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

FACILITY OPERATING PROCEDURE
FOR
THERMAL VACUUM CHAMBER
V7

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
THERMAL VACUUM CHAMBER V7

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

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1.0 GENERAL INFORMATION

1.1 PURPOSE

This document describes the procedures for the operation of Thermal Vacuum Chamber V7 located in the Marshall Space Flight Center (MSFC) Building 4619.

1.2 SCOPE

The procedures and practices outlined in this document are to be followed in the operation of chamber V7. This document provides a record copy of chamber V7 operations.

1.3 APPLICABLE DOCUMENTS

MPR 8715.1	Marshall Safety, Health, and Environmental (SHE) Program
MWI 8715.1	Electrical Safety Program
ET24-UnattnOps-SOP-001	Unattended Operation of the Environmental Test Facility
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
MSOP-GS-ETF-435	Detailed Operating Procedure for Residual Gas Analyzer System (soon to be superseded by ET24-RGA-SOP-001)
MSOP-GS-ETF-443	Detailed Operating Procedure for Temperature-Controlled Quartz Crystal Microbalance (TQCM) System (soon to be superseded by ET24-TQCM-SOP-001)
ET24-ETF-OWI-001	Environmental Test Facility Test Operations
ED26 (02-001)	Memorandum, Safety Assessment for the Environmental Test Facility (soon to be superseded by an ET24 memo, number unknown)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.

Personnel involved in cryogenics facilities operation, repairs or modifications shall wear protective clothing including face shields and gloves. Repairs/modifications to cryogenic systems shall be performed by certified cryogenic handlers. Personnel shall be aware of the possibility of freeze burns by contact with cold surfaces or liquids. In the event of a cryogenics spill, line ruptures, or similar emergencies, personnel shall ensure that there is no possibility of asphyxiation due to oxygen displacement. Use a portable oxygen monitor to verify the area is safe before entering.

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 $\pm$ 10 degrees C ($\pm$ 18 degrees F) before removing the test article so that there is minimal extreme temperature hazard.

ET24 Safety Assessment, Memorandum of Record ED26 (02-01) delineates the procedures, personal protective equipment (PPE) requirements and job hazard analysis (JHAs) for hazards associated with operation of this chamber. Operators shall 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

Dial **911** for all emergencies, including medical, fire, ambulance, security, and chemical spills.

Other numbers that can be used to obtain information about emergency, security, safety, and utilities, and general help are:

Medical Center	544-2390
Security	544-4357
Safety	544-0046
Utilities	544-3919
Help Desk	544-HELP (4357)

1.6 CHECKOUT TEST

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

1.7 HAZARDS LIST

- 480 and 120 volts AC electrical power
- Extreme temperatures in the chamber (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.

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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 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 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 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 shall be considered energized.

1.7.1.11 If tag-out is the method used, two or more isolation 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.

1.7.1.12 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.

1.7.1.13 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.

1.7.1.14 Locking type connectors shall be properly secured when connecting.

1.7.1.15 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.

1.7.1.16 Over-current protective devices shall not be modified.

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

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

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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 removing the test article in order to minimize the extreme temperature hazard.

1.7.3 Minimizing LN_2 Hazards

Cryogenic hazards include risk from freeze burns and risk from asphyxiation due to oxygen displacement.

Personnel shall avoid contact with cold surfaces or liquids that may be at cryogenic temperatures to minimize the risk from freeze burns. Personnel involved in cryogenics facilities repairs or modifications shall wear PPE protective clothing including eye protection and gloves. Repairs/modifications to cryogenic systems shall be performed by certified cryogenic handlers.

In the event of a cryogenics spill, line ruptures, or similar emergencies, personnel shall ensure that there is no possibility of asphyxiation due to oxygen displacement. Use a portable oxygen monitor to verify the spill area is safe before entering. Evacuate the area when alarms are triggered on any of the ETF facility oxygen deficiency monitors.

1.7.4 Minimizing Pump Oil Hazards

There is a risk that the test article could be contaminated with vacuum pump oil. The chamber shall only be operated by trained personnel to minimize the risk of oil contamination. Ensure that the roughing pump cold trap is operational during roughing to mitigate the oil contamination risk.

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

1.8 RESPONSIBILITIES

ETF personnel shall be responsible for the operation of the V7 Thermal Vacuum Chamber. The designated operator of the chamber shall be responsible for the safe operation and conduct of the facility. The operator shall record their name in the chamber logbook.

