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**BRAYTON ISOTOPE POWER SYSTEM (BIPS)
FACILITY SPECIFICATION**

MASTER

76-311740

May 31, 1976

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B17331, Rev. 1 - Abbreviations
acronyms [follows
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TABLE BL7331, REV. 1
BIPS PROGRAM

ABBREVIATIONS AND ACRONYMS

A		E	
ABS	Auxiliary Battery System	ECS	Emergency Cooling System (for HSA)
ACS	Auxiliary Cooling System (for HSA)	EHS-D	Electrical Heat Source - Dynamic
ACS	Attitude Control System	EHS-S	Electrical Heat Source - Static
AEC	Atomic Energy Commission (now ERDA)	ELS	Eastern Launch Site
AEC PR	Atomic Energy Commission Procurement Regulation	EMS	Material Specification (AiResearch Term)
AIRPHX	AiResearch, Phoenix	EOM	End of Mission
AIRLA	AiResearch, Los Angeles	ESD	Electronic System Division (of Air Force Systems Command)
AFSCF	Air Force Satellite Control Facility	ET	External Expendable Tank
AM	Amplitude Modulation	EPS	Electrical Power System
AOA	Abort-Once-Around	ERDA	Energy Research and Development Administration (Formerly AEC)
ASE	Airborne Support Equipment	EVA	Extravehicular Activity
ARS	Atmospheric Revitalization Subsystem	F	
ATO	Abort-To-Orbit	F	Fahrenheit Degrees
ATCS	Active Thermal Control Subsystem	FBS	Flight Battery System Required for Start in Orbit
a/o	Atomic Percent	FIB	Fuel Impact Body
B		FM	Frequency Modulation
BCL	Battelle Columbus Laboratory	FMA	Failure Mode analysis
BOM	Beginning of Mission	FMEA	Failure Modes and Effects Analysis
BIPS	Brayton Isotope Power System	FMECA	Failure Modes, Effects and Criticality Analysis
BRU	Brayton Rotating Unit	FPR	Federal Procurement Regulation
C		fps	Feet per Second
C	Celsius (Centigrade) Degrees	FS	Flight System
CCAFS	Cape Canaveral Air Force Station	FSA	Fuel Sphere Assembly
CCD	Configuration Control Document	FSAR	Final Safety Analysis Report
CCTV	Closed Circuit Television	FSE	Flight Support Equipment
CFM	Cubic Feet per Minute	FSEC	Fairchild Space and Electronics Company
c.g. or CG	Center of Gravity	FUO	Follow-up Output
CO2	Carbon Dioxide	FT	Feet, Foot
CRT	Cathode Ray Tube	FWW	Food, Water and Waste Management
CSI	Control Servo Input	G	
D		g	Acceleration Due to Gravity
DAS	Data Acquisition System	GDS	Ground Demonstration System - PCS + EHS-S
db	Decibel	GE	General Electric, Valley Forge
DC	Direct Current	GET	Ground Elapsed Time
DCS	Demonstrator Cooling System	GFE	Government Furnished Equipment
Delta-V or ΔV	Velocity Change in Feet per Second	GMS	Gas Management System
DOD	Department of Defense	GMT	Greenwich Mean Time
DOD STS	Department of Defense Space Transportation System	GN2	Gaseous Nitrogen
E		GN&C	Guidance, Navigation and Control
EAI	Engineering Assembly Instructions	GSE	Ground Support Equipment
EAFB	Edwards Air Force Base	GTC	Ground Test Console (a STE/GSE item)
EPFS	Electrically Powered Flight System (PCS + EHS-D)		
ECLS	Environmental Control and Life Support		

TABLE B17331, REV. 1
BIPS PROGRAM

ABBREVIATIONS AND ACRONYMS
(CONTD)

H		M	
HIP	Hot Isostatic Press	MECO	Main Engine Cut-Off
HS	Heat Source (Same as and replaced by IHS)	MHW	Multi-Hundred Watt (AEC/GF IHS Technology)
HSA	Heat Source Assembly (Does not include EHS or HSS. Does include HSHX, structure, insulation, ACS and ECS.)	MHZ	Megahertz
HRHX	Heat Rejection Heat Exchanger (Radiator simulator for GDS)	MM	Millimeters
HSHX	Heat Source Heat Exchanger	MMD	Mean Mission Duration
HSIS	Heat Source Insulation System	MOS	Mission Operation System
HSS	Heat Source Simulator (Same as and replaced by EHS)	MR	Milliradians
HTGR	High Temperature Gas Cooled Reactor	MSS -	Mission Specialist Station
		MW	Molecular Weight
I		N	
IBFS	Isotope Brayton Flight System	NA	Not Applicable
IBGDS	Isotope Brayton Ground Demonstration System (PCS + EHS-S)	NASA LeRC	National Aeronautical and Space Administration Lewis Research Center
IHE	Isotope Handling Equipment	NRA -	Nuclear Research and Applications, Division of ERDA (formerly SNS)
IHS	Isotope Heat Source		
IMU	Inertial Measurement Unit		
IUS	Interim Upper Stage		
IVA	Intra Vehicular Activity		
J		O	
JPL	Jet Propulsion Laboratory (Pasadena, California)	OBP	Orbiter Processing System
JFC	Johnson Space Center (Houston)	OHA	Operational Hazard Analysis
K		ORNL	Oak Ridge National Laboratory
KB	Keyboard	OMS	Orbital Maneuvering Subsystem
Kbaud	Code Elements per Second in 1000's		
Kbps	Bits per Second in 1000's		
KSC	Kennedy Space Center		
KW _e	Kilowatts Electrical		
KW _t	Kilowatts Thermal		
L		P	
LASL	Los Alamos Scientific Laboratory	PCL	Power Conversion Loop (Use of PCS preferred)
LCC	Launch Control Center	PCM	Pulse Code Modulation
LES 8/9	Lincoln Experimental Satellite (No. 8 and 9)	PCR	Payload Changeout Room
LF	Load Factor	PCS I	Power Conversion System (HSA + BRU + MBR + Heat Sink + Controls + Piping and structure)
LH2	Liquid Hydrogen	PCS II	Power Conversion System (HSA + BRU + MBR + Radiator + Controls + Piping and Structure)
LiOH	Lithium Hydroxide	PGHM	Payload Ground Handling Mechanism
LO2	Liquid Oxygen	PHA	Preliminary Hazard Analysis
LPS	Launch Processing System	PLC	Parasitic Load Control System
M		P/L	Payload
M	Meters	PLCC	Payload Control Center
MARSCOM	Materials Review and Selection Committee	PLH	Payload Handling
MBR	Mini-Brayton Recuperator	PLM	Payload Management
Mini-BRU	350 to 2100 Watts Electrical Brayton Rotating Unit	POP	Perpendicular to Orbit Plane
MCC	Mission Control Center	PSAR	Preliminary Safety Analysis Report
MDM	Multiplexer-Demultiplexer	PSC	Power Supply Console (for RHS)
		PSC	Procurement Specification (AirResearch Term)
		PSE	Peculiar Support Equipment
		PSS	Payload Specialist Station
		PSSR	Preliminary System Safety Review
		PICS	Plutonium Isotope Containment Shield
		Q	
		QA	Quality Assurance

TABLE BL7331, REV. 1
BIPS PROGRAM

ABBREVIATIONS AND ACRONYMS
(CONTD)

R		V	
RCS	Reaction Control System	VAB	Vehicle Assembly Building
RCS	Radiator Cooling System	VAFB	Vandenberg Air Force Base
REM	Roentgen Equivalent Man	VDC	Volts Direct Current
RF	Radio Frequency	VHF	Very High Frequency
RM	Remote Manipulator	VRE	Voltage Regulator Exciter
RMS	Remote Manipulator System		
RSS	Root Sum Square		W
RTLS	Return to Launch Site	w/o	Percent by Weight
RTG	Radioisotope Thermoelectric Generator		
RTS	Remote Tracking Station		
S			
SAMSO	Space and Missile System Organization		
SNS	Space Nuclear Systems (now NRA)		
SMAB	Solid Motor Assembly Buildup		
SRB	Solid Rocket Booster		
SRM	Solid Rocket Motor		
SSP	Space Shuttle Program		
SSME	Space Shuttle Main Engine		
SSS	Space Shuttle System		
SSPP	System Safety Program Plan		
SSV	Space Shuttle Vehicle		
STDN/ TDRSS	Space Tracking and Data Network/Tracking Data Relay Satellite System		
STE	Special Test Equipment		
STS	Space Transportation System		
SURVSATCOM	Air Force Survivable Communication Satellite (now AFSATCOM III)		
T			
TACB	Temperature of Cabin		
TBD	To Be Defined		
TDRS	Tracking and Data Relay Satellite		
TECO	Thermo Electron Corporation		
TES	Teledyne Energy System (formerly Teledyne Isotopes)		
TIT	Turbine Inlet Temperature		
TV	Television		
U			
ULT	Ultimate Loads		
USAR	Updated Safety Analysis Report

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BRAYTON ISOTOPE POWER SYSTEM
(BIPS)
FACILITY SPECIFICATION

1. INTRODUCTION

This document defines general requirements for the Brayton Isotope Power System (BIPS)/Ground Demonstration System (GDS) assembly and test facility. This facility will include provisions for a complete test laboratory for GDS checkout, performance, and endurance testing, and a contamination-controlled area for assembly, fabrication, storage, and storage preparation of GDS components.

Work to be performed under this contract consists of furnishing all plant, labor, transportation, materials, equipment, and supplies, (including fuel, power, and water). Work shall be performed in accordance with the specifications, schedules, and drawings, included or referred to herein, all of which are made a part of this document.

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2. DRAWINGS

AiResearch shall prepare contract drawings and specifications for work to be performed under this contract. The work shall conform to the drawings listed in Appendix I, all of which form a part of this document.

In the event that the work described herein is awarded to a contractor, ten sets of the contract drawings and specifications will be furnished to the contractor by AiResearch. The contractor shall submit five copies of all shop drawings, as specified, to AiResearch for approval. These drawings shall be complete and contain all required detailed information. Shop drawings shall be prepared with due consideration for field measurements, dimensions, and special requirements of equipment to be installed. The contractor shall certify that his and all subcontractor shop drawings are in conformance with the above instructions as well as with specification requirements before submittal to AiResearch. Approval of shop drawings shall not relieve the contractor of responsibility for any error which may exist, as the contractor shall be responsible for the dimensions and design of adequate connections, details, and satisfactory performance of all work.

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3. GENERAL SPECIFICATIONS

The contractor shall keep, on the site, a copy of the drawings and specifications and shall, at all times, give AiResearch access thereto. Requirements imposed by the specifications and not shown on the drawings, or the inverse, shall have the effect of having been shown or imposed in both. In case of differences between specifications and drawings, the specifications shall govern. In any case of difference in the figures, drawings, or specifications, the matter shall be promptly submitted to AiResearch for written determination; adjustment by the contractor without this determination shall be at the contractor's risk and expense.

Periodically, AiResearch shall furnish detail drawings and other information as it may consider necessary. Contract drawings have been prepared based upon representative types of available equipment suitable for the intended service.

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4. ASSEMBLY AND TEST FACILITY REQUIREMENTS

This section presents a description of technical requirements for the BIPS/GDS Assembly and Test Facility. Paragraphs 4.1 through 4.10 present individual requirements of major facility categories. The AiResearch facility shall include a complete test laboratory for GDS checkout, performance and endurance testing, and a contamination-controlled assembly area for assembly, fabrication, storage, and storage preparation of GDS components. Specific requirements for construction and outfitting the assembly and test facility, and control of the facility environment, are discussed in the following paragraphs.

4.1 Contamination-Controlled Area (CCA)

The CCA shall be a segregated area that includes the GDS test area, assembly areas, and storage and cleaning area (see Figure 1). The control room, noncontrol room, and change room shall serve as a positive pressure buffer between the CCA and outside environment.

4.1.1 CCA Environment

A Class 100 environment, as defined in Federal Standard 209B, shall be preserved at some component assembly areas and an intermediate environment in the GDS assembly area. A Class 10,000 environment shall be preserved in rooms ④ and ⑤ (Figure 1). Clean, lint-free outer-wear and gloves shall be worn. Equipment used to support and handle pieces shall be maintained free from dirt, fingerprints, unapproved lubricants, and other contaminants. Entryway ③ shall serve as a positive pressure air lock for the CAA.

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- I. DIGITAL DATA ACQUISITION SYSTEM / 750 K BCG RECORDING
- II. GDS VISUAL EMERGENCY SHUTDOWN
- III. GDS COMPONENT PANEL
- IV. GAS CONTROLS
- V. FACILITY STATUS PANEL

CONTAMINATION CONTROLLED AREA

FIGURE 1

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The clean air system shall flow north to south, exiting along the south wall of Rooms ① and ②. The door between Rooms ① and ⑤ shall be airtight and serve as an emergency exit only. Room ② will serve as a noncontrolled work area and locker room. Room ③ shall be an air lock and used as a dressing area before entering the CCA.

