National Aeronautics and
Space Administration

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

FACILITY OPERATING PROCEDURE
FOR
V5 THERMAL VACUUM CHAMBER

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

FACILITY OPERATIND PROCEDURE
FOR
V5 THERMAL VACUUM CHAMBER

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1.0 GENERAL INFORMATION

1.1 SCOPE

The procedures and practices outlined in this document are to be followed in the operation of chamber V5. This document provides a record copy of chamber V5 operations.

1.2 PURPOSE

This document describes the procedures for the operation of thermal vacuum chamber V5, located in the Marshall Space Flight Center (MSFC) Environmental Test Facility (ETF) building 4619.

1.3 APPLICABLE DOCUMENTS

MPG 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-ETF-OWI-001	Environmental Test Facility (ETF) Test Operations
ED26 (02-01)	Memorandum for Record, Safety Assessment for the ETF (soon to be re-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 incidents or near misses to the ETF Branch Leader or the 4619 Assistant Building Manager.

All 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. 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 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 chamber can reach extreme temperatures both hot and cold. The test chamber and test article shall be given sufficient time to return to a temperature above the dew point and less than 40^{o}C (104 ^{o}F) before removing the test article.

ET24 Safety Assessment, Memorandum of Record ED26 (02-01) lists procedures, personal protective equipment (PPE) requirements and job hazard analysis (JHAs) for hazards associated with operation of this chamber. Operators shall review the safety assessment to determine the JHAs and PPE that applies to this operation. 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.

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, a dummy test article can be used to determine program set-points for the thermal controllers and safety devices. Use a dummy test article that provides 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)
- Oil contamination risk from the diffusion pump
- 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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**********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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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 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 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, when 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

Avoid contact of the diffusion pump to minimize the burn hazard. The diffusion pump can reach a temperature of 600^{o}F.

The test chamber and test article shall be given sufficient time to return to a temperature above the dew point and less than 40^{o}C (104^{o}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 shall be aware of possible freeze burns by contact with cold surfaces or liquids. All personnel involved in handling of cryogenics or when making repairs/modifications to cryogenic facilities shall wear 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 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 area.

1.7.4 Minimizing Oil Contamination Hazards

There is a risk that the test article could be contaminated with diffusion pump oil. The chamber shall only be operated by trained personnel to minimize the risk of oil contamination. Ensure the cold trap between the diffusion pump and chamber is operational to reduce the 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 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 area 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 V5 Thermal Vacuum Facility. The designated operator of the chamber will be responsible for the safe operation and conduct of 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 ET24-ETF-OWI-001.

2.0 FACILITY DESCRIPTION

2.1 CHAMBER DESCRIPTION AND DIMENSIONS

Chamber V5 is a stainless steel vessel with polished interior surfaces. The gross internal dimensions are 35 inches diameter by 60 inches long. Porting consists of two (2) 5 3/4 inch diameter ports on each side of the chamber, one (1) 5 3/4 inch diameter port in the door centered on the longitudinal axis of the chamber, one (1) 3 inch port in the rear dome centered on the longitudinal axis of the chamber, and one (1) 10 inch port centered in the bottom of the chamber that is used as the pumping port.

Shrouds are available for use in the chamber. One has internal dimensions of 33 inches diameter by 55 inches long. It is constructed of stainless steel, and the internal surface is painted black.

2.2 VACUUM SYSTEM

The vacuum system consists of a 10 inch 4200 liter per second (l/s) diffusion pump, a 17 l/s (35 cubic feet per minute) mechanical roughing pump, a roughing valve, a 27 l/s (51 cubic feet per minute) foreline pump, a foreline

valve, and a purge line valve. There is a 10" LN_2 cold trap between the 10 inch diffusion pump and the chamber.

2.3 CONTROL SYSTEM

The control system consists of a desktop computer running Windows NT operating system software and Intellution Dynamics *Ifix* control software for operating the chamber systems. A liquid level controller for LN_2 is used to control cooling of the cryo trap. The Intellution software is used to control the thermal conditioning although it can be controlled from the Dimension controller if required.

The control panel for chamber V-5 contains the components listed below for the control of the indicated functions.

