4.0 SPACECRAFT GROUND SUPPORT EQUIPMENT (GSE)

The following GSE is used at the Western Range for the WIRE spacecraft in preparation for launch. Specific GSE capabilities are detailed in the following sections.

4.1 SPACECRAFT GSE

4.1.1 Material Handling Equipment

The spacecraft ground handling equipment is used during integration and test, transportation, and launch vehicle integration. Ground handling equipment includes the spacecraft dolly, the shipping containers, the hoist assembly, and the mating table.

The ground handling equipment has a minimum factor of safety of 5.0 and lift hardware has been proof tested. Data on rated load, proof load, and safety factors are shown in Table 4-1. Written acknowledgment will be provided that proof testing has been performed within one year of use at VAFB.

Ground handling equipment, with exception of the mating table for a short period, is never sited in vicinity of the launch vehicle and would pose no hazard during a seismic event.

4.1.1.1 The Spacecraft Dolly

The Spacecraft Dolly is a commercially manufactured hand truck commonly used in factories and warehouses. It is a wagon type platform truck with welded steel frames, smooth corners, and wagon type steering with a T handle. It is fitted with a flush steel deck to which an adapter ring is attached for mating with the payload support ring. The tires are pneumatic for cushioned ride over uneven surfaces. The dolly is manipulated by hand and is used to position the spacecraft after off loading from the transport van. The dolly has a rated capacity of 2500 pounds, weighs 200 pounds, has 12-inch O.D. tires, and the platform measures 36 by 60 inches. Once in position the wheels of the dolly are chocked to prevent movement; there is no locking mechanism. The dolly is similar to the dolly used on the SAMPEX and FAST missions. See Figure 4-1.

4.1.1.2 Shipping Containers

The shipping container is used when the WIRE spacecraft is transported from NASA/GSFC to the WR. The shipping container is designed to fit on the spacecraft dolly. The Shipping Container is similar to those used on the SAMPEX and FAST missions. See Figure 4-1.

4.1.1.3 The Hoist Assembly

The WIRE spacecraft (fully integrated) will be lifted using a special lift fixture called the Hoist Assembly. This multi-member fixture is constructed primarily of carbon steel that bolts to the spacecraft and allows lifting in either vertical or horizontal orientations.

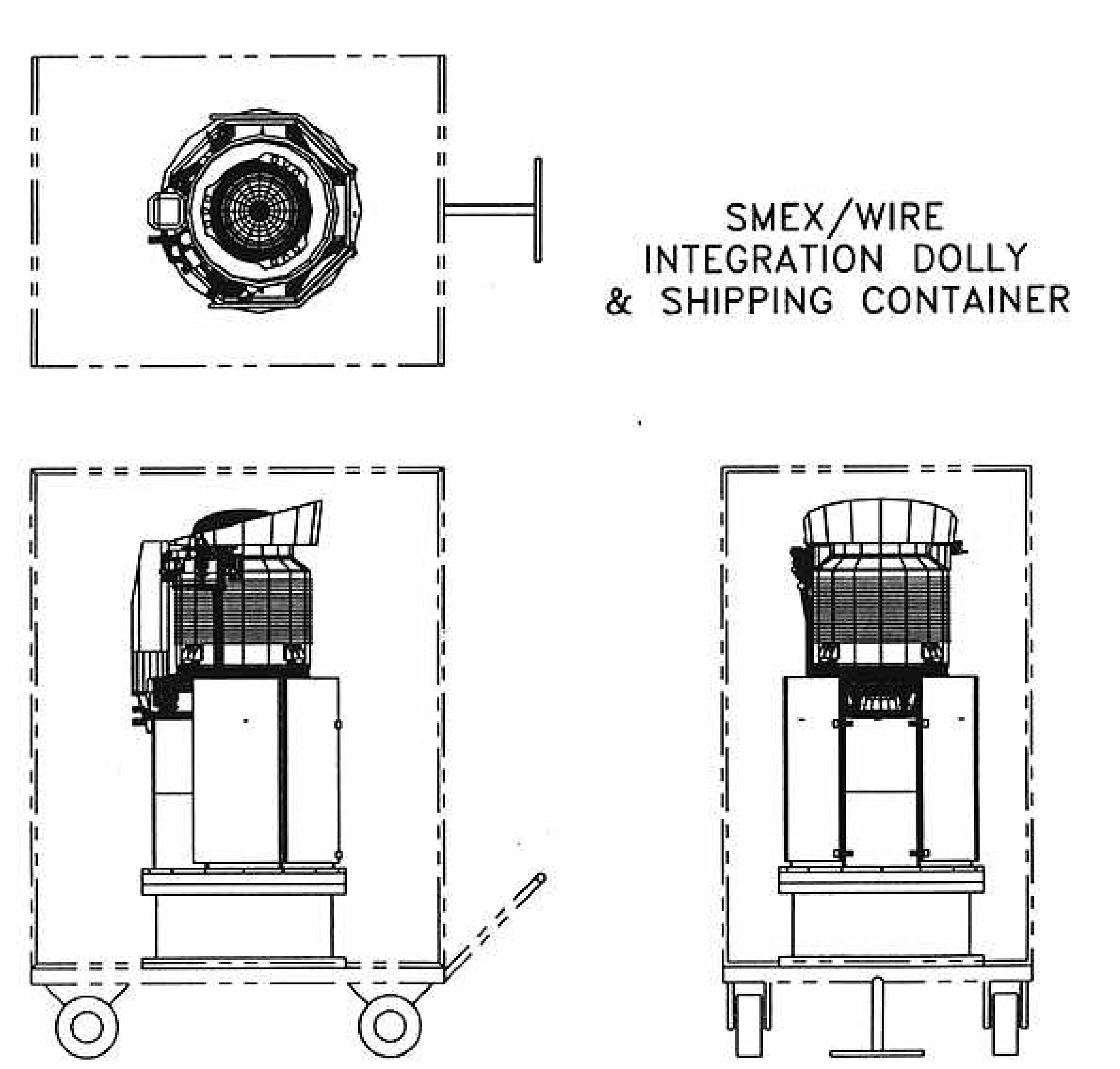
Table 4-1 Ground Handling Equipment Data

ITEM NAME	SLING		NDI REQ'D		RATED LOAD (LBS)	DESIGN FACTOR OF SAFETY *	PROOF LOAD (LBS)	ACTUAL LOAD (LBS)	PROOF TEST DATE
	METAL	SYNTHETIC	YES	NO					
WIRE Lifting Sling (Vertical & horizontal Configuration)	X		X†		3000	5.0	1200	550	
Hoist Assembly	X		X†		3000	5.0	1200	550	
Spacecraft Dolly				X	5000	5.0	2000	1000	
Turnover Fixture				X	5000 @ 30”	3.0	2000 @ 30”	600 @ 30”	
Mating Table	X			X	5000	5.0	2000	600	
Hydraset				X		TBD††			

† required for fabrication   ** based on data from manufacturer   * without yielding

††Note: Hydrasets used for the WIRE mission are obtained from a pool of lifting and hoisting equipment. Design Factor of Safety (FOS) for the Hyradset used at the launch will be identified prior to shipment.

Figure 4-1 Integration Dolly and Shipping Container



The Hoist Assembly is shown in Figures 4-2, and 4-3. The hoist assembly is an integral part of the sling assembly. Information on the rated load, proof load, and design factors are specified in Table 4-1. It was designed to 5:1 ultimate and will be proof loaded this year prior to use at WR.

4.1.1.4 WIRE Lifting Sling

The WIRE spacecraft is lifted using the WIRE Lifting Sling. This is a four legged, wire rope sling and a multi-member carbon steel structure.

The lift sling was designed for 5:1 on yield and will be proof tested at two times the rated load within a year before use at WR. The lifting sling is proof tagged and separable components are independently tagged. Proof testing will be accomplished in the vertical and both horizontal configurations. Data on rated load, proof load, and design factors are specified in Table VII. Orientations are shown in Figure 4-2, and 4-3.

4.1.1.5 Turnover Fixture

The Turnover Fixture is a modified version of a commercial item manufactured by K.N. Aronson, Inc. The Model HD 30-6A Floor-Mounted Positioner can rotate its tilt table from horizontal through an arc of 135 degrees with loads up to 3,000 lbs. It has a 38,250 lb.-in. rotation gearing with a self-locking wormgear drive for its rotation pinion. The table has a FOS of greater than 3.0.

The turnover fixture, as configured for WIRE, includes casters on the support legs for mobility on the floor and an adapter ring bolted to the tilt table for attaching the spacecraft. Figure 4-4 illustrates the positioner. The turnover fixture may be fitted with outriggers to enhance stability when the spacecraft is being rotated. The purpose of the turnover fixture is to rotate the spacecraft from vertical to the horizontal to facilitate mating to the launch vehicle.

4.1.1.6 Mating Table

After rotating the WIRE spacecraft to a horizontal orientation in Building 1555, the mating table (or integration platform assembly), a wheeled multi-axis adjustable cradle, is used. The mating table allows adjustment of the WIRE spacecraft in any desired axis. The table is also used to mate the WIRE to the launch vehicle. The mating table is proof-tagged. The actual mating operation is expected to require fewer than two hours.

Designed for a 5:1 FOS, the mating table will be proof tested before use at WR. Information on rated load, proof load, and design factors is specified in Table VII. The mating table is shown in Figure 4-5. The Mating Table is the same table that was specified for use on the FAST mission.