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 V7 is a stainless steel vessel with polished interior surfaces. The inside dimensions are 8’ diameter and 10' length. The chamber is equipped with a thermal shroud that has a 7’ diameter and is 8’ long. The thermal shroud is for cooling and heating of the test article. Infrared lamps are available for heating.

2.2 VACUUM SYSTEM

The rough vacuum pumping system consists of three mechanical roughing pumps. For pumping in the high vacuum pressure there are two 20 inch cryogenic (cryo) pumps and a turbo pump. One of the mechanical pumps is a 150 CFM roughing pump with a LN_2 cold trap that is used to pump the chamber to a rough vacuum. The second mechanical pump is a smaller pump used to rough pump the cryo pumps through a cryo roughing line. The third is a 50 CFM used as the fore pump for the turbo Pump. System valves are two pneumatic valves for cryo roughing, two pneumatic high vacuum valves, a pneumatic chamber roughing valve and a pneumatic foreline valve on the turbo pump. The system is capable of pumping the chamber to the 10^{-7} torr range.

2.3 CONTROL SYSTEM

The control system consists of switches for operating valves, pumps, and control relays. The cryo pumps have temperature indicators. There are controls for the turbo pump near the pump. The LN_2 cold trap has a liquid level controller. A Dimension Controller is used for thermal conditioning. Pressure monitoring is by a convectron and ion gauges.

2.4 THERMAL SYSTEM

Chamber thermal conditioning is provided by a thermal shroud and infrared lamps. Cold conditions are provided by injecting liquid nitrogen (LN_2) into the thermal shroud or by flowing cooled gaseous nitrogen (GN_2) through the shroud. Hot conditions can be provided by flowing heated GN_2 through the shroud or by energizing **i**nfrared lamps. The method used is dependent on the required temperature, with the coldest condition provided by LN_2 in the shroud and hottest conditions provided by infrared lamps. The chamber thermal conditioning system can provide temperature extremes from $350^{O}F$ to $-300^{O}F$ ($177^{O}C$ to $-184^{O}C$).

2.5 PERFORMANCE

Pumping speeds will vary with test specimen, gas load, and internal chamber conditions. A clean-dry system will perform approximately as follows:

* Atmosphere to 50 E-3 torr (1.0 E 5 to 6.6 Pascal) in about 90 minutes
* Atmosphere to 1 E-6 torr (1.0 E 5 to 1.3 E-4 Pascal) in about 3 hours

NOTE

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

3.0 FACILITY OPERATION

The operations of Chamber V7 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 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 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 sheet 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), 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 the test is ready to start.

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.

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3.1.3 Calibration

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

3.1.3.2 Verify that that the calibration shall not expire before the expected test conclusion date.

3.1.4 Place all switches on the control panel to the **OFF, SAFE** or **NORMAL** operating position.

3.1.5 Visually inspect the level and condition of the oil in both mechanical roughing 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 safety glasses and gloves when changing oil.

3.1.6 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.

3.1.7 Verify LN2 Scavenger Panel and drip pan are clean.

3.1.8 Loading of the test article using the fork truck shall be in accordance with the ETF procedure Powered Industrial Fork Truck Operation Safety Requirements, MSOP-FA-ETF-414 (soon to be superseded by ET24-ForkLift-SOP-001).

3.1.9 Photograph the test article inside the test chamber before the chamber is sealed. Take as many photographs as considered necessary dependent on the complexity of the test. Submit the photograph(s) to the ETF Test Data Administrator. This step shall be omitted if the customer requests no photographing of the test article.

3.1.10 Data Acquisition

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

3.1.10.2 Start recording data prior to chamber pump down.

3.2 VACUUM SYSTEM OPERATION

3.2.1 Secure the chamber door using 4 bolts, two each on opposite sides of the door.

3.2.2 Switch **ON** the system power.

3.2.3 Switch **ON** the cooling water.

3.2.4 Ensure the GP model 316 and 307 convectron gauge controllers are **ON**.

3.2.5 Switch **ON** the mechanical roughing pump for the chamber.

3.2.6 After the roughing pump has been on 5 minutes, switch **ON** the roughing trap LN_2 controller.

3.2.7 **OPEN** the roughing valve.

3.2.8 At 500 Torr remove the bolts that hold the door closed.

3.2.9 Select set point (**SP**) on the Process Control Card top toggle switch in the Granville Phillips ion gauge controller.

3.2.10 When the chamber is a 10 torr or less, switch **ON** the mechanical roughing pump for Cryo1 and Cryo2.

3.2.11 **OPEN** Cryo1 foreline valve and pump to 75. x 10^{-3} torr (75 millitorr).