A vacuum system with flexible hose connections and a recirculating air blower system, which shall include a Farr HP cleanable filter with basket type filter element, shall be provided in the airlock for decontaminating personnel before entry into the controlled area.

Wall and ceiling surfaces in Rooms ④ and ⑤ shall be covered with a vinyl-type layered material. All floor areas shall be covered with vinyl sheet stock. All corners shall be rounded or coved. Waxes or other similar dressing compounds shall not be used. Benches shall leave the floor unobstructed for cleaning. All electrical outlets shall be flush. Lighting fixtures shall be completely enclosed with no horizontal projections to catch dust. A central, clean, compressed air supply shall be provided. Air line connecting fittings shall be accessible above work benches. A central vacuum cleaning system shall be provided with flush capped outlets on the inside walls. Rooms ④ and ⑤ shall be provided with an intercom system or talk-through windows for communication with Room ①. The partition between Rooms ① and ⑤ shall be equipped with a positive-pressure pass-through sufficient to transfer system components from Room ① into Room ⑤.

Heating and air conditioning systems shall be provided for clean room areas as described below.

Rooms ④ and ⑤ shall be equipped with a separate pressurization and air conditioning system comprised of a cooling coil, fan, filtration system, and thermostatic controls. Ventilation air, taken from the main building air surrounding the rooms, shall be filtered through filters installed in series before being supplied to the contamination-controlled room.

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Final filters shall be HEPA type, 99.97 percent minimum efficiency on 0.3 micron DOP test. Pressures shall be monitored by gauges mounted on a panel outside the CCA.

"Sticky mats" shall be placed inside the entrance to Rooms ① and ③ to capture tracked-in contamination.

CCA environment inspection shall be performed on a periodic basis in accordance with AiResearch Report 76-311745.

4.1.2 Laminar Flow Benches

Three laminar flow benches are required. These benches shall be located in accordance with Figure 1. Required working areas for each bench are as follows:

<u>Bench</u>	<u>Length (in.)</u>	<u>Height (in.)</u>	<u>Depth (in.)</u>	<u>Freeboard (in.)</u>
①	47	66	30 (min)	32 (min)
②	59	66	30 (min)	32 (min)
③	59	66	30 (min)	32 (min)

Environment at the laminar flow stations shall meet or exceed Federal Standard 209B Class 100 clean air conditions. The work station shall provide integral fluorescent lighting satisfactory for long-term detailed work. All laminar flow stations structure shall be easily cleanable, and noise level and vibration shall be minimal. Filter units shall be HEPA type or equivalent, and be front or top loading with a ceiling clearance of 8 feet 0 inches. Prefilters shall also conform to the preceding replacement criteria. Laminar-flow work benches shall conform to cleaning requirements discussed above. Working surfaces shall be stainless steel or equivalent.

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Overhead laminar-flow hoods will be utilized in the GDS assembly area. These units shall be mounted on a portable supporting structure to allow continuous test article shrouding. These hoods shall be selected to provide a low contamination area of sufficient size to shroud the completed test article.

A particle counter shall be utilized to verify satisfactory contamination levels in the CCA, laminar-flow stations, and GDS assembly area. The counter shall detect 0.5 micron or larger particles on Range 1, and 5 micron or larger on Range 2.

4.1.3 Work Benches

A total of three work benches are required in the CCA, and will be located in accordance with Figure 1. The required size range of these benches is as follows:

<u>Bench</u>	<u>Length (in.)</u>	<u>Height (in.)</u>	<u>Depth (in.)</u>
Ⓓ	47	30	30 (min)
Ⓔ	58	34	30 (min)
Ⓕ	58	30	30 (min)

All work bench structures shall be easily cleanable. The work surface shall be stainless steel or equivalent. Work benches shall be compatible in appearance with the selected laminar-flow station components.

4.1.4 Stools

All work stations (control room, laminar booths, and work benches) shall be supplied with stools having molded fiber glass-reinforced plastic and anodized aluminum or stainless steel legs.

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4.1.5 Cleaning Equipment

Room ⑤ (Figure 1) shall be furnished with cleaning equipment as described in the subparagraphs that follow.

4.1.5.1 Degreaser and Ultrasonic Tank

Room ⑤ shall include a trichloroethylene ultrasonic and vapor degreaser. The degreaser shall be equipped with a clean solvent reservoir and part spraying fixture. The required size is TBD.

4.1.5.2 Detergent Cleaning Tank

Room ⑤ shall be fitted with an all stainless steel construction or approved plastic detergent cleaning tank. The tank shall be fitted with a heater/thermostat to maintain the solution at the desired temperature. The required size is TBD.

4.1.5.3 Tap Water Rinse Tank

Room ⑤ will be fitted with a water rinse tank using deionized water and water spray. A 10-micron absolute stainless-steel line filter shall be incorporated in the spray line.

4.1.5.4 Vacuum Drying Oven

A drying oven of TBD size will be located in Room ⑤ for (1) drying parts after cleaning, and (2) preconditioning components of organic materials. The oven interior shall be of stainless steel construction. The oven shall be electrically heated to a maximum temperature of 250°F and equipped with a thermostatic control capable of maintaining a $\pm 25^\circ\text{F}$ tolerance. The oven vacuum pump shall have a capacity of 26 in. Hg vacuum.

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4.1.6 Tools

All tools used in Rooms ④ and ⑤ shall be either stainless steel, plated steel, or plastic, and shall be cleaned immediately before entering the CCA. Tool boxes shall be all-metal and easily cleaned, and shall be thoroughly cleaned immediately before entering the CCA.

4.1.7 Desiccator Dry Boxes

After GDS component parts have been cleaned in accordance with requirements of AiResearch Report No. 76-311746, the parts shall be stored in desiccator dry boxes located in Room ⑤ until needed for GDS assembly. These boxes shall provide maximum drying recovery rate immediately following door closure. Dry nitrogen gas shall be periodically circulated through the box to maintain an environmental purity as stated in 4.1.1.

Nitrogen storage may be located outside Room ⑤ along the south wall of the "N" Building. The nitrogen delivery system shall be fitted with an automatic timer/valve assembly to provide a sufficient purge per volume storage of nitrogen. Provision shall also be made for manually initiated nitrogen purge following placement or removal of items in, or from, storage.

4.2 Vacuum System Requirements

A detailed description of the function and requirements for a high-vacuum test chamber and pumping system design is presented in this paragraph. This design, intended specifically for use in closed-loop power system testing, shall consist of a containment vessel with attendant penetrations and supporting structure, a high-vacuum pumping system including valves, and associated pumps. In addition, the system design shall include instrumentation required for pressure measurement and pumping system control.

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Documents currently considered applicable to design of this facility system are as follows:

- (a) Section VIII of the ASME Code for Unified Pressure Vessels
- (b) National Electrical Code
- (c) American Vacuum Society Tentative Standards 3.2 for Metal Seal Flanges
- (d) American Vacuum Society Test Procedures for Determination of Pumping Speeds (4.1)

During Phase I of the ERDA BIPS program, engine testing shall encompass engine checkout, engine performance, and 1000-hour-plus endurance testing. A total of 5000 test hours has been defined for purposes of facility design and component selection. During this period, the test facility shall provide a reliable and suitable environment for the test article, the Ground Demonstration System (GDS).

The GDS is a flight prototypical closed Brayton-cycle power system utilizing an electrical heat source (EHS), simulation of the Flight System (FS) isotope heat source, and a liquid-cooled heat-rejection heat-exchanger (HRHX) to simulate the FS space radiator. With the following exceptions, the GDS will be totally enclosed within the vacuum system:

- (a) HRHX - This component will be external and linked to the GDS by two ducting penetrations in the chamber wall.

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- (b) GDS Controls - The electronic portion of the GDS controls will be external to the vacuum chamber to facilitate control logic development.
- (c) EHS Power Supplies - EHS power supplies will communicate with the GDS by power-lead feed throughs.

A current GDS configuration, including location of major components that will be enclosed in the vacuum chamber and an outline definition of the GDS, has been prepared to facilitate chamber design and is included as Drawing No. 241001 of Appendix I.

Also included in this figure, to allow for flexibility in instrumenting and servicing the GDS, are certain minimum clearance requirements that shall be maintained for both open and closed chamber conditions. The open-chamber condition applies primarily to accessibility of the GDS for installation and service. The closed-chamber condition applies to required clearances for instrumentation leads, sensors, etc.

The structural interface between the vacuum chamber and GDS shall be accomplished at mount points defined in Drawing No. 241001 of Appendix I. GDS structural support to the tank foundation shall be essentially continuous to minimize vacuum chamber flange distortion.

The GDS will incorporate a significant investment in components fabricated of refractory alloys, particularly Columbium Alloy C-103. In addition, the GDS will utilize a radiation shield (Multi-Foil) insulation system to minimize thermal losses and enhance engine performance. The two major vacuum system design objectives relate directly to GDS design requirements, mentioned previously, of attaining and preserving an environment sufficient to:

- (a) Protect hot ($T > 450^{\circ}\text{F}$) refractory components from concentrations of contaminants which will significantly impair material properties over the duration of the test program.
- (b) Provide a level of vacuum sufficient to allow proper thermodynamic evaluation of the GDS. The Multi-Foil insulation system will perform satisfactorily with a maximum of 10^{-4} Torr pressure level between the foil layers.

In accordance with major design objectives, a facility design philosophy of isolation and automated protection shall be utilized. Sensory inputs to a facility protection system shall initiate the protective action sequence when a potential for contamination is identified.

A combination of the following have been identified as reliability/protection features:

- (a) Use of isolation valves
- (b) Emergency inert gas backfill of chamber
- (c) Vacuum or inert gas shrouding of seals and penetrations
- (d) Minimum use of lubricated devices where contamination potential exists
- (e) Selection of high reliability equipment
- (f) Backstreaming protection (e.g., foreline cold traps, molecular sieves)

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- (g) Use of liquid argon for cold traps, if applicable
- (i) Incorporation of substantial impact shields over all vulnerable tank penetrations (e.g., ion gage heads, feed-throughs, etc.)
- (j) Use of annunciation and automatic protection

The vacuum system shall be installed in the northeast corner of the building (Figure 1). Vacuum support equipment may be located outside the east wall of the building if necessary or desired.

A control panel shall be provided to operate all pumps and valves in their proper sequence with sufficient interlocks to guard against catastrophic damage to the GDS or pumps due to utility failures or an up-to-air accident. Individually lighted push-button switches, arranged schematically, shall be provided on the control panel to operate each of the valves and pumps. Sufficient vacuum gauging instrumentation shall be provided to read chamber pressure from 1 to 10^{-9} Torr, high vacuum pumping system pressure from 1 to 10^{-9} Torr, sustaining pump pressure from 1 to 10^{-9} Torr, backing roughing pump pressure from 1 to 10^{-3} Torr, and holding pump pressure from 1 to 10^{-3} Torr.

The installed test chamber and associated environmental control equipment shall be subjected to acceptance testing, performed by the vendor, in accordance with procedures delineated in Section 10. These tests will verify attainment of desired performance including:

- (a) Clean, dry, and empty pump down pressure of less than 5×10^{-8} Torr in 10 hours.

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- (b) Tank inboard leakage, detected from a totally He-shrouded (bagged) leak test, of less than 2×10^{-10} scc/sec.
- (c) Tank leakage and outgassing as determined from an isolated tank vacuum decay test.

4.2.1 Chamber Requirements

Vacuum system chamber design shall be consistent with general facility requirements and requirements for chamber performance discussed in Paragraph 4.2. Specific requirements of chamber ancillaries (ports, valves, seals, etc.) are discussed individually in Paragraphs 4.2.1.3 through 4.2.1.5.

4.2.1.1 Tank Geometry

Preliminary conceptual designs and facility layouts have shown a horizontal chamber arrangement to be preferable.

The GDS will be extensively instrumented and joined to facility support equipment. Therefore, the GDS, as well as the chamber section to which it is mounted, should be stationary, whereas the movable portion of the vacuum chamber shall traverse a sufficient distance to meet clearance and accessibility requirements of Paragraph 4.2. The movable chamber section shall be closed at one end and flanged at the other. The fixed section shall be a similar flanged head that will contain pumping system ports and other stationary devices.

4.2.1.2 Chamber Construction and Materials

Chamber structural interface and support structure will be designed to meet general requirements of Paragraph 4.2. Specific design reference data is summarized as follows:

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- o GDS and support ring weight - 600 pounds
- o CG location (refer to - 24 inches from tank
Drawing No. 241001 of
Appendix I

The vacuum chamber shall be constructed with CRES 304, and shall be compatible with attainment of a chamber gas evolution rate of 5×10^{-5} Torr - liters/second after 10 hours at 5×10^{-8} pressure level. Material selection shall also be accomplished with due consideration given to ancillary and joint materials compatibility.