Figure 4-2 Lift Sling-Vertical

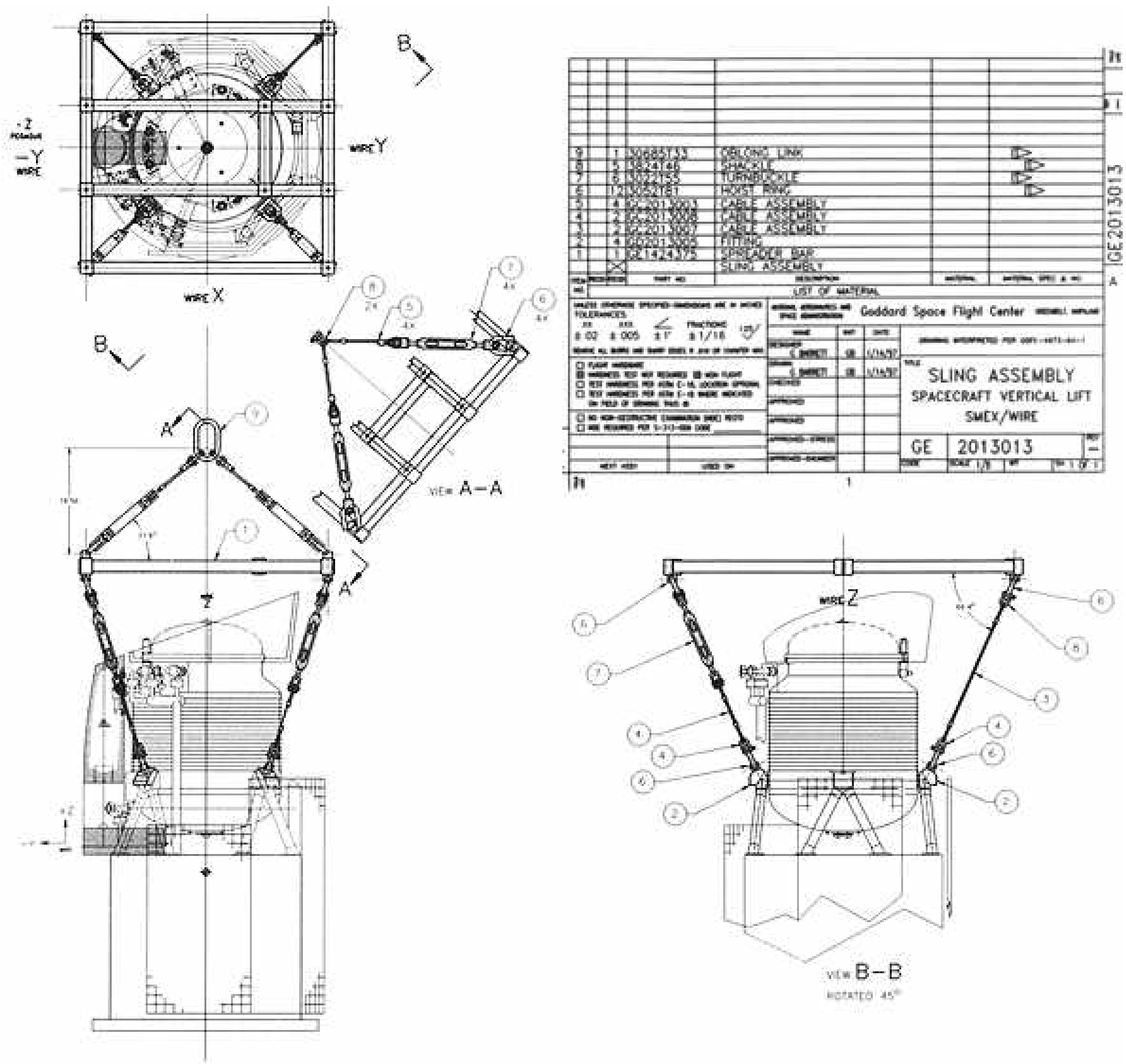


Figure 4-3 Lift Sling-Horizontal

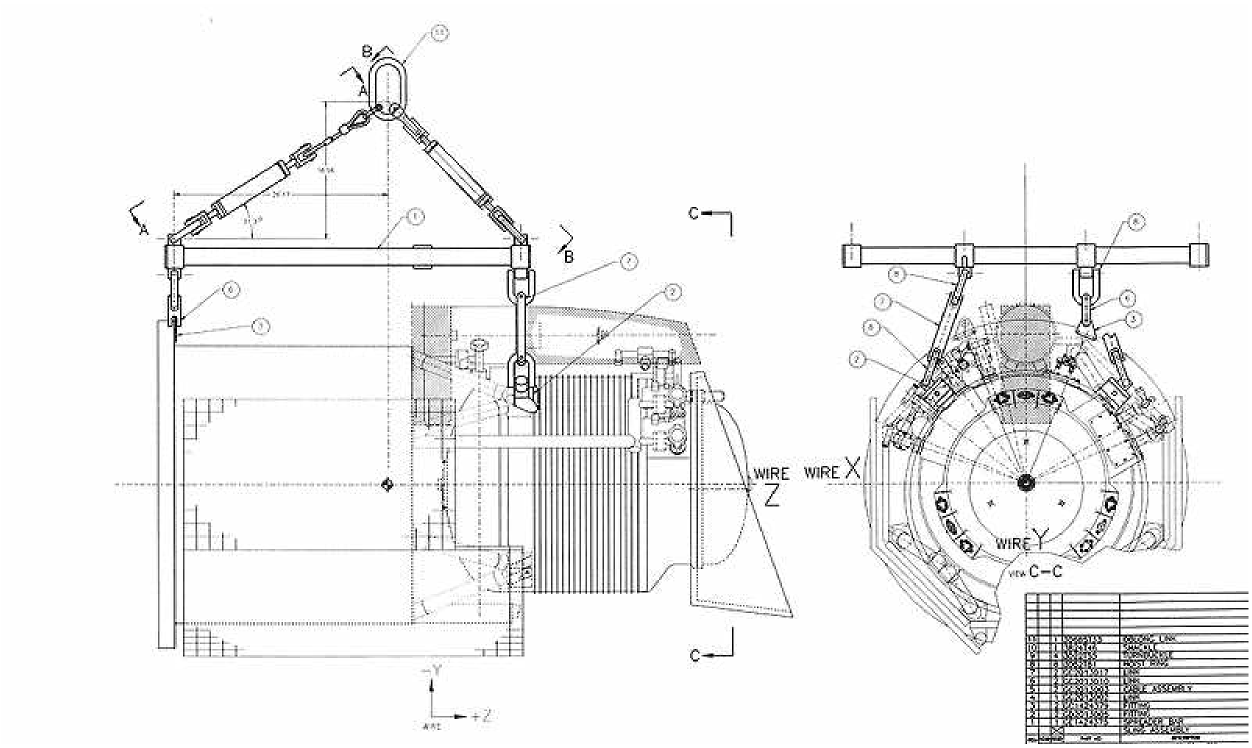


Figure 4-4 Turnover Fixture

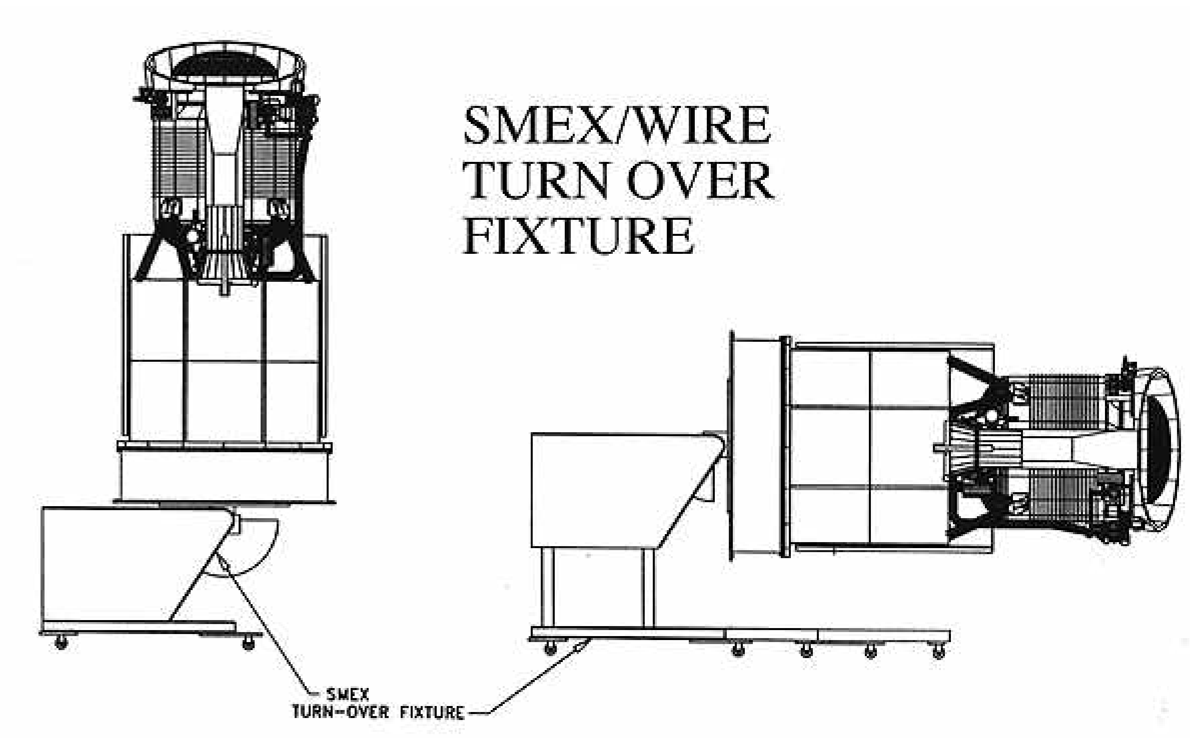
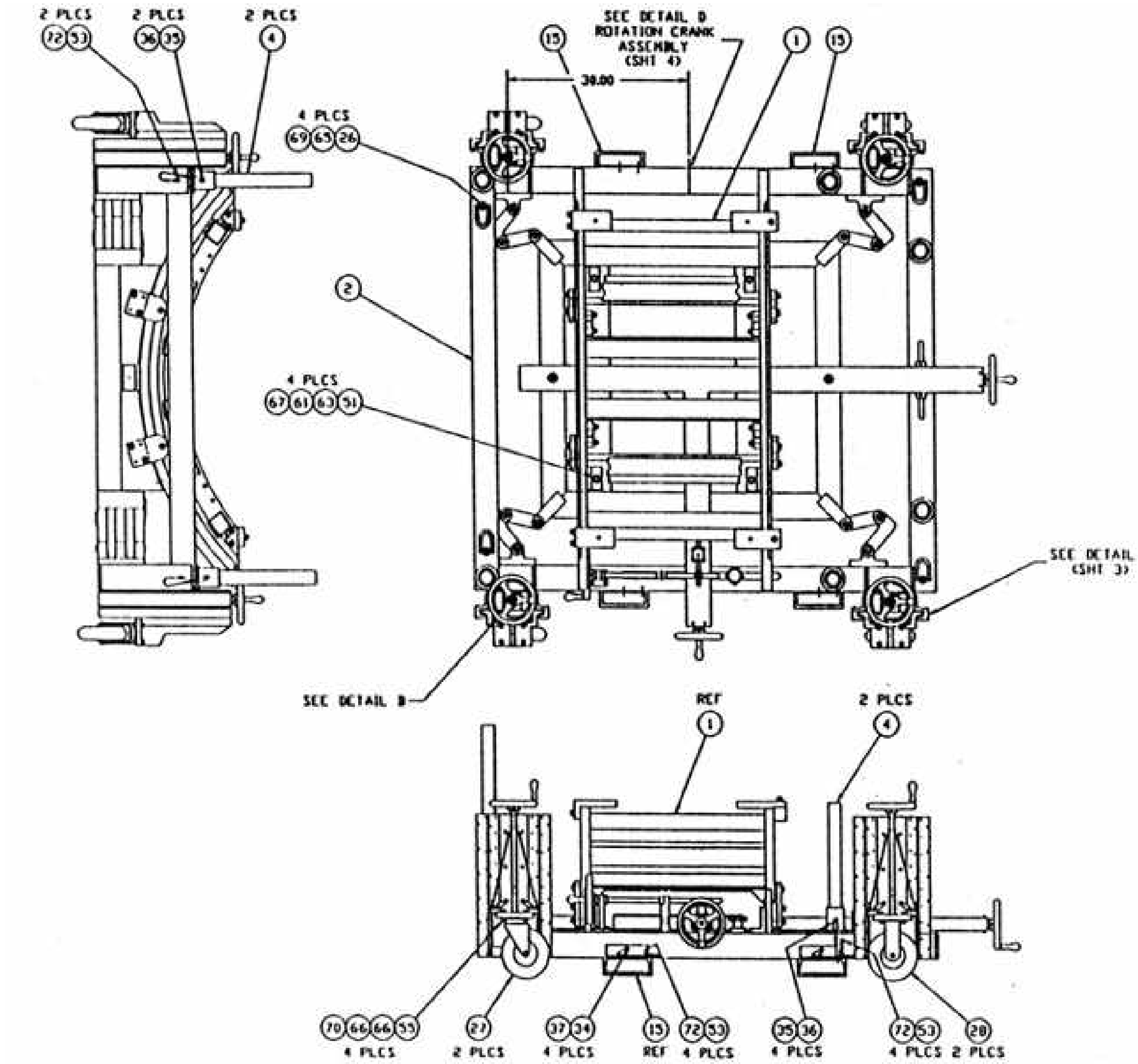


Figure 4-5 Mating Table



4.2 PRESSURE AND PROPELLANT SYSTEMS

There are no pressure or propellant systems, which are part of the WIRE spacecraft.

4.3 ELECTRICAL AND ELECTRONIC SUBSYSTEMS

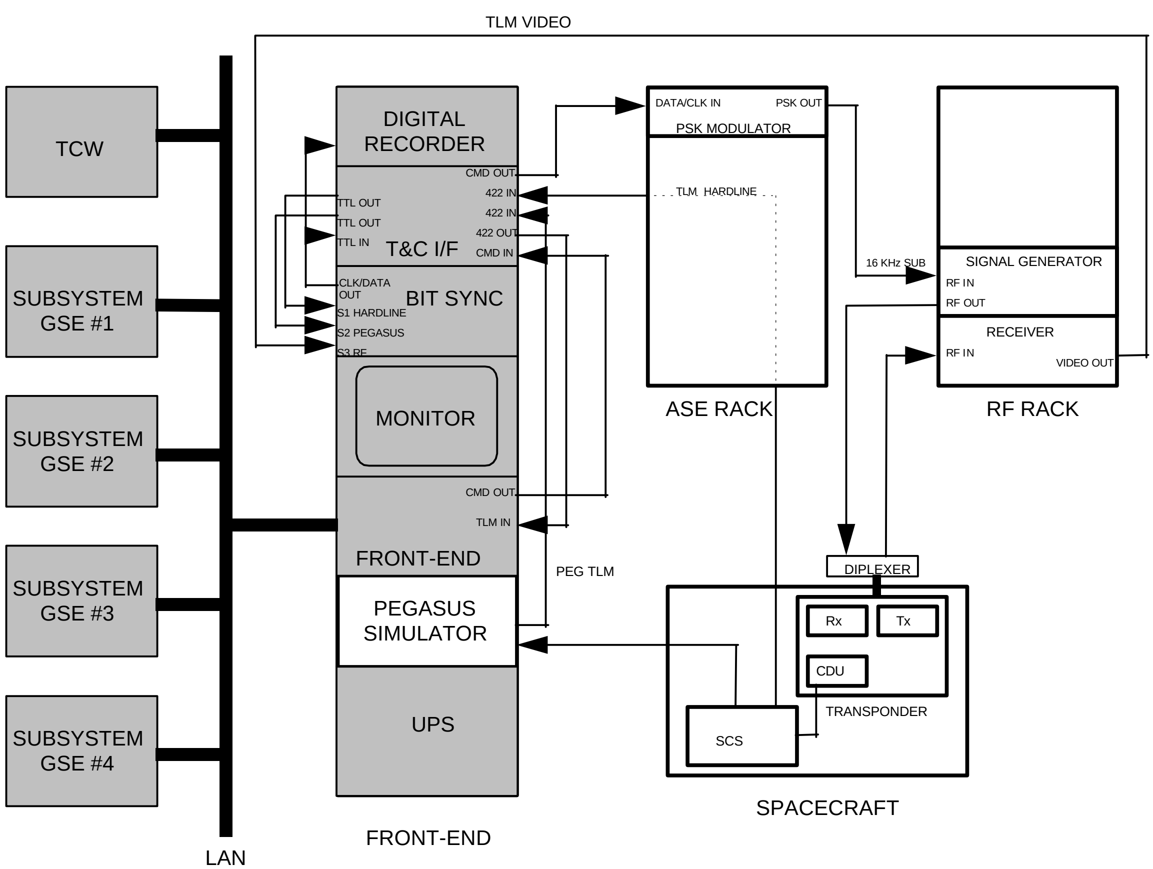
The electrical GSE provides for the support of the spacecraft during subsystem and experiment integration and test, and launch vehicle integration activities. The electrical GSE allows full up testing of the spacecraft and systems by providing needed signal and power conditioning. These activities include battery conditioning and RF verification testing.

4.3.1 Integration and Test (I&T) GSE

The spacecraft I&T GSE is used to determine whether the spacecraft and its subsystems are functioning properly during spacecraft integration and test, launch, and orbit operations. The I&T GSE handles real-time spacecraft communications, and provides test control and monitoring capabilities to validate the spacecraft performance and readiness for flight. The I&T GSE processes the incoming telemetry stream received from the RF GSE or the Pegasus simulator and distributes the data to the subsystem GSE's over a local area network in real-time. Spacecraft commands are formatted and transmitted to the spacecraft from the I&T GSE through the ASE's PSK modulator. The raw telemetry stream, after it has been convolutionally decoded, is recorded to a digital storage device. In addition, formatted telemetry data (i.e., CCSDS packets) are archived to a local hard disk as needed.

The shaded boxes in Figure 4-6 represent the I&T GSE used to support spacecraft integration and test activities at Goddard Space Flight Center as well as the prelaunch activities at VAFB. The I&T GSE includes a number of workstations, a front-end rack, and two laser jet printers.

Figure 4-6 I&T GSE Overview



4.3.1.1 Workstations

The Test Conductor Workstation (TCW) is the main workstation from which the test conductor controls all testing of the spacecraft. The remaining workstations are used to provide monitoring capability for each spacecraft subsystem. The workstations will be Sun Sparc computers and/or Intel based Pentium PC's and will be mounted in a standard 19 inch rack. Some of the workstations will have external hard drives and tape storage devices connected to them. The workstations will be powered by 1.3 KVA uninterruptable power supplies.

4.3.1.2 Front-end Rack

The front-end rack provides the telemetry and command interface to the spacecraft indirectly through the Airborne Support Equipment (ASE) and the RF Ground Support Equipment (GSE).