3.2.12 **CLOSE** Cryo1 foreline valve and **START** Cryo1.

3.2.13 Repeat Steps 3.2.11 and 3.2.12 for Cryo2.

3.2.14 Turn OFF the mechanical roughing pump for Cryo1 and Cryo2.

3.2.15 Manually **OPEN** the Cryopumps foreline repress valve.

3.2.16 Switch **ON** the LN2 Scavenger Panel at 500 milltorr.

3.2.17 Ensure the turbo pump foreline repress valve is **CLOSED**.

3.2.18 **START** the turbo pump's foreline pump.

3.2.19 **OPEN** the turbo pump foreline valve and **START** turbo pump.

3.2.20 Wait until the chamber pressure reaches 1x10^{-1} torr (100 millitorr) or less, and then **CLOSE** the roughing valve.

3.2.21 Select the **ON** position on the Model 307 ion gauge controller's Process Control Card. This allows all high-vac valves to be operated manual.

3.2.22 When the turbo pump is at full speed, **OPEN** the turbo pump high vacuum (Hi-vac) valve.

3.2.23 Switch **ON** the ion gauge. If the ion gauge switches itself off, wait five minutes and switch it **ON** again.

3.2.24 Wait until the cryo pump temperature reaches 20^{o}K or less and chamber pressure is 5x10^{-4} torr or less then **OPEN** either or both hi-vac valves 1 and 2 as needed. If the cryo pump is not being used, its hi-vac valve shall remain closed.

3.2.25 Switch the Model 307 ion gauge controller Process Control Card back to **SP** once the chamber is at high vacuum. Adjust the vacuum gauge set point to 5x10^{-4} torr times greater than the pressure it is maintaining. This controller will automatic bring the chamber to a safe mode by closing high vacuum valves if there is a spike in pressure greater than the set point.

3.2.26 Start thermal conditioning. Refer to Section 3.4 for the thermal conditioning procedure.

3.2.27 Switch **OFF** the roughing trap LN_2 controller.

3.2.28 **OPEN** the roughing cold trap purge hand valve. This hand valve is located near the north east corner of the chamber and above the cold trap.

3.2.29 Wait at least 30 minutes for the roughing cold trap to purge and return to ambient temperature, and then **CLOSE** the roughing trap purge hand valve.

3.2.30 Switch **OFF** the roughing pump.

3.3 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 repressurizing 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 level 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 MSOP-GS-ETF-435 (soon to be superseded by ET24-RGA-SOP-001) and MSOP-GS-ETF-443 (soon to be superseded by ET24-TQCM-SOP-001) respectively.

3.3.1 Complete initial monitoring of chamber contamination. Skip the next step and complete the rest of testing before returning to Contamination Monitoring Step 3.3.2.

3.3.2 Monitor the contamination once more before the end of test. Return to Section 3.6.2 once monitoring is completed.

3.4 THERMAL CONDITIONING

Thermal conditioning is accomplished using the thermal shroud system or the infrared lamps. The thermal shroud has three different modes for various temperature ranges as follows.

Temperature Range	Method of Thermal Conditioning
-300 to –280^{o}F	Cool Shroud by Flooding with LN_2
Ambient to -280^{o}F	Cool Shroud with Cold GN_2
Ambient to 250^{o}F	Heat Shroud with Heat Exchanger

3.4.1 Hot Shroud Operation

3.4.1.1 Switch **ON** the Dimension controller power.
3.4.1.2 Switch **ON** the shroud R.I. limiter power.

3.4.1.3 Adjust the Dimension controller so that Loop 4 is set to Analog Input 4. Push the diamond button up or down to highlight the RI icon  .

3.4.1.4 Push the diamond button left or right to put the controller in Unit Configuration mode. UNIT_CNF shall be shown at the top of the screen.

3.4.1.5 Push the diamond button up or down to highlight the Process Configuration icon  .

3.4.1.6 Push the diamond button left or right to get the CONF LOP screen.

3.4.1.7 Turn the round button to highlight the PV SOURCE, then PUSH the button.

3.4.1.8 Turn the round button to get ANALIN04 to the right of PV SOURCE and then push the round button again.

3.4.1.9 Turn the round button to highlight END, then push the round button.

3.4.1.10 Push the diamond button up or down to highlight the RI icon.  .

3.4.1.11 Push the diamond button left or right to put the controller in the Unit Operation mode. UNIT will be shown at the top of the screen.