All containment seam welds shall be vacuum side, full-penetration, single-sided, groove-type welds, using a weld material commonly accepted as being compatible with the chamber material. The welding process shall be either metal inert gas or tungsten inert gas. All fillet welds will be ground smooth, and fusion welds will be permitted only on penetrations with diameters not in excess of 8 inches and wall thicknesses of not more than 1/16 inch. All seal welds will be made on the interior side. Any outside welds required for structural strength shall be intermittent tack welds in conformance with accepted vacuum practice. All welds shall be X-rayed in accordance with MIL-X-6141.

The interior surface subject to vacuum shall be smooth and free from slag, scale, pits, etc. Interior chamber surfaces shall be polished to a number 4 finish, or electropolished, at the vendor's option.

All external surfaces of the system, with the exception of CRES surfaces, shall be provided with a durable, solvent-resistant epoxy finish using a primer conforming to Specification MIL-P-23377 and a top coat conforming to Specification MIL-C-22750.

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The main chamber flange shall be dual O-ring sealed, using standard cross section O-rings. A third groove shall be provided between the O-ring grooves for vacuum pumpout and an NPT fitting shall be attached to the back side of the stationary flange for connection to this groove. Sealing surfaces shall have a minimum 32 RMS finish. All O-ring grooves shall be dovetailed for retention of the O-ring during assembly.

The main portion of the chamber shall be supported by four non-swivel type casters with grooved wheels. These casters shall ride on rails which shall be at least the length required to meet GDS clearances with the chamber open. The fixed end of the chamber shall be supported by a structure capable of maintaining the fixed end in its proper position and supporting the equipment shown in Drawing No. 241001 of Appendix I, without overstressing or distorting flanged joints. All structural members shall be fabricated of carbon steel. The load transmitted to the chamber footing by the chamber structure shall not exceed 500 pounds per square foot.

Vacuum chamber support-footing requirements and loading shall be specified, within a suitable lead time, by the selected vendor. The footing shall be designed to assure flange alignment and that no undue structural loading is imparted to the tank or ancillary equipment.

4.2.1.3 Chamber Port Requirements

The vacuum system port design shall utilize a standard bolted and sealed flange design to assure replacement availability and compatibility with ancillary components. Design provisions shall be made to isolate the port from the main chamber where any reasonable chance exists that change-out or repair of the related component will be required. Isolation shall be accomplished by incorporating isolation valves in accordance with requirements discussed in detail in Paragraph 4.2.3. Seals incorporated at port interfaces shall comply with seal requirements delineated in Paragraph 4.2.1.4.

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High port conductance (molecular flow) is desirable at high-speed vacuum pump inlets as well as other possible locations. Port conductance requirements definition shall be accomplished by the selected vacuum system vendor, and shall reflect a good match with the selected pump or other related device.

A view port shall be incorporated and shall consist of a minimum 1-inch thick pyrex plate retained with a metal retainer and O-ring sealed to a view port flange. Minimum clear viewing area shall be 12 inches. The port shall be located on the movable section of the chamber.

Other chamber flanged port locations currently anticipated are summarized in the following tabulation together with a preliminary inside diameter estimate for each port:

<u>Location</u>	<u>Size (in.)</u>
High Vacuum Pump Inlet(s)	12 to 16 (1 or 2 required)
Sustaining Pump	12 (1 required)
Ion Gages	As required (3 required)
Residual Gas Analyzer	As required (1 required)
Elec/Pneu Feed-Throughs	As required (instrumentation, pneumatic, power)
HRHX Penetrations	5.25 (2 required)
Sustaining Pump Roughing Pump	As required (1 required)

4.2.1.4 Seal Requirements

The seal design shall be consistent with allowable leakage requirements of Paragraphs 4.2(b). The only seal likely to be subjected to a significant number of open/close cycles is the main chamber seal. Therefore, this seal is critical and a redundant seal arrangement (concentric) is desirable. This type of arrangement

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should be buffered using inert gas or roughed vacuum. A third groove, to facilitate annulus evacuation or filling, is required for this configuration. Single seal failure detection, either internal or external, is required.

In accordance with requirements pertaining to chamber contamination, no seal lubricant shall be used on any seal exposed at any time to the main chamber. Preliminary vacuum system studies have indicated that use of metal C-seals, V-seals, or similar type seals on smaller diameters, and foil seals on larger diameters would yield satisfactory vacuum integrity. Use of elastomer seals for the main chamber seal is acceptable provided that high reliability of such seals can be documented or otherwise verified. Selected seal configurations shall be such that spare units can be provided at minimal cost and procured on a short-term basis.

4.2.1.5 Feed-Through Requirements

Selection/design of vacuum system feed-throughs shall reflect high vacuum, high reliability requirements.

To preserve instrumentation accuracy, power feed-throughs (HSA power supply, alternator output, and field) shall be on a separate port from instrumentation leads in order to minimize noise transmission.

Standard flange designs shall be utilized for feed-through mounting to assure compatibility and availability.

Feed-through design for HRHX ducts shall be separate from all others and shall comply with dimensional requirements of Drawing No. 241001 of Appendix I.

Current requirements for feed-throughs, by category, are as follows:

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(a) Electrical instrumentation

- (1) 230 thermocouple pairs (115 W/Re, 115 C/A) -
No. 22 AWG
- (2) 20 transducer pairs - No. 22 AWG
- (3) 3 speed sensors - No. 22 AWG

(b) Overspeed - 4-wire, No. 20 AWG

(c) Electrical power

- (1) Alternator output - 4 conductors, No. 12 AWG
- (2) Alternator field - 4 conductors, No. 20 AWG
- (3) EHS power supply - 4 conductors, No. 6 AWG
- (4) Shutdown by-pass valves - 4 wire, No. 20 AWG
- (5) Automatic welder - 2 conductors, No. 8 AWG

(d) Pneumatic instrumentation and controls

- (1) Loop pressures - 5, CRES tubing, 0.125 in. dia
- (2) HSA ACS vent - 2, CRES tubing, 0.5 in. dia
- (3) Sample lines - 6, CRES tubing, 0.025 in. dia
- (4) Inert gas backfill - 1, CRES tubing, 1 in. outer dia

(e) Pneumatic - HRHX ducting

Primary loop ducting - 2, CRES flange ports,
5.25 in. dia. minimum inside diameter

4.2.2 Pump Requirements

Vacuum system pump design, pumping sequence, and pump integration shall be accomplished with contaminant isolation as the prime objective. A pump concept has been developed which is intended to provide a highly reliable and contaminant safe design. This concept involves use of two phases of chamber pumping:

- (a) High vacuum pump(s) (HVP) are used to handle high gas loads during initial pumpdown and chamber "clean-up" when loop temperatures are low and refractory components are not vulnerable to contaminant attack.
- (b) During loop operation at elevated temperatures, the HVP(s) are isolated from the main chamber by use of suitably reliable valve(s). The gas load, which is evolved during long-term operation, will be pumped by intermittent operation of a sealed static pump system. This system is referred to as the sustaining pump system.

The GDS will be cleaned and outgassed by a series of inert gas pump backfill and purge cycles, both inside and outside the closed loop. Therefore, it is required that inert gas pumping be accomplished using the HVP(s).

4.2.2.1 High Vacuum Pumps

Selection of the HVP configuration and capacity shall be predicated on satisfying facility requirements regarding:

- o Contaminant protection of the GDS
- o Chamber pumpdown time with GDS in place

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- o Effectively pumping inert gasses, particularly Argon

Objectives and design constraints, discussed in the following subparagraphs, influenced the design and/or selection of pumping equipment.

A reasonable time limit is required for accomplishing chamber pumpdown such that test program progress is not unduly delayed. Figure 2 presents the best, though conservative, current estimate of GDS outgassing characteristic versus time. The maximum outboard leakage of helium from the GDS is specified as 2×10^{-7} scc/sec.

The combination of inboard chamber leakage, vendor estimates of chamber outgassing, GDS leakage, GDS outgassing, and any other relevant gas load shall be the basis of HVP selection such that the vacuum system shall attain a pressure level of 6×10^{-7} Torr in a maximum of 48 hours. A lesser pumpdown time is desirable if cost impact is not severe.

The HVP type selected shall ensure that no volatile lubricants and/or pump working fluids enter the test chamber.

No pump or trap configuration shall be considered for which a power failure, loss of coolant, or single coolant-system rupture would result in chamber influx of anything other than an inert gas. Proposed HVP arrangements should include all peripherals required to interface with standard facilities and energies (e.g. special pump power supplies from standard 110 volt ac single-phase or 440 volt ac 3-phase junction).

A suitable bellows assembly, fabricated from a compatible material, shall be supplied for chamber vibration isolation from any dynamic HVP configuration considered.

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GDS GAS LOAD CHARACTERISTICS

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4.2.2.2 HVP Forepump(s)

Capacity of the HVP forepump(s) shall be properly matched to complement HVP operation. Forepump(s) performance shall be consistent with meeting overall system pumping requirements. A reciprocating design or any design prone to vibration shall be isolated from the facility by a suitable mounting system and from the HVP(s) by a reliable, flexible conduit (bellows) such that excessive vibration is not communicated to the vacuum system or general facility components.

In the event that such a configuration shows any significant performance or reliability advantage, a mechanical or other forepump, backed with a Rootes vapor booster or other boost type pump of intermediate capacity, shall be considered. The forepump shall be thoroughly trapped against contaminant backstreaming to the HVP interface.

4.2.2.3 Sustaining Pump

The sustaining pump (SP) will be utilized to maintain chamber environment during GDS hot testing. The selected pump configuration shall be capable of maintaining a 10^{-7} Torr pressure level of reactive gasses during a 1000-hour test while all other pump systems are isolated and inactive. The vendor shall recommend the reference pump speed based on experience and an estimate of evolved and influx gas loads.

Reliability of the SP selected shall be such that an "up-to-air" failure is essentially precluded. Loss of pumping action is significantly less critical as a failure mode for the SP than chamber contamination.

The SP shall ensure that pumped gases are permanently bonded, either chemically or mechanically, and that no loss of power or coolant failure shall result in any significant evolution of gases.

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Provision for SP isolation from the main chamber shall be included in the design to facilitate SP refurbishment and/or change-out. The SP assembly shall be provided with a roughing and vacuum pump system such that maintenance functions can be performed and the SP returned to service without main chamber pressure exceeding 2×10^{-6} Torr, assuming a test article gas load per Figure 2. Need for spares and provision of emergency SP power for periods up to 1/2 hour shall be evaluated. The design shall allow the SP to be replaced and returned to operation in 1.5 hours from initiation of unit removal.

Orientation of the SP assembly shall be such that pump-generated solids (scale, etc.) will not interfere with proper operation of the isolation valve or other ancillary equipment. Any vulnerable areas of the selected pump will be substantially shielded from impact damage.

Pump configurations considered for the SP shall include, but are not limited to, sputtering and sublimation designs.

4.2.2.4 Tank Roughing Pump

Main chamber roughing can be accomplished using a discrete roughing pump system or, if no compromise in reliability, safety, and performance is incurred, by using the HVP forepump(s).

Since a chamber purge and back-fill sequence is anticipated, a realistic time limit to accomplish tank roughing will be required. The roughing system shall be capable of roughing the chamber to 5×10^{-3} torr in 30 minutes from an initial one atmosphere of air or argon. If a separate roughing system is utilized, provisions shall be included to reliably isolate the roughing system during normal operation.

The roughing system shall be effectively vibration-isolated from adjoining facility components.

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4.2.2.5 Seal Analysis Pump

The seal annulus pump will be used in conjunction with the redundant main chamber seal. The pump shall be capable of maintaining 10^{-2} Torr in the seal annulus operating on either a continuous or intermittent duty basis.

Provisions shall be incorporated to allow isolation of the seal annulus pump from the annulus. The pump shall be vibration-isolated from surrounding facility components.

4.2.2.6 Sustaining Pump Transition Pump

The sustaining pump transition pump (SPTP) shall function to allow the sustaining pump to be brought on-line following service without main chamber pressure exceeding 2×10^{-6} Torr. Pumpdown shall be consistent with requirements of Paragraph 4.2.2.3. The SPTP shall serve to pump down the SP before opening the isolation valve.

Pumping systems considered shall include, but not be limited to, sorbtion and/or mechanical pumps. The sustaining pump may be used to complete pumpdown before opening the isolation valve.

Provisions shall be made to reliably isolate the SPTP from the SP before opening the valve to the main chamber.

The SPTP system shall be protected against impact damage to vulnerable areas.

4.2.3 Valve Requirements

Selection of valves directly interfacing with, or affecting, the main chamber environment shall reflect the basic design philosophy

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of Paragraph 4.2. It is intended that valves be selected to reflect a fail-closed, reliable configuration.

Critical valves shall be reliably sealed from ambient and upstream leakage. At present, bellows sealed valves appear to offer the only viable configuration.

All valves shall be selected to mate with standard and readily available flange designs.

To consolidate requirements of each specific valve, general requirements for each are tabulated in standardized form. A brief discussion of each critical valve, delineating its function and special requirements, is presented in Paragraphs 4.2.3.1 through 4.2.3.6.