The front-end rack equipment includes the following:

- Digital Tape Recorder
- Telemetry & Command Interface Box
- Bit Synchronizer
- Front-end
- Uninterruptable Power Supply

4.3.1.2.1 Digital Tape Recorder

The digital tape recorder is used to record the convolutionally decoded telemetry stream output from the bit synchronizer. The recorder uses VHS tape cartridges that can each hold up to 10 gigabytes of data.

4.3.1.2.2 Telemetry and Command Interface Box (T&C Box)

The T&C Interface Box provides line drivers and conversions between RS-422 and TTL formats. Most external interfaces to the I&T GSE are through this box.

4.3.1.2.3 Bit Synchronizer

The bit synchronizer is used to convert the RF telemetry signal into a serial bitstream and clock. In addition, the bit synchronizer performs convolutional decoding.

4.3.1.2.4 Front-end

The front-end is a Intel-based PCI PC which performs frame synchronization with CRC, provides a NASA-36 timing signal interface, outputs command data at the required 2 kbps rate, and performs barker code time capture.

4.3.1.2.5 Uninterruptable Power Supply

The 3.1 KVA uninterruptable power supply provides power to the all of the equipment in the front-end rack.

4.3.1.3 Laser Jet Printers

There are two laser jet printers. One is dedicated for use by the Test Conductor and the other is shared between the remaining workstation users. The printers are mainly used to provide telemetry page display snapshots and listings of test procedures.

4.3.2 RF Ground Support Equipment

RF test equipment (RF test rack) is provided to support I&T. The equipment allows for end-to-end testing of the transponder and antennas.

4.3.2.1 RF Test Rack

The RF test rack (see Figure 4-7) is part of the electrical GSE. The RF Test Rack is used to test operating characteristics of the WIRE communications subsystem, or to provide link simulations for analysis of various operating conditions. In addition, a system self-check capability provides for rapid failure isolation. The RF test rack is used for uplink and downlink command signals. When operating in the downlink loop, carriers from the transponder transmitter are phase-locked by the test rack receiver and telemetry is demodulated from the carrier, filtered and displayed on a direct readout device.

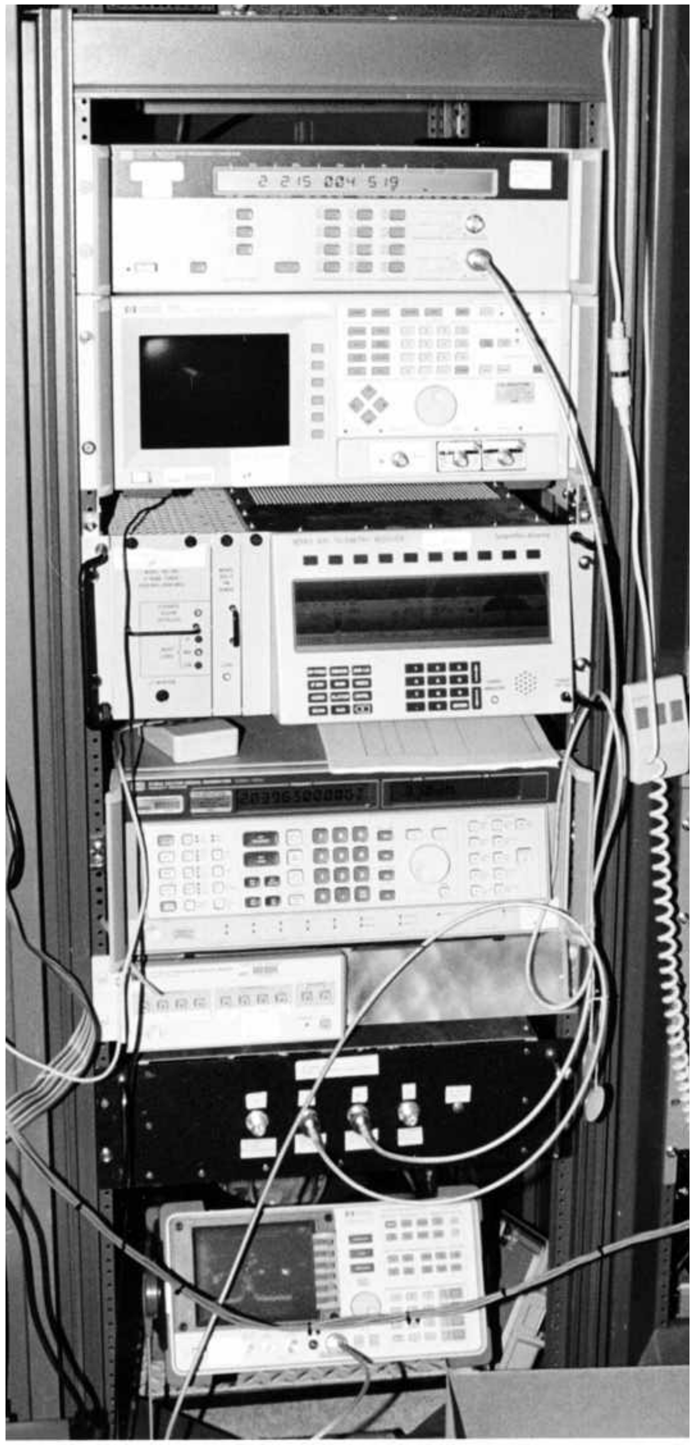
The RF test rack is enclosed in a 24 inches wide, 30 inches deep, and approximately 60 inches high equipment panel. The cabinet is mounted on four recessed casters. AC power is connected to the rack AC power convenience strip through a polarized connector (J1) at the lower back of the cabinet. The power required for the rack is 115 VAC, 15 amps, and single-phase power at 60 Hz. The major assemblies of the test rack are non-tilt, slide-mounted drawers. Table 4-2 list the major functional characteristics of the RF test rack.

The main components of the RF test rack are the test transmitter, the test receiver, spectrum analyzer, and frequency counter.

The test transmitter generates an uplink carrier in the band from 2025 MHz to 2120 MHz. The test transmitter is an HP 8780 Vector Signal Generator with a maximum output level of +11 dBm. The test transmitter can be phase modulated by three different sources, individually or simultaneously. The RF output level is controlled by a precision variable S-band attenuator.

The RF GSE has the capability to radiate open loop in the Astrotech (PDF). However, the levels are on the order of -133 dBm or $5x10^{-14}$ mW and are therefore not considered hazardous.

Figure 4-7 RF Test Rack



Frequency Counter

Signal Analyzer

Telemetry Receiver

Signal Generator

Attenuator Driver

RF Interface Box

Portable Spectrum Analyzer

Table 4-2 RF Test Rack Electrical Characteristics

DESCRIPTION	CHARACTERISTIC
Transmitter	
Transmitter Maximum Output Level	+9 dbm ± 2 dbm
Sweep Rate at S-Band	10 to 35 kHz/sec at S-band
Modulation Frequency Response (P.M.)	10 Hz to 2.2 Mhz min. (-1 dB points)
Sweep Range	± 150 kHz minimum
Transmitter Simulator	
Residual Group Delay	less than 20 nanoseconds
Four internal oscillators	
Receiver	
Phase Lock Loop BW	2 BL of 20Hz, 200Hz, or 2000 Hz (strong signal BW). Auto acquisition in 2000 Hz BW.
Phase Stability	5 degrees rms maximum in a 20 Hz BL loop BW
Baseband Signal Output	55 mv/radian with a 4.2 dB carrier suppression
Message BW	High end equal to or greater than 2.2 MHz Low end set by loop BW

Most WIRE testing occurs closed loop. There is no plan to conduct open loop testing. The RF hat may be used in the Astrotech PPF. Any open loop testing without the RF hat would be performed while the spacecraft is outside the fairing. The fairing is not RF transparent. This activity will be coordinated with the appropriate parties.

The test receiver will receive an S-band signal at any point in the downlink band 2200 to 2300 MHz. The test receiver is a Scientific Atlanta 930B unit. The receiver demodulates the PM signal and outputs at baseband to other equipment for further processing.

The equipment racks are never sited in vicinity of the launch vehicle or other critical hardware or emergency access/egress paths and would pose no hazard during a seismic event.

4.3.3 Power Generation GSE

The power system GSE test the power system, conditions the battery, and supplies power to the spacecraft during integration and test. Power is supplied by the solar array simulator (external power) and the I&T battery or the airborne support equipment rack. The battery is conditioned using the battery conditioning GSE and the air conditioner.

Anytime prior to connecting the battery to the Power System Electronics (PSE) main bus, the bus is +31 ±0.5 volts. This is accomplished through a ground power supply providing power through the imbilical interface. In no event is the battery connected to a dead main bus. The battery terminal voltage must be within ±0.1 volts of the main bus voltage prior to its connection to the main bus. No single power generation GSE is capable of damaging the spacecraft. GSE interfaces with battery are provided with proper fusing in the power leads and the proper resistor sizing in the data leads to prevent damage to the battery.

WIRE uses a new partial array shunt solar simulator. Power Generation Ground Support Equipment includes: the Power Console (3 feet x 3 feet x 4 feet Rack), the Solar Array Simulator (two 3 feet x 3 feet x 5 feet Racks), the battery conditioning GSE, and the Battery Air Conditioner.

4.3.4 Battery GSE

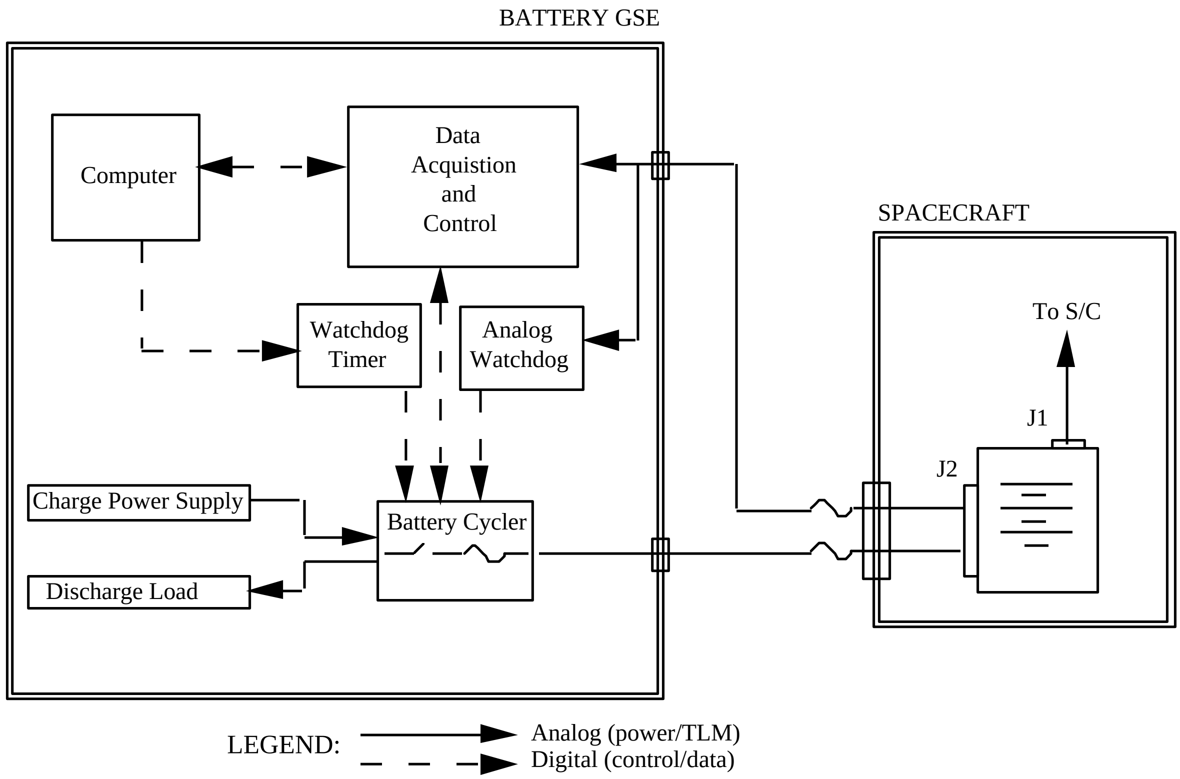
The WIRE battery GSE consists of the battery EGSE and the battery air conditioner. If the flight spare battery is transported to the launch site, the battery trickle charge system and the battery-cooling cart will be needed in addition to the first two units. The data on these items will be supplied at the time it is decided to bring the flight spare battery to WR.

4.3.4.1 Battery EGSE

The battery EGSE consists of one rack with printer that contains the data acquisition and control equipment used for the testing, reconditioning, and monitoring of one battery on and off the spacecraft. This rack also contains an UPS, containing sealed gel lead-acid batteries. The 750 pound wheeled rack is 81.3 inches high, 24 inches wide, and 32.6 inches deep. The power required for operation of the rack is 115 VAC, 30 amps, and single-phase power at 60 Hertz. This equipment will be used in Building 836 (for initial reconditioning of the flight battery and for spacecraft integration and test), in the Astrotech PPF for trickle charge of the flight battery during non-hazardous operations, and at the hot pad (for trickle charging, monitoring and possible reconditioning of the flight battery). Figure 4-8 shows a block diagram of the battery EGSE interfaced to WIRE.

The battery EGSE is two-fault tolerant against overcharging or discharging the battery. The computer responsible for the data acquisition and control checks at least twice a minute to see that operations are within warning/safety limits and terminates charge or discharge if limits are exceeded. There is an independent analog watchdog that checks battery voltage and current. If the voltage or current are out of limits, it will terminate charge or discharge operations. There is an independent watchdog timer that monitors the computer to ensure it is scanning data, if it is not, the watchdog timer will open the battery cycler to terminate charge or discharge operations.

Figure 4-8 Battery GSE Block Diagram



Additionally there is a 50-ampere charge/discharge fuse in the battery cycle that will isolate GSE faults. All power and telemetry cables are fused at the spacecraft end prior to entering the flight hardware. There is an emergency shutdown switch on the battery EGSE that removes AC power from the rack and disconnects the batteries from power. The battery EGSE is checked with a test battery before being mated to the spacecraft.

