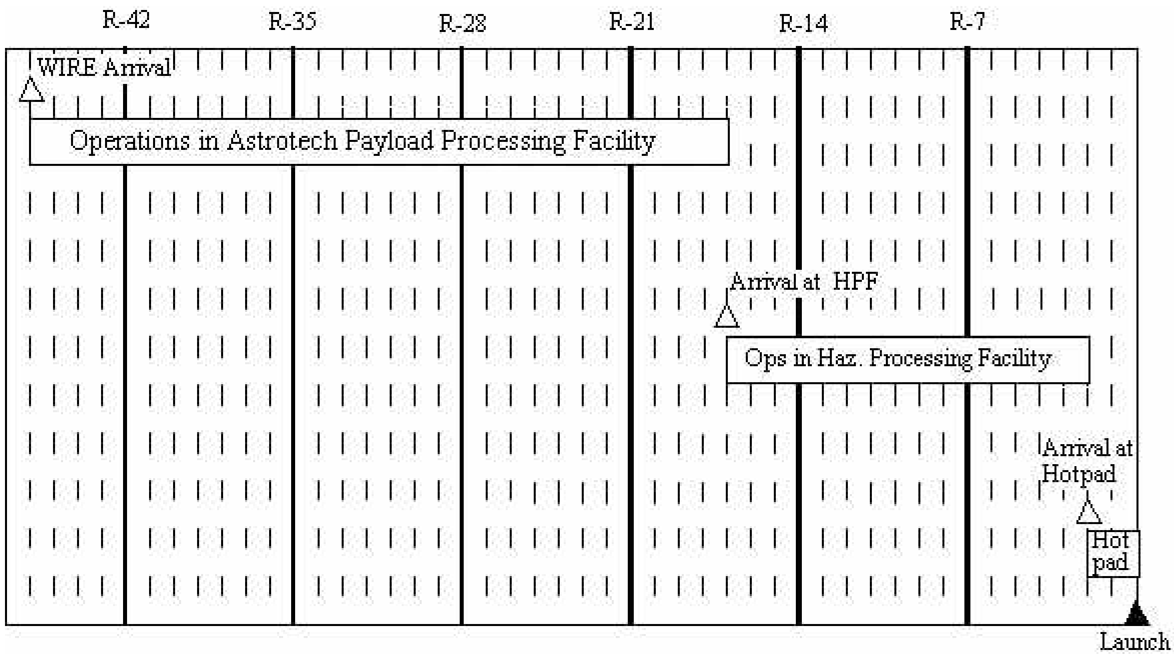
6.0 FACILITIES AND GROUND OPERATIONS

Figure 6-1 is the schedule of processing activities while at VAFB.

Figure 6-1 Processing Schedule @ VAFB



6.1 FACILITIES

6.1.1 Astrotech Payload Processing Facility

Approximately three weeks prior to coordinated ground operations with Orbital and Astrotech Space Operations (ASO), the integrated WIRE instrument and spacecraft bus will be transported from Goddard Space Flight Center to the ASO PPF. There, WIRE will be removed from its shipping container. The spacecraft will go through a checkout procedure to determine if there was any damage caused by transportation. The ASO PPF is the only facility readily prepared to handle operations with H_2. The PPF is also a short distance to the hot pad. The initial He cooling, the payload mating with the Pegasus, the hydrogen filling of the instrument cryostat, and the fairing installation will all take place in the PPF.

6.1.2 Runway Hot Pad

Following system close-out, the integrated payload and Pegasus launcher will move to the “hot pad” site adjacent to the VAFB runway where it will undergo integration with the Pegasus carrier aircraft, a Lockheed L-1011. Cryogenic operations at the hot pad will entail a LHe recool of the H_2 at the latest possible moment before final fairing close-out.