Component	Control Function
Switches	System power, limiter power, Dimension controller power, red emergency stop button
Liquid nitrogen level controllers	Liquid nitrogen flow in cold trap
Pressure gauge controller	Convectron gauges, Ion gauge and pressure interlock
Lamp	Temperature out of limit
Fuses	System, phasers, and aux LN_2/ heaters
Watlow limiter	Limits temperatures to within operator set limits
Dimension Controller	Chamber temperature.

In addition, there are pressure switches in the air and water lines and a flow switch in the water line used as safety interlocks.

2.4 THERMAL SYSTEM

A heat exchanger that heats and cools gaseous nitrogen (GN_2) provides shroud temperatures of -170^{o} C to +175^{o}C. Liquid nitrogen (LN_2) is used for cooling and electric resistance heated GN_2 for heating.

2.5 PERFORMANCE

The pumping time of the system will vary with the gas load of the test specimen and internal conditions of the chamber. A clean-dry chamber will perform as follows:

- Atmosphere to 50 millitorr (1.0 E 5 to 6.7 Pascal) in 25 minutes

- 50 millitorr to 10 millitorr (6.7 to 1.3 Pascal) in 35 minutes
- 50 millitorr to 1 x 10^{-4} torr (6.7 to 0.13 Pascal) in 50 minutes
- 50 millitorr to 10^{-5} torr (6.7 to 1.3 x 10^{-2} Pascal) in 110 minutes
- 50 millitorr to 10^{-6} torr (6.7 to 1.3 x 10^{-3} Pascal) in 125 minutes

NOTE

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

3.0 FACILITY OPERATION

The operations of Chamber V5 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 shall be thoroughly familiar with vacuum chamber operation and be familiar with the Intellution control screen prior to operating this chamber.

Complete the As-run Buy-off Sheets when operating the chamber. These sheets are typically provided with the TPS. If none are provided, then use a copy of Attachment A. Additional Buy-off sheets shall be added to the test record 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 apply 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 completed and compatible with proper operation of the chamber.

3.1.3 Place all switches on the control panel and computer control screen in the off, safe, or normal position.

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 the next step.

3.1.5 Calibration

3.1.5.1 Verify that all instrumentation used to record data on this test have current calibration labels. If the label is missing or not current, confer with the ETF Calibration Contact.

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

3.1.6 Visually inspect the level and condition of the oil in the roughing, foreline, and diffusion 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 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.

3.1.7 Verify control GN_2 is set at 80 ± 5 psig.

3.1.8 Verify cold trap Purge GN_2 is set at 10 ± 5 psig.

3.1.9 Determine that the test is ready to start.

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 Closed and secure the chamber door.

3.2.3 Switch **ON** system power and power for DIM, LIM.

3.2.4 Switch **ON** the roughing pump.

3.2.5 Switch **ON** the foreline pump.

3.2.6 Allow a few minutes for the roughing pump to warm.

3.2.7 **OPEN** the chamber roughing valve.

3.2.8 Remove door fasteners so the door will open on a positive pressure in the chamber.

3.2.9 **OPEN** the foreline valve to the diffusion pump.

3.2.10 Once the foreline pressure reaches 1torr or less, switch **ON** the cold trap level controller.

3.2.11 Once the foreline pressure reaches 100 millitorr or less, switch **ON** the diffusion pump.

3.2.12 Allow the roughing pump to evacuate the chamber to $8.0x10^{-2} \pm 2.0x10^{-2}$ torr (100 to 60 millitorr) as indicated by the convectron gauge A and the diffusion pump to reach an operating temperature (about $600^{o}F$).

3.2.13 **CLOSE** the chamber roughing valve. Wait about 30 seconds to allow the roughing valve to completely close before executing the next step.

3.2.14 Select **ON** at the gauge controller process control card top toggle switch.

3.2.15 **OPEN** the Hi-Vac valve.

3.2.16 Wait for chamber pressure to be less than or equal to $1.0x10^{-3}$ (1 millitorr), as indicated by convectron gauge, and then switch **ON** the ion gauge filament. If the filament will not remain on, wait two minutes and try again. The ion gauge controller should indicate the chamber pressure is in the 10^{-4} torr range or lower.

