ET24-V20-FOP-001
5 October, 2005

National Aeronautics and
Space Administration

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

FACILITY OPERATING PROCEDURE
FOR
THERMAL VACUUM CHAMBER V20

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

CHECK THE MASTER LIST—
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FACILITY OPERATING PROCEDURE
FOR
THERMAL VACUUM CHAMBER V20

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Release Date: 10 / 5/ 2005		**Marshall Space Flight Center** **Specification/Document Change Instruction** Spec. / Doc. No. ET24-V20-FOP-001	Page 1 of 1 _____ Copy No.:
Change No./Date	SCN/DCN No./Date	Replacement Page Instructions	
Baseline 10-5-2005	MFOP-405E-004 &-005	Initial issue for the ET24 organization. Supersedes MFOP-FA-ETF-405.	

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ATTACHMENT A

1.0 GENERAL INFORMATION

1.1 PURPOSE

This document describes the procedures for the operation of the Thermal Vacuum Chamber V20 located in MSFC Building 4619.

1.2 SCOPE

The procedures and practices outlined in this document are to be followed in the operation of Chamber V20. This document provides a record copy of Chamber V20 operations. Loading and handling of test articles shall be in accordance with the Test Preparation Sheets (TPS) and outside the scope of this procedure.

1.3 APPLICABLE DOCUMENTS

NPR 8715.3	NASA Safety Manual
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
ET24-ForkLift-SOP-001	Powered Industrial Fork Truck Operation Safety Requirements
ET24-RGA-SOP-001	Detailed Operating Procedure for Residual Gas Analyzer System
ET24-TQCM-SOP-001	Detailed Operating Procedure for Temperature-Controlled Quartz Crystal Microbalance (TQCM) System
ET24-OWI-ETF-001	Environmental Test Facility Test Operations
ED26 (02-01)	Memorandum for Record, Safety Assessment for the ETF (soon to be issued as an 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 the event of serious personnel injury, do not move the injured person unless necessary to prevent further serious injury. The emergency telephone number is **911**.

All ETF personnel involved in facilities using cryogenics shall be aware of the possibility of freeze burns by contact with cold surfaces or liquids. Protective clothing including eye protection and gloves shall be worn by all personnel involved in handling of cryogenics or when making repairs/modifications to cryogenic facilities. Only certified cryogenic handlers shall perform repairs/modifications to cryogenic systems. In the event of a cryogenics spill, line ruptures, or similar emergencies, personnel shall 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.

The personal protective equipment (PPE) requirements and job hazard analysis (JHAs) for operation of the chamber are listed in the ET24 Safety Assessment, Memorandum ED26 (02-01). Chamber operators shall be familiar with these documents to understand associated hazards and methods to mitigate the risk from these hazards.

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, security, safety, and system maintenance information are:

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

1.6 CHECKOUT TEST

A recommended method to ensure the chamber performs as expected is to use a "dummy" test article in a checkout test prior to testing. The checkout test is particularly critical for high value program critical hardware (PCH). The checkout test is effective for determining 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

- 480, 240 and 120 volts AC electrical power.
- Extreme temperatures (hot and cold)
- 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 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 shall 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 shall 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 shall never blindly reach into an area that potentially contains 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 shall 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 the chamber when there are 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 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 shall 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 shall 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, the circuit shall be inspected by an ETF electrical technician 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 ±10 degrees C (± 18 degrees F) before entering the chamber to minimize the extreme temperature hazard.

1.7.2 Minimizing LN_2 Hazards

All personnel involved in facilities using cryogenics shall be aware of possible freeze burns by contact with cold surfaces or liquids. Protective clothing including eye protection and gloves shall be worn by all personnel involved in handling of cryogenics or when making repairs/modifications to cryogenic facilities. Only certified cryogenic handlers shall perform repair/modifications to cryogenic systems. In the event of a cryogenics spill, line ruptures, or similar emergency, personnel shall 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.

1.7.3 Minimizing Pump Oil Hazards

There is a risk that the test article could be contaminated with vacuum pump oil. The chamber must only be operated by trained personnel to minimize the risk of oil contamination. Ensure that all cold traps are operational to mitigate the oil contamination risk.

The vacuum pump oil can cause skin irritation. Avoid skin contact with the oil. Remove this oil from the skin using soap and water. Wear eye protection and gloves while adding or changing oil. 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 area of any spilled oil immediately. Use barricades to limit access in the area until the spill is cleaned.

1.8 RESPONSIBILITY

ETF personnel shall be responsible for the operation of the V20 Thermal Vacuum Facility. The designated operator of the chamber shall be responsible for the safe operation and conduct of the facility. The operator shall record his name in the chamber logbook.

