National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

FACILITY OPERATING PROCEDURE
FOR
V3 THERMAL VACUUM CHAMBER

ENVIRONMENTAL TEST FACILITY BRANCH
STRUCTURAL AND ENVIRONMENTAL TEST DIVISION
TEST LABORATORY
ENGINEERING DIRECTORATE

CHECK THE MASTER LIST—
VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

FACILITY OPERATING PROCEDURE
FOR
V-3 THERMAL VACUUM CHAMBER

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1.0 GENERAL INFORMATION

1.1 PURPOSE

This document describes the procedures for the operation of Thermal Vacuum Chamber V3 located in Marshall Space Flight Center (MSFC) Environmental Test Facility (ETF) Building 4619.

1.2 SCOPE

The procedures and practices outlined in this document are to be followed in the operation of ETF Thermal Vacuum Chamber V3. This document provides a record copy of chamber V3 operations.

1.3 APPLICABLE DOCUMENTS

MPR 8715.1	Marshall Safety, Health, and Environmental (SHE) Program
MWI 8715.1	Electrical Safety Program
ET24-LOTO-SOP-001	Control of Hazardous Energy (Lockout/Tagout) Procedure for the Environmental Test Facility
MSOP-SC-ETF-408	Overhead Crane Operations Safety Requirements Document Utilizing Overhead Cranes CRN 0001 and 0002 (soon to be superseded by ET24-Crane-FOP-001)
ET24-UnattnOps-SOP-001	Unattended Operation of the Environmental Test Facility (soon to be superseded by)
ET24-ETF-OWI-001	Environmental Test Facility Test Operations
ED26 (02-01)	Memorandum for Record, Safety Assessment for the ETF (soon to be re-issued as a ET24 memo, number unknown)

1.4 SAFETY

All test personnel working in this facility shall be familiar with the safety documents listed above and shall report any safety hazards, unsafe practices, safety incident or near misses to the ETF Branch Chief or the 4619 Building Manager Assistant.

In addition to the above safety precautions, all personnel involved in facilities using cryogenics should be aware of possible freeze burns by contact with cold surfaces or liquids. Protective clothing including eye protection and gloves must be worn by all personnel involved in handling of cryogenics or when making repairs/modifications to

cryogenic facilities. Repairs/modifications to cryogenic systems must be performed by certified cryogenic handlers. In the event of a cryogenics spill, line ruptures, or similar emergencies, personnel must first be sure that there is no possibility of asphyxiation due to oxygen displacement. Use a portable oxygen monitor to verify oxygen is adequate before entering the spill area.

The chamber can reach extreme temperatures both hot and cold. The test chamber and test article shall be given sufficient time to return to ambient temperature ± 10 degrees C (± 18 degrees F) before removing the test article in order to minimize the extreme temperature hazard.

ET24 Safety Assessment, Memorandum of Record ED26 (02-01) (soon to be re-issued as an ET24 memo, number unknown) delineates the procedures, personal protective equipment (PPE) requirements and job hazard analysis (JHAs) for hazards associated with operation of this chamber. Operators must follow procedures, implement the risk mitigation methods listed in the JHAs and use the required PPE to minimize risk from potential hazards during chamber operations.

1.5 EMERGENCY TELEPHONE NUMBERS

In case of an emergency Call **911**;

Medical	**911**
Ambulance	**911**
Fire	**911**
Security	**911**
Chemical Spills	**911**

Other numbers that can be used for emergency information, security, safety, and system maintenance are:

Medical Center	544-2390
Security	544-4357
Safety	544-0046
Utilities	544-3919
Other Assistance	544-4357 (4-HELP)

1.6 CHECKOUT TEST

Prior to testing an item in the facility, particularly for critical qualification tests, it is recommended that a "dummy" test article be used to determine program set-points for the thermal controllers and safety devices. The "dummy" test article should provide an accurate thermal simulation of the actual test article.

1.7 HAZARDS LIST

- ***** 208 and 120 volts AC electrical power.
- ***** Extreme temperatures in the chamber (hot and cold)
- ***** Extreme heat at the diffusion pumps

* Liquid nitrogen (LN_2)
* Vacuum pump oil

********** WARNING **********

Maintenance or operating procedures, techniques, restrictions, etc., may result in severe personnel injury, loss of life or major equipment damage if not followed exactly.