6.2 GROUND OPERATIONS

6.2.1 Astrotech PPF Instrument Operations

6.2.1.1 GSE Setup and Checkout

On arrival at the PPF, the integrated cryostat and spacecraft bus will be unloaded, cleaned, and moved into the cleanroom facility. A complete operational checkout of all the GSE will take place to ensure that the hardware was not damaged during shipment. The initial checkout is to include a complete leak check of all vacuum pumping modules. Once the GSE is checked out and deemed qualified for connection to the instrument, the GSE will be set up around the spacecraft, as shown in Figure 6-2. The figure also shows the 4-ft wide cleared area around the spacecraft that provides a “keep out” zone for the non-explosion-proof cryogenic GSE used during the fill and a 1-ft exclusion zone around the facility safety vent line.

6.2.1.2 Ground Data Checkout Equipment Setup and Checkout

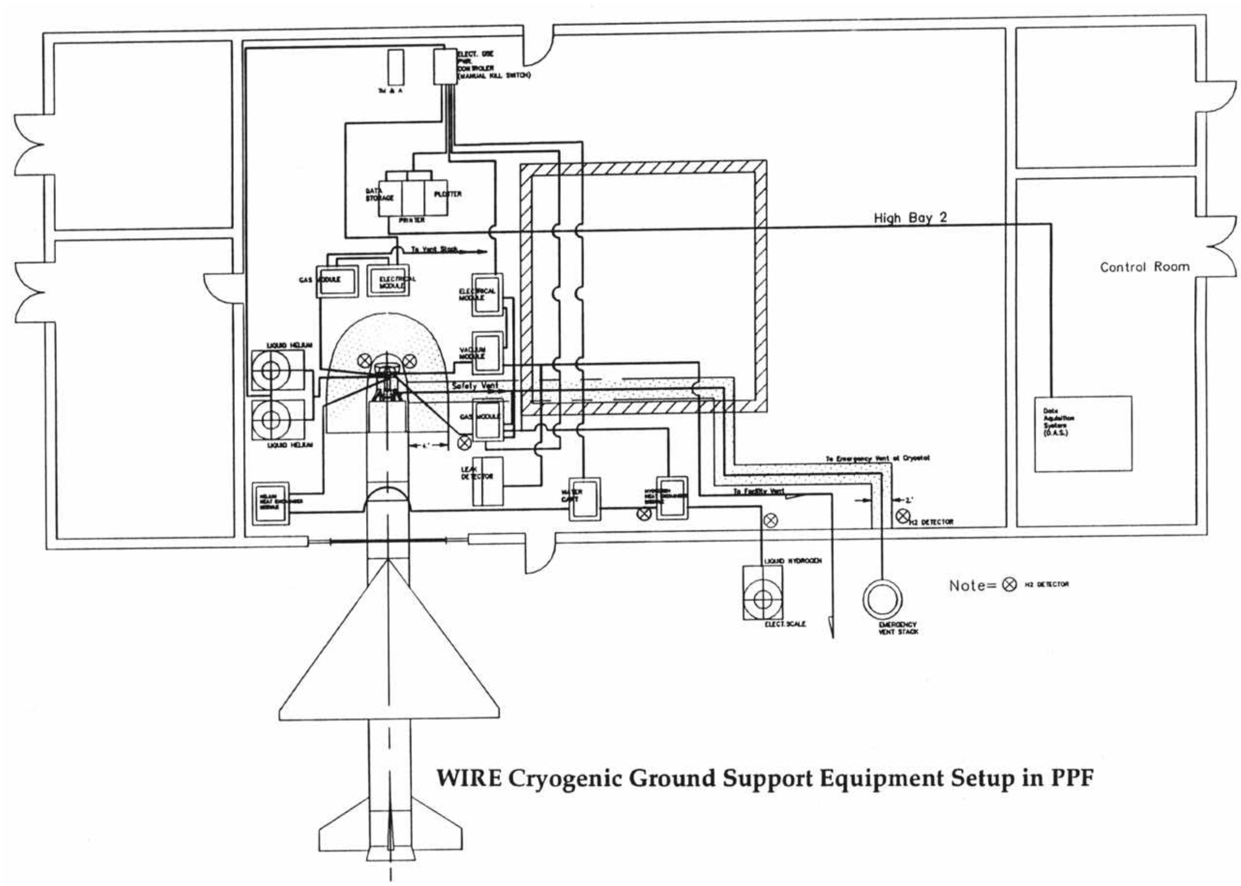
The WIRE instrument will undergo an instrument functional electrical checkout with the cyrogenic system uncooled. The functional checkout will require the use of the ground data checkout (GDC) system, which is designed to support the engineering checkout and integration of the WIRE instrument on the ground.