The battery air conditioner is an air cooling unit designed to supply clean (Class 1,000) ducted air up to 150 feet through ductwork, to cool the spacecraft battery. The 750-pound unit is capable of ducting both the supply/return air and the condenser cooling air. If required, the unit is weatherproofed to operate outdoors. The wheeled unit is 72 inches high, 34 inches wide, and 60 inches deep. The power required for operation of the unit is 208 VAC, 60 amps, and three-phase power at 60 hertz. The cooling capacity is 40,000 BTU/hr and it uses HCFC-22 type refrigerant. This unit will be used in the Astrotech PPF for cooling during initial reconditioning of the flight battery, during spacecraft integration and test activity, during reconditioning, and trickle charging of the flight battery on the spacecraft. The air conditioner will also be used at the hot pad during trickle charging and possible reconditioning of the flight battery on the spacecraft. The battery air conditioner is shown in Figure 4-9.

Figure 4-9 Battery Air Conditioner

4.3.4.2 Battery Trickle Charge System

The battery trickle charge system consists of one rack containing data acquisition and control equipment used for storage, trickle charging of the Flight Spare battery, and a stand-alone printer. It also contains UPS, containing sealed gel lead-acid batteries. The 500 pound rack is 64 inches high, 24 inches wide, and 25 inches deep. The power required for operation of the unit is 115 VAC, 15 amps, and one phase power at 60 hertz.

The printer is 33 inches high, 24 inches wide, and 29 inches deep. It weighs 80 pounds and plugs into the rack. This rack will be used in Astrotech after the flight spare battery is initially reconditioned. The flight spare battery will be maintained on the battery-cooling cart at 6°C on continuous trickle charge until launch.

4.3.4.3 Battery Cooling Cart

The battery-cooling cart is a single assembled unit consisting of a chiller and cold plate, through which chilled antifreeze circulates. The cold plate can accommodate two batteries. A clear, rigid cover is placed over the cold plate and batteries. The cooling cart is purged with dry nitrogen or dry air. The 1000-pound cart is 59 inches high, 25 inches wide, and 49 inches deep. The power required for operation of the unit is 115 VAC, 20 amps, and single-phase power at 60 hertz. The cooling capacity is 8,000 BTU/hr and it uses 6 pounds of R-12 type refrigerant. This unit will be used in Astrotech for initial reconditioning of the Flight and Flight Spare Batteries, and for maintaining the Flight Spare battery at 6°C while on continuous trickle charge until launch. A continuous purge will be required to prevent condensation on the batteries.

4.3.5 Attitude Control System (ACS) GSE

The ACS GSE consists of:

- ACE Box GSE rack,
- Closed Loop Dynamic Simulator,
- Magnetic Calibration GSE,
- Reaction Wheel Simulator,
- and assorted BTE.

During ACS I&T to the Spacecraft, the ACE Box GSE is interfaced to the I&T GSE via RS-232 link, and may be commanded by the I&T GSE via STOL procedures.

The ACS spacecraft GSE is the same as Submillimeter Wave Satellite Astronomy (SWAS) ACS GSE to handle WIRE.

4.3.5.1 Dynamic Simulator

The ACE Dynamic Simulator has the following characteristics:

- Same as SWAS/TRACE design for WIRE dynamics
- Software only version simulates ACE at 1553 I/F
- Hardware version connects through spacecraft harness and test connectors to simulate sensors and actuators to ACE box
- Real time simulation for comparison to analysis simulation

4.3.5.2 Momentum Wheels

The WIRE momentum wheels will be activated under ground processing as part of the overall spacecraft functional testing and checkout. There are no unique momentum wheel tests planned at the launch site. The maximum commanded speed of the momentum wheels is 3600rpm. The speed is limited by the software limits imposed by the ACS and ultimately by the maximum possible spacecraft voltage. The momentum wheel Engineering Test Unit (ETU) was tested with maximum possible spacecraft voltage applied (40 volts) resulting in a speed of 5000 rpm, which correlates to a safety factor of greater than three for fatigue. (At 6000 rpm, the safety factor of the momentum wheel is three for fatigue failure.) A NDI test was performed on December 16, 1993. The momentum wheels pose no personnel hazards at the launch site.

4.4 ORDNANCE SUBSYSTEMS

All functions concerning the ordnance subsystems are described in section 3.1.5.

4.5 NON-IONIZING RADIATION SOURCE DATA

There are no non-ionizing radiation hazards associated with the spacecraft GSE.

4.6 IONIZING RADIATION SOURCE DATA

There are no ionizing radiation sources associated with the GSE.

4.7 ACOUSTIC HAZARDS

There are no high noise sources associated with the GSE.

4.8 HAZARDOUS MATERIALS

Cleaning materials and other processing materials will be used during ground processing. Table 4-3 list the hazardous chemicals. Appendix B provides the MSDS's for these chemicals.

Table 4-3 Hazardous Chemicals

Chemical Name	Quantity	Use	Hazard
Acetone	1 quart	Cleaning fluid	Flammable, eye irritation, inhalation
Apiezon L Vacuum Grease	4 tubes	Lubricant instrument GSE	
Isopropol alcohol	1 quart	Cleaning fluid	Flammable, eye irritation, inhalation
Liquid nitrogen	Unlimited	Purge	Asphyxiant
Molecular sieve	4 quarts	Lubricant instrument GSE	
Vacuum pump oil	4 quarts	Lubricant instrument GSE	

4.9 OPERATIONS SAFETY CONSOLE

Operations safety console is located in the L-1011. Safety data is presented in Orbital’s Accident Risk Assessment Report.

4.10 VEHICLE DATA

Safety data is presented in Orbital’s Accident Risk Assessment Report.

4.11 COMPUTING SYSTEMS DATA

Section 3.2.11 references all critical commands.

4.12 W.R. SEISMIC DATA REQUIREMENT

Seismic restraining mechanisms will be in place for all large equipment that will stay in a location for longer than 24 hours. To minimize hazards due to seismic events, the racks contain one of three possible controls: restraining hooks, anti-tipping plates, or low center of gravity. The main concern is that these racks may tip over and cause injury. There are three types of controls to prevent this from occurring: restraining eye-hooks are attached to the top of racks where they can be lashed to walls or other racks in a stable configuration; anti-tipping plates protrude out the bottom of the rack preventing it from tipping over; and some equipment has a low center of gravity to physically prevent the rack from tipping. Table 4-4 shows the locations and seismic characteristics of the large GSE associated with WIRE spacecraft.

4.13 INSTRUMENT GSE

The WIRE instrument GSE consist of two types, the ground data checkout (GDC) equipment, and the cryogenic ground support equipment (CGSE). The GDC will be used in NASA's Astrotech Payload Processing Facility (PPF) at Vandenberg Airforce Base (VAFB) prior to hydrogen fill. CGSE will also be used at the hot pad site as well as the PPF.

4.13.1 Cryogenic GSE

The CGSE was developed from the many years of experience in design, building, and testing for LMMS research and development cryostat programs. The modules, connecting cables and plumbing provide the ability to monitor the cryostat status, create and maintain a vacuum in the vacuum shell, fill and empty the cryostat, cool the cryostat to operational temperatures, and maintain the cryogen system in a ground hold mode.

The CGSE consists of all equipment necessary to perform the fill and recooling operations and to maintain the cryostat in the ground hold mode. Table 4-5 describes the functions, operational locations, electrical characteristics, explosion protection, and protective circuitry of the cryogenic

GSE. The following paragraphs highlight the design and safety features for each of the CGSE modules.

4.13.1.1 Temperature Monitor and Alarm

The temperature monitor and alarm (TM&A) is designed to monitor the temperatures of each of the H_2 tanks when or if the CGSE cannot perform that function. Because the TM&A uses the same tank temperature sensors as the CGSE, the two cannot be run concurrently. Use of the TM&A depends on what operation is occurring. For example, if H_2 (or some other safety hazard) is detected in the PPF, the CGSE will not continue operating and will shut down; at that point the TM&A will begin monitoring temperatures. The TM&A will also be used during the transportation of the spacecraft/Pegasus on the Assembly and Integration Trailer (AIT) or during any operation when cabling cannot be connected. Monitoring of the tank temperatures is

Table 4-4 Locations And Seismic Characteristics For WIRE Spacecraft GSE

GSE	Location		Dimensions				Seismic Protection			
	PPF	Hot Pad	Height (inches)	Width (inches)	Depth (inches)	Weight (lbs)	Anti-tip Plates	Low CG	Restraint hooks	Tie downs
ASE			60	36	36					
Front End			60	36	36					
TCW			60	36	36					
ACS GSE			60	36	36					
Battery GSE			81	24	32					
Battery Trickle Charge System			64	24	25					
Air Conditioner			72	34	60					
Solar Array Simulator			60	36	36					
RF Rack			60	24	30					
UPS 1										
UPS 2										
Pegasus Simulator										

Table 4-5 Cryogenic GSE

GSE Item	Function	Operations		Electrical Characteristics			Explosion Protection		Protective Circuitry		
		Used during H_2 loading	Used after H_2 loading	Amps	VAC	Battery	Explosion proofed	Purged	PPF Power	Internal cut-off	Power distribution (single-source shutdown) unit
Cooling Cart	Supplies warm water to cyrogenic heat exchangers	X	X	30	208						X
WIRE electrical module	Provides electrical power to all cryo GSE	X	X	30	208					X	X
WIRE gas module	Evaluates and backfills cryogen tanks	X	X	30	208					(1)	
WIRE vacuum module	Pumps on insulation space around H_2 tanks	X	X	30	208					(1)	
Plotter	Makes real-time temperature plots	X	X	0.7	120						X
Plotter computer	Controls plotter	X	X	2.9	120						X
Plotter monitor	Displays plots	X	X	0.8	120						X
H_2 leak detectors (portable)	Hand-held H_2 detector	X	X	0.1	9DC	X	X				
He leak detector	Leak check sensor vacuum space and transfer lines	(2)	X	30	120						X
LHe platform scales (3)	Measures amount of He left in tanks	X	X	0.1	110						X
Power distribution unit	Distribution power for all GSE	X	X	?	208				(3)		

GSE Item	Function	Operations		Electrical Characteristics			Explosion Protection		Protective Circuitry		
		Used during H_2 loading	Used after H_2 loading	Amps	VAC	Battery	Explosion proofed	Purged	PPF Power	Internal cut-off	Power distribution (single-source shutdown) unit
Vapor-cooled shield heater power supplies (located in DAS rack in control room)	Supplies power to heaters on cryo system vapor-cooled shields	X		3	120						X
TM&A	Monitors temperature of WIRE H_2	X	X	0.1	12DC	X	X				
CLAES electrical module	Provides electrical power to all cryo GSE	X	X	30	208					X	X
Met-1 particle counter (two)	Monitors contamination particulate levels		X	0.25	5DC	X					
CLAES gas module	Evaluates and backfills cryogen tanks	X	X	30	208					(4)	
Pressure monitoring rack (also contains RGA computer and CQCM)	Monitors pressure and residual gas output from WIRE and CLAES vacuum and gas modules	X	X	12	117						X
Transfer line heaters (2 boxes)	Control temp. in transfer line joints	X		~9 (per box)							X

Notes:
(1) Powered by WIRE electrical module
(2) Contingency use only
(3)Facility shunt trip switch for Crouse Hinds
(4)Powered by CLAES electrical module

therefore available at all times either by the CGSE or the TM&A. The TM&A is housed in a sealed metal case and is self-powered by an internal battery, making it portable.

4.13.1.2 Vacuum Module

The vacuum module (VM) is designed to pump the insulation space around the cryogen tanks to a hard vacuum. Figure 4-10 is a schematic of the vacuum module. Figure 4-11 shows the vacuum module. A rotary-vane roughing pump and a turbomolecular pump are used to obtain pressures to less than 1×10^{-6} torr. The equipment is mounted in a forced-air-ventilated cabinet mounted on a pontoon base with four casters (two fixed and two swivel) and a foot-operated floor brake. The base contains pockets for forklift pickup. Four safety swivels are mounted at the top four corners of the module for sling pickup.

These swivels may also be used for tie down and lashing during shipment. A stress analysis of the VM structure shows positive margins on factors of safety of 3.0 to yield and 5.0 to ultimate. The VM was proof-load tested to two times its weight to verify structural integrity for lifting.

Facility air or N_2 from a pressurized gas cylinder is routed to operate electro-pneumatic valves in the VM. Two 75 psi relief valves, one in the GM and one in the VM, prevent overpressurization of the system.

A 4-inch diameter, 15-foot stainless-braided vacuum line is attached at the back of the VM and routed to the cryostat to evacuate the vacuum space. The following safety features have been designed into the VM for use with H_2:

- A main manifold vacuum valve, backed by an electro-pneumatic valve, closes automatically (fail-safe) if power is lost or if the vacuum pressure exceeds preset values. This closure protects the vacuum space from contamination and prevents potential damage to the turbomolecular pump. Once power is regained, reopening of both valves requires operator interaction to either manually open the valves or re-initiate a “ready” switch.
- A H_2 detector is located on the top inside panel of this module. If either detector senses H_2 at 0.01% concentration, i.e., 0.25% of its lower flammability limit, audio and visual alarms will be activated at the EM. If the H_2 concentration increases to more than 1% concentration, i.e., 25% of its lower flammability limit, a second audio and visual alarm will be activated at the EM. Additionally, power to the VM will be shut off with the resultant closure of the electro-pneumatic and electro-magnetic operated valves and shutdown of all other electrical equipment except the rechargeable battery-powered alarm system.
- The rupture disk in the VM vent line vents the cooler to the facility vent, bypassing all pumps, if the pressure in the vacuum space exceeds eight psig.
- The initial pumpdown metering valve, (a needle valve) is preset to prevent excessive pumpdown and vacuum relief rates (including He backfill) which could damage the multi-layer insulation or the vapor cooled shields in the cooler vacuum space.
- Access ports permit thorough leak testing prior to use.