****

**********WARNING**********

Prior to performing maintenance on any equipment, lockout and tag the equipment in accordance with Lockout/Tagout Procedure MSOP-FA-ETF-413 (soon to be superseded by ET24-LOTO-SOP-001). Maintenance shall be performed by qualified technicians only.

****

1.7.1 Minimizing Electrical Shock Hazards

1.7.1.1 All electrical repairs and modifications shall be performed by electrical technicians to minimize the electrical shock hazard.

1.7.1.2 All bare electrical parts inside the chamber with a potential to ground of 50 volts or greater should remain de-energized when the chamber is open. If this is infeasible, then safety related work practices shall be employed to prevent electrical shock. The safety related work practices shall be documented in accordance with MWI 8715.1 and approved by a senior ETF electrical engineer. All work near energized bare electrical parts shall be performed by qualified persons.

1.7.1.3 Personnel must not enter into or reach into a chamber with energized bare electrical parts where there is a lack of illumination or an obstruction of view. Personnel must never blindly reach into an area that may contain energized bare electrical parts.

1.7.1.4 Personnel shall remove all conductive apparel before working near energized bare electrical parts, including jewelry, watches, key chains, metalized aprons, and metal head gear.

1.7.1.5 Personnel may not perform housekeeping duties at close distances to energized bare electrical parts unless adequate safeguards are provided. Only non-conductive cleaning materials shall be used.

1.7.1.6 Any ladder used to enter chambers containing bare electrical parts energized at 50 volts or greater shall have nonconductive side-rails.

1.7.1.7 Personnel working near bare electrical parts energized at 50 volts or greater shall be provided protective equipment adequate to insulate the potential shock hazard. Personnel shall use insulating tools near energized bare electrical parts.

1.7.1.8 Safety signs or tags shall be used to warn personnel that an electrical shock hazard is present when there are bare electrical parts energized at 50 volts or greater.

1.7.1.9 Barricades shall be used in conjunction with signs or tags to limit personnel access.

1.7.1.10 Any de-energized electrical parts that are not locked-out, tagged-out, or unplugged will be considered energized. If tag-out is the method used, two or more safeguard measures shall be used. Any bare electrical part that is energized at less than 50 volts to ground need not be locked-out or tagged-out provided there is no risk of burns or arcing.

1.7.1.11 All live electrical parts located outside the chamber and energized at 50 volts or greater must be guarded against accidental contact. Guarding methods include approved enclosures or permanent partitions or screens that restrict access by non-qualified personnel.

1.7.1.12 Personnel shall not handle, energize or de-energize, plug-in or unplug any electrical device when the device is wet, the employee is wet, or the floor is wet.

1.7.1.13 Locking type connectors shall be properly secured after connection.

1.7.1.14 After a circuit has been de-energized by the opening of a protective device, an ETF electrical technician shall inspect the circuit before the circuit is re-energized.

1.7.1.15 Over-current protective devices shall not be modified.

1.7.2 Minimizing Extreme Temperature Hazards

The test chamber and test article shall be given sufficient time to return to ambient temperature $\pm$ 10 degrees C ($\pm$ 18 degrees F) before removing the test article in order to minimize the extreme temperature hazard.

1.7.3 Minimizing LN_2 Hazards

All personnel involved in facilities using cryogenics should be aware of possible freeze burns by contact with cold surfaces or liquids. Protective clothing including eye protection and gloves must be worn by all personnel involved in handling of cryogenics or when making repairs/modifications to cryogenic facilities. Repairs/modifications to cryogenic systems must be performed by certified cryogenic handlers. In the event of a cryogenics spill, line ruptures, or similar emergencies, personnel must first ensure that there is no possibility of asphyxiation due to oxygen displacement. Use a portable oxygen monitor to verify oxygen is adequate before entering the spill area.

1.7.4 Minimizing Extreme Heat Hazards at the Diffusion Pump

Stay clear of the diffusion pumps to minimize the burn hazard. The diffusion pumps can reach a temperature of 600^{o}F.

1.7.5 Minimizing Pump Oil Hazards

The vacuum pump oil can cause skin and eye irritation. Avoid skin and eye contact with the oil. Remove this oil from the skin using soap and water. Wear safety glasses while adding or changing oil. Remove oil from the eyes by flushing with water for 15 minutes. Avoid breathing vacuum oil mist.