6.2.1.3 Liquid Helium Cooling of the Cryostat

Once the Pegasus and spacecraft bus are located near each other in preparation for mating, the WIRE instrument team will perform a cold functional test to prove the functionality of the instrument. The spacecraft should be as close as possible to its mating position with the Pegasus so that following the cold functional test a minimal reconfiguration of the GSE will be necessary for H_2 operations. The functional test requires the instrument to be cooled with liquid He for the duration of the test. Prior to the cooling, the tanks and vacuum shell will be leak checked for the final time.

LHe cooling operations of WIRE’s two cryogenic tanks entails circulating LHe through the cryostat’s cooling coils to reduce the tank temperatures to about five K. This process will take about two days and will begin once the integrated instrument and spacecraft bus arrive at the PPF, the cleanroom is set up, and the GSE has been checked out. The cooldown rate witll be controlled so that the H_2 temperature drops less than 10 K per hour. The He servicing will require

Figure 6-2 WIRE Cryogenic Ground Support Equipment Setup In PPF



setting up of several 500-liter He dewars, platform scales, vacuum-jacketed transfer lines and siphon tubes, a coolant cart, pressure regulation systems and GHe, a heat exchanger, the vacuum module, and a coolant line disconnect system. Temperature control and fluid use will be maintained by instrument heaters, the LHe supply overpressure, and the flowback pressure of the LHe at the heat exchanger. The temperature gradients are lightly controlled manually by Technicians.

The post-transportation functional test at He temperatures using the GDC will be conducted before checkout operations are turned over to the spacecraft bus electronics. The instrument and spacecraft health should be assured prior to continuing on to H_2 operations. At the end of this functional checkout, all GSE will be disconnected from the spacecraft to allow its safe integration with the Pegasus.

6.2.1.4 Gas-phase Fill and Freezing of Both Tanks

Following LHe cooling operations, the WIRE payload will be mated to the Pegasus launch vehicle in the PPF's north highbay. Because the north set of roll-up doors are not wide enough to allow the full entry of the wide-winged Pegasus into the highbay, the exterior portion of the roll-up bay will be modified slightly to accommodate the Pegasus-spacecraft bus integration operations by adding a "clamshell" housing to the exterior of the building around the roll-up door. The clamshell will enclose the rear portion of the Pegasus; its anterior section, into which the payload will be installed, will be inside the PPF cleanroom and will be accessible to the integration and cryogenic support teams.

The H_2 fill will require setting up all the cryogenic GSE equipment and a checkout of the setup to ensure that all H_2 paths are leak tight and that the H_2 monitors are functioning. During this setup time, Orbital will conduct Pegasus-instrument flight simulations three and four (flight simulations one and two will have been done earlier in Orbital's Building 1555). When these tests have been completed and the H_2 fill configuration checked out, the filling of its two cryogenic tanks with H_2 will commence. The fill and subsequent solidification of the H_2 will take approximately ten days to complete.

The secondary tank will be filled first. This provides a "buffer" for the primary tank fill because of the secondary tank's larger mass. Following the fill, the H_2 in the secondary tank will be frozen using LHe.

After the secondary tank is frozen, the fill setup will be reconfigured for the primary tank fill. The secondary tank will be kept at or below triple point (13.8K) while the primary tank is filled with H_2. Freezing the H_2 in the primary tank and recooling the already frozen H_2 in the secondary tank will require an additional 48 hours. The disconnect of the cooling coils will take approximately three to four hours.