Other task assignments and responsibilities at the ETF shall be in accordance with ET24-ETF-OWI-001.

2.0 FACILITY DESCRIPTION

2.1 CHAMBER DESCRIPTION AND DIMENSIONS

Chamber V20 is a stainless steel vessel with polished interior surfaces. The dimensions are 20' diameter and 28' long. Installation of cryogenic shroud, infrared lamps, or cold plates reduces the useable interior space.

Pressure is monitored in the control room by Granville-Phillips convectron and ionization gauges.

2.2 VACUUM PUMP DESCRIPTION

The chamber has two large mechanical roughing pump systems, three cryogenic (cryo) pumps and three turbomolecular (turbo) pumps. Six small mechanical pumps are used for roughing of the cryo pumps and backing of turbo pumps. Liquid nitrogen (LN_2) cold traps are used in the chamber roughing line, the cryo pump roughing lines, and in one of the three turbo backing lines. The cryo pumps and turbo pumps each have high vacuum (hi-vac) valves that are used to isolate the pumps from the chamber.
The sum of pumping speeds for all high vacuum pumps is 98,000 liters per second. The chamber's delivered high vacuum pumping speed is 66,000 liter per second.

2.3 CONTROL SYSTEM

The control system consists of a programmable logic controller (PLC), and a control computer using Microsoft Windows and Intellution Dynamics iFIX software. Electrical solenoids and relays are used to control the chamber pumping system and devices. Granville Phillips vacuum gauge controllers are used to acquire pressure data. Liquid level controllers for all LN_2 cold traps and cryogenic-pump shrouds are used in conjunction with the PLC. Manual overrides for gas, fluid, and electrical subsystems exist to safe the system as necessary. There is a nine zone variable 240 VAC power source provided for lamp arrays or other electrical power uses

2.4 TEST ARTICLE WEIGHT CONSTRAINT

V20 is capable of performing high vacuum testing with test articles weighing up to 15 tons (mass of 27000 kg).

2.5 PERFORMANCE

Pumping times have not been determined since the modification of the pump system. Typical chamber performance will be determined and added to this procedure in a future revision. Pump down times are typically from two to four hours.

2.6 FAIL-SAFE FEATURES

In the event of a building power failure the chamber is operated to protect both the safety of personnel and facility and test article equipment. The design of the control power logic includes interlocks to prevent improper operation of valves or pumps. Emergency power is provided for the control system and the data acquisition system.

3.0 FACILITY OPERATION

The operation of the V20 Chamber varies 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 for a typical test, but does not cover every possible scenario. Operating personnel shall be thoroughly familiar with vacuum chamber operation, the thermal conditioning software, instrumentation and the data acquisition software.

Complete the As-run Buy-off Sheets when operating the chamber. Buy-off Sheets are typically provided with the TPS. If none is provided, use a copy of Attachment A.

NOTE

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

3.1 FACILITY PREPARATION AND MAINTENANCE

The following checks and maintenance actions shall be performed prior to each test run

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

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

****

3.1.1 Review the Safety Assessment, Memorandum ED26 (02-01) (soon to be issue 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 V20 Overhead Work Platform Safety Requirements

Not more than three people shall be on the V20 overhead platform. The last person to enter and leave the platform shall latch the safety chain. While personnel are on the platform, all personnel on the floor near the platform shall wear a hard hat. A circumference of ten feet around the chamber shall be established and roped-off to indicate a hardhat area. Personnel working on the platform shall ensure that all tools, equipment, oils, cleaning solutions, etc. are accounted for and removed from the chamber platform before leaving. When first entering and before leaving the platform, it shall be inspected for hazards including oils, grease and trip hazards. Hazards shall be corrected immediately.

3.1.3 Visually inspect all water, high purity (HP) air and gaseous nitrogen (GN_2) system components for leaks.

3.1.4 Visually inspect electrical equipment for external damage including flexible cords, connectors, and plugs. An ETF electrical technician shall repair damage before proceeding to Section 3.2.

3.1.5 Visually inspect the level and condition of the pump oils. There are 16 sight glasses to check, three sight glasses on each of the two Roots pumps, two sight glasses on each the two Microvac pumps, one sight glass on each of the three cryo roughing pumps and one sight glass on each of the three turbo backing pumps. Add or change oil as needed. Oil shall be changed whenever it is darkened, contaminated, milky, or if the pump performance has degraded.

Wear eye protection and gloves when handling oil. Any spilled oil is a slip hazard. Clean the area of any spilled oil immediately. Use barricades to limit access in the area until the spill is cleaned.