There is a risk that the test article could be contaminated with diffusion pump oil. To minimize the risk of oil contamination, only allow trained personnel to operate the chamber. Also, ensure the cold trap between the diffusion pump and chamber is operational to reduce the contamination risk.

Any spilled oil is a slip hazard. Clean the floor of any spilled oil immediately. Use barricades to limit access in the area until the spill is cleaned.

1.8 RESPONSIBILITIES

ETF personnel will be responsible for the operation of the V3 Thermal Vacuum Chamber. The designated operator of the chamber will be responsible for the safe operation and conduct of the facility. This responsibility includes safety for personnel, the test article, and the facility. The operator will record his name in the chamber logbook.

Other task assignments and responsibilities at the ETF will be in accordance with the organizational work instruction ET24-ETF-OWI-001.

2.0 FACILITY DESCRIPTION

2.1 CHAMBER DESCRIPTION AND DIMENSIONS

Chamber V3 is a stainless steel vessel with polished interior surfaces. The inside dimensions are 4 foot diameter and 8 foot length. Installation of infrared lamps and/or cold boxes reduces the available interior space.

2.2 VACUUM SYSTEM

The rough vacuum system consists of a mechanical roughing pump with a roughing valve and a LN_2 cold trap between the roughing valve and the roughing pump. The high vacuum system consist of two diffusion pumps with two backing pumps, two high vacuum valves to isolate each diffusion pump from the chamber, two foreline valves and two LN_2 cold traps upstream of the diffusion pumps.

2.3 CONTROL SYSTEM

The control system consists of a desktop computer running Windows operating system software and Intellution Dynamics *Ifix* control software for operating the chamber systems through a programmable logic controller. Liquid level controllers are used to control

cooling of the LN_2 cold traps. A Watlow controller is used to control the thermal conditioning. A Watlow limiter is used to limit maximum and minimum temperature.

Pressure monitoring is by convectron and ion gauges.

2.4 THERMAL SYSTEM

Thermal conditioning is provided by infrared lamps mounted on a metal frame. The lamps are controlled by the Watlow controller. The lamp array is removable if additional space is needed.

NOTE

Maintenance or operating procedures, techniques, restrictions, etc., requires emphasis for safe operation.

3.0 FACILITY OPERATION

The operations of Chamber V3 will vary according to the temperature range, off-gassing rate of the test article, and whether steady state or varying environments are required. This procedure provides general instructions on how to operate the chamber but does not cover every possible scenario. Operating personnel should be thoroughly familiar with vacuum chamber operation, the thermal conditioning software and the data acquisition software.

Complete the As-run Buy-off Sheet when operating the chamber. This sheet is typically provided with the TPS. If none is provided, use a copy of Attachment A. Additional As-run Buy-off sheets shall be used if the test is required to restart.

3.1 FACILITY PREPARATION

3.1.1 Review the safety assessment, Memorandum of Record ED26 (02-01) (soon to be re-issued as an ET24 memo, number unknown), to determine the JHAs and PPE that applies to operation of this chamber. Implement the risk mitigation methods listed in the JHAs and use the required PPE to minimize risk from potential hazards while operating this chamber.

3.1.2 Ensure that all connections to the chamber are compatible with proper operation of the chamber. Determine that the test is ready to start.

3.1.3 Verify that system purge air supply is regulated to 20 psig.

3.1.4 Visually inspect the level and condition of the oil in the roughing pump, the two backing pumps and two diffusion pumps. Add or change oil as needed. Oil should be changed whenever it is darkened, contaminated, milky, or if the pump performance

has degraded. Wear safety glasses and gloves when changing oil. Remove oil from the skin using soap and water. Remove oil from the eyes by flushing with water for 15 minutes. Avoid breathing vacuum oil mist.

Any spilled oil is a slip hazard. Clean the floor of any spilled oil immediately. Use barricades to limit access in the area until the spill is cleaned.

3.1.5 Visually inspect electrical equipment for external damage including flexible cords, connectors, and plugs. An ETF electrical technician shall repair damage before proceeding to the next step.