3.2.17 Switch **OFF** the chamber roughing pump.

3.2.18 Select set point (**SP**) on the ion gauge controller process control card top toggle switch.

3.3 THERMAL CONTROL

Thermal control is by use of the V-5 thermal conditioning heat exchanger. This heat exchanger uses liquid nitrogen to cool and electric heaters to heat GN_2 supplied from Panel 1. The GN_2 is then fed to the thermal controlling components inside the chamber. The heat exchanger components shall be controlled by the Intellution Dynamic's iFIX software through the Dimension controller, but may be controlled by a Dimension controller directly when required.

3.3.1 Verify the input GN_2 pressure to the heat exchanger from Panel 1 is no more than 45 psig and **OPEN** the V-5 shroud GN_2 purge/supply valve (GNV154).

3.3.2 Set the Watlow limiter to 10 degrees F above the high temperature for heating and/or 10 degrees F below the lowest temperature for cooling.

3.3.3 Set the computer set-point (or Dimension controller) to the required temperature.

3.3.4 Switch **ON** the Aux LN2, HTR Fuses.

3.3.5 Adjust the temperature set-point on the control computer (or Dimension) as necessary to achieve required the thermal conditions.

3.3.6 When the heat exchanger is to be stopped **SET** set-point high enough so that no LN_2 is sent to the heat exchanger and switch **OFF** the chamber Aux LN2, HTR Fuses.

3.3.7 When the heat exchanger is to be stopped **CLOSE** the V-5 shroud GN_2 supply valve.

3.4 UNATTENDED OPERATION

This facility is designed for continuous automatic operation. The following shall be completed before leaving the equipment unattended in the operating mode.

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

3.4.2 Complete applicable sections of the procedure ET24-UnattnOps-SOP-001, Unattended Operation of the Environmental Test Facility Building 4619.

3.5 PARTIAL SHUTDOWN

3.5.1 Switch **OFF** the ion gauge controller.

3.5.2 **CLOSE** the High-Vac valve.

3.5.3 Allow the chamber and specimen to cool to ambient $\pm$10 degrees C ($\pm$18 degrees F) if it was heated or warmed to above the dew-point temperature if it was cooled.

3.5.4 The system shall now be vented back to ambient pressure.

3.5.5 If the chamber door is to be opened, or if the shutdown is expected to extend to 72 hour or longer, perform full shutdown.

3.6 SYSTEM HOT RESTART

3.6.1 The diffusion pump and LN_2 cold trap controller are in operation with the high vacuum valve closed. Verify that the door is closed and secured.

3.6.2 Verify the vacuum gauge controller with a Process Control card has the SP switch position selected.

3.6.3 Switch **ON** the chamber roughing pump.

3.6.4 Allow a few minutes for the roughing pump to warm.

3.6.5 **OPEN** the chamber roughing valve.

3.6.6 Loosen the door fasteners.

3.6.7 At 100 millitorr or less **CLOSE** the roughing valve. Wait about 30 seconds for the valve to completely close before proceeding.

3.6.8 Select the **ON** position on the Process Control card in the vacuum gauge controller.

3.6.9 **OPEN** the Hi-Vac valve.

3.6.10 Switch **ON** the ion gauge once the pressure indication on the convectron gauge is near $1x\ 10^{-3}$ torr.

3.6.11 Switch **OFF** the roughing pump.

3.6.12 Select the SP position on the gauge controller once the pressure has reached high vacuum. Adjust the set point to about 10 times the gauge pressure when needed as the chamber pressure changes.

3.7 VACUUM SYSTEM SHUTDOWN

3.7.1 Adjust all temperatures inside the chamber to a temperature above the dew point and less than 40^oC (104^oF).

3.7.2 **CLOSE** the Hi-Vac valve.

3.7.3 Switch **OFF** the diffusion pump.

3.7.4 Switch **OFF** the cold trap LN_2 level controller.

3.7.5 Warm the cold trap by **OPENING** cold trap purge valve.

3.7.6 Switch **OFF** ion-gauge.

3.7.7 Continue pumping on foreline with the foreline pump for 1 hour to allow the cold trap to warm.

3.7.8 If a shutdown needs to expedited, open the diffusion's pumps quick quench valve.

3.7.9 **CLOSE** the diffusion pump foreline valve.