3.1.6 Preparing Roughing Pumps

3.1.6.1 **OPEN** the cooling water inlet hand valves (V201 & V202) at the pumps. Verify the flow of cooling water at the outlet. Do not adjust the cooling water outlet hand valves (V101 & V102), these shall remain at their last settings.

3.1.6.2 **CLOSE** the pump vent valve (small “Variant” stainless valve just above each gas ballast valve on the south side of the “Microvac” pumps).

3.1.6.3 **CLOSE** the gas ballast valve (small cock valve near center on north and south side of each “Microvac” pump).

3.1.6.4 **CLOSE** the oil drain valve (faucet valve on southeast corner of each “Microvac” pump.

3.1.6.5 Configure the off-auto switches to the **OFF** position at the roughing pumps.

3.1.6.6 **CLOSE** the leak detector attachment-port hand valve (small stainless “Variant” valve on line between “Roots” pump and “Microvac” pump).

3.1.6.7 Visually inspect the condition of the roughing pump drive belts (4 belts). Replace damaged and worn belts.

3.1.7 Cryo and Turbo Pump Cooling Water

3.1.7.1 **OPEN** the main cooling water hand valves 6, 027, 048 and 069 (CP1-WH-HEM, CP2-WH-HEM, CP3-WH-HEM and TP1-WH-TPM).

3.1.7.2 **OPEN** the primary cooling water hand valves 5, 026, 047 and 068 (CP1-WH-HEBP, CP2-WH-HEBP, CP3-WH-HEBP AND TP1-WH-TPBP).

3.1.7.3 Keep **CLOSED** the quick quench cooling water hand valves V205, V209, and V213.

3.1.8 Control Air and GN2

3.1.8.1 Verify the GN_2 is available at the Panel Primary GN_2 Reducing Station near the north wall. The inlet pressure shall be 1000 psig. The Panel Inlet Valve (GNV137) shall be open.

3.1.8.2 The first stage GN_2 shall be at 400 psig $\pm$ 50 psi. Adjust as needed at the 1st Stage Regulator (GNR42).

3.1.8.3 The 2nd stage GN_2 shall be at 100 psig $\pm$5psi. Adjust as needed at the 2nd Stage Regulator (GNR44). The outlet hand valve (GNV141) shall be open.

3.1.8.4 Verify the Primary HP Air is available at the same panel near the north wall. The inlet pressure shall be about 2500 psig. The Panel Inlet Valve (AR235) shall be open.

3.1.8.5 The 1st stage Primary HP Air shall be 400 psig $\pm$ 50 psi. Adjust as needed at the 1st Stage Regulator (AR71).

3.1.8.6 The 2nd stage Primary HP Air shall be at 100 psig $\pm$5psi. Adjust as needed at the 2nd Stage Regulator (AR73). The outlet hand valve (AV239) shall be open.

3.1.8.7 Verify the Secondary HP Air is available at the same panel near the north wall. The inlet pressure shall be about 100 psig. The Panel Inlet Valve (AV240) shall be open. The outlet pressure shall be 20 psig $\pm$ 2 psi. Adjust as needed at the pressure regulator (AR75). The 20 psig outlet valve (AV243) shall be open.

3.1.9 Valve Operation

3.1.9.1 Verify the following HP air hand valves are OPENED.

Valve Number	Valve Description
V107	Control Air for Roughing Valve
3 (CP1-AH-HV)	Control Air for Cryo Pump 1(CP1) Hi-Vac
17 (CP1-AH-RV)	Control Air for CP1 Roughing Valve
24 (CP2-AH-HV)	Control Air for CP2 Hi-vac
38 (CP2-AH-RV)	Control Air for CP2 Roughing Valve
45 (CP3-AH-HV)	Control Air for CP3 Hi-vac
59 (CP3-AH-RV)	Control Air for CP3 Roughing Valve
V161	Control Air for Roughing Pump Isolation ROV105
V162	Control Air for Roughing Pump Isolation ROV104
80 (TP1-AH-CT)	Purge Air for Turbo Pump 1 (TP1) Foreline Cold Trap (CT)
66 (TP1-AH-HV)	Control Air for TP1 Hi-vac Valve
76 (TP1-AH-FV)	Control Air for TP1 Foreline Valve
V163	Control Air for Re-press Valve ROV106
V168	Control Air to PRV101 on Re-press Line
13 (CP1-AH-SH)	Purge Air for CP1 Shroud Purge
21 (CP1-AH-CT)	Purge Air for Roughing CT on CP1
34 (CP2-AH-SH)	Purge Air for CP2 Shroud Purge
42 (CP2-AH-CT)	Purge Air for Roughing CT on CP2
55 (CP3-AH-SH)	Purge Air for CP3 Shroud Purge
63 (CP3-AH-CT)	Purge Air for Roughing CT on CP3

3.1.9.2 Verify the following HP air valves are **CLOSED**. Verify the pressure regulators on the purge air lines are set at 7.5 psig $\pm$2 psig except as noted.