During the H_2 tank filling process, the CLAES/SPIRIT III gas modules will be used. Solidifying the H_2 will be accomplished by flowing LHe through the cryostat's cooling coils. The equipment required for the H_2 fill and freeze includes: a 1000-liter H_2 dewar, vacuum-jacketed transfer lines and siphon tube, platform scales, a heat exchanger and coolant cart, the gas modules, the vacuum module, the electrical modules, pressure regulation systems and He gas, H_2 detectors, and a hand-held H_2 leak detector.

The fill "bookkeeping," i.e., controlling the mount of H_2 being put into the tanks, will be verified by using a dual serial integrating flowmeter at the inlet of the gas module. This procedure has been checked for accuracy during the two Santa Cruz test fills.

The entire filling operation will be monitored using facility H_2 detectors and a portable, hand-held H_2 leak detector that will sequentially monitor any H_2 venting from the fill lines and hose connections. Once the H_2 fill operations are complete, the H_2 will be maintained in the frozen state by circulating LHe around each tank. This process will continue until a few hours prior to the installation of the fairing. During the ten hours, the LHe cooling coils are disconnected and evacuated.

While the H_2 is being maintained in a solid state, the aperture shade will be installed. Because of its delicate nature, the aperture shade is installed as late as possible prior to fairing installation.

6.2.1.5 Cryogen Recooling Operations

Following the fill and freeze of the cryogen in the primary and secondary tanks, the two tanks must thereafter be periodically recooled to maintain their temperatures at or below the triple point. The recooling operation consists of flowing He through the cryostat's cooling coils and cooling the primary and secondary tanks to below five K. The equipment required for the recool operation includes multiple 500-liter He dewars, platform scales, VM, EM, GM, vacuum-jacketed transfer lines, siphon tubes, and a coolant line disconnect system.

6.2.1.6 Contingency Cryogen Offloading Operations

In the event the primary and secondary tanks need to be emptied, a 15 cfm roughing pump in the gas module will be used to "pump" off the cryogen at a rate that will not permit the seals on the vacuum shell to drop below 273 K in temperature nor allow the cryogen to exceed the triple point. The offload is maintained using tank heaters and valve control in the gas module. The equipment needed in this operation includes the gas module and the tank heater power supplies.

6.2.1.7 Installation of the Fairing

The fairing installation/close-out will occur in two phases. Phase one will occur at the PPF after the H_2 fill, solidification, and recool operation is completed. The two-piece fairing shroud will be mated to the Pegasus second stage and the ordnance connections will be completed. During this initial close-out phase, the instrument will be disconnected from the facility safety vent for a short period of time while one-half of the fairing is installed. During this period, however, continuous temperature data will be supplied by the DAS and TM&A.

Once the phase-one close-out is complete, the spacecraft's vent will be reconnected to the facility safety vent through the OSC line, and cooling operations (circulation of He through the cooling coils), will continue up to approximately ten hours before the instrument is move to the pad. Prior to the move, both the cooling coils and the high-vacuum pumps will be disconnected. The facility safety vent stack will be replaced by a portable safety vent adapted for transporting the instrument to the hot pad. In addition, the TM&A will again be used to monitor the temperature of the H_2 tanks during pad transportation. This procedure will require access through two fairing access doors.

6.2.2 Hot Pad and L-1011 Operations

Three days before the scheduled launch, the integrated spacecraft and Pegasus launcher will be moved to the hot pad at the edge of the runway via the AIT. During the move, the instrument will be connected to the portable safety vent line, which will be purged with GHe. In addition, there will be continuous nitrogen purging on the fairing. In case of a vehicular breakdown, there will be contingency of both He and N_2 gas for these purging operations.

The Pegasus launch vehicle will be mated to the L-1011 immediately following its arrival at the hot pad. During this time, the instrument will be disconnected from the safety vent. In addition, the TM&A will monitor the status of the primary and secondary tank temperatures. Thus, the instrument team will be able to monitor their status at all time during ground operations. Immediately after the mating is completed, the portable safety vent line will be reconnected to the instrument.