3.4.1.12 Push the diamond button up or down until the LOOP icon is highlighted  .

3.4.1.13 Push the diamond button left or right until LOOP 4 is shown.

3.4.1.14 **SET** the Dimension controller to the required temperature or temperature profile as required by the test.

3.4.1.15 **PRESS** the shroud heater R.I. limiter reset button.

3.4.1.16 **ADJUST** shroud heater R.I. limiter dial to that temperature at which cutoff is to occur (see Attachment B).

3.4.1.17 Ensure the GN_2 supply valve (GNV158) at Panel 3 (V7 GN_2 Shroud Purge Panel) is **OPEN**. This panel is north east of the pit entrance.

3.4.1.18 Ensure the Air Pressure Regulator (GNR53) is adjusted to 35 psig.

3.4.1.19 **OPEN** the blue handle GN_2 valve. This valve is located under the neck-down rear area at the chamber and faces southeast.

3.4.1.20 Switch **ON** Shroud Heat at the Chamber No. 7 control rack.

3.4.1.21 Monitor the temperature of the test article once the thermal conditioning starts. Verify test article temperatures on data system, and **ADJUST** the Dimension set-point accordingly.

3.4.2 Hot Shroud Shutdown

3.4.2.1 Switch **OFF** Shroud Heat at the Chamber No. 7 control rack.

3.4.2.2 Allow the heater to cool to 90°F or less.

3.4.2.3 **CLOSE** the blue handle GN_2 valve. This valve is located under the neck-down rear area of the chamber, over the heater, facing southeast.

3.4.3 Cool Shroud with Cold GN_2

3.4.3.1 Ensure the GN_2 supply valve (GNV158) at Panel 3 (V7 GN_2 Shroud Purge Panel) is **OPEN**. This panel is north east of the pit entrance.

3.4.3.2 Ensure the Shroud Heat is switched **OFF** at the Chamber No. 7 control rack.

3.4.3.3 Adjust the Dimension controller so that Loop 4 is set to Analog Input 3. Push the diamond button up or down to highlight the RI icon  .

3.4.3.4 Push the diamond button left or right to put the controller in Unit Configuration mode. UNIT_CNF will be shown at the top of the screen.

3.4.3.5 Push the diamond button up or down to highlight the Process Configuration icon  .

3.4.3.6 Push the diamond button left or right to get the CONF LOP screen.

3.4.3.7 Turn the round button to highlight the PV SOURCE, and then PUSH the button.

3.4.3.8 Turn the round button to get ANALIN03 to the right of PV SOURCE and then push the round button again.

3.4.3.9 Turn the round button to highlight END, and then push the round button.

3.4.3.10 Push the diamond button up or down to highlight the RI icon.  .

3.4.3.11 Push the diamond button left or right to put the controller in the Unit Operation mode. UNIT will be shown at the top of the screen.

3.4.3.12 Push the diamond button up or down until the LOOP icon is highlighted  .

3.4.3.13 Push the diamond button left or right until LOOP 4 is shown.

3.4.3.14 Ensure the Dimension controller is set to the temperature or temperature profile required by the test.

3.4.3.15 **ADJUST** Shroud LN_2 R.I. limiter dial to that temperature at which cutoff is to occur (see Attachment B)

3.4.3.16 **OPEN** the blue handle GN_2 valve. This valve is located under the neck-down rear area at the chamber and faces southeast.

3.4.3.17 Switch **ON** Shroud LN_2 at the Chamber No. 7 control rack.

3.4.3.18 Monitor the temperature of the test article once the thermal conditioning starts. Verify test article temperatures on data system, and **ADJUST** the Dimension set point accordingly.

3.4.4 Cold Shroud Shutdown

3.4.4.1 Switch **OFF** Shroud LN_2 at the Chamber No. 7 control rack.

3.4.4.2 Perform hot shroud operation, Section 3.4.1, until the test article is warmed to 50^{o}F.

3.4.4.3 Perform hot shroud shutdown, Section 3.4.2.

3.4.5 Flooded Cold Shroud Operation

3.4.5.1 Ensure blue handle GN_2 valve is **CLOSED**. This valve is located under the neck-down rear area of the chamber, over the heater, and faces southeast.

3.4.5.2 Ensure the HEAT switch on the control panel is **OFF**.

3.4.5.3 Adjust the Dimension controller so that Loop 4 is set to Analog Input 2. Push the diamond button up or down to highlight the RI icon  .

3.4.5.4 Push the diamond button left or right to put the controller in Unit Configuration mode. UNIT_CNF will be shown at the top of the screen.