Valve Number	Valve Description
V181	Purge Air for CT5 at VP101
V183	Purge Air for CT6 at VP102
V185	Roughing Line Purge
11 (CP1-AS-SH)	CP1 Shroud Purge Solenoid Valve / Set at 2 +0-0.5 psig
32 (CP2-AS-SH)	CP2 Shroud Purge Solenoid Valve / Set at 2 +0-0.5 psig
53 (CP3-AS-SH)	CP3 Shroud Purge Solenoid Valve / Set at 2 +0-0.5 psig
19 (CP1-AS-CT)	CP1 Roughing CT Purge Solenoid Valve
40 (CP2-AS-CT)	CP2 Roughing CT Purge Solenoid Valve
61 (CP3-AS-CT)	CP3 Roughing CT Purge Solenoid Valve
78 (TP1-AS-CT)	TP1 Backing CT Purge Solenoid Valve

3.1.9.3 Verify the following GN_2 valves are **OPEN**. Verify the pressure regulators on these purge lines are set at 5 to 6 psig.

Valve Number	Valve Description
10 (CP1-GH-PP)	CP1 Pump Body Purge
31 (CP2-GH-PP)	CP2 Pump Body Purge
52 (CP3-GH-PP)	CP3 Pump Body Purge

3.1.9.4 Verify the following GN_2 valves are **CLOSED**.

Valve Number	Valve Description
8 (CP1-GS-PP)	CP1 Pump Body Purge Solenoid Valve
29 (CP2-GS-PP)	CP2 Pump Body Purge Solenoid Valve
50 (CP3-GS-PP)	CP3 Pump Body Purge Solenoid Valve

3.1.9.5 Verify the following water valves are **OPEN**.

Valve Number	Valve Description
4 (CP1-WS-HE)	CP1 Helium Compressor H2O Solenoid Valve
25 (CP2-WS-HE)	CP2 Helium Compressor H2O Solenoid Valve
46 (CP3-WS-HE)	CP3 Helium Compressor H2O Solenoid Valve
67 (TP1-WS-TP)	TP1 Cooling H2O
V201	VP101 Water
V202	VP102 Water

3.1.9.6 Verify the flow of cooling water at the drains of the three cryo pumps, the TP1 turbo pump, and the two Microvac roughing pumps.

3.1.9.7 Configure the LN_2 controllers' auto-manual toggle switches to the **AUTO** position.

3.1.9.8 Verify the control GN_2 valve for turbo pumps 2 and 3 is **OPENED**. This is a small stainless steel valve with a green colored T-handle located floor level below turbo pumps 2 and 3.

3.1.10 Inspect connections to the chamber to verify they are connected properly. Determine that the test is ready to start.

3.1.11 Calibration

3.1.11.1 Verify all instrumentation to be used on the test has current calibration labels where applicable.

3.1.11.2 Verify the calibration does not expire before the expected test conclusion date.

3.1.11.3 Visually inspect the condition of all pressure transducers. Replace broken and damaged convectron and ion gauge transducers.

3.1.12 Data Acquisition

3.1.12.1 If using PACRATS, verify that the data acquisition system is programmed in accordance with customer's data requirements.

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

3.1.12.3 Verify data acquisition system and transducers are operational. Monitor the pressure transducer outputs in the data acquisition computer to verify they are near ($\pm$25%) to the LED output on the gauge controller. Verify the thermocouples have outputs in the range expected and are stable within $\pm$2 degrees.

3.1.13 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.

3.2 CRYO PUMP OPERATION

3.2.1 **CLOSE** CP1, CP2, and CP3 hi-vac (HV) valves.

3.2.2 Verify LN_2 supply and return valves are **CLOSED** at the Rome chamber if the Rome chamber is inactive.

3.2.3 **OPEN** the 20 ft. Chamber Supply for LN_2 (located on the LN_2 control panel).

3.2.4 Switch **ON** the convectron gauges for the cryo pump roughing pressures.

3.2.5 Switch **ON** CP1, CP2, and CP3 Roughing Pumps.

3.2.6 **OPEN** the VC Cool-down at the LN_2 control panel for one minute if using Vessel 2.

3.2.7 **OPEN** the LN_2 bypass hand valve at the chamber.