Figure 4-10 WIRE Vacuum Module Schematic

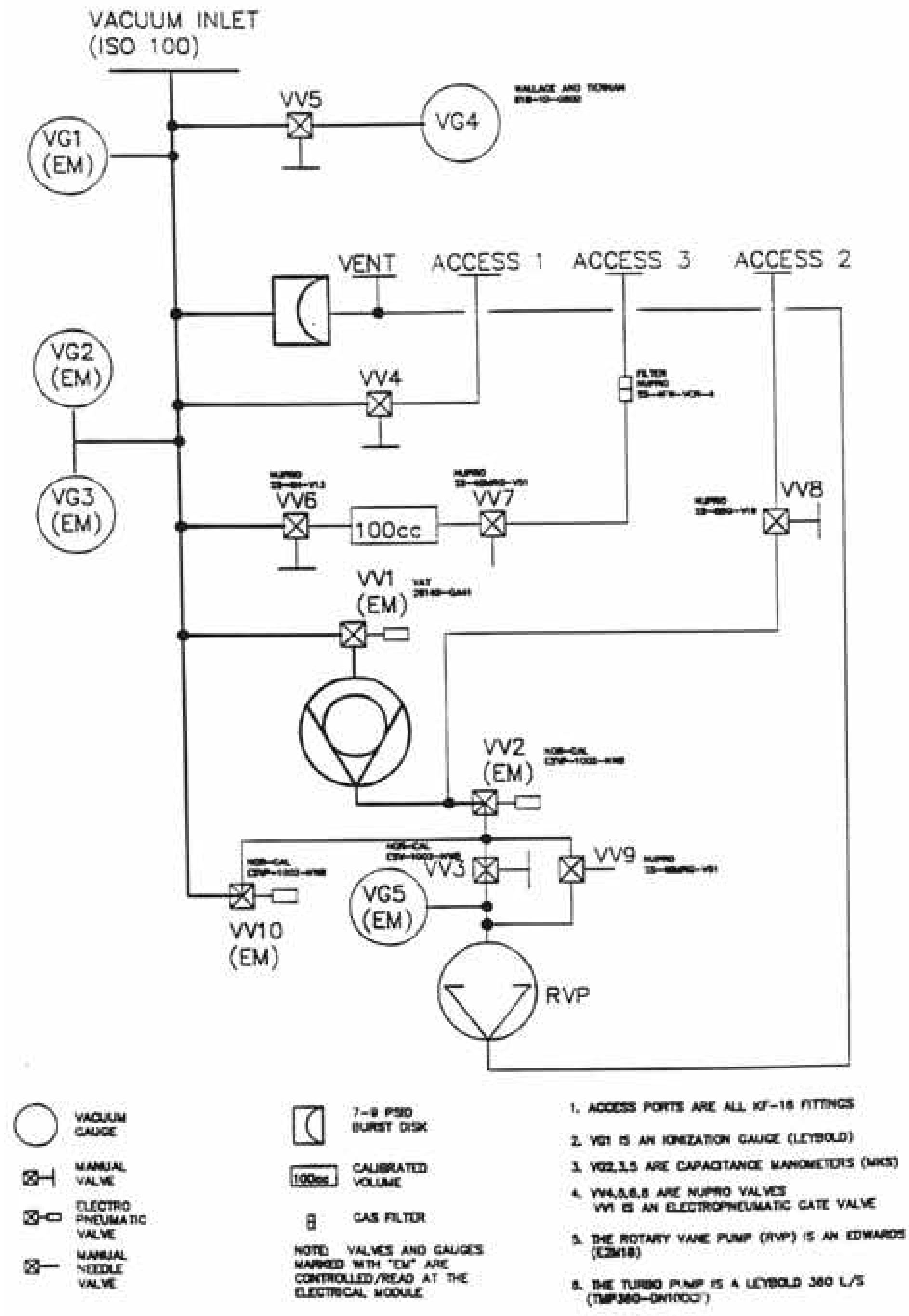
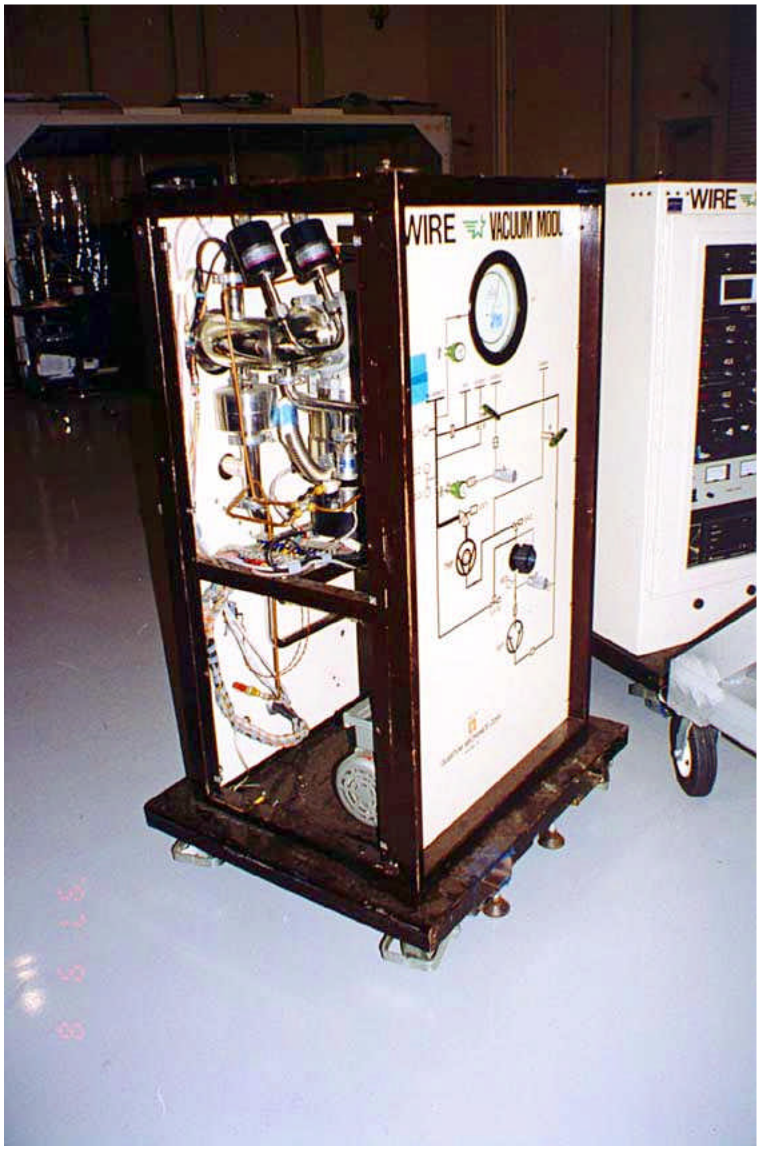


Figure 4-11 Vacuum Module



- The roughing pump is powered by an explosion-proof motor. An automatic thermal-overload reset system activates automatic shutdown of the pump motor if the pump motor temperature exceeds a specified limit. After cooldown to operating temperatures, the pump motor restarts automatically.
- The VM has a terminal for connecting to facility ground.

Facility I/F requirements for connecting to facility ground are as follows:

Pneumatic: Facility air at 70 to 100 psig. Optionally, a pressurized gas cylinder of N_2 may be used.

Vent: Facility vent.

4.13.1.3 Gas Module

The H_2 filling processing will require the use of two gas modules (GM). These two GM (one a WIRE, the other a CLAES) are of different vintage but are functionally identical. The GM is designed to evacuate and backfill the cryogen tanks. The module can also be used to pump the H_2 within the tanks and measure the tank heat rates. A schematic of the GM is shown in Figure 4-12. The GM is shown in Figure 4-13.

The equipment is mounted in a forced-air-ventilated cabinet mounted on a pontoon base with four casters (two fixed and two swivel) and a foot-operated floor brake. The base contains pockets for fork-lift pickup. Four safety swivels are mounted at the top four corners of the module for sling pickup. These swivels may also be used for tie down and lashing during shipment. The VM structural stress analysis showing positive margins on factors of safety of 3.0 to yield and 5.0 to ultimate is considered applicable to the GM by the similarity of construction. The GM was proof-load tested to two times its weight to verify structural integrity for lifting.

Facility air or N_2 from a pressurized gas cylinder is routed to operate electro-pneumatic valves in the GM. Two 75 psi relief valves on the GM and one in the VM prevent overpressurization of the system.

A 2-inch diameter vacuum line is attached at the back of the GM and routed to the cryostat to evacuate the H_2 tank.

The following safety features have been designed into the GM for use with H_2:

- Under normal operating conditions, the GM plumbing and components are under vacuum. The cooler cryogen tank could cause a pressure rise in the GM under some failure scenarios. The GM plumbing and components are designed and proof tested to withstand an operating pressure of 8 psid. To prevent the GM for experiencing pressures above this, the cooler gas inlet port and cryogen inlet port are fitted with normally-open fast-acting valves which are closed when a pressure of 5 psig is sensed in those lines. An operator will be required to manually reopen the valves. On the GM side of the fast-acting valves, a burst disk is set to

Figure 4-12 WIRE Gas Module Schematic

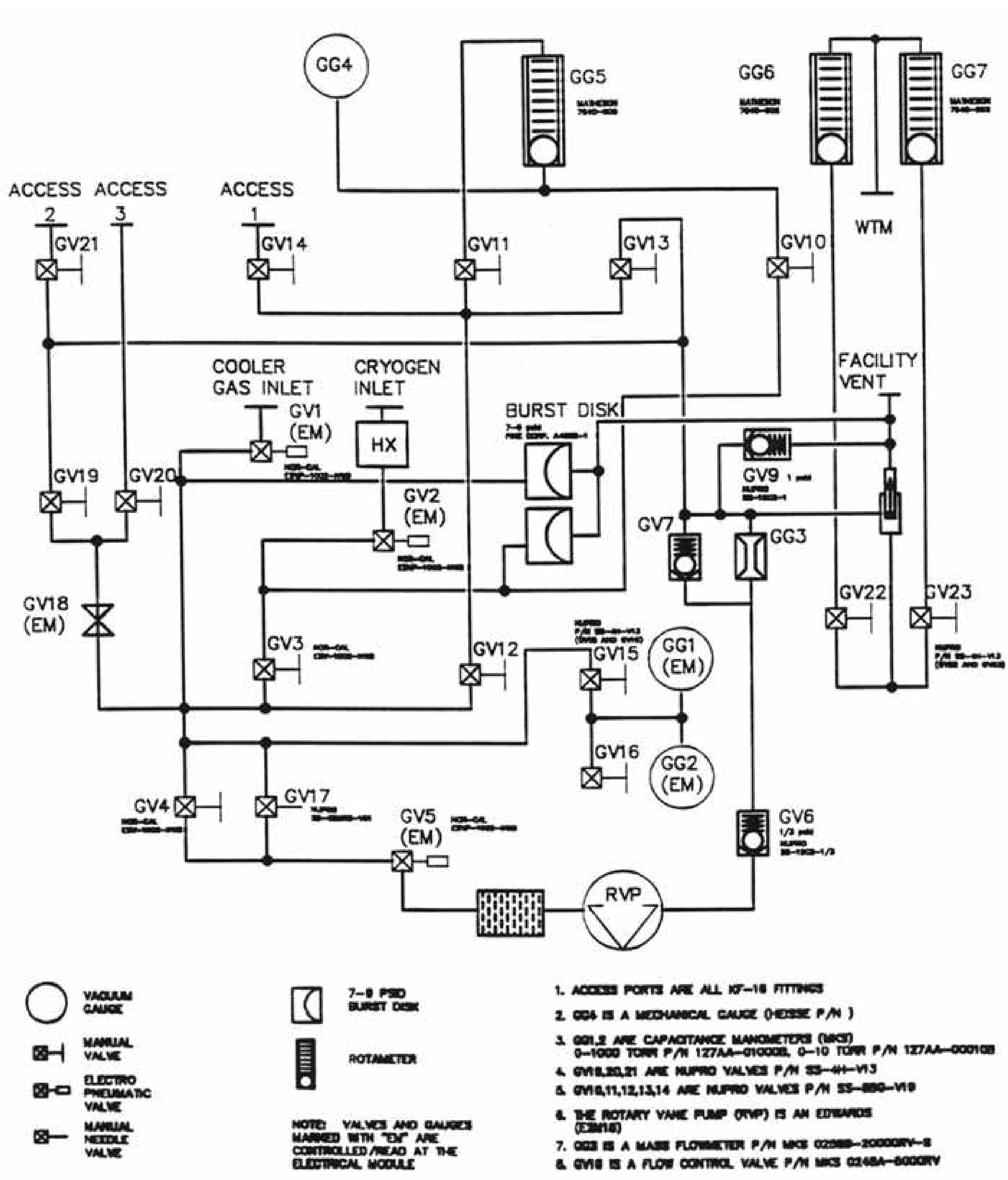
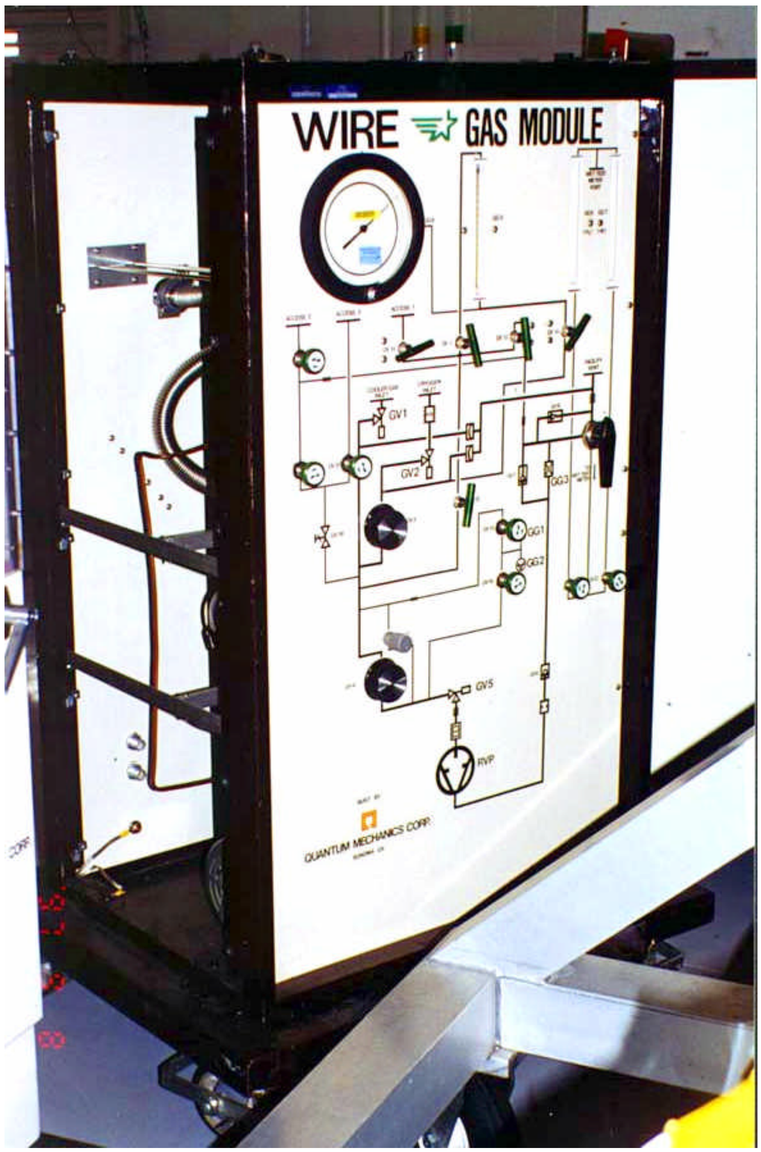


Figure 4-13 Gas Module



operate at 8 psid, which then dumps into the emergency H_2 vent line. Should the cooler tank rupture its own burst disks and dump into the facility vent, the pressure will drop to less than 2-3 psid at the point where the GM connects to the facility vent and thus does not present a hazard to the GM.

