacuum chamber, and other specialized equipment for working with electronic equipment.

4.21.4 Specific Facility Requirements

1. Personnel who operate or work around laser equipment shall read and comply with the safety requirements described in Section 2.6 in Volume 1 of this Manual. In Room C62B at the ZYGO laser, there is a black curtain that can be drawn to block outside illumination and to protect personnel from inadvertent exposure.
2. All personnel shall wear PPE appropriate for the activity at hand (see Section 3.6 in Volume 1 for PPE information and Section 2.6 in Volume 1 for specific eye protection requirements for laser operations).
3. Only authorized and trained operators shall operate specialized facilities, such as the lasers, vacuum chambers, hot/cold ovens, etc. During potentially hazardous operations, the operators shall post warning signs and erect personnel control barriers to prevent inadvertent access.
4. Liquefied and pressurized gases shall be supplied in standard cylinders/canisters, and handled per the safety requirements in Section 2.3 in Volume 1. 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 Delta 9059 cold/hot temperature chamber.
5. LEV ducts shall be placed as near to vapor producing activities as possible, particularly when performing soldering activities while using solder pots.
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. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
7. Small machine tools are provided for minor fabrication activities (see Sections 3.2 in Volume 1 and 4.7 for tool and machine shop safety requirements).
8. The standard refrigerator in Room 62B is for storing dry cell batteries and photographic film. Do not store food in this refrigerator.

4.21.5 GSFC Contacts

Electromechanical Systems Branch, Head: (301) 286-5194

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.21.6 Reference Documents Unique to this Section

GHB 1860.3, *Radiation Safety Handbook—Laser*

See Section 2.3 references for pressurized vessel information (see Volume 1).

See Section 2.6 references for additional laser information (see Volume 1).

See Section 2.8 references for electrical systems information (see Volume 1).

4.22 Mechanical Assembly Laboratory

4.22.1 Scope

This section covers the Mechanical Assembly Laboratory located in Building 5, Rooms W22, W22A, and C62A.

4.22.2 Acronyms/Definitions

N/A

4.22.3 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 hot/cold temperature oven, a dehumidifier/dry keeper, and a freezer for epoxy storage.

4.22.4 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, hot/cold oven, 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 Volume 1. (See Section 4.15 for thermal vacuum operations information.)
4. Store alcohol, acetone, and other volatile materials in the flammable storage cabinets provided for the purpose.
5. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).
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. 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 Sections 3.2 in Volume 1 and Section 4.7 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.

4.22.5 GSFC Contacts

Electromechanical Systems Branch, Head: (301) 286-5194

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.22.6 Reference Documents Unique to this Section

See Section 2.1 references for mechanical handling information (see Volume 1).

See Section 2.3 references for pressurized vessel information (see Volume 1).

See Section 4.7 references for machine shop information.

4.23 Thermal Coating Degradation Facility

4.23.1 Scope

This section covers the Thermal Coating Degradation 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.

4.23.2 Acronyms/Definitions

N/A

4.23.3 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.

4.23.4 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 Volume 1 of this Manual. 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 Section 3.6 in Volume 1 for PPE information). Ear defenders are provided for working in the area when the vacuum pumps are running (see Section 2.9 in Volume 1 for noise information).
3. Only authorized and trained operators shall operate the specialized facilities described in Section 4.23.3 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 Section 2.3 in Volume 1.
5. Gases used in these facilities have the potential for displacing oxygen in Room 12. A permanent oxygen monitor is installed on the south wall of the inner room. In the event of an oxygen deficiency in the room, the oxygen monitor automatically sounds an audible alarm, and illuminates a visual

alarm, to warn personnel to evacuate the area until normal atmospheric conditions can be restored. The room's ventilating system capacity has been increased to provide sufficient air flow for maintaining normal atmospheric conditions when the facilities are running.

6. Ventilation ducts are connected to the solar simulators to exhaust ozone vapors to the outside of the Building 7 roof.
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. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
8. A flammable storage cabinet is provided for storing alcohol, acetone, and other volatile materials.
9. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).
10. The electronic measuring equipment, described in Section 4.23.3 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.