6.2.2.1 Hot Pad Recooling Operations

After the L-1011 integration is complete, the GSE will be set up and the LHe cooling of the instrument will begin. The safety vent will be connected through the L-1011 and will purged with GHe. The location of the safety vent is shown in Figure 6-3. Setup of the cryogenic equipment at the pad will require about eight hours. Equipment locations at hot pad are shown in Figure 6-4.

Figure 6-3 Hydrogen Vent Line on the Pegasus Carrier Aircraft

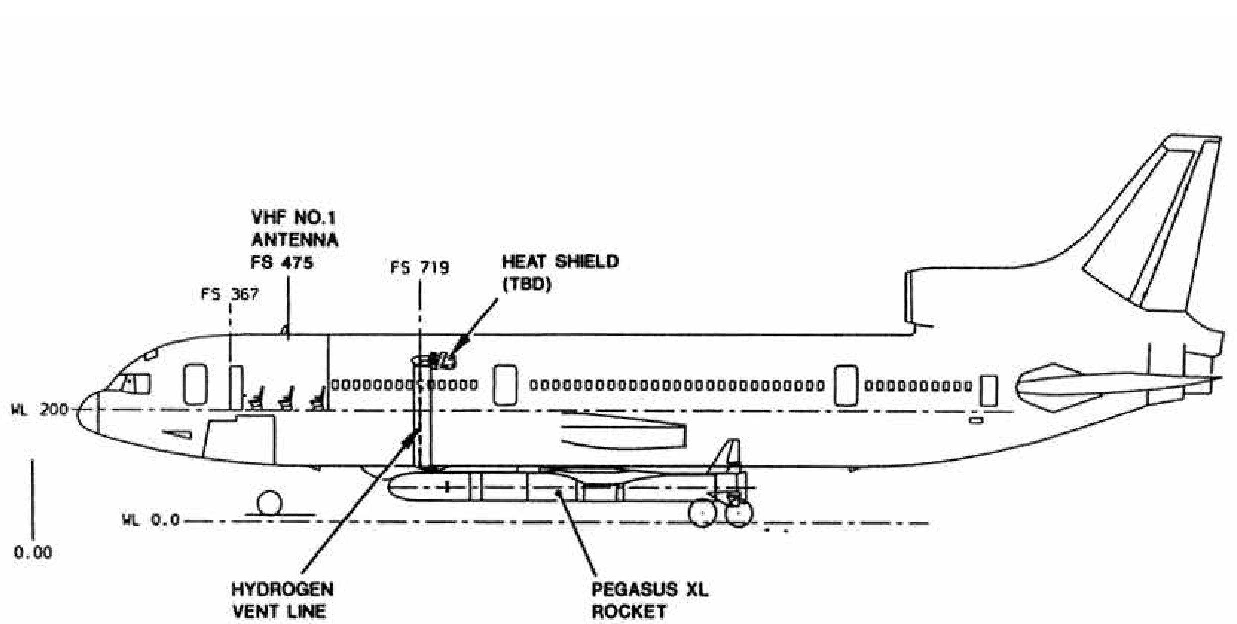
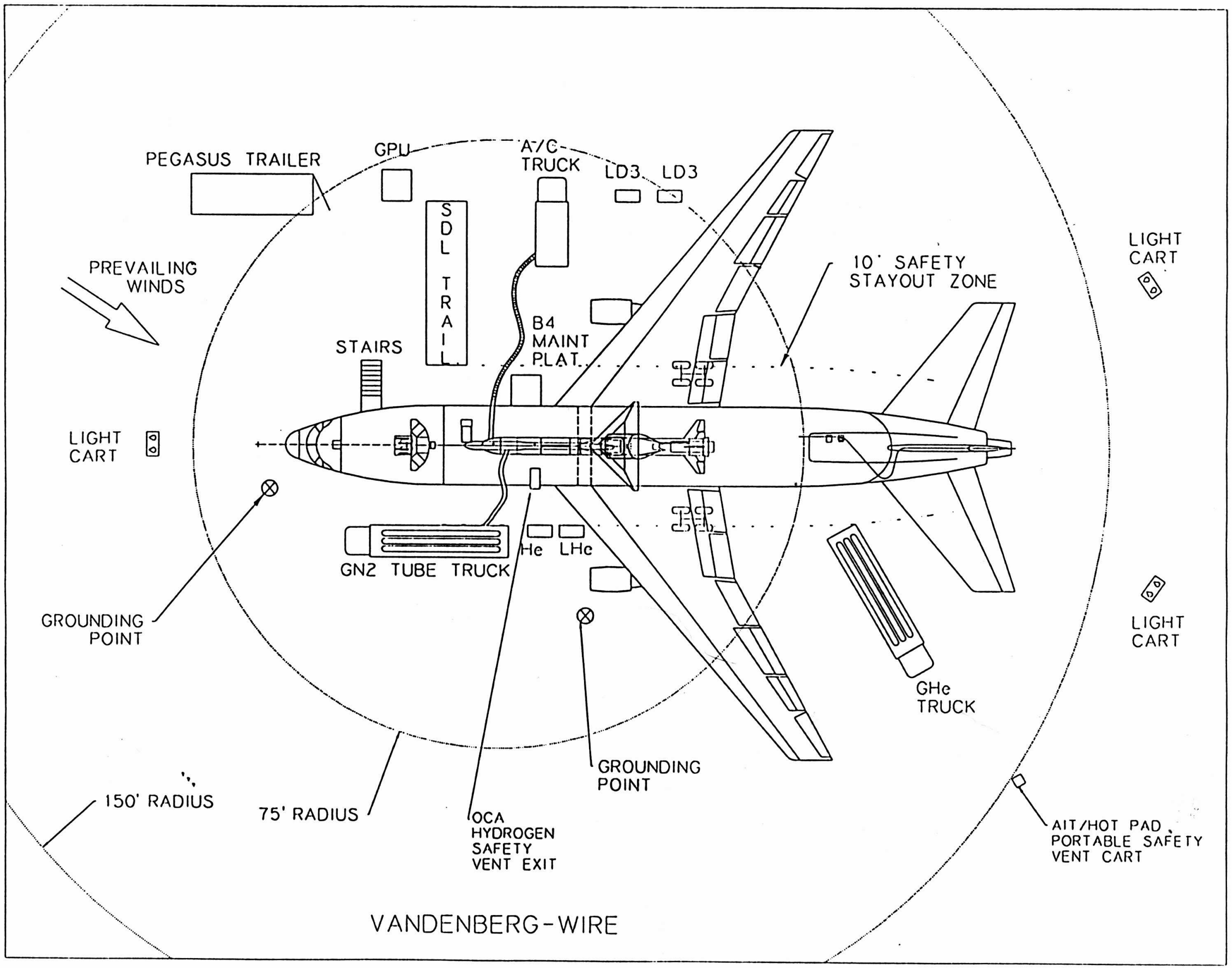