4.2.3.1 HVP Isolation Valves

HVP isolation valve(s) are used to:

- (a) Isolate the main chamber rapidly from an influx of contaminants indicated by a rapid rise in tank pressure signaled by an ion gage alarm.
- (b) Effectively isolate the main chamber during long-term testing when the system is maintained by the sustaining pump.

Valve response time is critical to adequately satisfy objective (a) if the HVP is proposed for use during maintenance of replacement of the SP.

The HVP isolation valve selected shall have a flow conductance capability consistent with efficient operation of the selected HVP configuration. General requirements of this device are summarized in Table I.

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TABLE I
HVP ISOLATION VALVE(S) SPECIFICATION

<u>Geometry and Construction</u>	<u>Requirement</u>
Passage Diameter	As proposed (approx. 10 to 12 in.)
Neutral Psn. (N.O., N.C.)	N.C., air to open
Actuation	Pneumatic, N.O. solenoid
Lube or Lubrication allowable	Dry film, no volatiles
Materials	CRES
Protective cover	As required
Seal Type	Viton or equivalent
Closed Pressure Range (Tank)	10^{-8} torr to 15 psia
Closed Pressure Range (Downstream)	10^{-4} torr to 15 psia
Actuation Time to Open	N/A
Actuation Time to Close	Less than 2 seconds
Seal Face Orientation	As proposed
Conductance	Compatible with supplied HVP(s)
Main Plate Leakage	Less than 10^{-10} Scc/Sec helium
Body structure Leakage	Less than 10^{-10} Scc/Sec helium
Orientation	As proposed

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4.2.3.2 HVP Foreline Valve(s)

The HVP foreline valve(s) shall provide more rapid response to a backflow emergency, and a degree of isolation redundancy during normal operation. Requirements of this device are presented in Table II.

4.2.3.3 Emergency Argon Backfill Valve

In the event of an "up-to-air" emergency, or similar occurrence, the main chamber will be flooded with one atmosphere of argon to protect refractory components. The emergency argon backfill valve will normally be required to seal against a regulated argon pressure of 20 psia. Upon electrical actuation, this device shall be required to open and allow argon flow at an initial rate of 1000 SCFM.

Requirements of the emergency argon backfill valve are shown in Table III.

4.2.3.4 Sustaining Pump Isolation Valve

This valve will function to allow repair, refurbishment, or change-out of the sustaining pump assembly by isolating the SP from the main chamber. This valve must exhibit good leak integrity to minimize contaminant influx during SP maintenance. Presently defined requirements of this device are provided in Table IV.

4.2.3.5 Sustaining Pump Transition/Isolation Valve

This valve is normally closed during all modes of operation except following contamination of the SP chamber. During this time, this valve is open to allow SPTP evacuation of the SP cavity.

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TABLE II

HVP FORELINE VALVE SPECIFICATION

<u>Geometry and Construction</u>	<u>Requirements</u>
Passage Diameter	As proposed
Neutral Psn. (N.O., N.C.)	N.C., air to open
Actuation	Pneumatic, N.O. solenoid
Lube or Lubrication allowable	Dry film, no volatiles
Materials	CRES
Protective cover	As required
Seal type	Viton or equivalent
Closed Pressure Range (Tank)	10^{-6} to 15 psia
Closed Pressure Range (Downstream)	10^{-3} to 15 psia
Actuation Time to Open	N/A
Actuation Time to Close	Less than 1 second
Seal Face Orientation	As proposed
Conductance	Compatible with supplied pump assy.
Main plate leakage	Less than 10^{-10} Scc/Sec helium
Body Structure Leakage	Less than 10^{-10} Scc/Sec helium
Orientation	As proposed

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TABLE III
EMERGENCY ARGON BACKFILL VALVE SPECIFICATION

<u>Geometry and Construction</u>	<u>Requirements</u>
Passage Diameter	As required for flow reqmt.
Neutral Psn. (N.O., N.C.)	N.C.
Actuation	Solenoid, power to open
Lube or lubrication allowable	Dry film, no volatile
Materials	CRES
Protective cover	As required
Seal type	Viton or equivalent
Closed Pressure Range (Tank side)	10^{-8} torr to 15 psia
Closed Pressure Range (Argon Pressure side)	15 psia to 25 psia
Actuation time to open	Less than 1/2 second
Actuation time to close	Less than 1/2 second
Seal face orientation	As proposed
Conductance	N/A
Main Plate Leakage	Less than 10^{-10} Scc/Sec helium
Body Structure Leakage	Less than 10^{-10} Scc/Sec helium
Orientation	As proposed

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TABLE IV
SUSTAINING PUMP VALVE SPECIFICATION

<u>Geometry and Construction</u>	<u>Requirement</u>
Passage Diameter	As proposed
Neutral Psn. (N.O., N.C.)	N/A
Actuation	Manual
Lube or Lubrication allowable	Dry film compounds - no volatiles
Materials	Cres
Protective cover	As required
Seal type	Viton or equivalent
Closed Pressure Range (Tank)	10^{-8} torr to 15 psia
Closed Pressure Range (Downstream)	10^{-8} torr to 15 psia
Actuation time to open	N/A
Actuation time to close	N/A
Seal face Orientation	As required for pumping
Conductance	Compatible with pumping req.
Main Plate Leakage (Scc/S)	Less than 10^{-10} Scc/Sec helium
Body Structure Leakage (Scc/S)	Less than 10^{-10} Scc/Sec helium
Orientation	As proposed

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Generally, this valve interfaces with the main chamber environment, and as a result, must be a high reliability, leak-tight device. Requirements for this valve are found in Table V.

4.2.4 Vacuum System Instrumentation

Vacuum system instrumentation will be utilized during facility operation to monitor and record GDS environmental characteristics and to verify normal and satisfactory operation of the vacuum system.

The instrumentation will, in general, be arranged with the sensor element at the chamber wall, and readout display remotely located in the control room. (Refer to Figure 1.) Vacuum system designs shall describe and reflect a unified and organized method of communication between these locations.

Philosophy regarding vacuum chamber integrity and reliability shall be reflected in the design of instrumentation/chamber seals. All vulnerable instrumentation components shall be provided with substantial impact protection (shielding). All vacuum instrumentation sensors (e.g., residual gas analyzer heads, ion gauge heads, etc.) shall be integrated using high-vacuum type, quick-disconnect fittings.

4.2.4.1 Chamber Residual Gas Analyzer

The chamber residual gas analyzer (RGA) will be employed to monitor constituent concentration and pressure within the main chamber during test preparation and duration. Periodic, permanent recording of the residual gas spectrum and chamber total pressure are desired.

During closed-loop preparation and preconditioning, a separate RGA or, if possible, separate RGA head (using the same control) shall

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TABLE V .

SUSTAINING PUMP TRANSITION ISOLATION VALVE SPECIFICATION

<u>Geometry and Construction</u>	<u>Requirements</u>
Passage Diameter	As proposed
Neutral Psn. (N.O., N.C.)	N/A
Actuation	Manual
Lube or Lubrication Allowable	Dry Film - No Volatiles
Materials	CRES
Protective cover	As required
Seal type	Viton or equivalent
Closed Pressure Range (Tank)	10^{-8} torr to 15 psia
Closed Pressure Range (downstream)	10^{-4} torr to 15 psia
Actuation time to open	N/A
Actuation time to close	N/A
Seal Face Orientation	As required for pumping
Conductance	Compatible with pump requirements
Main Plate Leakage (Scc/S)	1×10^{-10} Scc/Sec helium
Body structure leakage (Scc/S)	1×10^{-10} Scc/Sec helium
Orientation	As proposed

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be employed to evaluate closed-loop residual gasses. Specific requirements for the chamber RGA that have been identified, are summarized in Table VI.

4.2.4.2 Closed-Loop Residual Gas Analyzer

As discussed in Paragraph 4.2.4.1, the closed-loop RGA may share a common control/display unit with the chamber RGA. The purpose and requirements of the closed-loop RGA are similar and are presented in Table VII.

4.2.4.3 Chamber Ion Gages

A requirement for three ion gages has been identified. A continuous-duty ion gage, required as a sensory component of the protection system, will be utilized to detect tank pressure rises (resulting from a number of possible failure modes) and to initiate protective action. This gage shall incorporate a setpoint alarm feature variable from 10^{-4} to 10^{-6} Torr and generate an output alarm signal to initiate control logic.

Two ion-gage heads with a single control unit (redundant) shall be used for more accurate data acquisition regarding vacuum system performance. Pressure readings will be completed on a periodic basis. Requirements for ion gages are presented in Tables VIII and IX.

4.2.4.4 Interstage Vacuum Gage(s)

This gage(s) shall span the intermediate pressure range between the HVP(s) and the HVP forepump(s). Pressure readings will be used to monitor and verify HVP and forepump system operation. Requirements now established for the interstage vacuum gage(s) are tabulated in Table X.

TABLE VI

CHAMBER RESIDUAL GAS ANALYZER INSTRUMENTATION SPECIFICATION

<u>Performance and Features</u>	<u>Requirements</u>
Mass Range	1 - 100 AMU
Auto. Range Transition	N/A
Output Mode (Meter, Digital, CRT, BCD, Recording Analog, etc.)	Digital and CRT
Resolution	1 AMU @ 10% peak height
Response Time Required	N/A
Direct Total Pressure Readout	Digital or meter
Direct Partial Pressure Readout	
Leak Detection Capability	Yes
Remote On/Off Switching	Yes
Overpressure shutoff	Required
Automatic emission control	Optional
Automatic control output (set points)	Overpressure shutoff
Scan Rate	2 Scans/Sec or faster
 <u>Facility Installation</u>	
Available Power for Component	110 VAC, 60 Hz
 <u>Duty Cycle, Life, and Environment</u>	
On Time Percentage and Rate (Cycle Time)	10%, 1 cycle per hour
Total Life Required (hours)	5000 (total off and on)
Maximum Operating Flange Temperature (°F)	200
Maximum Nonoperating Temperature (°F)	200
Maximum Nonoperating Pressure (psia)	15
 <u>General</u>	
Redundancy Required	No
Impact Shield Required	Vulnerable areas

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TABLE VII

CLOSED LOOP RESIDUAL GAS ANALYZER INSTRUMENTATION SPECIFICATION

<u>Performance and Features</u>	<u>Requirements</u>
Output Range	1 - 100 AMU
Auto. Range Transition	N/A
Output Mode (Meter, Digital, CRT, BCD, Recording Analog, etc.)	Digital and CRT
Resolution	1 AMU @ 10% peak height
Response Time Required	N/A
Direct Total Pressure Readout	Digital or meter
Direct Partial Pressure Readout	N/A
Leak Detection Capability	No
Remote On/Off Switching	Yes
Overpressure Shutoff	Required
Automatic Emission Control	No
Automatic Control, Output (Set points)	N/A
Scan Rate	2 Scan/Sec or faster
<u>Facility Installation</u>	
Available Power for Component	110 VAC, 60 Hz
<u>Duty Cycle, Life, and Environment</u>	
On Time Percentage and Rate (Cycle Time)	1%, 1 cycle/hr.
Total Life Required (Hours)	5000 (total off and on time)
Maximum Operating Flange Temperature (°F)	400
Maximum Nonoperating Temperature (°F)	400
Maximum Nonoperating Pressure (psia)	15
<u>General</u>	
Redundancy Required	No
Impact Shield Required	Vulnerable areas

TABLE VIII

ION GAGE REQUIREMENTS (SENSORY COMPONENT) INSTRUMENTATION SPECIFICATION

<u>Performance and Features</u>	<u>Requirement</u>
Pressure Range	10^{-3} torr to 10^{-8} torr
Auto. Range Transition	Optional
Output Mode (Meter, Digital, Scope, BCD, Recording Analog, etc.)	Digital or meter
Response Time Required	1 Second
Direct Total Pressure Readout	Digital or meter
Direct Partial Pressure Readout	N/A
Leak Detection Capability	N/A
Remote On/Off Switching	Yes
Overpressure Shutoff	10^{-4} torr setpoint alarm
Automatic Emission Control	N/A
Automatic Control Output (Set Points)	Dual, 10^{-4} to 10^{-6} torr (adjustable)
Scan Rate	N/A
<u>Facility Installation</u>	
Available Power for Component	115 VAC 60 cycle single phase
<u>Duty Cycle, Life, and Environment</u>	
On Time Percentage and Rate (Cycle Time)	100% at pressures below 10^{-3} torr
Total Life Required (Hours)	5000 hrs.
Maximum Operating Flange Temperature (°F)	200
Maximum Nonoperating Temperature (°F)	200
Maximum Nonoperating Pressure (psia)	15
<u>General</u>	
Redundancy Required	No
Impact Shield Required	Vulnerable Areas