3.1.6 Calibration

3.1.6.1 Verify all instrumentation used to record data on this test have current calibration labels.

3.1.6.2 Verify the calibration will not expire before the expected test conclusion date.

3.1.7 Data Acquisition

3.1.7.1 Verify that the data acquisition system is programmed and recording in accordance with customer's data requirements.

3.1.7.2 If using PACRATS, start recording data prior to chamber pump down.

3.2 VACUUM SYSTEM OPERATION

3.2.1 Photograph the test article and test setup. Take as many photographs as necessary dependent on the complexity of the test setup. Copies of these photographs shall be given to the ETF Test Data Administrator before or immediately following the end of testing. This section shall be omitted if the customer requests no photographing of the test article.

3.2.2 Use the crane to close the door. Operate the crane in accordance with the crane procedure MSOP-SC-ETF-408 (soon to be superseded by ET24-Crane-FOP-001).

3.2.3 Switch **ON** the inside lights and video camera and verify the camera is operating properly.

3.2.4 Seal the door to the chamber with at least two or more clamps. Install two bolts in the door that will support it.

3.2.5 Switch **ON** the roughing pump. Allow a few minutes for it to rough pump the inlet pipe.

3.2.6 **OPEN** the roughing valve.

3.2.7 After chamber pressure reaches 500 torr, loosen the door clamps and bolts so the chamber would vent if there was a positive pressure in the chamber. Leave two loose bolts in place so they will support the door if there is a loss of vacuum.

3.2.8 Switch **ON** the roughing cold trap.

3.2.9 Switch **ON** diffusion backing pump #1 and /or #2 as needed.

3.2.10 **OPEN** the diffusion pump (DP) foreline valve #1 and/or #2 as needed.

3.2.11 Verify the diffusion pumps have water flow then switch **ON** diffusion pump #1 and/or #2 as needed.

3.2.12 Switch **ON** the LN_2 cold traps for the diffusion pumps for the diffusion pumps #1 and/or #2 as needed.

3.2.13 When chamber pressure reaches 5×10^{-1} torr (500 millitorr) switch **ON** the scavenger plate.

3.2.14 Allow the chamber to rough pump to $8.0 \times 10^{-2} \pm 2.0 \times 10^{-2}$ (100 to 60 millitorr). Never rough pump the chamber less than 50 millitorr.

3.2.15 When the diffusion pumps reach operation temperature (near 600^0F, dependent on the condition of the pump heaters and the temperature transducer) **CLOSE** the roughing valve. Record diffusion pumps temperature in the log.

3.2.16 Wait until the roughing valve is fully closed, then **OPEN** high-vac valves #1 and/or #2 as needed.

3.2.17 Switch **OFF** the roughing cold trap.

3.2.18 **PURGE** the roughing cold trap for 30 minutes then **CLOSE** the roughing cold trap purge.

3.2.19 **STOP** the roughing pump.

3.2.20 **VENT** the roughing line.

3.3 THERMAL CONDITINING

Thermal conditioning is accomplished by using infrared lamps to heat or a cold plate to cool. Lamps and the cold plate are controlled by the Watlow controller

3.3.1 Verify the heater phasers are powered and ready to energize the IR lamps and/or cold plate line are properly connected.

3.3.2 Set the Watlow controller to the desired temperature or temperature profile.

3.4 VACUUM SYSTEM SHUTDOWN

3.4.1 Thermal Cycling Shutdown

3.4.1.1 Change thermal set point to a temperature near ambient so that the chamber is not heating or cooling.
3.4.1.2 Switch **OFF** the IR lamp power.
3.4.1.3 Switch **OFF** the cold plate.
3.4.1.4 **OPEN** Cold Plate Purge hand valve as needed. This is a green handle hand valves located under the chamber on the west side.
3.4.1.5 Allow the chamber and test article to cool until temperatures are returned to temperature near ambient $\pm$ 10 degree C ($\pm$18 degrees F) and above the dew point.

3.4.2 Diffusion Pump Shutdown

3.4.2.1 **CLOSE** the hi-vac valves.
3.4.2.2 Switch **OFF** the diffusion pumps being used.
3.4.2.3 Switch **OFF** the LN_2 cold trap to diffusion pump being used.
3.4.2.4 After the diffusion pumps are cooled, **OPEN** the cold trap purge valve. Pressurize to about 20 psig GN_2. Allow 30 minutes for the LN_2 trap to warm.
3.4.2.5 **CLOSE** the LN_2 trap purge valve.
3.4.2.6 **CLOSE** the foreline valves.
3.4.2.7 Switch **OFF** the backing pumps in use.
3.4.2.8 Vent the foreline.