3.4.5.5 Push the diamond button up or down to highlight the Process Configuration icon  .

3.4.5.6 Push the diamond button left or right to get the CONF LOP screen.

3.4.5.7 Turn the round button to highlight the PV SOURCE, and then PUSH the button.

3.4.5.8 Turn the round button to get ANALIN02 to the right of PV SOURCE and then push the round button again.

3.4.5.9 Turn the round button to highlight END, and then push the round button.

3.4.5.10 Push the diamond button up or down to highlight the RI icon.  .

3.4.5.11 Push the diamond button left or right to put the controller in the Unit Operation mode. UNIT will be shown at the top of the screen.

3.4.5.12 Push the diamond button up or down until the LOOP icon is highlighted  .

3.4.5.13 Push the diamond button left or right until LOOP 4 is shown.

3.4.5.14 Ensure the Dimension controller is set to the temperature or temperature profile required by the test.

3.4.5.15 **SET** the Dimension's Loop 4 Analog Input to Number 2.

3.4.5.16 Switch **ON** the Shroud Cold LIM Bypass.

3.4.5.17 Switch **ON** the Shroud LN_2 at the Chamber No. 7 control rack.

3.4.5.18 Monitor the temperature of the test article once the thermal conditioning starts. Verify test article temperatures on data system, and **ADJUST** the Dimension set-point accordingly.

3.4.6 Flooded Cold Shroud Shutdown

3.4.6.1 Switch **OFF** the Shroud LN_2 at the Chamber No. 7 control rack.

3.4.6.2 Perform hot shroud operation, Section 3.4.1, until the test article is warmed to 50^{o}F.

3.4.6.3 Perform hot shroud shutdown, Section 3.4.2.

3.4.7 Infrared Lamp Operation

3.4.7.1 Ensure the Dimension controller loops are set to the temperature or temperature profile required by the test.

3.4.7.2 Switch on the lamp phaser heater rack to Enable.

3.4.7.3 Set the limiter's hi limit to 10 degrees F above the required temperature. Hold down the up and down arrows together for three seconds. If the limiter does not display LIM, then press the up or down arrow until LIM is displayed. Press the green button twice. Use the up or down arrow to raise or lower the hi set temperature. Then press the reset button or wait one minute for the limiter to automatically reset.

3.4.7.4 Switch **ON** phaser power 1, 2, and/or 3 as required by the test setup.

3.4.7.5 Monitor the temperature of the test article once the thermal conditioning starts. Verify test article temperatures on data system, and **ADJUST** the Dimension set-point accordingly.

3.4.7.6 Once the test article reaches the set temperature, set the limiter's low limit to 15 degrees F below above the required temperature. Hold down the up and down arrows together for three seconds. If the limiter does not display LIM, then press the up or down arrow until LIM is displayed. Press the green button. Use the up or down arrow to raise or lower the set temperature. Press the green button again to check the upper limit. Then press the reset button or wait one minute for the limiter to automatically reset.

3.4.8 Infrared Lamp Shutdown

3.4.8.1 **ADJUST** the Dimension control loop or loops set-point(s) to about 50^0F.

3.4.8.2 Switch **OFF** phaser power 1, 2, and 3 on the phaser panel.

3.4.8.3 Switch **OFF** the lamp phaser rack.

3.4.8.4 Switch **OFF** Lamp Phaser LIM.

3.4.8.5 Wait until the test article temperature is 90^oF or less before repressurizing the chamber.

3.5 UNATTENDED OPERATION

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-SOP-001, Unattended Operation of the Environmental Test Laboratory.

3.6 COMPLETE SYSTEM SHUTDOWN

3.6.1 Go to Section 3.3 to perform the final contamination monitoring.

3.6.2 Ensure that temperatures of the chamber and test article are above dew point to reduce the risk of condensation.

3.6.3 Switch **OFF** and **DE-ENERGIZE** all circuits in the chamber including IR lamp circuits. Verify all of the customer's circuits are switched off and de-energized.

3.6.4 **CLOSE** the opened cryo pump hi-vac valves 1 and 2.

3.6.5 **CLOSE** the turbo pump hi-vac valve.

3.6.6 Switch **OFF** the turbo pump.

3.6.7 **CLOSE** turbo pump foreline valve.

3.6.8 Switch **OFF** turbo's foreline pump and **REPRESS** turbo pump foreline.

3.6.9 Switch **OFF** the ion gauge on the Model 307 controller.

3.6.10 Verify the chamber and test article has returned to ambient temperature $\pm$ 10 degrees C ($\pm$18degrees F).

3.6.11 **OPEN** the chamber vent valve.