3.2.8 Wait one minute then **CLOSE** the LN_2 bypass hand valve at the chamber.

3.2.9 Switch **ON** CP1, CP2 and CP3 Roughing CT.

3.2.10 Wait until each cryo roughing lines LN_2 controller cycles, and then **OPEN** its roughing valve (CP1, CP2 and CP3 Roughing Valves).

3.2.11 When each cryo pump pressure reaches 7.5×10^{-2} torr, **CLOSE** its roughing valve (CP1, CP2 and CP3 Roughing Valves).

3.2.12 **OPEN** water to three Helium Compressors.

3.2.13 If the pressure rises at a rate greater than 15 millitorr ($1.5x10^{-2}$ torr)/ minute, then rough that cryo pump again by returning to step 3.2.9.

3.2.14 Switch **ON** CP1, CP2 and CP3 Helium Compressors.

3.2.15 Switch **ON** CP1, CP2 and CP3 Shroud LN_2.

3.2.16 **STOP** the CP1, CP2 and CP3 Roughing CT.

3.2.17 **OPEN** the CP1, CP2 and CP3 Roughing CT Purge.

3.2.18 Allow the cryo roughing cold traps to purge for 30 minutes, and then **CLOSE** the CP1, CP2 and CP3 Roughing CT Purge.

3.2.19 **STOP** the CP1, CP2 and CP3 Roughing Pumps.

3.3 CHAMBER OPERATION

3.3.1 **CLOSE** and **Clamp** the door to seal the chamber. If using a fork truck to push the door, operate the truck in accordance with MSOP-FA-ETF-414 (soon to be superseded by ET24-ForkLift-SOP-001). Push the door at the support frame and never push on the door itself.

3.3.2 Verify all six high-vac valves are closed (CP1, CP2, CP3, TP1, TP2, and TP3 HighVac Valves).

3.3.3 Verify the chamber vent-line hand valve is **CLOSED**, located at the chamber (V169).

3.3.4 **OPEN** the V20 LN_2 supply valve (located on the LN_2 control panel).

3.3.5 Switch **ON** all convectron gauges.

3.3.6 **Roughing The Chamber**

3.3.6.1 Switch **ON** the MV1 and MV2 Roughing Pumps.
3.3.6.2 **OPEN** the MV1 and MV2 Valves.
3.3.6.3 **OPEN** the Chamber Roughing Valve (ROV107).
3.3.6.4 Configure the 2 roughing pump off-auto switches to **AUTO** at the roughing pumps.
3.3.6.5 Wait until the chamber pressure reaches 500 torr or less, and then remove the door clamps.
3.3.6.6 Wait until the pressure reaches 10 torr or less, and then switch **ON** cold traps MV1-CT, MV2-CT and the Roughing Line CT.

3.3.7 Wait for the chamber to reach $1x10^{-1}$ torr (100 millitorr) or less before proceeding.

3.3.8 Start The Turbo Pumps

3.3.8.1 **RUN** turbo backing pumps (TP2BP, TP3BP and TP1 Backing Pump).
3.3.8.2 Switch **ON** the TP1 Backing CT.
3.3.8.3 **OPEN** the turbo foreline valves (TP1 Foreline Valve, TP2FV and TP3FV).
3.3.8.4 Allow the turbo TP1 backing cold trap to cycle before proceeding.
3.3.8.5 **START** the three turbo pumps.
3.3.8.6 Once the chamber reaches 100 millitorr or less and the turbo pumps are at operating speed, **OPEN** the turbo hi-vac valves (TP1, TP2, and TP3 HighVac Valve).
3.3.8.7 Wait until the chamber is 100 millitorr or less then **CLOSE** the Chamber Roughing Valve. Never allow the chamber to pump lower than 10 millitorr before closing the Roughing Valve.

3.3.9 Switch **ON** the ion gauge. If it switches itself off, wait a minute and re-try switching it **ON**.

3.3.10 If the turbo pumps are not maintaining chamber pressure at 25 millitorr or less, **OPEN** the Chamber Roughing Valve. Once the chamber pressure is at or below 25 millitorr **CLOSE** the Roughing Valve. Repeat this step if the turbo pumps are not holding the chamber below 25 millitorr.

3.3.11 Wait until the cryo pumps reach 20K or less (15K is best) and chamber pressure is below 25 millitorr ($9x10^{-4}$ torr is best), then **OPEN** the high-vac valves to the three cryo pumps, (CP1, CP2 and CP3 HighVac Valves).