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TABLE IX

ION GAGE (CONSTANT READOUT) INSTRUMENTATION SPECIFICATION

<u>Performance and Features</u>	<u>Requirement</u>
Pressure Range	10^{-3} to 10^{-8} torr
Auto. Range Transition	Optional
Output Mode (Meter, Digital, Scope, BDC, Recording Analog, etc.)	Digital or meter and analog
Response Time Required	N/A
Direct Total Pressure Readout	Digital or meter
Direct Partial Pressure Readout	N/A
Leak Detection Capability	N/A
Remote On/Off Switching	Yes
Overpressure Shutoff	Yes
Automatic Emission Control	Optional
Automatic Control Output (Set Points)	Not required
Scan Rate	N/A
<u>Facility Installation</u>	
Available Power for Component	115 VAC 60 cycle single phase
<u>Duty Cycle, Life, and Environment</u>	
On time percentage and rate (Cycle Time)	100% at pressures below 10^{-4} torr
Total Life Required (Hours)	5000 hrs.
Maximum Operating Flange Temperature ($^{\circ}$ F)	200
Maximum Nonoperating Temperature ($^{\circ}$ F)	200
Maximum Nonoperating Pressure (psia)	15
<u>General</u>	
Redundancy Required	Yes two
Impact Shield Required	Vulnerable areas

TABLE X

INTERSTAGE VACUUM GAGE INSTRUMENTATION SPECIFICATION

Performance and Features

Requirement

Pressure Range	10^{-3} to 15 psia
Auto. Range Transition	N/A
Output Mode (Meter, Digital, Scope, BCD, Recording Analog, etc.)	Meter or digital
Response Time Required	N/A
Direct Total Pressure Readout	Yes
Direct Partial Pressure Readout	N/A
Leak Detection Capability	N/A
Remote On/Off Switching	Yes
Overpressure shutoff	As required.
Automatic Emission Control	N/A
Automatic Control Output (Set Points)	Yes
Scan Rate	N/A

Facility Installation

Available Power for Component	115 VAC 60 Hz, single phase
-------------------------------	-----------------------------

Duty Cycle, Life, and Environment

On Time Percentage and Rate (Cycle Time)	100% of forepump operation (10% of total)*
Total Life Required (Hours)	5000 (total off and on time)
Maximum Operating Flange Temperature (°F)	150
Maximum Nonoperating Temperature (°F)	150
Maximum Nonoperating Pressure (psia)	15

General

*1 cycle/day

Redundancy Required	No
Impact Shield Required	Vulnerable areas

4.2.4.5 Sustaining Pump Vacuum Gage

The sustaining pump vacuum gage shall provide a total pressure measurement within the SP cavity when isolated from the main chamber. A pressure reading of less than 10^{-6} Torr will constitute a sufficient vacuum to allow the SP to be returned to service.

Table XI contains identified requirements for this device.

4.2.4.6 Seal Annulus Vacuum Gage

If a redundant main chamber seal is incorporated, annulus pressure, expected to range from 10^{-1} to 10^{-3} Torr total pressure, shall be monitored. The seal annulus vacuum gage shall provide a vacuum control panel display of this parameter. The seal annulus vacuum gage shall be located on the stationary flange of the chamber.

4.2.5 Vacuum System Protection Instrumentation

A free-standing, 19-inch panel-type control console shall be used to contain all electrical controls and instrumentation. All circuits shall be properly fused. All pumps shall be provided with thermally protected magnetic motor starters with time delay alarm interlocks. All valve connections shall terminate in a terminal strip in the control console with all terminals labeled and identified.

4.2.6 Operating Instructions and Maintenance Manuals

Complete operating instructions and maintenance manuals shall be provided and, as a minimum requirement, shall include the following:

- (a) Operating instructions
- (b) Installation instructions
- (c) Complete electrical schematics and wiring diagrams

TABLE XI

SUSTAINING PUMP VACUUM GAGE INSTRUMENTATION SPECIFICATION

Performance and Features

Requirement

Output Range	10^{-8} to 10^{-2} torr
Auto. Range Transition	Optional
Output Mode (Meter, Digital, Scope, BCD, Recording Analog, etc.)	Digital or meter
Response Time Required	N/A
Direct Total Pressure Readout	Yes
Direct Partial Pressure Readout	Not required
Leak Detection Capability	Not required
Remote On/Off Switching	Yes
Overpressure Shutoff	10^{-4} torr and above
Automatic Emission Control	Optional
Automatic Control Output (Set Points)	No
Scan Rate	N/A

Facility Installation

Available Power for Component	115 VAC 60 Hz, single phase
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Duty Cycle, Life, and Environment

On Time Percentage and Rate (Cycle Time)	As required per pump operation
Total Life Required (Hours)	5000
Maximum operating flange temperature (°F)	150
Maximum Nonoperating Temperature (°F)	150
Maximum Nonoperating Pressure (psia)	15

General

Redundancy Required	No
Impact Shield Required	Vulnerable Areas

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4.3 Gas/Facility Instrumentation and Recording

The GDS and test facility shall incorporate sufficient instrumentation to verify satisfactory performance of individual components and accurately assess system performance. Key operating instrumentation shall be interlocked to an appropriate alarm system with automatic protective action sequence. Instrumentation, particularly GDS pressure sensing, shall be arranged in a manner which will minimize the cumulative error in measurement from sensor to readout device.

Electrical instrumentation leads shall be adequately shielded against electrical noise reception from the power supply control and return lines, GDS, and other facility noise sources. Instrumentation associated directly with the vacuum system is discussed in Paragraph 4.2. A summary of current GDS instrumentation detail is provided in Table B17303 of Appendix I.

4.3.1 GDS Instrumentation

The locations, type and required accuracies of the GDS instrumentation are summarized in Table B17303 of Appendix I. The GDS instrumentation arrangement is also shown on the system Plumbing and Instrumentation Diagram, Drawing No. 306960 of Appendix I.

4.3.1.1 Pneumatic Pressure Acquisition

The instrumentation shall include five high resolution pneumatic pressure gages, Heise or equivalent, yielding a full scale accuracy of 0.1 percent. Pressures monitored will include the inlet and discharge pressures from the GDS compressor and the inlet pressure to the flow measuring section.

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Gage mounting and display shall be in accordance with Paragraph 4.4.

4.3.1.2 Transducer Pressure Acquisition

The instrumentation shall include a total of 12 direct pressure and 8 differential pressure transducers as summarized in Table B17303 of Appendix I. The specifications of the transducers shall be equivalent to or better than those for Stratham bi-directional transducers. The selected transducers shall be compatible with trend recorder (Sanborn or equivalent) or digital (AUTODATA 9 or equivalent) acquisition. The direct pressure transducers shall be referenced to hard vacuum within the test chamber.

4.3.1.3 Thermocouple Temperature Acquisition

The combined total of thermocouple instrumentation locations in the GDS (including HSAs) and related facility is as follows:

Chromel/Alumel - 115 locations

W/Re - 115 locations

In order to obtain the temperature accuracies desired, premium chromel/alumel wire shall be used. Its accuracy shall be at least $\pm 3/8$ percent full scale between 530 and 2300°F and $\pm 2^\circ\text{F}$ from 32 to 530°F. Metal sheathed, MgO insulated wire shall be used.

4.3.1.4 Rotating Speed Acquisition

The GDS rotating speed shall be acquired with a magnetic monopole. The speed shall be indicated on an EPUT counter. More than one transducer shall be available for reliability. The EPUT shall be calibrated to read rpm directly with an accuracy of ± 10 -rpm.

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The GDS rotating speed shall also be frequency to analog converted to a form compatible with trend recording (Sanborn Recorder).

Rotating speed readout mounting and display shall be in accordance with Paragraph 4.4.

4.3.1.5 Coolant Flowrate Acquisition

Flow measurement of the loop coolant will be measured with a turbine type meter. The meter output in digital form shall be displayed on an EPUT. The flowmeter output shall be converted, if necessary, for digital acquisition on the data logger. The mounting and display shall be in accordance with Paragraph 4.4.

4.3.1.6 Working Fluid Flowrate Acquisition

The working fluid flowrate shall be measured with a differential pressure transducer reading across a venturi section in the GDS compressor inlet line. The venturi shall be sized to operate at a pressure loss of 0.14 psid at the GDS (2 HSA) reference operating point.

4.3.1.7 WFMS Instrumentation

The instrumentation for the WFMS shall be similar to the thermocouples and pressure transducers used in the closed loop system. Ranges and accuracies shall be the same as in the closed loop.

4.4 Ground Test Console Requirements

The ground test console (GTC) design philosophy shall be to provide an attractive, functional, and flexible unit. All components shall be installed in locations that are easily accessible without

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disturbing other components. As is typical of all development units, system modification capability is essential and therefore this design shall provide for ease of modification of all key components. Figure 3 shows a preliminary rendering of the GTC and related control and recording equipment.

The floor plan arrangement for the control room is shown in Figure 4. (Also refer to Figure 1).

Control stations ① and ② shall be occupied by trend recorders, Sanborn type or similar, with a total capacity of at least 12 channels. Three recording channels shall be adapted for digital (frequency) input consistent with the GDS monopole speed signal and coolant turbine flowmeter signal. The remaining channels shall be consistent with recording of thermocouple (C/A and W/Re) and strain gage pressure transducer input.

Control station ③ shall be occupied by the vacuum system control console specifications for which are described in Paragraph 4.2 of this document. The vacuum system console will be contained in one standard 19 inch vertical console.

Alarm signals generated in the vacuum system controls HSA control panel station ⑦. Appropriate protection system circuitry shall be provided to accomplish alarm and action interlock in accordance with the final control specifications.

Control station ④ shall house the primary data acquisition equipment and selector type digital thermocouple readout.

The selected digital data acquisition device shall incorporate the basic features and accuracies of the AUTODATA Nine Monitor. Specifically the following features are required:

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GDS CONTROL CONSOLES

FIGURE 3

CONTROL ROOM DIAGRAM

FIGURE 4

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- (a) A minimum of 350 channel capacity
- (b) A minimum scan rate of 20 channels/second
- (c) Permanent scan recording via line printer
- (d) Compatibility with BCD tape recording
- (e) A minimum of 3 alarm levels per channel
- (f) Alarm output signals segregated by channel groupings

Also included in the control station ④ panel shall be:

- (a) A digital thermocouple readout, doric or equivalent for C/A sensors and a 48 channel selector
- (b) Same as (a) for W/Re thermocouples
- (c) A digital frequency display, EPUT or equivalent, to display coolant flowmeter output signal

Control station ⑤ shall provide individual digital display of key GDS operating parameters as summarized below:

- (a) Turbine inlet temperature
- (b) Compressor inlet temperature
- (c) GDS rotating speed
- (d) Compressor inlet flowrate
- (e) User supply power
- (f) Parasitic load power

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Also included on the control station ⑤ panel will be the manual emergency shutdown actuator and facility alarm and warning system.

Provision shall also be made to provide 24 component GDS status indicators and associated manual/automatic selector switches for each component. A graphic layout of status indicators shall be implemented if practical.

Control station ⑥ shall include the basic GDS control panel as described herein. Five high resolution pressure gages shall be mounted above station ⑥ as shown in Figure 3. The panel at station ⑥ shall provide to facility status indicators and associated manual/automatic selector switches. A graphic layout of status indicators shall be implemented if practical.

Control station ⑦ shall be the GDS/Facility Protection System. This unit shall accomplish communication with the vacuum system controls, GDS overspeeds control, manual emergency shutdown, GDS controls and the two HSA power supply consoles (PSC). The GDS/Facility Protection System shall provide a remote indication of HSA control status and provide automated protective/emergency action sequencing.

Control stations ⑧ and ⑨ shall be the HSA Power Supply Consoles. The PSC requirements and description is contained in Paragraph 4.4.6.

Specific requirements for the control equipment is given in the following paragraphs.

4.4.1 Data Acquisition Panel

The data acquisition panel provides the capability of acquiring, converting, and recording up to 1000 channels of system data. The basic components and a description of each is given below:

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4.4.1.1 Data Acquisition, Computing and Alarm Module

This device shall be an off-the-shelf device manufactured by ACUREX Corporation, 485 Clyde Avenue, Mountain View, California 94042. The name of this device is the AUTODATA NINE. Its capabilities are:

- (a) Acquires and converts up to 1000 channels (with optional scanners) of instrumentation data
- (b) Provides up to 127 levels of alarm (i.e., a level is a parameter value--example 200 psia is one level and may be applied to more than one channel)

Each channel may have up to 4 levels of alarm (i.e., high, low, medium, etc.) of alarm. The scan rate is approximately 25 channels/sec.

- (c) Provides a printed record of all alarm setpoints.
- (d) Provides capability of monitoring any channel while maintaining scan.
- (e) Interface capabilities with peripheral devices (i.e., magnetic tape, cathode ray tubes, teletypes, etc.)

4.4.1.2 Magnetic Tape Storage Device

The magnetic tape storage device shall be incorporated and provide the functions as outlined below.