3.6.12 Turn **OFF** the LN_2 Scavenger panel after the chamber is above 650 Torr.

3.6.13 Switch **OFF** the cryo pumps that are operating.

3.6.14 **OPEN** the pump purge valves for the cryo pumps that were operated.

3.6.15 When the chamber reaches ambient pressure, **CLOSE** the chamber vent.

3.6.16 Allow the cryo pump(s) to purge at least two hours.

3.6.17 **CLOSE** the cryo pump purge valves.

3.6.18 Switch **OFF** system power.

3.6.19 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.

3.6.20 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.

3.6.21 Test article may now be removed from the chamber.

3.6.22 Note any contamination on Scavenger Panel in the log book. Clean Panel and drip panel with alcohol.

4.0 EMERGENCY SHUTDOWN

_____ 4.1 Switch **OFF** system power.

_____ 4.2 **OPEN** the knife switch on the side of the control panel.

_____ 4.3 Switch **OFF** Panel PP3 breaker positions 13, 15, 17, and 19 through 30. This panel is located in the V1 tent.

_____ 4.4 Switch **OFF** Phasers 1, 2, and 3 at the phaser control panel. Unplug phaser power at receptacle D34A located in the V1 tent.

_____ 4.5 Switch **OFF** Panel PP2 breaker position 13. This panel is located near V2 and column 7 on the south wall.

_____ 4.6 **CLOSE** hand GN2 supply valve GNV158 on Panel 3 located at the north east corner of the pit entrance if a GN_2 leak is causing a hazard.

V7 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 _____

3.1 Facility Preparation

3.1.1 _____

3.1.2 _____

3.1.3.1 _____

3.1.3.2 _____

3.1.4 _____

3.1.5 _____

3.1.6 _____

3.1.7 _____

3.1.8 _____

3.1.9 _____

3.1.10.1 _____

3.1.10.2 _____

3.2 Vacuum System Operation

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 _____

3.2.21 _____

3.2.22 _____

3.2.23 _____

3.2.24 _____

3.2.25 _____

3.2.26 _____

3.2.27 _____

3.2.28 _____

3.2.29 _____

3.2.30 _____

3.3Contamination Monitoring

3.3.1 _____

3.3.2 _____

3.4 Thermal Conditioning

3.4.1 Hot Shroud Operation

3.4.1.1 _____

V7 As-run Buy-off Sheet

3.4.1.2_____

3.4.1.3_____

3.4.1.4_____

3.4.1.5_____

3.4.1.6_____

3.4.1.7_____

3.4.1.8_____

3.4.1.9 _____

3.4.1.10 _____

3.4.1.11_____

3.4.1.12_____

3.4.1.13_____

3. 4.1.14_____

3.4.1.15_____

3.4.1.16_____

3.4.1.17_____

3.4.1.18_____

3.4.1.19 _____

3.4.1.20 _____

3.4.1.21 _____

3.4.2 Hot Shroud Shutdown

3.4.2.1 _____

3.4.2.2 _____

3.4.2.3 _____

3.4.3Cold Shroud GN_2

3.4.3.1_____

3.4.3.2_____

3.4.3.3_____

3.4.3.4_____

3.4.3.5 _____

3.4.3.6_____

3.4.3.7 _____

3.4.3.8 _____

3.4.3.9 _____

3.4.3.10 _____

3.4.3.11_____

3.4.3.12 _____

3.4.3.13 _____

3.4.3.14 _____

3.4.3.15 _____

3.4.3.16 _____

3.4.3.17 _____

3.4.3.18 _____

3.4.4 Cold Shroud Shutdown

3.4.4.1_____

3.4.4.2_____

3.4.4.3_____

3.4.5 Flooded Cold Shroud

3.4.5.1 _____

3.4.5.2 _____

3.4.5.3 _____

3.4.5.4 _____

3.4.5.5 _____

3.4.5.6 _____

3.4.5.7 _____

3.4.5.8 _____

3.4.5.9 _____

3.4.5.10 _____

3.4.5.11 _____

3.4.5.12 _____

3.5.5.13 _____

3.4.5.14 _____

3.5.5.15 _____

3.4.5.16 _____

3.4.5.17 _____

V7 As-run Buy-off Sheet

3.4.5.18 _____ (N/A if not applicable)