4.23.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.23.6 Reference Documents Unique to this Section

GHB 1860.4, *Radiation Safety Handbook—Ultraviolet and High Intensity Light*

See Section 2.3 references for pressurized vessel information (see Volume 1).

See Section 2.6 references for non-ionizing radiation information (see Volume 1).

4.24 Thermal Technology Development Facility

4.24.1 Scope

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

4.24.2 Acronyms/Definitions

1. 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.

4.24.3 General

This laboratory contains a variety of specialized facilities for developing 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 the Capillary Pumped Loop (CAPL) experiment. Other facilities include two thermal vacuum chambers, bake-out ovens, chillers, argon/krypton charging station, 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.

4.24.4 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. Personnel who work with or around anhydrous ammonia shall read and comply with the requirements of this Manual's Section 2.5 in Volume 1, 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 4.15 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 liquid helium which is supplied in standard Dewars. 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 shall be handled and used per the safety requirements of Section 2.3 in Volume 1.

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. 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 Volume 1 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 moved or disassembled. 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.
11. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).
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 Volume 1 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 Section 4.7 for Machine Shop safety requirements).

4.24.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.24.6 Reference Documents Unique to this Section

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

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 4.7 references for machine shop information.

See Section 4.15 references for thermal vacuum operations information.

4.25 Thin Film Deposition Facility

4.25.1 Scope

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

4.25.2 Acronyms/Definitions

N/A

4.25.3 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.

4.25.4 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. 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 the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).
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 4.15 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 Section 2.3 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. 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.

4.25.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.25.6 Reference Documents Unique to this Section

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 4.15 references for thermal vacuum operations information.

4.26 Thermal Coatings Facility

4.26.1 Scope

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

4.26.2 Acronyms/Definitions

N/A

4.26.3 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.

4.26.4 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). When spraying polyurethane paints containing isocyanates, the operator shall wear a respirator face mask. 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 must 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. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.
5. The laboratory contains an automatic, 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 Section 2.5.4 in Volume 1 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 the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).

4.26.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.26.6 Reference Documents Unique to this Section

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 4.15 references for thermal vacuum information.

4.27 Contamination Control Laboratory

4.27.1 Scope

This section covers the Contamination Control Laboratory and its subsystems, located in Building 4, Rooms 193A–B.

4.27.2 Acronyms/Definitions

N/A

4.27.3 General

This laboratory contains thermal vacuum chambers and special equipment necessary to measure outgassed products during vacuum bake-out testing. Room 193A contains a 2.5' diameter x 5' long (0.76 m x 1.52 m) horizontal vacuum chamber for performing bake-outs. Room 193B contains a 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 specifications of the American Society for Testing Materials (ASTM). Quartz crystal microbalance sensors inside the vacuum chambers measure the outgassed materials.

4.27.4 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 4.15 for thermal vacuum operations information.)
3. Use extreme caution when handling and cleaning QCM 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.
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 the Hazardous Waste Environmental Specialist, 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. Vacuum equipment is preferred for removing dust and debris from hardware and machinery.

4.27.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.27.6 Reference Documents Unique to this Section

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 4.15 references for thermal vacuum information.

4.28 Coatings and Contamination Facility

4.28.1 Scope

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

4.28.2 Acronyms/Definitions

N/A

4.28.3 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.

4.28.4 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). 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 Section 2.6 in Volume 1 of this Manual. 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 Section 2.3 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. 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 Section 2.5.4 in Volume 1 for fume hood operational information.)
8. A permanent eyewash station is located adjacent to the fume hood in the staging area.
9. For removal of hazardous waste, contact the Hazardous Waste Environmental Specialist, telephone x6-9233 (see Section 2.5 in Volume 1).

4.28.5 GSFC Contacts

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.28.6 Reference Documents Unique to this Section

GHB 1860.3, *Radiation Safety Handbook—Laser*

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 2.6 references for additional laser information (see Volume 1).

4.29 Recertification (RECERT) Laboratories

4.29.1 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, Rooms 10 and 115; 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.

4.29.2 Acronyms/Definitions

N/A

4.29.3 General

1. 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, Room 115. 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.
2. 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.
3. 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.

4.29.4 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 must 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 Section 3.4 in Volume 1 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 must 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. The Hazardous Waste Environmental Specialist (x6-9233) makes regularly scheduled pickups of hazardous waste materials from the labs, and is on-call to assist as needed.