3.3.12 **Roughing Shut Down**

3.3.12.1 The rough system shall be shut down once the cryos and the turbos are pumping the chamber.

3.3.12.2 Switch **OFF** the MV1-CT, MV2-CT and the Roughing Line CT.
3.3.12.3 **OPEN** the purge valves to the Roughing Line CT (V179), MV1-CT (V181) and MV2-CT (V183). These are hand valves located at the chamber.
3.3.12.4 Allow these three cold traps to purge for 30 minutes, and then **CLOSE** the purge valves to the MV1-CT, MV2 –CT and Roughing Line CT.
3.3.12.5 **CLOSE** the MV1 Valve and MV2 Valve.
3.3.12.6 Switch **OFF** MV1 and MV-2 Roughing Pumps.
3.3.12.7 Configure the 2 roughing pump OFF-AUTO switches to **OFF** at the roughing pumps.
3.3.12.8 **OPEN** the roughing-line-vent hand valve located at the chamber (V185).
3.3.12.9 **OPEN** the 2 vent hand valves for the roughing pump located at the pumps (small valve above ballast valve on south side of each “Microvac” roughing pump).
3.3.12.10 Wait until the roughing pumps are vented, then **CLOSE** the 2 roughing pump vent hand valves (small hand valve above ballast valve on south side of “Microvac” roughing pumps).
3.3.12.11 Wait until the roughing line is vented, then **CLOSE** the roughing-line-vent hand valve (V185).

3.4 CONTAMINATION MONITORING

The contamination levels in the chamber shall be monitored at least twice during the test. The first monitoring period shall be soon after the chamber reaches high vacuum. The chamber contamination levels shall be monitored again before venting the chamber at the end of the test. This last monitoring period is to establish the chamber's contamination baseline for the next test. If the chamber has significant contamination, the next-test baseline shall be established after the chamber is cleaned. Contamination monitoring data shall be maintained as record separate from the test data. This data shall be provided to the customer upon request. Use both a temperature-controlled quartz crystal microbalance (TQCM) and a residual gas analyzer (RGA) to monitor the contamination. The RGA and TQCM shall be operated in accordance with ET24-RGA-SOP-001and ET24-TQCM-SOP-001.

3.4.1 Complete initial monitoring of chamber contamination. Skip the next step and complete the rest of testing before returning to Contamination Monitoring Step 3.4.2.

3.4.2 Monitor the contamination once more before the end of the test. Return to Section 3.7.2 once monitoring is completed.

3.5 CRYOGENIC SHROUD OPERATION

An operator at the control panel using valve position switches controls flow of the LN2 in the cryogenic shroud. The V20 cryogenic shroud has 13 zones that are controlled independently. Each of the 13 zones has a configuration of 3 valves arranged to provide either manual or automatic (if programmed) temperature control. The 3 valve arrangement consists of one solenoid (Normally Open - NO) paralleled with two other valves in series consisting of a second solenoid (Normally Closed - NC) and a hand valve located on the chamber platform. These 13 sets of valves control the LN_2 exhaust flow from the 13 shroud zones. The 13 hand valves are located in a panel on the chamber overhead platform, and are arranged consecutively with number 1 on the left and 13 on the right.

The temperature at the shroud exhaust is monitored by the programmable logic controller (PLC) and is available through the computer attached to the PLC. These temperatures are sensed by resistive temperature devices (RTDs) inline with the exhaust LN_2 flow for the respective shroud zone.

LN_2 input to the shroud is through a large blue hand valve (V112) located at the east end of the chamber. A shroud purge system is available with ambient or heated GN_2. The GN_2 heater has five power levels selected by a rotary switch on a control box located at the east end of the chamber. A push button switch located inside the same control box controls power for the system. There are hand valves located at the east end of the chamber to route the GN_2 by or through the heater. Input GN_2 is available from the gas panel, and purge control to the shroud is by a switch on the chamber control computer.

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

Prior to ascending the V20 overhead work platform, obtain hard hat(s) and rope an area 10 feet around the platform. All work on the platform shall be per Section 3.1.1.

****

3.5.1. Once flow has started, visually inspect all liquid nitrogen (LN_2) supply lines for leaks typically indicated by frost or condensate. If a leak is found with liquid spilling or dripping, the area shall be roped-off to prevent personnel from inadvertently entering this area. Personnel shall comply with safety precautions in Section 1.7.3 when entering this spill area.

3.5.2 Manual Control of LN2 flow in Shroud

3.5.2.1 **OPEN** SOV's 119 through 144.

3.5.2.2 Ensure all shroud zones RTDs used are displayed on the computer.

3.5.2.3 **OPEN** the LN_2 input hand valve V112, located at the chamber (blue hand valve under CP3).