Figure 6-4 WIRE Ground Support Equipment Setup at the Hot Pad



The cryostat will be cooled until approximately 13 hours prior to take-off, which will reduce the likelihood of the cryogen's warming before launch. Once the system is ready for launch, the high-vacuum lines and coolant loop will be disconnected; the temperature monitoring GSE will be the last piece of equipment removed. As this disconnection takes place, the connection for monitoring the temperature throughout the L-1011 umbilical will be made.

After the last recooling phase two of the fairing closeout activity will occur. Flight hardware access doors will be permanently installed and certified ready for flight. The final close-out phase will be completed with the removal of all safe-and-arm locking pin hardware.

6.2.2.2 L-1011 Operations

Once the WIRE cryostat is attached to the L-1011, the temperatures of its tanks will be monitored in the L-1011 by an umbilical line that connects to the spacecraft. The temperature for each tank indicated what state the H_2 is in (i.e., solid, at triple point, melted). From this temperature, the pressure can be inferred. Therefore, as long as the temperatures read out in the L-1011 are below the triple point reading of 13.8 K, the cryogen remains a solid, and the aircraft can take off. A curve of nominal temperature rise trends will be given to the L-1011 personnel.

If an event occurs that causes the tanks' insulation to degrade, the temperatures inside the tanks will rapidly rise to 13.8 K, melting the SH_2 and warming the liquid. Because the temperature sensors are on the tank walls, they will indicate a slightly warmer temperature than the actual cryogen inside. Thus, they will provide an early indication to the WIRE team that there is a possibility that H_2 might vent.

If a temperature sensor reaches 13.8 K, the instrument launch will have to be aborted and the instrument returned for recooling operations. In the event of significant problem, venting will occur at 19.4 ± 2 K. This temperature monitoring will continue during rollout and taxiing maneuvers, takeoff, and flight-to-launch destination. Flight time to the drop zone is approximately 55 minutes, and throughout transit to drop zone, live Pegasus telemetry will be monitored. Alarms placed on the temperature monitoring unit will be set to indicate launch criteria or safety criteria (yellow light if 13.3 K is reached and red light if 16.0 K is reached). Flight electronics will also permit ground cryogenic personnel to monitor cryogen status until just prior to drop. At 13.3 K, the time to triple point is ~1 hour, enough time to allow the L-1011 to safely return to base.

6.2.2.3 Abort and Return to Base Operations

Several events could cause an abort and return to base scenario. Events having nothing to do with the cryostat (e.g., the sudden advent of poor weather or high winds within the drop zone, failure to launch within the prescribed period after actuating the flight battery, etc.) would require that the L-1011 return to base, the Pegasus be safed, the cryogenic GSE be redeployed, and the ground support purge and safety vent lines be reconnected. Cryostat cooling would continue the next launch attempt.

Cryostat anomalies during flight will be monitored by the L-1011 team who will be in radio communication with the ground instrument team. Tank temperature readings above 13.8 K would immediately indicate to the L-1011 team that there is a need to abort the launch.

The possibility of venting H_2 exists only if the temperature of the secondary tank exceeds 19.4 ± 2 K. If the temperature is above 19.4 ± 2 K, the L-1011 team should return to base immediately, and a ground He purge will be implemented. The red alarm at 16 K indicates this point will soon be reached. In the case of venting H_2 (H_2 above 19.4 ± 2 K), by the time the plane lands, the H_2 may have fully vented, partially vented, or some LH_2 may remain in the tanks. If the plane lands and the temperatures are still below 19.4 ± 2 K, H_2 will not be venting and the instrument team will make a decision in conjunction with safety personnel about whether to commerce He recooling operations.

6.2.2.4 Abort and Return to Remote Site Operations

The alternate landing site for the L-1011 in case of a launch abort after the plane is in the air is Edwards Air Force Base (EAFB). Landing the L-1011 at a EAFB site would occur only if the conditions at VFAB were degraded sufficiently to preclude landing there at the time the mission was aborted. This could happen for several reasons:

- poor weather or bad wind conditions at VAFB at the time of the abort decision,
- heavy air traffic, unusable runway, etc., at VAFB at the time of the abort decision,
- malfunction of the L-1011 aircraft (whether an abort decision was made or not), necessitating its landing at an alternative air field.

Any of these cases would require that cryogenic GSE and support personnel be transported from VAFB to EAFB for recooling operations. Again, depending on the abort scenario, the cryo ground crew could be faced with an instrument whose tanks are fully vented, partially vented, or still partially filled with LH_2. A landing at any remote site would require that the be H_2 solidified or completely off-loaded prior to the L-1011's flight back to VAFB.