- A filter located on the exhaust side of the roughing pump traps oil vapor, preventing oil contamination.
- A water trap placed in front of the water saturator prevents possible backflow of water into the roughing pump.
- A relief valve on the vent side of the coolant flow loop prevents excess pressure buildup during coolant flow.
- The roughing pump is powered by an explosion-proof motor. An automatic thermal-overload reset system activates automatic shutdown of the pump motor if the motor temperature exceeds a specified limit. The pump motor restarts automatically, after cool down to operating temperatures.
- A H_2 detector is located on the inside top panel of this module. If the detector senses H_2 at 0.01 percent concentration (i.e. 0.25 percent of its lower flammability limit), audio and visual alarms will be activated at the EM. If the H_2 concentration increases to more than 1 percent concentration (i.e. 25 percent of its lower flammability limit), a second audio and visual alarm will be activated at the EM. Additionally, power to the GM will be shutoff with the resultant closure of all other electrical equipment except the rechargeable battery-powered alarm system.
- The GM has a grounding lug for connection to facility ground.

Facility I/F requirements for the GM are as follows:

Pneumatic: Facility air at 70 to 100 psig. Optionally, a pressurized gas cylinder of N_2 may be used.

Vent: Facility vent.

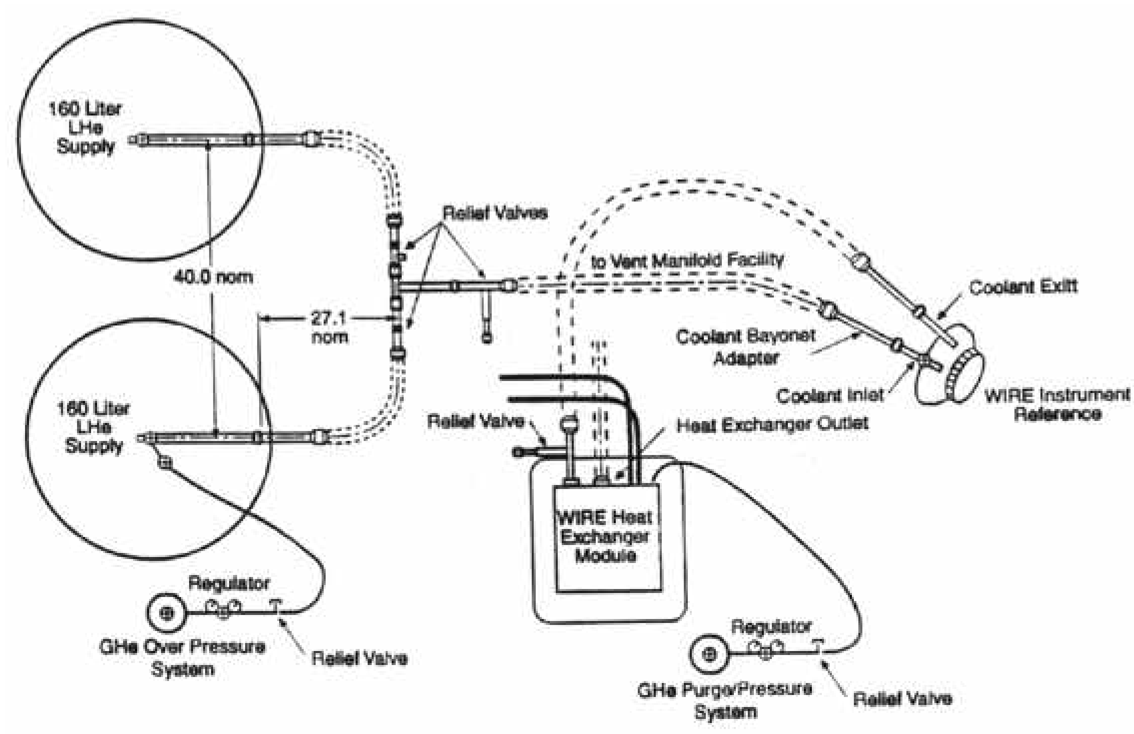
4.13.1.4 Liquid Helium Coolant Subsystem

Liquid helium (LHe) will be used to cool the instrument and freeze or recool the H_2 cryogens. The LHe subsystem consists of:

- Two LHe supply dewars,
- A low-pressure regulator system for use in maintaining the LHe supply dewar delivery pressure between 3 and 7 psig,
- Cryogenic transfer plumbing required to connect the LHe supply dewars to the cryostat coolant bayonet inlet and exit,
- A heat exchanger for warming the coolant cryogen, and a facility vent line connection.

The LHe coolant subsystem is shown in Figure 4-14.

Figure 4-14 LHe Coolant Subsystem



During cooling operations, the two LHe dewars will be located immediately adjacent to each other. Only one dewar is to be used at a time. After the cryogen is depleted in the first supply dewar, the second is brought on line. The empty dewar is replaced with a full dewar. Platform scales are placed under each LHe dewar and are used to estimate the amount of LHe remaining so that the LHe supply dewars can be changed out in a timely fashion.

At the hot pad following fairing installation, the cooling operations will be performed through two access doors in the fairing. One door will allow access to the high-vacuum connection, the other door to the coolant loop and ground monitor connectors.

The cryogen transfer lines are vacuum-jacketed, with stainless flexhose construction. Each line is equipped with a 20-25 psi relief valve. There is a pumpout port located on the vacuum jacket of each line to allow evacuation of the jacket. This operation is performed infrequently, but

whenever vacuum degradation in the jacket is evidenced by a layer of frost forming on the outside of the line.

Facility I/F requirements for the LHe coolant subsystem during the recooling operations are as follows:

Cryogen: Two 500-liter LHe supply dewars (Cryofab 500L or equivalent) for each recool operation. Additional resupply dewars will be required in a quantity determined by the specific test requirements.

Lifting: Lifting hardware (as necessary) to lift the LHe supply dewars into position. Each dewar weighs approximately 950 pounds empty and 1150 pounds full.

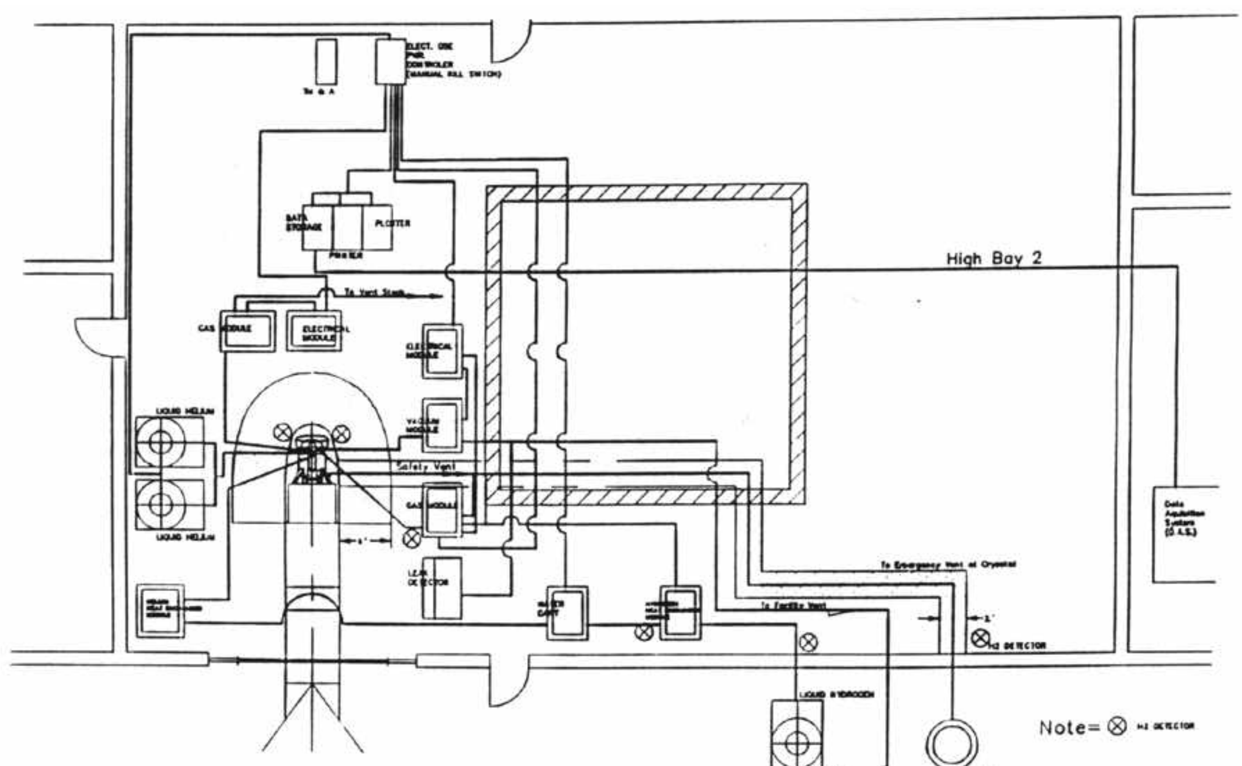
Gaseous He: Pressurized gaseous He cylinders (A-bottles) or a facility supply for pressurizing the LHe dewars (and all other recool uses) during each operation.

4.13.1.5 Hydrogen Filling Subsystem

Approximately 10 pounds of LH_2 will be loaded into the WIRE cryostat tanks. The liquid is supplied from a 1000-liter supply dewar that is located outside the PPF facility on a cement slab. The supply dewar is pressurized with a GHe source to 3 psig. The LH_2 is transferred though 50 feet of vacuum-jacketed line directly into the WIRE cryostat tanks. The exhaust from the tank is routed through a heat exchanger and into the facility H_2 gas vent stack. See Figure 4-15 for the layout of the H_2 fill subsystem.

4.13.1.6 Heat Exchanger System

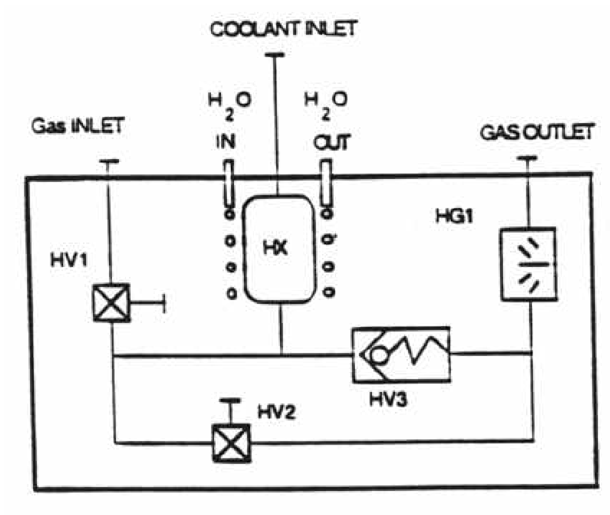
Figure 4-15 Liquid Hydrogen Fill Subsystem Layout



Liquid Hydrogen Fill Subsystem Layout

The heat exchanger module is used to warm the He exiting from the cryostat coolant system and can also be used to warm H_2 to a gas form during H_2 fills. Water required by the heat exchanger can be connected individually or in series, depending on the application.
Facility water with a flow rate of 2 gpm and pressure of 60 psig is required to operate the heat exchanger; a recirculating water cart can also be used. The system is shown in Figure 4-16. The HV3 relief valve is incorporated as a relief between valves HV1 and HV2 and the coolant inlet.

Figure 4-16 Heat Exchanger System



Because transfer lines that connect into the coolant inlet also contain relief valves, HV3 becomes a secondary relief for the connected system.

Cold He gas exiting from the cryostat coolant line at approximately 30 K enters the heat exchanger and is warmed to above 50° F. The warm He gas is then routed through a rotameter for flow measurement, and is directed to the facility vent for safe disposal outside the cryogen tank either in the form He or H_2.

4.13.1.7 Data Acquisition System

The data acquisition system (DAS) is a subsystem of the CGSE and consists of an automatic data acquisition and control unit, along with a voltmeter, extender, and a disk drive. In addition, there is a plotter, printer, terminal, and video display which are used during re-cool operations and need to be located near the WIRE instrument.

Facility I/F requirements for the DAS are as follows:

Table: A table, 30 x 60 x 28 inches high for holding a plotter, a printer, a terminal, and a video display. The table must be stationed within 5 feet of the DAS.

Power: (1) DAS - 110 VAC, 1-phase, 60 Hz, 20 A.
(2) Other equipment - 110 VAC, 1-phase, 60 Hz, 15 A.

4.13.1.8 Helium Leak Detector

A Blazer model HLT-1160 He leak detector is used, as necessary, for sensitive leak checking of the cryostat, all fluid interconnect lines, and the vacuum and GM plumbing prior to and after any cryogen servicing operation. It can be used to evacuate the cooling loop at the end of each recool operation. Along with this operation, all plumbing joints are leak checked. (Calibration intervals are verified procedurally.) The leak detector is housed in a cabinet on wheels.