4.29.5 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 must insert an authorized keycard to open the motorized gate before driving onto the grounds. This security measure restricts the number of personnel who would be in harm's way during potentially hazardous testing activities. 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 Section 2.3 in Volume 1.
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. 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.
9. 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.

10. 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.
11. There is a portable eyewash station located at the doorway of Building 302, Room 115.

4.29.6 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 Section 2.5.4 in Volume 1 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 Section 2.8 in Volume 1 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.

4.29.7 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. 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. A sign shall be posted at the vertical ladder warning that access to the lab is for authorized personnel only. Contact the RECERT group leader for permission to enter.
4. 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.

5. Due to the configuration of the equipment and limited floor space, good housekeeping must be maintained.
6. There is a portable eyewash station near the operator's console.

4.29.8 GSFC Contacts

RECERT Manager: (301) 286-4209

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

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Support Contractor Safety: (301) 286-1035

4.29.9 Reference Documents Unique to this Section

See Section 2.3 references for pressurized systems information (see Volume 1).

See Section 2.5 references for hazardous materials and waste information (see Volume 1).

See Section 2.6 references for ultraviolet radiation information (see Volume 1).

4.30 SSPP Mechanical Laboratory, W51 Integration and Test Facility, and W59A Cleanroom

4.30.1 Scope

This section covers the SSPP Mechanical Laboratory, Room W51 Integration and Test Facility, and W59A Cleanroom, which are involved in buildup, testing, and checkout of small projects such as the HITCHHIKER, SPARTAN, and SMEX programs. The SSPP Mechanical Laboratory is also used for parts and materials storage.

4.30.2 Acronyms/Definitions

N/A

4.30.3 General

The SSPP Mechanical Laboratory is used for storage of both flight hardware and GSE, tools, miscellaneous parts and supplies, and light assembly work. This facility is located in Building 5, Rooms W45 and W69. Primarily handwork on small satellite parts is performed in this facility.
The Integration and Test Facility is used for assembly, checkout and test of flight hardware. It is located in Building 5, Rooms W47 and W51. Primarily cleanroom work is performed in the two cleantents located within Room W51 of the facility. Room W47 is used to set up GSE.
The W59A Cleanroom is primarily used for assembly of small experiments onto their carrier bridge, and SPARTAN integration testing. This facility is located in Building 5, Room W59A.

4.30.4 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, cranes, etc. 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 Section 2.5 in Volume 1).
5. GN_2 is used for purging and parts cleaning. LN_2, which is supplied in Dewars, is used in Room W59A. Liquefied and pressurized gases shall be supplied in standard cylinders/Dewars and handled per the safety requirements in Section 2.3 in Volume 1.
6. Hand tools are provided for fabrication activities (see Section 3.2 in Volume 1 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 performing ordnance operations in W59A shall follow the requirements stated in Section 2.2 in Volume 1. Operations consist primarily for EEDs.
9. The five-ton facility crane in W59A has been derated to 1/2 ton by the RECERT Manager.

4.30.5 GSFC Contacts

Carrier Systems Branch, Head: (301) 286-3327

Lead Mechanical: (301) 286-8116

S&EB: (301) 286-2281

AETD Safety Engineer: (301) 286-3816

MSD Safety Lead: (301) 286-1034

Safety Committee Head: (310) 286-6453

Support Contractor Safety: (301) 286-1035

4.30.6 Reference Documents Unique to this Section

See Section 2.1 references for mechanical handling information (see Volume 1).

See Section 2.2 references for Ordnance information (see Volume 1).

See Section 2.3 references for pressurized vessel information (see Volume 1).

See Section 3.2 references for Hand Tool information (see Volume 1).

4.31 Materials Engineering Branch Facilities

4.31.1 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 & Spectroscopy
110	Mass Spectroscopy
114	Auger Electron Spectroscopy
123	Scanning Electron Microscopy
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 5	Chemical Storage
Bsmnt	Ozone Depleting Chemical Storage
Bsmnt	Cabinet Storage (Non-chemical)

(Bsmnt*= Basement of Building 30)

4.31.2 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 handbook, *Materials Engineering Branch Instruments & Capabilities* (latest revision), contains photographs and a comprehensive description of the MEB instruments and facilities.