In preparation for such contingency, a limited subset of the cryogenic GSE will be taken to EAFB following the H_2 fill at the PPF that will enable cryogenic personnel to perform a cooling operation if an abort takes place. Equipment at EAFB would included the electrical and vacuum modules, the heat exchanger, transfer lines, scales, LHe, siphon tubes, GHe bottles, regulators and gas carts for the He, and a compressed air supply. Again, depending on the abort senario, the cryogenic ground crew at EAFB could be faced with an instrument whose tanks are fully vented, partially vented, or still partially filled with LH_2. Personnel traveling to EAFB will also take both the temperature monitor and the TM&A, along with some other miscellaneous GSE.

6.2.3 Hydrogen Detection System

6.2.3.1 Facility System

The ASO facility is equipped with flammable atmosphere sensing system calibrated for H_2 detection. This system is the second line of defense (local sensors on cryo plumbing joints being the primary defense) for safing the facility in the event of H_2 release. This facility system, unlike the local system will initiate automatic responses.

The system consist of four sensors mounted in the ceiling above the ceiling tiles. Two of the sensors are in the air lock and two are in the high bay above the spacecraft. They are connected to a controller unit in the control room which is behind thick plate glass. The controller display is visible to personnel in the control room and to personnel in TBD via a video link.

The system will respond in two phases, 10 percent and 25 percent LEL. The following occurs when the ASO system detects 10% LEL:

1. A yellow warning light will activate.

2. The roof louver will open.

The system will stay in this configuration until the detectors sense 25% LEL or the system is manually reset. At 25 percent LEL, the following will occur:

1. A klaxon horn will activate,
2. The power to the non-explosion proof high bay receptacles will be disabled,
3. VAFB fire department will be notified,
4. The heating ventilation and air conditioning (HVAC) return air damper will be automatically closed and outside air damper will be fully opened,
5. The telephones and communication head sets will loose power, and
6. The red warning light will activate.

The system will then be manually reset.

6.2.3.2 Local System

Six local H_2 vent sensors will be monitoring H_2 concentrations at joints where H_2 leaks might occur during the fill process. Figure 6-3 shows the locations of these sensors. During the fill, the following safety measures will be observed using the local sensors:

- After the fill has begun, each joint and/or connection in the facility associated with the liquid fill will be checked with a portable, hand-held H_2 detector.
- During the liquid transfer, the person monitoring the H_2 sensors in the control room will be in constant communication with the cryogenic test conductor inside the cleanroom. Because the sensors allow measurement from 0 to 100% LEL, the cryogenic test conductor will be able to shut down the H_2 flow operation at the first sign of any localized leak (<5% LEL). Shutting down the operations requires that both the liquid supply valve at the exterior dewar and the valve at the gas module be closed.
- After the H_2 supply is closed, investigations and discussions will be held and procedures developed to repair the leak in a timely fashion. Safety personnel will be apprised of the repair approach and work will continue after approval is given.
- If cutting off the H_2 fill has not reduced the increase in gas, and if local sensors increase to a 15% LEL, the power to all WIRE non-explosion-proof equipment in the area will be shut off manually at the WIRE power distribution box. It will remain off until the problem is solved.
- In addition to the local detection system, the building-level sensor system may also be used. In the case where the 10% LEL facility sensors activate the alarm in the control room, the H_2 supply will be cut off.

Once the liquid transfer is complete, the H_2 will be frozen and subcooled to ~6 K using liquid He. At this point, H_2 cannot vent from the WIRE instrument.

6.2.4 Facility Emergency Vent

Located outside the PPF is the building's safety vent stack. This stack, which was used for the SPIRIT III H_2 fill and subsequent operations, is used to eject H_2 vapors during the course of normal operations while also providing the emergency release path in an emergency event.

The vent stack (Figure 6-5) includes a 35-gallon liquid reservoir with a stack extending above the roof to safety vent GH_2. The stack is terminated with an atmospheric isolator and low ESD emission vent tip. A constant 30 SCFH GHe purge is supplied to inert the stack.

Figure 6-5 Facility Emergency Vent Stack