3.5.2.4 Monitor the RTD temperatures for evidence that LN_2 reached the RTD.

3.5.2.5 When a zone is sufficiently cold, **CLOSE** the odd # (NO) solenoid valves.

3.5.2.6 **ADJUST** zone hand valve as needed to reduce LN_2 flow and maintain RTD temperature in the range of -250 to -280 degrees F, and **RECORD** valve position (number of turns open from full closed position) in the chamber logbook.

3.5.2.7 Wait until the RTD temperature is in range and stable, repeating step 3.4.1.6 periodically as required.

3.5.2.8 Repeat Steps 3.4.1.4 through 3.4.1.7 for other required zones.

3.5.3 Shroud Purge

3.5.3.1 **CLOSE** the LN_2 input hand valve V112 (blue hand valve under CP3).

3.5.3.2 **OPEN** SOV's 119 through 144.

3.5.3.3 **SET** GN_2 gas panel output regulator to 20 psig maximum output pressure.

3.5.3.4 **OPEN** the GN_2 purge flow control hand valve to bypass the heater.

3.5.3.5 **OPEN** the shroud purge valve on the V20 control computer.

3.5.3.6 Wait for the RTD temperatures to increase to -200°F or greater.

3.5.3.7 Configure valves on the GN_2 heater so that the purge GN_2 flows through the heater and not through the bypass.

3.5.3.8 Switch **ON** power to the GN_2 heater control panel near the GN_2 heater.

3.5.3.9 Select heater circuit # 1 using the rotary switch on the heater control panel.

3.5.3.10 Wait for the RTD temperatures to increase to 50°F or warmer.

3.5.3.11 Switch **OFF** heater # 1 and switch **OFF** power to the GN_2 heater control panel.

3.5.3.12 Wait for the GN_2 heater to cool to 100°F or cooler, as indicated by the temperature gauge at the GN_2 heater.

3.5.3.13 **CLOSE** the shroud purge valve.

3.5.3.14 **CLOSE** all GN_2 purge flow control hand valves, located at the chamber.

3.6 CRYO PUMP REGENERATION

The cryo pumps may be regenerated at any time. Indications that the pump needs regeneration include increased pump-down times, unable to pump to a lower pressure or a second stage operating temperature above 20K.

*************************************CAUTION************************************

Never warm the pump more than 338K (65°C, 149°F). Heating above 338K will damage internal gaskets and effect calibration of the internal temperature sensing transducer.

****

3.7.4 If shrouds were used, purge the shrouds with GN_2 until they reach ambient temperature.

3.7.5 **STOP** the turbo pumps TP1, TP2 AND TP3.

3.7.6 **CLOSE** turbo foreline valves TP1FV, TP2FV and TP3FV.

3.7.7 Switch OFF CP1, CP2 and CP3 Helium Compressors.

3.7.8 Switch **OFF** the TP1 backing cold trap and TP2 and TP3 backing pumps.

3.7.9 **OPEN** the TP1 Backing CT Purge.

3.7.10 Switch **OFF** CP1, CP2, and CP3 Shroud LN_2.

3.7.11 **OPEN** CP1, CP2 and CP3 Shroud Purge.

3.7.12 Allow the TP1 Backing CT to purge for 30 minutes, then **CLOSE** TP1 Backing CT Purge.

3.7.13 Switch **OFF** the TP1 Backing Pump.

3.7.14 **STOP** water to TP1.

3.7.15 Allow the CP1, CP2, and CP3 LN_2 Shrouds to purge until they reach ambient temperature, then **CLOSE** CP1, CP2 and CP3 Shrouds Purge.

3.7.16 **CLOSE** the V20 LN_2 supply valve on the LN_2 control panel.

3.8 CHAMBER REPRESSURIZATION

3.8.1 Verify all circuits in the chamber are switched off and de-energized, including IR lamp circuits and 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.

3.8.2 Configure the V20 control computer as follows:
3.8.2.1 **OPEN** the high purity (HP) air supply valve (SOV108).
3.8.2.2 **OPEN** the chamber vent-line hand valve located at the chamber (V169).
3.8.2.3 **OPEN** the chamber vent valve (ROV106).
3.8.2.4 Wait until the chamber is vented (typically 1.5 to 2 hours), and then **CLOSE** the chamber vent valve (ROV106).

3.8.3 **CLOSE** the HP air supply valve (SOV108).

3.8.4 Verify the V20 LN_2 supply valve is **CLOSE** on the LN_2 control panel.

3.8.5 Ensure that chamber and test article temperatures are ambient ± 10 degrees C (± 18 degrees F) and above the dew point.