3.4.6 Flooded Shroud Shutdown

3.4.6.1 _____

3.4.6.2 _____

3.4.6.3 _____

3.4.7 Infrared Lamp Operation

3.4.7.1 _____

3.4.7.2_____

3.4.7.3 _____

3.4.7.4 _____

3.4.7.5 _____

3.4.7.6 _____

3.4.8 Infrared Lamp Shutdown

3.4.8.1 _____

3.4.8.2 _____

3.4.8.3 _____

3.4.8.4 _____

3.4.8.5 _____

3.5 Unattended Operation

3.5.1 _____

3.5.2 _____

3.6Complete System Shutdown

3.6.1 _____

3.6.2 _____

3.6.3 _____

3.6.4 _____

3.6.5 _____

3.6.6 _____

3.6.7 _____

3.6.8 _____

3.6.9 _____

3.6.10 _____

3.6.11 _____

3.6.12 _____

3.6.13 _____

3.6.14 _____

3.6.15 _____

3.6.16 _____

3.6.17 _____

3.6.18 _____

3.6.19 _____

3.6.20 _____

3.6.21 _____

3.6.22 _____

QA _____
(N/A if not applicable)

Research Incorporated Temperature Limiter
SETPOINT DIAL SETTINGS VS TEMPERATURE

DEG F	0	1	2	3	4	5	6	7	8	9
-300	0.									
-290	6.9	6.2	5.5	4.8	4.1	3.4	2.7	2.0	1.3	0.7
-280	14.0	13.3	12.5	11.8	11.1	10.4	9.7	9.0	8.3	7.6
-270	21.4	20.6	19.9	19.1	18.4	17.7	16.9	16.2	15.5	14.7
-260	29.1	28.3	27.5	26.7	26.0	25.2	24.4	23.7	22.9	22.1
-250	37.0	36.2	35.4	34.6	33.8	33.0	32.2	31.4	30.6	29.8
-240	45.2	44.3	43.5	42.7	41.9	41.0	40.2	39.4	38.6	37.8
-230	53.6	52.7	51.9	51.0	50.2	49.3	48.5	47.7	46.8	46.0
-220	62.3	61.4	60.5	59.6	58.8	57.9	57.0	56.2	55.3	54.5
-210	71.2	70.3	69.4	68.5	67.6	66.7	65.8	64.9	64.0	63.2
-200	80.4	79.5	78.5	77.6	76.7	75.8	74.9	73.9	73.0	72.1
-190	89.8	88.9	87.9	87.0	86.0	85.1	84.1	83.2	82.3	81.3
-180	99.5	98.5	97.5	96.6	95.6	94.6	93.7	92.7	91.7	90.8
-170	109.4	108.4	107.4	106.4	105.4	104.4	103.4	102.4	101.5	100.5
-160	119.6	118.6	117.5	116.5	115.5	114.5	113.4	112.4	111.4	110.4
-150	130.0	128.9	127.9	126.8	125.8	124.8	123.7	122.7	121.6	120.6
-140	140.6	139.6	138.5	137.4	136.4	135.3	134.2	133.2	132.1	131.0
-130	151.6	150.4	149.4	148.3	147.2	146.1	145.0	143.9	142.8	141.7

Research Incorporated Temperature Limiter
SETPOINT DIAL SETTINGS VS TEMPERATURE

DEG F	0	1	2	3	4	5	6	7	8	9
-120	162.7	161.6	160.4	159.3	158.2	157.1	156.0	154.9	153.8	152.7
-110	174.1	172.9	171.8	170.6	169.5	168.4	167.2	166.1	165.0	163.8
-100	185.7	184.5	183.4	182.2	181.0	179.9	178.7	177.5	176.4	175.2
-90	197.6	196.4	195.2	194.0	192.8	191.6	190.4	189.2	188.1	186.9
-80	209.7	208.5	207.2	206.0	204.8	203.6	202.4	201.2	200.0	198.8
-70	222.0	220.8	219.5	218.3	217.0	215.8	214.6	213.3	212.1	210.9
-60	234.5	233.3	232.0	230.8	229.5	228.2	227.0	225.7	224.5	223.2
-50	247.3	246.0	244.7	243.5	242.2	240.9	239.6	238.4	237.1	235.8
-40	260.3	259.0	257.7	256.4	255.1	253.8	252.5	251.2	249.9	248.6
-30	273.5	272.2	270.8	269.5	268.2	266.9	265.5	264.2	262.9	261.6
-20	286.9	285.5	284.2	282.8	281.5	280.1	278.8	277.5	276.1	274.8
-10	300.4	299.1	297.7	296.3	295.0	293.6	292.3	290.9	289.6	288.2
-0	314.1	312.8	311.4	310.0	308.6	307.3	305.9	304.5	303.1	301.8
0	314.1	315.5	316.9	318.3	319.7	321.1	322.5	323.8	325.2	326.6
10	328.0	329.4	330.8	332.2	333.6	335.0	336.4	337.8	339.2	340.6
20	342.0	343.4	344.9	346.3	347.7	349.1	350.5	351.9	353.3	354.8
30	356.2	357.6	359.4	360.6	362.1	363.5	365.0	366.4	367.9	369.4
40	370.8	372.3	373.8	375.2	376.7	378.2	379.6	381.1	382.6	384.1
50	385.5	387.0	388.5	390.0	391.5	393.0	394.4	395.9	397.4	398.9