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- (a) The magnetic tape storage device is interfaced with the AUTODATA NINE and has the capability of recording 886,000 words of data per reel of tape
- (b) The tape format is flexible and can be tailored to existing computer systems at AiResearch
- (c) The recording rate is selectable and controlled by the data acquisition, computing, and alarm module (i.e., adjustable from continuous scan up to one scan per hour).

4.4.2 Operator Panel

The operator, panel shall be comprised of a series of critical data displays and a status panel.

- (a) The critical data displays and alarms are necessary because the data acquisition, computing, and alarm module will be set to scan at a given rate and during fast transients (i.e., startup, load changes, etc.) certain parameters will possibly vary too rapidly to be caught by the scanner. Capability of separately monitoring and recording these parameters shall be incorporated.
- (b) The status panel shall annunciate system events (i.e., valve closures, pump status, etc.) and have the capability of manual override on selected parameters. This panel shall be interfaced with the rest of the system and give a visual indication of system status.

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- (c) Included on the operator panel shall be an emergency shutdown button. This button shall be integrated with the rest of the system so the system can be shutdown in a safe manner.
- (d) A facility warning button shall be included on the panel to activate an alarm system to prevent personnel injury in the event of a hazardous condition.
- (e) Also included shall be an engine system mass flow rate indicator and an intercom system terminal.

4.4.3 Control/Monitor Panel

The control/monitor panel shall contain the engine system electronic control system direct pressure gage readouts and a control panel for system ancillary devices.

- (a) The system electronic control shall perform the function of operating the GDS in a safe, efficient manner. Sufficient flexibility shall be incorporated commensurate with a development system. The control shall be completely integrated with the system and shall be subject to all safety and operating procedures.
- (b) Provision for readouts of miscellaneous parameters shall be provided on the miscellaneous readout panel.
- (c) The control panel for system ancillary devices shall provide control of devices/function which are always attendant to a laboratory system (i.e., boost pumps, facility power, water pumps, etc.)

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4.4.4 Pressure Monitor Panel

The pressure monitor panel shall provide a direct gage readout of critical system pressures. High resolution Heise gages are used in parallel with transducers in monitoring for the data acquisition system.

4.4.5 Vacuum Control Console

This unit shall be comprised of vacuum control panels to be manufactured by the selected vacuum system vendor. Complete integration with the system shall be made to insure safe maintenance of system vacuum. Also included on this console is a gas analyzer. This unit shall also be integrated into the system. A power supply and control for these units shall be included in the console.

4.4.6 HSA Power Supply Consoles

These consoles shall be supplied by the subcontractor General Electric and control the power to the electric heat sources. These consoles and their associated requirements (i.e., alarms, interlocks, etc.) shall be integrated with remainder of the system controls.

4.4.7 Transient Recorders

These units shall be standard 6 or 8 channel Sanborn recorders. Pertinent parameters shall be monitored and recorded subject to test operator discretion. All cabling for the recorders shall utilize the control room cabling to the highest possible extent to maintain system reliability and integrity.

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4.4.8 Cabling

The cabling system shall be designed for maximum flexibility subject to the design constraints normally used in laboratory environments, (i.e., electrical noise, safety, etc.) Instrumentation/power leads shall be designed so as to be routed behind the panels for aesthetic/operational purposes. Wherever possible access to instrumentation cabling shall be provided.

4.5 Working Fluid Management System (WFMS)

The working fluid management system (WFMS) shall be designed to

- (1) purify, sample, and control GDS closed-loop working fluid, and
- (2) provide the GDS with working fluid overpressure protection. The current WFMS configuration is depicted in Piping and Instrumentation Diagram, (Drawing No. 306960 in Appendix I).

To provide a contaminant-free gas inventory and to facilitate GDS decontamination, vacuum leak-tight connections and components are required for the WFMS. A helium leak rate of less than 10^{-8} sec/sec is acceptable for the combined WFMS assembly.

Isolation valves connecting the GDS and WFMS will require a combined maximum helium leakage rate of less than 1×10^{-10} sec/sec to properly evaluate GDS loop integrity.

4.5.1 Hot Titanium Getter

The hot titanium getter (HTG) will provide dual functions of

- (1) de-contaminating the purge-bake out-backfill medium in GDS closed-loop cleanup, and
- (2) purifying the GDS working fluid.

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During the GDS closed-loop cleanup operation, the purge medium (probably argon) will be introduced into the GDS through the HTG. Before entering the GDS loop, the purge medium will pass over chemically activated surfaces of the HTG, thereby removing most of the reactive contaminants.

In the GDS gas inventory loading (either krypton or Xe/He), the HTG shall purify the GDS working fluid.

The HTG shall be an electrically heated, high-surface-area bed of activated titanium chips. The HTG core shall be maintained at $1400^{\circ}\text{F} \pm 50^{\circ}\text{F}$ during the gas or loop purification procedure. Titanium bed size, chip size, and maximum gas throughput shall be determined such that a 95-percent complete capture of reactive elements is assured. A containment and/or size grading procedure shall be incorporated to preclude particulate carry-over from the HTG to the GDS.

HTG design shall provide for replenishment of the titanium load and/or heating element, if necessary.

4.5.2 Working Fluid and Purge Gas Supply

Two independent gas supply systems feed the WFMS (refer to Drawing No. 306960 of Appendix I). Argon will be laboratory-supplied; individual argon bottles will not be required. Gas supply purity is 99.995 percent (5 ppm H_2O) and it is intended that the ppm contaminants will be further reduced by the HTG. As a result, a line of laboratory-supplied argon will be connected to the WFMS at a pressure of 215 psia, regulated at 100 psia.

The Xe/He will be supplied by a vendor (to be selected) in bottles with a pressure of 500 psia. A regulated pressure of 50 psia shall be supplied to WFMS. Contaminant level shall not exceed values tabulated below:

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Contaminant level shall not exceed values tabulated below:

CO ₂ - 3.335 ppm	O ₂ - 3.52 ppm
CO - 1 ppm	THC - 3.335 ppm
CH ₄ - 3.335 ppm	H ₂ O - 0.815 ppm
Ne - 1.85 ppm	H ₂ - 3.15 ppm
N ₂ - 8.15 ppm	ΔK _r - 15.75 ppm
N ₂ O - 0.1 ppm	

Both the working fluid and purge gas supply systems shall also include the following:

- o Downstream sensor pressure regulator adjustable from 0 to 100 psig
- o 0 to 100 psi +2 psi pressure gage
- o Manual isolation valve

Flow from both gas supply systems shall be metered to the downstream WFMS system using a suitable low-leakage manual valve.

4.5.3 WFMS Overpressure Protection

The WFMS shall incorporate a relief valve upstream of the HTG to preclude WFMS or GDS overpressure accidents. The relief valve shall be adjustable from 20 to 100 psig cracking pressure.

4.5.4 Vacuum Pump and Vent

The WFMS shall be equipped with both a vacuum pump, for WFMS and GDS evacuation, and a vent to ambient. Both the pump and vent forelines shall incorporate a suitable manual isolation valve.

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The WFMS vacuum pump shall be capable of evacuating the GDS from one atmosphere of argon to 5×10^{-3} Torr vacuum in 30 minutes. The pump foreline shall be equipped with a McLeod, or similar vacuum gage to indicate WFMS vacuum level.

4.5.5 Sample Port

The WFMS shall incorporate a port to extract working fluid samples on a periodic basis. The sample line shall be isolated from the GDS loop using a manual valve/metering needle valve series arrangement. The sample line shall include a termination fitting compatible with the 0.25 in. sample ampule. The ampule shall have a 0.5 in. line compatible with the mass specification unit for purposes of drawing the sample gas from the ampule.

4.6 Control System Interface

Primary control system objectives are to:

- o Provide appropriate conditioned power required to start the BIPS
- o Provide field current control to maintain desired output voltage consistent with operating conditions
- o Adjust parasitic load to maintain the most efficient combination of turbine inlet temperature and speed.

The GDS control system shall be breadboard style consisting of microcircuits, discrete transistors (signal and power), and passive components configured to eliminate possibility of system failure due to a single fault. Provision shall be made to allow rapid, front panel changes in gains and set points. Easy access to all replaceable components and test points shall be a primary goal.

To the greatest extent possible, control circuits, parasitic load, and sensors shall be located outside the vacuum chamber. Connections to power and signal leads within the chamber shall be made by hermetic feed-throughs.

4.6.1 Facility and System Interface

Facility and system interfaces consist of electrical wiring only. Refer to Table XII for a summary of wire sizes, voltages, currents, etc.

4.6.2 Instrumentation Requirements

Instrumentation is required to monitor electrical power output for:

- o Evaluation of voltage regulator and filtering circuits
- o GDS speed and T_6 for speed control loop evaluation
- o Input power for start-up inverter evaluation

Instrumentation requirements and a list of parameters to be monitored are presented in Table XIII.

4.6.3 Required Facilities and Energies

Facility support requirements include a variable 0 to 30 volt, 50 amp dc supply and a source of 110 vac for instrumentation and power supplies.

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TABLE XII

Signal/ Power Source	No. of Leads	AWG	-	Volts	Amps
T ₆	6	No. 18*		<1v	<500 ma.
N ₁	6	No. 20		<5v	<500 ma
Search coil	2	No. 20		<10v	<500 ma
Field	4	No. 18		<20v	<2A
Alt output/ inverter output	4	No. 12		<160v PK	<50A
Facility 28 vdc	2	No. 12		<30 vdc	<50A
Facility 120 vac	3	No. 16		120 vdc	<20A

*Thermocouple type

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TABLE XIII

<u>Parameter</u>	<u>Instrumentation</u>
Parasitic load status	5
Speed	1, 4
T_6	2, 4
E_ϕ (A-N, B-N, C-N)	6
I_ϕ (ϕA , ϕB , ϕC , N)	6
E_{DC}	3, 4
I_{DC}	3, 4
P_O DC	6, 4
P_O AC	6, 4
KVA	6, 4
I_{FIELD}	3, 4
Inverter volts	6, 4
Inverter current	6, 4

- 1 Counter - Anadex
- 2 Doric
- 3 Voltmeter, Digital
- 4 Sanborn
- 5 Indicator Lamps
- 6
- 7 Oscilloscope*

*Used at test points

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4.7 Dry Box Requirements

A dry box system is utilized for contaminant-free welds of GDS components, preconditioning and preparation of the GDS system for test, and preparation of components and subassemblies for long-term storage. The system will be installed within the overall test facility shown in floor plan Figure 1.

To accomplish final GDS fabrication and assembly, the dry box shall comply with the same dimensional and structural interface requirements, as applicable, for the vacuum chamber discussed in Paragraph 4.2.

The dry box will be purified by repeated vacuum purging, followed by backfill with high purity inert atmosphere. The environment within the dry box shall exhibit less than 1 ppm of any given contaminant, and be capable of achieving such a level within two hours following exposure to ambient air.

Glove port locations and the basic dry box geometry shall allow easy access to, and maneuverability of, components and assemblies within the controlled environment.

4.7.1 Geometry and Construction Requirements

The dry box shall be of 3/8-inch ASTM-A285, Grade 3 carbon steel plate or 304 stainless steel construction to minimize desorption of gases from the dry box walls. The dry box design shall incorporate a full opening door at one end of the chamber. A vacuum-purged air lock shall also be incorporated. A minimum of six glove-port pairs is required to meet accessibility objectives of Paragraph 4.7.

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To verify dry box vacuum integrity, at an ultimate pressure of 1 micron (clean, dry and empty), a rate of rise of 0.5 microns Hg per minute, starting at 1 micron, is required. Total in-leakage shall not exceed 60 microns Hg in two hours.

4.7.2 Ancillary Equipment and Instrumentation

The dry box design shall incorporate a gas purification train for water vapor and oxygen to (1) accomplish final atmospheric purification, (2) lessen the purity requirements of the inert gas used, and (3) continually remove evolved (desorbed, leaked) H_2O and O_2 from the chamber.

Controls, valves, and piping required to accomplish glove port pressure equalization shall be provided. An air lock shall be provided for tools, parts, and completed assemblies to be passed into or out of the chamber without adding more than 0.01 percent contamination to the existing atmosphere.

The chamber shall be internally fitted with a grounded 110-vac duplex outlet and suitable lighting for performance of close and detailed procedures. The chamber shall also be fitted with a tungsten inert gas (TIG) welding head pass through, and power supply.

A chamber gas regulator for controlled flow and a chamber blow-off relief valve, set at 1.1 atmospheres, shall be provided.

The dry box shall be fitted with a residual gas analyzer (RGA) with a sensitivity sufficient to detect 5.0 ppm water vapor and 1 ppm oxygen.

The vacuum pumping system shall be capable of providing an ultimate pressure to the enclosure of 10 micron in less than 30 minutes.

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The mechanical vacuum pump shall be capable of attaining a base pressure of 0.10 micron Hg. Power required will be 10 KVA, 440 v, single-phase, 60 cycle, with the capability of converting from 3 phase to form required.

Glove-port assemblies shall be fabricated from aluminum and installed in pairs. To provide low permeability, the gloves shall be made of Butyl rubber.