3.4.3 Chamber Shutdown

3.4.3.1 Verify all circuits inside the chamber are switched off and de-energized, including all of the customer's circuits. If it is infeasible to de-energize all circuits, comply with all requirements of Section 1.7.1 Minimizing Electrical Shock Hazards. If it is infeasible to de-energize all circuits on the test article, provide the customer with a copy of Section 1.7.1 Minimizing Electrical Shock Hazards.

3.4.3.2 Connect the chamber door to the crane or verify the door is supported.
3.4.3.3 Ensure that all temperatures are at ambient $\pm$10 degrees C ($\pm$18 degrees F) and above the dew point, then **OPEN** chamber repress valve.
3.4.3.4 Switch OFF the scavenger panel when pressure reaches 500 torr.

3.4.3.5 **OPEN** Scavenger Plate Purge hand valves if the scavenger plated in installed. This is a green handle hand valve located under the chamber on the west side.

3.4.3.6 After the door is opened, and before other activities, an ETF electrical technician shall check for potential on all of the ETF's bare electrical parts energized at 50 volts or greater. The customer shall check for potential on the test article's bare electrical parts energized at 50 volts or greater.

3.5 UNATTENDED OPERATIONS

The thermal vacuum chamber is designed for continuous automatic operation. To preclude inadvertent automatic shutdown of the chamber or anomalies in the test environment and/or test data, complete the following steps before leaving the operating equipment unattended.

3.5.1 Verify that all facility expendable sources will be available for the unattended period.

3.5.2 Complete applicable sections of the procedure ET24-UnattnOps-FOP-001, Unattended Operation of the Environmental Test Facility.

4.0 EMERGENCY SHUTDOWN

4.1 If there is an electrical fault in the heat circuits, **PUSH** the RED Stop Button.

4.3 If there is a LN_2 leak close the other chamber LN_2 supply in the control room. Use portable oxygen monitors to verify oxygen is adequate when re-entering the spill area.

4.4 Vent the chamber and remove the test article only when there is no risk of injury to personnel and no risk of damage to the test specimen.

V-3 As-run Buy-off Sheet

Test Number _____ Customer Contact _____

Calling TPS or Work Instructions _____Start Time & Date _____

Test Description_____ End Time & Date _____

Data Process Rate _____

Test Operator(s) (Print name and initial) _____ _____

3.1 Facility Preparation

3.1.1 _____

3.1.2 _____

3.1.3 _____

3.1.4_____

3.1.5 _____

3.1.6.1_____

3.1.6.2_____

3.1.7.1_____

3.1.7.2_____

3.2 Vacuum Sys. Oper.

3.2.1 _____

3.2.2 _____

3.2.3 _____

3.2.4 _____

3.2.5 _____

3.2.6_____

3.2.7 _____

3.2.8 _____

3.2.9 _____

3.2.10_____

3.2.11 _____

3.2.12 _____

3.2.13 _____

3.2.14 _____

3.2.15 _____

3.2.16 _____

3.2.17 _____

3.2.18 _____

3.2.19 _____

3.2.20 _____

3.3 Thermal Conditioning

3.3.1_____

3.3.2 _____

3.4 Vacuum System Shutdown

3.4.1 Thermal Cycling Shutdown

3.4.1.1 _____

3.4.1.2 _____

3.4.1.3 _____

3.4.1.4 _____

3.4.1.5 _____

3.4.2 Diff Pump Shutdown

3.4.2.1 _____

3.4.2.2_____

3.4.2.3_____

3.4.2.4_____

3.4.2.5_____

3.4.2.6_____

3.4.2.7 _____

3.4.2.8 _____

V-3 As-run Buy-off Sheet

3.4.3 Chamber Shutdown

3.4.3.1 _____

3.4.3.2_____

3.4.3.3_____

3.4.3.4_____

3.4.3.5 _____

3.4.3.6 _____

3.5 Unattended Ops

3.5.1 _____

3.5.2 _____

QA _____
N/A if not applicable