Liquid nitrogen (LN_2) from a supply dewar is required to operate the leak detector. LN_2 is transferred from supply dewar, into a one-gallon dewar flask, and then poured from the flask into the leak detector reservoir.

Facility I/F requirements for the leak detector are as follows:

Power Input: One outlet providing 110 VAC, 1-phase, 60 Hz, 30 A.

Nitrogen: Two Liters of LN_2 every 5 to 8 hours during performance of leak checks.

Gaseous He: Gaseous He during performance of leak checks.

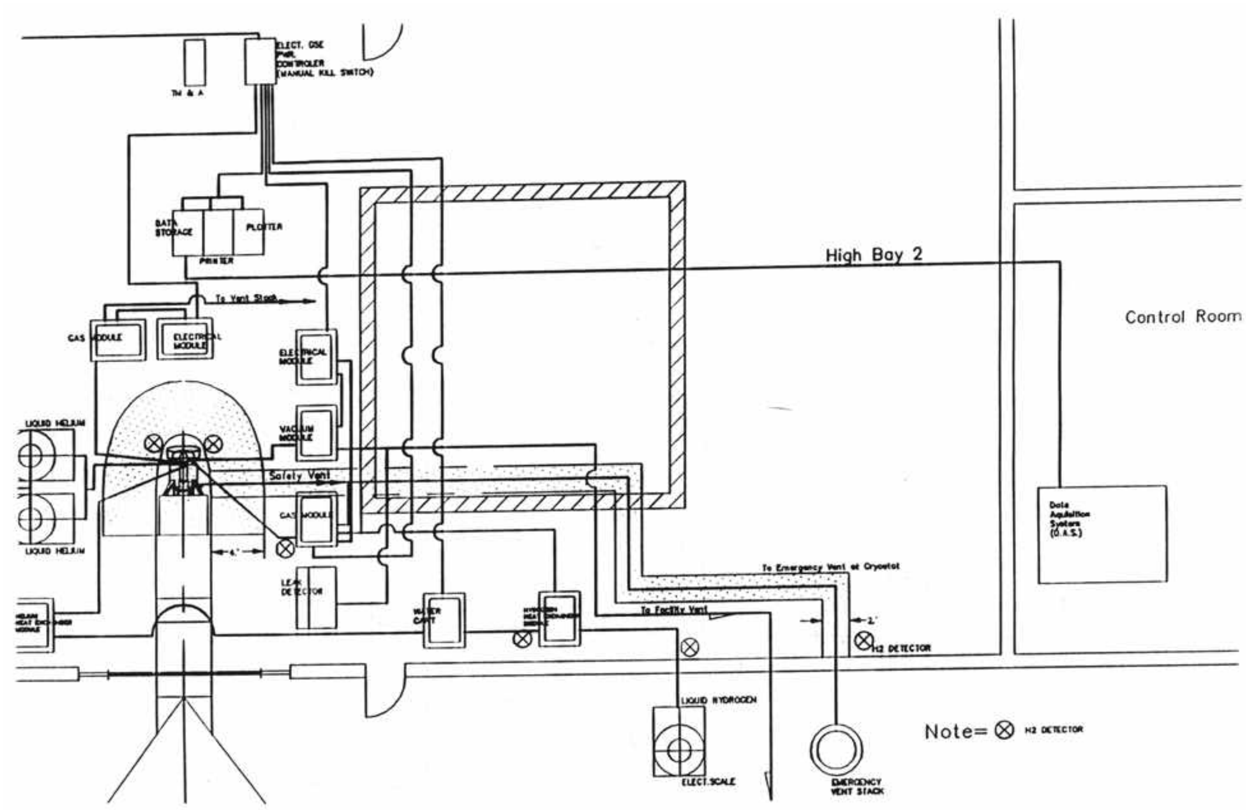
4.13.1.9 Local-Level Hydrogen Leak Detectors

General Monitors will provide a portable H_2 detection system to be used for local hydrogen detection around suspect joints while at the PPF. The H_2 leak detector's location is shown in Figure 4-17. This system is manually monitored from a location in the PPF control room. Six locations will be monitored at floor level around the CGSE. The sensors will be watched 24 hours a day from the control room during the hydrogen-fill operations, using an 8-channel relay unit that has a common digital display. Each CGSE local sensor will be over a joint, or group of joints, under an enclosed "hat" to concentrate any leaking H_2 gas. This serves to make the local detection more sensitive. The purpose for the local GSE sensors is to provide early detection of small leaks (see Section 6.2.4). The sensor model number is S104.

4.13.1.10 Portable Leak Detector

A Gastech, Type 100 Model, portable, hand-operated hydrogen detection unit will be used as an additional detection measure during the liquid-fill operations. Use of this device will be called out in the procedure following the start of hydrogen transfer into facility. Periodic measurements of all joints will be made manually during the fill operation by cryogenic operation personnel. This

Figure 4-17 Location of Local Hydrogen Detectors in PPF



device will also be used for investigation and verification should a small leak be detected by the remote monitors.

4.13.1.11 Oxygen Deficiency Monitor

A Matheson Gas Products, Model 8062-01 oxygen monitor will also be used during cryogenic operations to ensure that oxygen depletion is not a hazard for personnel. The monitor has a pulsating, audible alarm that automatically is triggered when the oxygen availability becomes less than 19.5 percent.

4.13.1.12 Operations

The procedures that will be used for cryogen operations are listed in Table 4-6.

4.13.2 Cryogenic EGSE

4.13.2.1 Ground Data Checkout Equipment

The WIRE GDC equipment, which is not part of the flight hardware, is designed to support the engineering checkout, calibration, and integration of the WIRE instrument on the ground. Prior

Table 4-6 Cryo Procedures

Document Number	Document Title	Hazardous
WIRE-01	Goddard cryogenic operation	Yes
WIRE-02	PPF cryogen operations	Yes
WIRE-03	Hot pad cryogenic operations	Yes
WIRE-04	Contingency off-loading hydrogen	Yes
WIRE-05	Contingency pumping solid hydrogen	Yes
WIRE-06	Contingency safety vent/burst-disk rupture	Yes
WIRE-07	Contingency plug removal	Yes
WIRE-08	Fill of hydrogen supply dewar	Yes
WIRE-09	Off-loading hydrogen supply dewar	Yes
WIRE-10	TM&A operations procedures	No
WIRE-11	WIRE sunshade installation	No
WIRE-12	Ordnance checkout/installation	Yes

to the instrument's integration with the spacecraft bus, the GDC will serve as the command and data acquisition system used to send commands to the instrument, monitor housekeeping, and capture, store, and display pixel data. The GDC major components are a computer, monitor, printer, and data interface box. The data interface box and power supply will be used during testing and calibration at SDL/USU and during checkout of the instrument at GSFC prior to spacecraft integration.

Once the WIRE instrument is integrated to the spacecraft bus, the GDC will no longer send commands to the instrument; rather the I&T GSE will take over that task. The GDC however, will still be needed to receive instrument data from both the spacecraft and the I&T GSE during any functional testing. Data acquisition at the time will be via the network.

All GDC items, except for the data interface box, are commercially available. The data interface will consist of a printed circuit board and a five volt power supply that is fully enclosed in a metal box.

The recognizable hazards are those of personnel exposure to high voltages or those that may result when heavy objects fall from work tables or when equipment racks fall over as a result of seismic activity. The laser printers and CRT monitors will also rest on the work tables and could also cause injury should they fall. The CRT monitors operate with a second anode voltage of 21,000 volts. The GDC computer operates with 120 volts ac input. However, all conductors and items at high potential voltages are insulated and/or enclosed within the equipment cases. The monitor CRT is a large-volume, glass vacuum vessel, as is the NTSC video monitor; it has been designed to minimize the possibility of injury to nearby personnel in case the vacuum integrity of the device is compromised. All instrument chassis and cabinets are grounded when the three-conductor power cord is connected, a procedure that complies with NEMA standards. Each element of the configuration is UL-listed. The power jack and mating plug of the power cable meet UL and International Electrotechnical Commission (IEC) safety standards. The computer complies with the requirements of part 15 of the FCC ruling for a class-A computing device. The monitor complies with FCC ID J92512102, which is a radiation emission specification.

Except for the computer system(s), all checkout equipment will be mounted within either the "quick-look" or the data analysis rack by means of bolts and/or screws. To prevent inadvertent movement of the GDC while at VAFB (including seismic activity), the equipment racks will be secured with appropriate restraints and will have locking devices on the wheels to prevent movement.

The GDC does not operate at a temperature that would ignite any surrounding material. There is no switching of high currents or voltages; therefore, the possibility of electrical arcs is also minimized. Cooling fans, strategic fusing, and appropriate insulating materials are used to ensure that all equipment operates at safe temperature levels.

Expected humidity levels during storage and operation of the equipment will not present problems, and personnel safety will not be compromised if ac power is interrupted.

4.13.2.2 Electrical Module

Cryostat processing will require the use of two electrical modules (EM) that are the primary power and function distribution units. The two electrical modules (one a WIRE, the other a CLAES module) are of different vintage but are functionally identical.

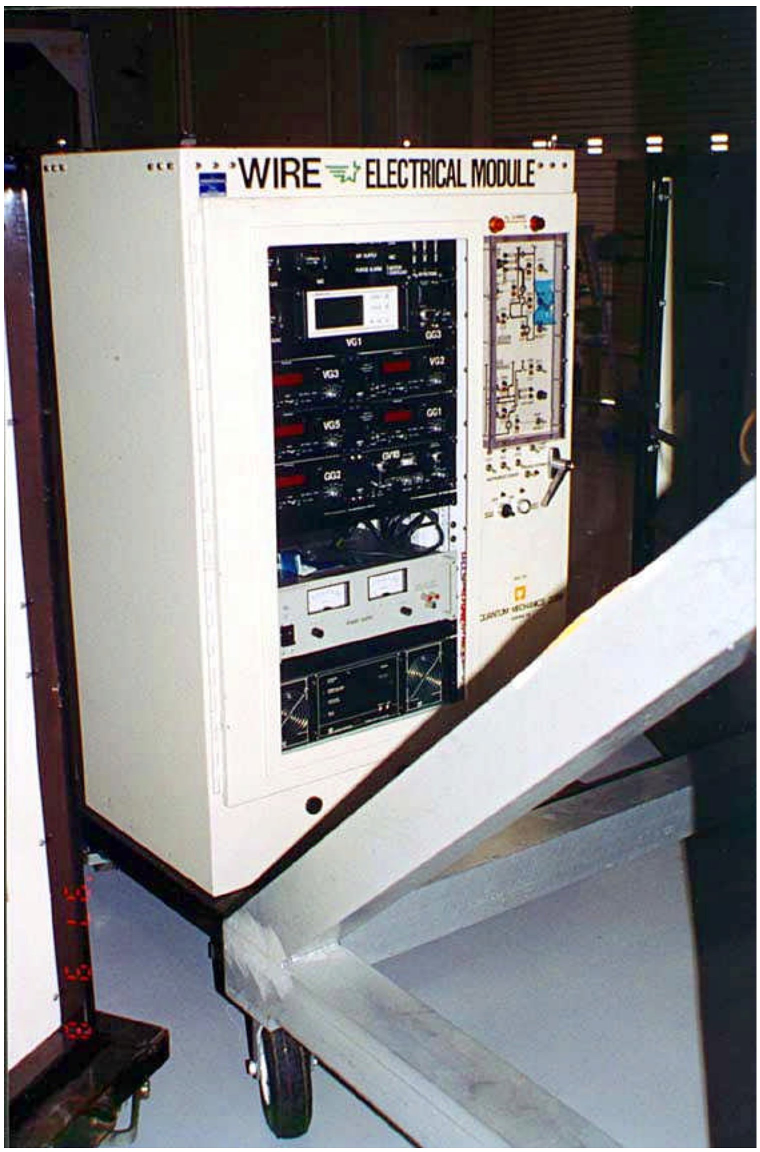
The EM is designed to provide electrical power, controls, and electrical monitors for the other modules. Facility electrical power (208 VAC, 3 phase, 30 A) enters the EM where it is controlled by a master power switch and circuit protection devices. Separate switches on the front panel of the EM control power distribution to, and valve status of, the vacuum module (VM) and gas module (GM). A clear-plastic hinged door covers all switches to prevent inadvertent actuation. The EM is also designed for central monitoring of critical vacuum pressure and to provide a central location for audio and visual alarms should (variable) preset purge pressure levels be exceeded or H_2 gas be detected. All internal terminal blocks are labeled and covered to prevent accidental personnel contact in the event the door is opened.

The EM is electrically grounded through the power cord. In addition, all components within the EM are connected by ground straps to a copper bus bar located at the back of the module. A grounding strap can be attached to this bus bar and routed to a facility ground.

Electrical interconnect cables are required for connection of the EM to the data acquisition system (DAS), the VM, the GM, and facility power. These cables are configured and labeled to prevent inadvertent misconnection.

The EM is mounted on a pontoon base with four casters, two fixed and two swivel, and a foot-operated floor brake. The base contains pockets for fork-lift pickup. Four safety swivels are mounted at the top four corners of the module for sling pickup. These swivels may also be used for tie down and lashing during shipment. A stress analysis of the EM structure shows positive margins on factors of safety of 3.0 to yield, and 5.0 to ultimate. The EM was proof-load tested to two times its weight to verify structural integrity for lifting. Figure 4-18 shows the EM.

Figure 4-18 Electrical Module



The equipment contained in the EM includes the following:

- a turbovac frequency converter which is the power supply (P/S) for the turbovac pump in the VM.
- a VM vacuum readout and gate valve control which reads pressure in the VM from $1x10^{-3}$ torr to 1000 torr using 0-1 and 0-1000 torr Baratron gauges. A process controller closes the gate valve when the pressure exceeds preset values.
- a VM ionization gauge control which reads pressure in the VM over a $1x10^{-7}$ to $1x10^{-3}$ torr range.
- Three service-time timers, which record the total time power, are located on the EM and VM. They are used for determining the intervals for equipment servicing.
- Power supplies for the cryogen tank heaters which are used during heat rate tests or to quickly offload the cryogen in the tank.
- H_2 readout displays for remote H_2 sensors which indicate the set point and sensor alarm.
- Control valves which are actuation switches for key electro-pneumatic controlled valves in the GM and VM.