4.7.3 Instrumentation

Instrumentation provided shall include vacuum pressure gauges, gas regulators for argon supply to the dry box, and a residual gas analyzer to monitor constituents.

The two vacuum gauges shall be 0-30 inch Hg dial type, one mounted on the main chamber and one on the air lock. A two-station thermocouple gauge control, with elements in the main chamber and vacuum pumping line, shall be supplied for monitoring vacuum from 1 to 1000 microns.

An RGA or an integral console, capable of detecting 5.0 ppm H_2O and 1 ppm O_2 , is required to provide an atmosphere compatible for welding Cb-C103, etc.

4.7.4 Facility Interface

Facility interface requirements for the vacuum dry box operation are:

- o Power supply for pump, lamps, welding, gauges, etc.
- o Argon supply line
- o Ducting for vacuum pump

The argon gas supply line shall be at least 1/4-inch stainless steel tubing. The supply line to be attached to the box shall have a flared-type fitting.

Ducting to the main enclosure shall be fabricated from 2-inch diameter copper tubing with all joints silver-soldered for vacuum integrity. A 3/4-inch copper duct shall be used for the air lock and glove ports. These 3/4-inch lines shall be tapped off the 2-inch line used for the main pump-down line of the vacuum dry box. Valves needed for management of the air lock, glove ports, and vacuum dry box shall be determined by individual case.

4.8 HSA ACS Gas Management System

The HSA ACS gas management system (GMS) will be assembled and supplied by GE as support equipment for GFE HSAs (refer to Piping and Instrumentation Diagram, Drawing No. 360960 of Appendix I). AIRPHX responsibility will consist of GMS interfacing and integration with the GDS test facility. These areas are discussed in the paragraphs that follow.

4.8.1 Vacuum System Interface

The HSA-GMS function requires both pneumatic and electronic exchange with the two HSAs within the vacuum chamber. Because the final HSA ACS vent line configuration is not yet established, flexible provisions for interconnection are required.

The GMS-to-vacuum system interface shall include the following provisions:

- (a) Two vent and supply lines penetrating the vacuum chamber stationary dome (see Paragraph 4.2.1.5 for specific feed-through requirements). These lines shall be of 0.5 OD, 20-gage wall, CRES 304 construction. All connectors shall be high-vacuum-system

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type with positive leak protection. Lines shall interconnect chamber feed-throughs and GMS pump with the shortest possible length to enhance vacuum flow conductance. The lines shall be cleaned per AiResearch Report 76-311746 immediately before installation.

- (b) Four 20 AWG electrical lines to provide actuation current to the GMS vent/supply solenoids within the vacuum chamber. (Refer to Paragraph 4.2.1.5 for specific feed-through requirements.)

4.8.2 Facilities and Energies

The following subparagraphs delineate facilities and energies required for GMS support.

4.8.2.1 Electrical Power

The GMS will include a portable gas service cart which incorporates a vacuum pump for HSA venting. The gas service cart will require 30 amp, 110 vac, 60-cycle power. GMS solenoid valves will require 1.5 amp, max 35 vdc.

4.8.2.2 Argon Supply

The argon supply used to short circuit Multi-Foil HSA insulation in the ACS mode shall have 10 ppm maximum impurities. Argon will be in bulk supply at 215 psia and regulated at 15 psia. If laboratory-supplied argon purity is not acceptable, a separate supply must be made available for the GMS.

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4.8.3 GTC Interface

The GMS shall include an overpressure/overtemperature alarm system to alert the test operator. The alarm system interface with the GTC through the following connectors:

- o TBD 22 AWG 2-wire thermocouple connectors
- o TBD 24 AWG insulated wires

4.8.4 Floor Space

The GMS, including gas service cart, will require an area TBD feet by TBD feet immediately adjacent to the stationary vacuum chamber dome.

4.9 Power Supply Consoles (PSC)

Electrical heat input to the GDS cycle will be controlled and conditioned by two GFE power supply consoles (PSC). Since the PSCs are GFE, AIRPHX responsibility will consist of PSC integration and interfacing with the GDS test facility. PSC interfaces, area requirements and required energies are discussed in the following paragraphs.

4.9.1 Vacuum System Interface

The PSCs are required to deliver conditioned electrical power to the GDS within the vacuum chamber. Four conductors No. 6 AWG vacuum feed-throughs will be required to provide this function (refer to Paragraph 4.2.1.5 for feed-through requirements).

4.9.2 Facilities and Energies

Each PSC will require 50 amp, 208 volt, ac, 3-phase, 5-wire service.

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4.9.3 GTC Interface

The PSCs shall communicate with GTC components by electrical interlocks defined in the GDS/facility protection system (see Paragraph 4.4).

4.9.4 Floor Space

The two PSC will each occupy a TBD by TBD inch floor area in Room ① of Figure 1.

4.10 Facilities, Energies and Peripherals

The GDS assembly and test facility shall be provided with forms of energies and support equipment required to accomplish GDS component cleaning and storage and GDS Assembly, and to support the GDS test program.

4.10.1 Electrical Power

The basic facility electrical supply shall include the following:

- (a) 440 volt ac, 3-phase, 5-wire service
- (b) 208 volt ac, 3-phase, 5-wire service
- (c) 115 volt ac, single-phase, 3-wire service

A requirement for single-phase, 220 vac service may exist, depending on selected facility equipment. This requirement may be fulfilled by using transformed 440 volt service or other expedient means. Table XIII summarizes the current definition of electrical demand of facility components.

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4.10.2 Shop Air Supply

Facility shop air shall be provided to the stations and in the quantity stated in Table B17303 of Appendix I. To preserve the contamination-free assembly and test area environment, the shop air supply must be effectively filtered against passage of oils and related contaminants, as well as particulates. The filtration system shall effectively remove 99.94 percent of organic materials, and be equivalent to a 10 micron absolute particle filter. The delivery system shall also incorporate an air dryer. All shop air lines shall be effectively flushed or otherwise cleaned following final installation.

4.10.3 Liquid Argon Supply

Liquid argon shall be provided in the vacuum system installation area to provide the following functions:

- (a) Emergency backfill of vacuum chamber
- (b) Purge and backfill of GDS
- (c) ACS functions
- (d) Vacuum system cold traps (if incorporated)

Argon shall be delivered with a maximum active contaminant level of 10 ppm.

4.10.4 Dry Nitrogen Supply

Dry nitrogen shall be provided to Room ⑤ for use in storage cubicles. Specific requirements of the dry nitrogen supply is discussed in Paragraph 4.1.7.

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4.10.5 Tap Water

Tap water shall be provided to the locations required and identified to be completed by AiResearch Plant Engineering.

The tap water supply shall be fitted with a 10-micron absolute line filter. All water lines shall be effectively flushed following final installation.

4.10.6 Facility Coolant Systems

The vacuum system and GDS test article will require several coolant flows during test operations. Specific requirements for coolant flows are presented in the following paragraphs.

4.10.6.1 HRHX Coolant System

The GDS must be capable of rejecting approximately 75 percent of the gross thermal input to a coolant with a maximum inlet temperature of -20°F. Maximum anticipated load for this coolant flow is 20,000 BTUs per hour. This coolant function will require a refrigeration system rated at approximately 2 tons at -30°F operating at the maximum anticipated condenser temperature. System reliability requires that an emergency cooling tower, a reserve supply of coolant, or a reserve refrigeration unit be available to preserve coolant flow to the GDS in the event of prime unit failure. The total refrigeration system shall be located externally to the CCA.

4.10.6.2 Cooling Water

Facility cooling water will be required for operation of the following facility components:

- (a) Vacuum pump cooling; 80°F maximum at 10 GPM
- (b) Tank wall cooling (if required)
- (c) Facility refrigeration loading TBD at TBD GPM

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5. CHANGES

In the event of a contract award, no alteration shall be made in the work, and no claim for extra work shall be made by the contractor, except on written order of AiResearch.

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6. PERMITS AND REGULATIONS

Permits, licenses, and fees of every nature necessary for the prosecution of the work shall be secured, including connection to utilities, closing streets, and compliance with municipal and state codes. The following are specific examples of governmental and corporate agencies having cognizance of certain phases of work under consideration:

- (a) All ordinances, codes, and regulations of the City of Phoenix shall be complied with, except as specific waivers are or have been obtained. Supervision of water and sewer installations by city officials and inspectors shall be permitted, as required.
- (b) The Arizona Public Service Company shall be permitted to supervise and inspect, for safety and proper operation, all work affecting the distribution of electrical power and gas.

In the event that the subject work is let to an outside contractor, it shall be the contractor's responsibility to secure and pay for all necessary permits, licenses, and fees as previously described. The contractor shall give all notices and comply with all laws, ordinances, rules, and regulations (federal, state, and local) bearing on the conduct of the work as shown and specified.

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7. MATERIAL AND EQUIPMENT

Unless otherwise specifically provided for in the specifications, all equipment, materials, and articles incorporated in the work are to be new and unused and of the most suitable grade of their respective kinds for the purpose. In the case of a contractor, where equipment, materials, or articles are referred to in the specifications as "equal to" any particular standard, AiResearch shall decide the question of equality. Further, the contractor shall furnish for AiResearch approval, the name of the manufacturer of machinery, mechanical, or other equipment contemplated for use, together with performance capacities and other pertinent information. Samples of materials shall be submitted for AiResearch approval when so directed. Machinery, equipment, materials, and articles installed or used by the contractor without AiResearch approval shall be at the risk of subsequent rejection.

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8. WORK RESPONSIBILITY

Responsibility for all damages to persons or property that occur as a result of negligence in connection with the prosecution of the work shall be assigned to the contracting organization (i.e., AiResearch or the contractor, as applicable).- In addition, the contracting organization shall, at all times, protect and preserve all materials, supplies, and equipment of every description (including property which may be Government-furnished or owned) and all work performed until completion and final acceptance.

If a contract is let, the contractor shall procure, and maintain in full force and effect for the entire period of work under the contract, comprehensive public liability insurance, naming AiResearch as a coinsured, with a carrier and in a form and amount acceptable to AiResearch.

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9. INSPECTION

All materials and workmanship (if not otherwise designated by the specifications) shall be subject to inspection, examination, and test by representatives of the cognizant governmental and corporate agencies, and in the case of a contractor, by AiResearch at any and all times during manufacture and/or construction. As appropriate, these designated organizations shall have the right to reject defective material and workmanship or require its correction.

The contracting organization (AiResearch or the contractor) shall furnish all reasonable facilities, labor, and materials necessary for the safe and convenient inspection and tests that may be required. However, all inspection and tests will be performed in such a manner as to preclude unnecessary delay of the work.

In the case of a contractor, should it be considered necessary or advisable by AiResearch or cognizant governmental and corporate agencies at any times before final acceptance of the entire work to make an inspection of work already completed, by removing or tearing out same, the contractor shall, on request, promptly furnish all necessary facilities, labor, and material. If such work is found defective or nonconforming in any material respect, the contractor shall defray all expenses of such examination and of satisfactory reconstruction. However, if such work is found to meet requirements of the contract, the cost of labor and material necessarily involved in the examination and replacement shall be allowed the contractor. In addition, if completion of the work has been delayed as a result, a suitable extension of time shall be granted.

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10. OPERATIONAL ACCEPTANCE TESTS

All work covered by this document involving utilities or other installations will be subject to tests as specified herein. Rough-in tests shall be performed in the presence of AiResearch representatives, as required, before the installation is concealed in walls, floors, or otherwise, and before the service is connected into the distribution or collection systems. Final installation tests will be made in connection with the inspection for acceptance of the construction and shall be performed in the presence of the appropriate representatives of AiResearch. The final tests will govern any deficiencies which may develop between the time of rough-in test and final test will be corrected at the expense of the contracting organization prior to final acceptance. All tests will be performed at the expense of the contracting organization.

In addition to the utility components tests discussed above, each system and coordinated assembly of mechanical and electrical equipment and instrumentation shall be given a complete test under actual or simulated operating conditions to demonstrate full compliance with specification requirements. AiResearch will define test procedures and conditions, reports to be submitted, and minimum standards of acceptability. The contractor shall furnish all personnel, labor, instruments, and superintendence for performance of test procedures and provide any required assistance to enable authorized inspectors to observe and supervise the tests. AiResearch will furnish the water, electrical power, and fuel required.