Research Incorporated Temperature Limiter
SETPOINT DIAL SETTINGS VS TEMPERATURE

DEG F	0	1	2	3	4	5	6	7	8	9
60	400.4	401.9	403.4	404.9	406.4	407.9	409.4	410.9	412.5	414.0
70	415.5	417.0	418.5	420.0	421.6	423.1	424.6	426.1	427.7	429.2
80	430.7	432.3	433.8	435.3	436.9	438.4	439.9	441.5	443.0	444.6
90	446.1	447.7	449.2	450.8	452.3	453.9	455.5	457.0	458.6	460.1
100	461.7	463.3	464.8	466.4	468.0	469.6	471.1	472.7	474.3	475.9
110	477.5	479.0	480.6	482.2	483.8	485.4	487.0	488.6	490.2	491.8
120	493.4	495.0	496.6	498.2	499.8	501.4	503.0	504.6	506.2	507.8
130	509.5	511.1	512.7	514.3	515.9	517.6	519.2	520.8	522.4	524.1
140	525.7	527.3	529.0	530.6	532.2	533.9	535.5	537.2	538.8	540.5
150	542.1	543.8	545.4	547.1	548.7	550.4	552.0	553.7	555.4	557.0
160	558.7	560.3	562.0	563.7	565.4	567.0	568.7	570.4	572.0	573.7
170	575.4	577.1	578.8	580.5	582.1	583.8	585.5	587.2	588.9	590.6
180	592.3	594.0	595.7	597.4	599.1	600.8	602.5	604.2	605.9	607.6
190	609.3	611.0	612.8	614.5	616.2	617.9	619.6	621.3	623.1	624.8
200	626.5	628.3	630.0	631.7	633.4	635.2	636.9	638.6	640.4	642.1
210	643.9	645.6	647.4	649.1	650.8	652.6	654.3	656.1	657.9	659.6
220	661.4	663.1	664.9	666.6	668.4	670.2	671.9	673.7	675.5	677.2
230	679.0	680.8	682.6	684.3	686.1	687.9	689.7	691.4	693.2	695.0
240	696.8	698.6	700.4	702.2	704.0	705.7	707.5	709.3	711.1	712.9
250	714.7	716.5	718.3	720.1	721.9	723.8	725.6	727.4	729.2	731.0

Research Incorporated Temperature Limiter
SETPOINT DIAL SETTINGS VS TEMPERATURE

DEG F	0	1	2	3	4	5	6	7	8	9
260	732.8	734.6	736.4	738.3	740.1	741.9	743.7	745.5	747.4	749.2
270	751.0	752.9	754.7	756.5	758.4	760.2	762.0	763.9	765.7	767.5
280	769.4	771.2	773.1	774.9	776.8	778.6	780.5	782.3	784.2	786.0
290	787.9	789.7	791.6	793.5	795.3	797.2	799.1	800.9	802.8	804.7
300	806.5	808.4	810.3	812.1	814.0	815.9	817.8	819.6	821.5	823.4
310	825.3	827.2	829.1	830.9	832.8	834.7	836.6	838.5	840.4	842.3
320	844.2	846.1	848.0	849.9	851.8	853.7	855.6	857.5	859.0	861.3
330	863.2	865.1	867.1	869.0	870.9	872.8	874.7	876.6	878.5	880.5
340	882.4	884.3	886.2	888.2	890.1	892.0	894.0	895.9	897.8	899.7
350	901.7	903.6	905.6	907.5	909.4	911.4	913.3	915.3	917.2	919.2
360	921.1	923.0	925.0	927.0	928.9	930.9	932.8	934.8	936.7	938.7
370	940.6	942.6	944.6	946.5	948.5	950.5	952.4	954.4	956.4	958.3
380	960.3	962.3	964.3	966.2	968.2	970.2	972.2	974.1	976.1	978.1
390	980.1	982.1	984.1	986.1	988.0	990.0	992.0	994.0	996.0	998.0
400	1000.0									