3.8.6 Before entering the chamber, verify the oxygen is adequate using a portable oxygen monitor.

3.8.7 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.

4.0 EMERGENCY SHUTDOWN

This section covers operations necessary to safe the chamber in the event of a system failure such as water, air or electrical failure. Test article failures shall be handled with normal shutdown practices.

4.1 WATER FAILURE

4.1.1 **CLOSE** the four high-vac valves (CP1, CP2, CP3 and TP1 HighVac Valves) at the control computer.

4.1.2 **CLOSE** the Chamber Roughing Valve.

4.1.3 **CLOSE** the MV1 and MV2 Valves.

4.1.4 **STOP** the MV1 and MV2 Roughing Pumps.

4.1.5 **STOP** cryo compressors.

4.1.6 **STOP** the TP1 turbo pump.

4.1.7 If water flow cannot be resumed within 30 minutes, start system shutdown, Section 3.7.

4.2 AIRFLOW FAILURE (During high vacuum operation)

4.2.1 Hi-vac valves CP1-P-HV, CP2-P-HV, CP3-P-HV, TP1-P-HV, TP2-P-HV and TP3-P-HV fails closed.

4.2.2 Roughing valves fail closed.

4.2.3 If airflow cannot be resumed within 15 minutes, **SHUT DOWN** the turbo pumps. If air pressure is not back within two hours, go to Section 3.7 to **SHUT DOWN** the chamber.

4.3 POWER FAILURE (During high vacuum operation)

Lead V20 engineer shall assess the situation and advise as needed.

4.4 ELECTRIC POWER FAULT

4.4.1 **DE-ENERGIZE** as needed cryos, turbo pump, roughing pumps, and purge heater at electrical panel **PP** (also identified with yellow tag LL 241) located on the north wall at column 6. Chamber engineer shall assess the situation and advise as needed.

4.4.2 **DE-ENERGIZE,** as needed, the V20 control panel power at the **Feed From UPS** breaker located on the south wall behind the control panel. Chamber engineer shall assess the situation and advise as needed.

V20 As-run Buy-off Sheet

Test Number _____ Customer Contact _____

TPS or Work Instructions _____Start Time & Date _____

Test Description_____ End Time & Date _____

Data Process Rate _____

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 _____

3.1.6.3 _____

3.1.6.4 _____

3.1.6.5 _____

3.1.6.6 _____

3.1.6.7_____

3.1.7.1 _____

3.1.7.2 _____

3.1.7.3 _____

3.1.8.1 _____

3.1.8.2 _____

3.1.8.3_____

3.1.8.4_____

3.1.8.5_____

3.1.8.6_____

3.1.8.7 _____

3.1.9.1_____

3.1.9.2_____

3.1.9.3_____

3.1.9.4_____

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3.1.9.6_____

3.1.9.7_____

3.1.9.8 _____

3.1.10 _____

3.1.11.1_____

3.1.11.2_____

3.1.11.3_____

3.1.12.1 _____

3.1.12.2 _____

3.1.12.3 _____

3.1.13 _____

3.2 3.2 CRYO PUMP OPERATION

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3.2.2 _____

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3.3 CHAMBER OPERATION

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3.3.2 _____

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3.3.6.1_____

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3.3.12.7 _____

3.3.12.8 _____

3.3.12.9 _____

3.3.12.10 ____

3.3.12.11 ____

3.4 Contamination Monitoring

3.4.1 _____

3.4.2 _____

3.5 CRYO SHROUD OPERATION

3.5.1 _____

3.5.2.1 _____

3.5.2.2 _____

3.5.2.3_____

3.5.2.4_____

3.5.2.5 _____

3.5.2.6_____

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3.5.3.10_____

3.5.3.11 _____

3.5.3.12 _____

3.5.3.13 _____

3.5.3.14 _____

3.6 CRYO PUMP REGENERATION

3.6.1.1 _____

3.6.1.2_____

3.6.1.3_____

3.6.1.4_____

3.6.2.1 _____

3.6.2.2_____

3.6.2.3_____

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3.6.2.7_____

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3.6.2.9_____

3.6.2.10_____

3.6.2.11_____

3.6.2.12_____

3.6.2.13_____

3.7 CHAMBER SHUTDOWN

3.7.1 _____

3.7.2 _____

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3.8 CHAMBER REPRESSURIZATION

3.8.1_____

3.8.2.1 _____

3.8.2.2 _____

3.8.2.3 _____

3.8.2.4 _____

3.8.3 _____

3.8.4 _____

3.8.5 _____

3.8.6 _____

3.8.7 _____

QA _____ NA if not applicable