Facility I/F requirements for the EM are:

Power Input: One outlet providing 208 VAC, 3-phase, 60 Hz, 30 A (NEMA L21-30) twist-lock connector (mates to Bryant 72130-FR wall-mounted receptacle).

Grounding: Utility ground through the power cord with capability for facility ground from the bus at the rear of the module.

Pneumatic: Facility air at 70 to 100 psig. Optionally, a pressurized gas cylinder of N_2 can be used.

4.13.2.3 Vacuum Cleaner

The vacuum cleaner, which was used for SPIRIT III ground operations, will be used in the PPF and at the hot pad to periodically clean the surface of the spacecraft, GSE, and facility. The vacuum cleaner is a CRV™ manufactured by HAKO Minutemen, Inc. It features a 4-gallon heavy duty stainless steel tank with cast aluminum fittings and rubber tires. It has a 1.2 hp vacuum motor requiring 930 watts. The vacuum power cord is safety orange, 50 feet long, and easily wrapped around the vacuum head for storage. The vacuum is equipped with bearings. The vacuum motor requires 115 VAC and 11 amps. The standard power plug is a NEMA S-15P. Electrostatic discharge is prevented when the CRV™ is grounded through the power strap from the switch frame to the hose. In order to prevent short circuiting, all tools are made of non-conductive ABS polyvinyl chloride. The vacuum cleaner will not be used during the H_2 loading operations. The vacuum motor is not explosion-proof and will be subject to procedural controls to assure that there are no H_2 leaks prior to its use.

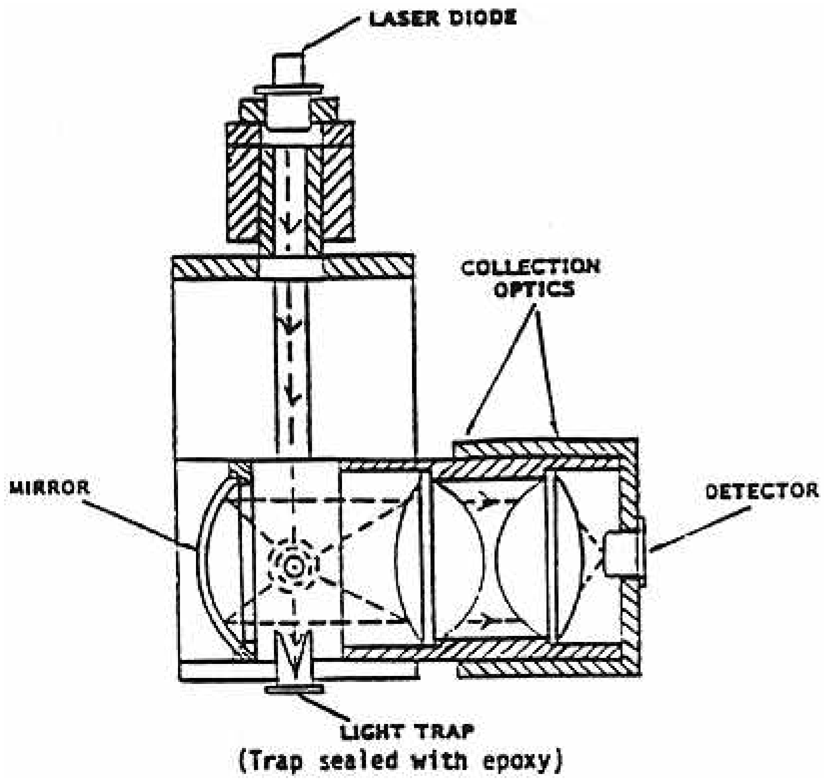
4.13.3 Non-ionizing GSE

4.13.3.1 MET-1 Model A2300 Particle Counter

The Model A2300 Laser Particle Counter manufactured by MET-1, Inc., Grants Pass, OR, samples and analyzes the same time. The Model A2300 measures airborne particles in six size ranges at the same time. The operation of the counter is through a built-in computer operating system. The particle counter uses a vacuum pump to continuously draw air at a flow rate of 1 CFM into the sensor. The sample air passes through the laser beam, deflecting burst of light onto a solid-state photodiode that converts the light to an electrical pulse. The size of the pulse is proportional to particle size. The electronic circuitry counts these pulses simultaneously in six real-time counting channels, and passes the information to the internal computer.

The Model A2300 is 15.5 inches wide, 17.5 inches high, and 14.5 inches long and weighs 31 lbs. The sensor is designed using one Sony 50mW diode laser as the light source. The laser sensor is sub-assembly fully enclosed within another main cabinet. The sensor sub-assembly is marked with a danger label that warns of "Invisible Laser Radiation When Open - Avoid Direct Exposure to Beam". The sensor sub-assembly is epoxy-sealed to the cabinet, thereby preventing access. Therefore, there are not any interlocks on the sensor sub-assembly. Removal of the sensor sub-assembly for maintenance would be done by MET ONE service personnel. Figure 4-19 shows the laser configuration for model A2300.

Figure 4-19 MET-1 Model A2300



Laser Characteristics of the Model A2300 are as follows:

Light Source: Solid-state, Gallium Arsenide diode laser
Radiant Power Output: P_0 = 50 mW
Mode: CW
Wavelength: = 780 nm
Laser Life: 30,000 hours

The Model A2300 is programmable up to 18 hours and will be operated for an extended period during spacecraft operations. It will be used on a continuous basis at the PPF, except during the 13-day period of hydrogen operations. The Model A2300 will be used only for a short time during the cooldown phases after verifying that hydrogen vapors are not present. It may be used as a stationary unit at the hot pad. The Model A2300 requires an AC power source of 115 VAC at 60 Hz capable of supplying 300 W. The unit will be connected to the power distribution in the PPF and to a receptacle at the hot pad so that it can be turned off in the event that a hydrogen leak is detected.

Using ANSI Z136-1 1986, the embedded laser is classified as a Class 3b laser. By the nature of the design, all laser light is contained within the sensor housing during normal operation so the instrument carries a Class I classification. The laser is filed with the Food and Drug Administration, Center for Devices and Radiological Health, in accordance with the Radiation Control for Health and Safety Act of 1968 (Title 21, Code of Federal Regulations, Subchapter J) as they pertain to laser products (except medical devices).

4.13.3.2 MET-1 Model A2420 Particle Counter.

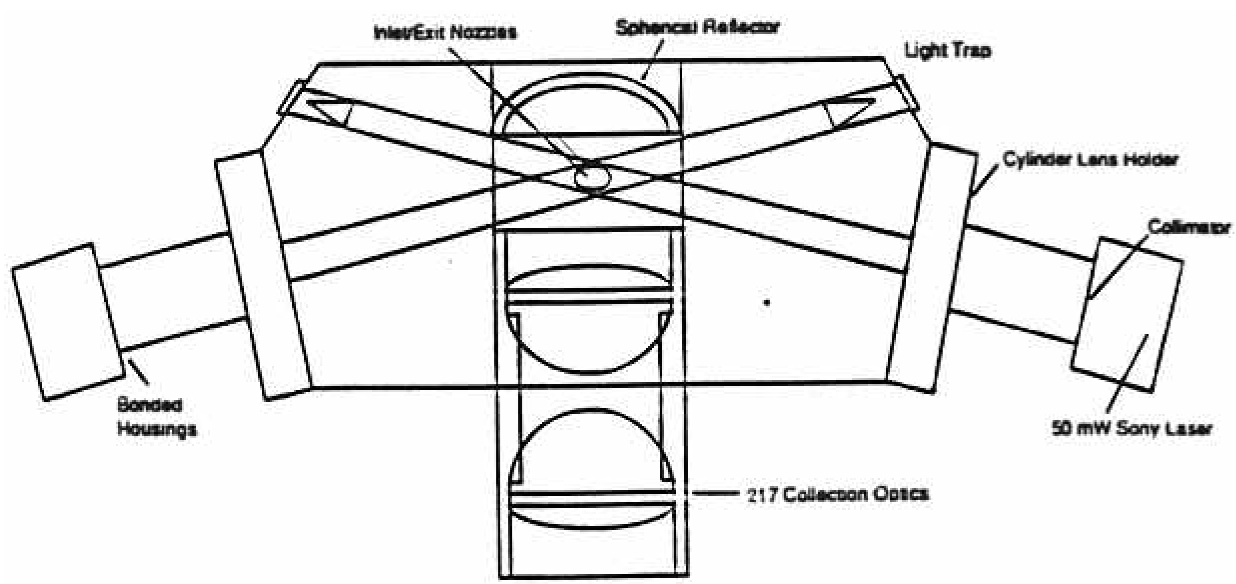
The model A2420 Laser Particle Counter manufactured by MET ONE, Inc., Grants Pass, OR, samples and analyzes the ambient air. The Model A2420 measures airborne particles in six size ranges at the same time. The counter is a state-of-the-art laser-based microprocessor-controlled instrument.

The particle counter uses a vacuum pump to continuously draw air at a flow rate of 2 CFM into the sensor. The sample air passes through the laser beam, deflecting bursts of light onto a solid-state photodiode that converts the light to an electrical pulse. The size of the pulse is proportional to particle size. The microprocessor and its associated circuitry sorts and counts these pulses.

The Model A2420 is 12.25 inches wide x 7.0 inches high x 14.5 inches deep and weighs 36 pounds. The sensor is designed using two Sony 50 mW diode lasers as the light source. The laser optical configuration is shown in Figure 4-20.

The laser sensor is a sub-assembly fully enclosed within another cabinet. The main cabinet is held in place by eight screws. The sensor sub-assembly is marked with a danger label that warns of “Invisible Laser Radiation When Open - Avoid Direct Exposure to Beam.” The sensor sub-assembly is epoxy-sealed to the cabinet thereby preventing access; therefore, there are not any

Figure 4-20 MET- 1 Model A2420



interlocks on the sensor sub-assembly. Removal of the sensor sub-assembly would only be done in the case of servicing by MET-1 service personnel.

Laser Characteristics of the Model A2420 are as follows:

Light Source: Solid-state, Gallium Arsenide diode laser
Radiant Power Output: $P_0 = 50$ mW
Mode: CW
Wavelength = 780 nm
Laser Life: 30,000 hours

Using ANSI Z136-1 1986, the embedded lasers are classified as Class 3B. By the nature of the design, all laser light is contained within the sensor housing during normal operation so the instrument carries a Class I classification. The laser is filed with the Food and Drug Administration, Center for Devices and Radiological Health, in accordance with the Radiation Control for Health and Safety Act of 1968 (Title 21, Code of Federal Regulations, Subchapter J) as they pertain to laser products (except medical devices).

The Model A2420 is programmable up to 24 hours and will be operated for an extended period during spacecraft operations. It will be used on a continuous basis at the PPF, except during the 13-day period of hydrogen operations. The Model A2420 will be used only for a short time during the cooldown phases after verifying that hydrogen vapors are not present. It may be used as a stationary unit at the hot pad. The Model A2420 requires an AC power source of 115 VAC at 60 Hz capable of supplying 300 W. The unit will be connected to the power distribution unit in the PPF and to a receptacle at the hot pad so that it can be turned off in the event that a hydrogen leak is detected.

4.13.4 Ionizing GSE

4.13.4.1 Air-line Ionizer

A Nuclecel™ Model 2021CR ion gun that is manufactured by NRD, Inc. will be used to remove particles clinging to surfaces through static charge attraction and to eliminate the electrostatic re-attraction of contaminants. The ion gun is used on a clean, dry compressed nitrogen line and emits a stream of ions that neutralize electrostatic charges fast. The ion stream is balanced as it leaves the cell and does not require distance consideration to achieve ion intermix. The ionizing source is 29 grams of Polonium-210 (Po), which emit 10 millicuries of alpha particles. The Po is encapsulated in a fold foil using a pressure-welded metallurgy technique. Since this item contains a small radioactive source, the item will be stored in a secure area under the control of SDL/LMMS. Disposal of the item after the shelf-life has been exceeded will be the responsibility of SDL/USU.

4.13.5 WR Seismic Data Requirement

Seismic restraining mechanisms will be in place for all large equipment that will stay in a location for longer than 24 hours. To minimize hazards due to seismic events, the racks contain one of three possible controls: restraining hooks, anti-tipping plates, or low center of gravity.

The main concern is that these racks may tip over and cause injury. There are three types of controls to
prevent this from occurring: restraining eye-hooks are attached to the top of racks where they can be lashed to walls or other racks in a stable configuration; anti-tipping plates protrude out the bottom of the rack preventing it from tipping over; and some equipment has a low center of gravity to physically prevent the rack from tipping. Table 4-7 shows the locations and seismic characteristics of the large cryogenic GSE associated with WIRE.

Cryogenic hoses and fill and vent lines will be secured throughout the PPF and hot pad areas according to the WR criteria for safing equipment that can be potentially dangerous during seismic events. Hoses and lines will be supported by tie-offs to support stands near the spacecraft and to support stands placed on the floor or pad, all of which will be secured to the floor and/or ground.

Table 4-7 Locations and Seismic Charateristics For WIRE Instrument GSE

GSE	Location		Dimensions				Seismic Protection			
	PPF	Pad	Height (inches)	Width (inches)	Depth (inches)	Weight (lbs)	Anti-tip Plates	Low CG	Restraint hooks	Tie downs
Cryogen hose supports	x	x	72	12	12	20			x	x
Data acquisition system (DAS)	x	x	64	25	32	800			x	x
Electrical module (2)	x	x	60	36	30	770		x	x	x
Gas module (2)	x	x	60	36	30	600		x	x	x
Vacuum module	x	x	60	36	30	570		x	x	x
GDC rack	x		76	40	38	585		x		
GSE power rack	x	x	54	32	33	463		x		
Heat exchanger	x	x	15	26	28	135		x		x
LH_2 dewar	Outside	x	78	52	52	1180			x	
LHe dewars (2)	x	x	91	60	42	1116			x	x
Water cart	x	x	36	36	36	?		x		x
Leak detector	x	x	48	30	18	?			x	x
GHe supply bottles	x	x	60	10	10	?				