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

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

MEB personnel should identify potential hazards in their operations, consult the appropriate Volume 1 Sections of the Safety Manual, and follow the requirements therein. The remainder of this section presents particulars that apply directly to the Building 30 operations.

4.31.3 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 Laboratory Response Team (pager # 202-666-7966) 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 (LN_2) fill station, storage tanks, and vaporizer are located outside of Building 30, south side. 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, GN_2, and LN_2 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. 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%. 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.)
5. There are separate rooms dedicated for the storage of hazardous chemicals (see Paragraph D below.)
6. The facility also has a MQUAL laboratory wastewater treatment system. All laboratory sinks and wastewater outlets drain into this automatic treatment system, located in the basement. 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 Section 3.6 in Volume 1.

C. Chemical Spill Kits and Chemical Wastes

Laboratories that handle or use hazardous chemicals shall be furnished with chemical spill kits. Two types of spill kits shall be used: one for aggressive fluids (acids, caustics, solvents) and the other for non-aggressive fluids (oils, coolants.) Specially marked waste containers shall be used to collect waste materials. The designated MEB Waste Material Specialist shall administer the hazardous waste program and coordinate pickup of hazardous wastes with the Hazardous Waste Environmental Specialist as required (see Section 2.5 in Volume 1).

D. Chemical Storage (Rooms 166 and Basement 5)

Refer to Section 2.5.1 in Volume 1 and follow guidelines described in the Mechanical Systems Center 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 Room 184 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 (Basement Caged Area)

There is a controlled access locked cage located in the Building 30 basement where quantities of oxygen depleting chemicals such as freon and chlorothene are stored. The floor inside the caged area has been built up using absorbent socks in the form of a dike to contain spills.

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.

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. Personnel shall wear protective gloves when handling hot surfaces.

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 closed as much as possible to improve 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 a permanent eyewash and shower station.

I. Liquid Nitrogen Fill Station (Room 103)

Personnel use the Room 103 fill station to transfer LN_2 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, 158A)

The MEB maintains and operates three 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 4.2 for cleanroom operating requirements and garment specifications.

K. Radiation Source (Room 130)

(Refer to Section 2.7.4 in Volume 1 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 Branch (S&EB) shall leak test and inspect the sealed probes quarterly, at a minimum.

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

(Refer to Section 2.7.4 in Volume 1 for training and use requirements for radiation systems.) This lead-lined room contains two facilities that use x-ray tubes. The Film Radiographic facility uses a 200-kV tube head, and the Digital Radiography facility uses a 125-kV x-ray source. Safety features of the lead-lined room are as follows:

1. Posted signs in the area clearly warning of hazardous x-ray operations, and warning lights that illuminate during operations.
2. 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.
3. RaySafe Alarm Panel installed by the manufacturer, Technical Equipment Marketing, with clearly written safety and emergency procedures.
4. Closed circuit television system monitors the room to ensure no personnel are inside before starting x-ray operations, and to monitor the test specimens.
5. 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.
6. Emergency stop switches for both systems located conveniently inside the room.
7. 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. Experimental Welding Station (Room 139)

There is an experimental welding station with flexible local exhaust ventilator in Room 139. A permanently installed adjustable welding curtain can be drawn completely around the job site to protect personnel from welding hazards. Refer to Section 3.4 in Volume 1 for welding, brazing, and cutting guidelines.

N. Electrostatic Discharge Station (Room 177B)

A separate area in Room 177B has 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.

O. Anhydrous Ammonia Usage (Room 110)

Certain operations and equipment in mass spectroscopy analysis require the use of small quantities of anhydrous ammonia. Guidelines for handling this extremely hazardous material are described in Section 2.5.4 in Volume 1.

P. Immersion Ultrasonic Inspection System (Basement Caged Area)

This facility has been set up in a caged area 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.

4.31.4 GSFC Contacts

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

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

4.31.5 Reference Documents Unique to this Section

Materials Engineering Branch Instruments & Capabilities, Handbook (latest revision)

See Volume 1, Sections 2.0 and 3.0 references by safety topic as applicable to the MEB.

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	03/10/2004	Initial Release