3.7.10 Switch **OFF** the foreline pump.

3.7.10 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.

3.7.11 Ensure the shroud and test article are at ambient temperature $\pm$10 degrees C ($\pm$18 degrees F) and above the dew point temperature.

3.7.12 The chamber shall be vented when desired by **OPENING** the chamber vent valve.

3.7.13 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.

3.7.14 If the chamber is to be left in a standby status, it shall be rough pumped and left sealed.

3.7.14.1 **CLOSE** and secure the door with the door fasteners.
3.7.14.2 Switch **ON** the roughing pump.
3.7.14.3 Allow a few minutes for the roughing pump to warm then **OPEN** the roughing valve.
3.7.14.4 Remove door fasteners so the door will open on a positive pressure in the chamber.
3.7.15.5 Allow the roughing pump to evacuate the chamber to 1.0×10^{-1} torr (100 millitorr) as indicated by the convectron gauge A.

3.7.15.6 **CLOSE** the roughing valve. Wait about 30 seconds to allow the roughing valve to completely close before executing the next step.

3.7.15.7 Switch **OFF** the roughing pump.

3.8 WEATHER EMERGENCY SHUTDOWN

If the chamber must be abandoned because of requirements to evacuate during a weather emergency, and if there is adequate time, perform the following steps. These steps are to prevent over cooling of the test article if a loss of electrical power occur while the chamber is abandoned. If no cooling is being performed, skip this section and proceed to a protected area.

3.8.1 **CLOSE** the LN_2 valve or shroud.

3.8.2 **OPEN** the V5 shroud purge valve (GNV154).

4.0 EMERGENCY SHUTDOWN

4.1 **PRESS** the big red button on the control panel to switch **OFF** the power.

4.2 If there is still an electrical fault, **OPEN** the knife switch on the rear of the chamber and **OPEN** Bus Switch 26B on the overhead electrical bus.

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

V5 **As-run Buy-off Sheet**

Test Number _____ Customer Contact _____

Calling TPS or Work Instructions _____Start Time & Date _____

Test Description_____ End Time & Date _____

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

3.1 **FACILITY PREP**

3.1.1 _____

3.1.2 _____

3.1.3 _____

3.1.4 _____

3.1.5.1 _____

3.1.5.2 _____

3.1.6 _____

3.1.7 _____

3.1.8_____

3.1.9 _____

3.2 **VAC SYS 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 _____

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3.2.11 _____

3.2.12 _____

3.2.13 _____

3.2.14 _____

3.2.15 _____

3.2.16 _____

3.2.17 _____

3.2.18 _____

3.3THERMAL CONTROL

3.3.1_____

3.3.2 _____

3.3.3 _____

3.3.4 _____

3.3.5 _____

3.3.6 _____

3.3.7 _____

3.4 UNATTENDED OPERATION
(N/A If Not Applicable)

3.4.1 _____

3.4.2 _____

3.5 PARTIAL SHUTDOWN

3.5.1 _____

3.5.2 _____

3.5.3 _____

3.5.4 _____

3.5.5 _____

3.6 SYSTEM HOT RESTART

V5 As-run Buy-off Sheet

3.6.1 _____

3.6.2_____

3.6.3 _____

3.6.4_____

3.6.5 _____

3.6.6 _____

3.6.7 _____

3.6.8 _____

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3.6.10 _____

3.6.11 _____

3.6.12 _____

3.7.10 _____

3.7.11 _____

3.7.12 _____

3.7.13 _____

3.7.14 _____

3.7.14.1 _____

3.7.14.2 _____

3.7.14.3 _____

3.7.14.4 _____

3.7.14.5 _____

3.7.14.6 _____

3.7.14.7 _____

3.7 VACUUM SYSTEM SHUTDOWN

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3.7.2_____

3.7.3 _____

3.7.4_____

3.7.5 _____

3.7.6 _____

3.7.7 _____

3.7.8 _____

3.7.9 _____

3.8 WEATHER EMERG SHUTDOWN

3.8.1 _____

3.8.2_____

QA _____

(NN/A If Not Applicable)