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APPENDIX I

Drawings

System Installation BIPS-GDS No. 241001
(2 Sheets)

Preliminary BIPS-GDS Piping and Instru-
mentation Diagram No. 306960 (1 Sheet)

Table

Instrumentation and Equipment List BIPS-
GDS Test No. B17303, Rev. 1. (3 Sheets)

TABLE B17303, REV. 1
INSTRUMENTATION AND EQUIPMENT LIST
SIPS-GDS TEST

Tag No. (Reference Drawing 306960)	Data Parameter	Nominal Value	Description	Model/ Part Number	Manufacture	Range	Accuracy	Data Usage	Remarks
N1A	Mini-BRU Shaft Speed	55,000 rpm	Monopole		Electro Products	0-100,000 rpm	±10 rpm	(1)	(1) Anadex Readout
N1B	Mini-BRU Shaft Speed	55,000 rpm	Monopole		Electro Products	0-100,000 rpm	±10 rpm	(2)	(2) Digital Data Acquisition and BCD Recording System
N1C	Mini-BRU Shaft Speed	55,000 rpm	Monopole		Electro Products	0-100,000 rpm	±3% FSV	(3), (5)	(3) Real Time Trend Recorder
T1:A,B,C	Mini-BRU Compressor Inlet Temperature	25°F	C-A Thermocouple	N/A	AiResearch Design	-20/150°F	±3°F	(2)	(5) System Shutdown and Activate Alarm
T1A	Mini-BRU Compressor Inlet Temperature	25°F	C-A Thermocouple	N/A	AiResearch Design	-20/150°F	±3% FSV	(3), (6), (7)	(6) PSC "A" Shutdown and Actuate Alarm
T2:A,B,C	Mini-BRU Compressor Discharge Temperature	150°F	C-A Thermocouple	N/A	AiResearch Design	0/300°F	±3°F	(2)	(7) PSC "B" Shutdown and Actuate Alarm
T3-1:A,B,C	Alternator Heat Exchanger Discharge Temperature, Duct "A"	168°F	C-A Thermocouple	N/A	AiResearch Design	0/350°F	±3°F	(2)	(8) Actuate Alarm
T3-2:A,B,C	Alternator Heat Exchanger Discharge Temperature, Duct "B"	168°F	C-A Thermocouple	N/A	AiResearch Design	0/350°F	±3°F	(2)	
T4:A,B,C	Recuperator High Pressure Inlet Temperature	168°F	C-A Thermocouple	N/A	AiResearch Design	0/350°F	±3°F	(2)	
T5.0:A,B,C	Recuperator High Pressure Discharge Temperature	1297°F	C-A Thermocouple	N/A	AiResearch Design	0/1500°F	±9°F	(2)	
T5.0A	Recuperator High Pressure Discharge Temperature	1297°F	C-A Thermocouple	N/A	AiResearch Design	0/1500°F	±3% FSV	(3)	
T5.1:A,B	HSA Inlet Temperature	1297°F	C-A Thermocouple	N/A	AiResearch Design	0/1500°F	±9°F	(2)	
T6.1-1:A,B,C	Turbine Inlet Temperature From HSA "A"	1600°F	C-A Thermocouple	N/A	AiResearch Design	0/1800°F	±9°F	(2)	
T6.1-1A	Turbine Inlet Temperature From HSA "A"	1600°F	C-A Thermocouple	N/A	AiResearch Design	0/1800°F	±3% FSV	(3), (6)	
T6.1-2:A,B,C	Turbine Inlet Temperature From HSA "B"	1600°F	C-A Thermocouple	N/A	AiResearch Design	0/1800°F	±9°F	(2)	
T6.1-2A	Turbine Inlet Temperature From HSA "B"	1600°F	C-A Thermocouple	N/A	AiResearch Design	0/1800°F	±3% FSV	(3), (7)	
T9.0:A,B,C	Mini-BRU Turbine Discharge Temperature	1340°F	C-A Thermocouple	N/A	AiResearch Design	0/1600°F	±9°F	(2)	
T9.1:A,B,C	Recuperator Low Pressure Inlet Temperature	1318°F	C-A Thermocouple	N/A	AiResearch Design	0/1600°F	±9°F	(2)	
T10.0:A,B,C	Recuperator Low Pressure Discharge Temperature	212°F	C-A Thermocouple	N/A	AiResearch Design	0/500°F	±3°F	(2)	
T10.0A	Recuperator Low Pressure Discharge Temperature	212°F	C-A Thermocouple	N/A	AiResearch Design	0/500°F	±3% FSV	(3)	
T10.1:A,B,C	HREX Inlet Temperature	212°F	C-A Thermocouple	N/A	AiResearch Design	0/500°F	±3°F	(2)	
T12.0:A,B	HREX Discharge Temperature	20°F	C-A Thermocouple	N/A	AiResearch Design	-20/250°F	±3°F	(2)	
T14:A,B	Mini-BRU Turbine Journal Bearing Temperature	450°F	C-A Thermocouple	N/A	AiResearch Design	0/600°F	±5°F	(2), (5)	
T15:A,B	Mini-BRU Compressor Thrust Bearing Temperature	300°F	C-A Thermocouple	N/A	AiResearch Design	0/450°F	±5°F	(2), (5)	
T16:A,B	Mini-BRU Compressor Journal Bearing Temperature	300°F	C-A Thermocouple	N/A	AiResearch Design	0/450°F	±5°F	(2)	
T20:A,B	Recuperator Structure Temperature	100°-1250°F	C-A Thermocouple	N/A	AiResearch Design	0/1500°F	±9°F	(2)	
T21:A,B	Recuperator Structure Temperature	100°-1250°F	C-A Thermocouple	N/A	AiResearch Design	0/1500°F	±9°F	(2)	
T25.1 (A-I)	Electric Heat Source Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.1A	Electric Heat Source Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±3% FSV	(3)	
T25.2 (A-K)	Heat Source Heat Exchanger Core Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.3 (A-J)	Heat Source Heat Exchanger Header Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.4 (A-D)	Heat Source Heat Exchanger Duct Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.5 (A-F)	Heat Source Insulation System Cylinder Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.6 (A-D)	Heat Source Insulation System Planar End Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.7 (A-H)	Heat Source Preload Screw Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	

TABLE B17303, REV. 1
INSTRUMENTATION AND EQUIPMENT LIST
BIPS-GDS TESTS

Tag No. Reference Drawing (6960)	Data Parameter	Nominal Value	Description	Model/ Part Number	Manufacture	Range	Accuracy	Data Usage	Remarks
T25.8 (A-D)	Heat Source Spider Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.9 (A-I)	Heat Source Housing Cylinder External Tem- perature, "A"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.10 (A,B)	Heat Source Housing Dome External Temperature, "A"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.11 (A-H)	Heat Source Housing Bel- lows External Temperature, "A"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.1 (A-I)	Electric Heat Source Tem- perature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.1A	Electric Heat Source Tem- perature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.2 (A-X)	Heat Source Heat Ex- changer Core Temperature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.3 (A-J)	Heat Source Heat Ex- changer Header Tempera- ture, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.4 (A-D)	Heat Source Heat Ex- changer Header Tempera- ture, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.5 (A-F)	Heat Source Insulation System Cylinder Tempera- ture, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.6 (A-D)	Heat Source Insulation System Planar End Tem- perature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.7 (A-H)	Heat Source Preload Screw Temperature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.8 (A-D)	Heat Source Spider Tem- perature, "B"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.9 (A-I)	Heat Source Housing Cylinder External Tem- perature, "B"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.10 (A,B)	Heat Source Housing Ex- ternal Temperature, "B"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T26.11 (A-H)	Heat Source Housing Bel- lows External Temperature, "B"		Cr-Al Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T40:A,B,C,D,E	Alternator Output Tempera- ture	380°F	C-A Thermocouple	N/A	AIResearch Design	50/450°F	±3°F	(2), (5)	
T120:A,B	Facility Coolant System Outlet Temperature	-20°F	C-A Thermocouple And/or Thermometer	N/A	AIResearch Design	-40/150°F	±3°F ±.5°F	(2)	A Laboratory Thermometer may be used to obtain ±.5° F accuracy
T121:A,B	Facility Coolant System Inlet Temperature	40°F	C-A Thermocouple and/or Thermometer	N/A	AIResearch	-40/150°F	±3°F ±.5°F	(2)	
P1A	Mini-BRU Compressor Inlet Pressure	37 psia	Pressure Transducer	PA220TC-50-350	Statham	0/50 psia	±.5% FSV	(2), (3)	
P1B	Mini-BRU Compressor Inlet Pressure	37 psia	Absolute Pressure Gauge		Heise	0/75 psia	±.5% FSV	(4)	(4) Heise Gauge
P3-2A	Alternator Heat Exchanger Discharge Pressure, Duct "B"	59 psia	Pressure Transducer	PA220TC-75-350	Statham	0/75 psia	±.5% FSV	(2), (3)	
P3-2B	Alternator Heat Exchanger Discharge Pressure, Duct "B"	59 psia	Absolute Pressure Gauge		Heise	0/75 psia	±0.1% FSV	(4)	
P4A	Recuperator High Pressure Side Inlet Pressure	100 psia	Pressure Transducer	PA220TC150-350	Statham	0/150 psia	±0.5% FSV	(2)	
P4B	Recuperator High Pressure Side Inlet Pressure	100 psia	Pressure Transducer	PA220TC150-350	Statham	0/150 psia	±0.5% FSV	(2)	
P4.1A	Recuperator Low Pressure Side Inlet Pressure	68 psia	Pressure Transducer	PA220TC100-350	Statham	0/100 psia	±0.5% FSV	(2)	
P4.1B	Recuperator Low Pressure Side Inlet Pressure	68 psia	Pressure Transducer	PA220TC100-350	Statham	0/100 psia	±0.5% FSV	(2)	
P6.1-2A	Turbine Inlet Pressure from HSA "B"	100 psia	Pressure Transducer	PA220TC150-350	Statham	0/150 psia	±0.5 psi	(2)	
P6.1-2B	Turbine Inlet Pressure from HSA "B"	100 psia	Absolute Pressure Gauge		Heise	0/150 psia	±0.1% FSV	(4)	
P9.0A	Mini-BRU Turbine Discharge Pressure	68 psia	Pressure Transducer	PA220TC-100-350	Statham	0/75 psia	±0.5 psi	(2)	
P9.0B	Mini-BRU Turbine Discharge Pressure	68 psia	Absolute Pressure Gauge	PA220TC-75-350	Heise	0/75 psia	±0.1 FSV	(4)	
	Mini-BRU Turbine Journal Bearing Pressure	86 psia	Pressure Transducer	PA220TC-75-350	Statham	0/100 psia	±0.5 psi	(2), (5)	
	Mini-BRU Compressor Thrust Bearing Pressure	86 psia	Pressure Transducer	PA220TC-75-350	Statham	0/100 psia	±0.5 psi	(2), (5)	
P16	Mini-BRU Compressor Journal Bearing Pressure	86 psia	Pressure Transducer	PA220TC-25-350	Statham	0/100 psia	±0.5 psi	(2)	

TABLE B17303, REV. 1
INSTRUMENTATION AND EQUIPMENT LIST
BIPS-GDS TESTS

Tag No. ence ing 50)	Data Parameter	Nominal Value	Description	Model/ Part Number	Manufacture	Range	Accuracy	Data Usage	Remarks
P25	HSA "A" Insulation Pressure	0-16 psia	Pressure Transducer	PA220TC25-350	Statham	0/25 psia	±0.5 psi	(2)	
3.2/3.1	ΔP Between Alternator HX Ducts "A" and "B"	15 in. H ₂ O	Differential Pressure Transducer	PM96TC ±4-350	Statham	±100 in. H ₂ O	±1 in. H ₂ O	(2)	
3.2/4	ΔP Between Alternator HX Ducts "B" and Recuperator HP Inlet	5 in. H ₂ O	Differential Pressure Transducer	PM96TC ±1-350	Statham	0-20 in. H ₂ O	±1 in. H ₂ O	(2)	
4/5.0	ΔP; Recuperator HP Inlet and Discharge	10 in. H ₂ O	Differential Pressure Transducer	PM96TC ±2-350	Statham	0-50 in. H ₂ O	±1 in. H ₂ O	(2)	
6.1-2/61-1	ΔP; HSA Inlet "A" and "B"	15 in. H ₂ O	Differential Pressure Transducer	PM96TC ±4-350	Statham	±100 in. H ₂ O	±1 in. H ₂ O	(2)	
6.1-2/5.2-1	ΔP; Turbine Inlet from HSA "B" to HSA "A" Inlet	10 in. H ₂ O	Differential Pressure Transducer	PM96TC ±2-350	Statham	0-50 in. H ₂ O	±1 in. H ₂ O	(2)	
6.1-2/5.2-2	ΔP; Turbine Inlet from HSA "B" to HSA "B" Inlet	10 in. H ₂ O	Differential Pressure Transducer	PM96TC ±2-350	Statham	0-50 in. H ₂ O	±1 in. H ₂ O	(2)	
9.0/9.1	ΔP; Turbine Discharge to Recuperator Low Pressure Inlet	10 in. H ₂ O	Differential Pressure Transducer	PM96TC ±2-350	Statham	0-50 in. H ₂ O	±1 in. H ₂ O	(2)	
9.1/10.0	ΔP; Recuperator Low Pressure Inlet to Recuperator Low Pressure Discharge	15 in. H ₂ O	Differential Pressure Transducer	PM96TC ±2-350	Statham	0-50 in. H ₂ O	±1 in. H ₂ O	(2)	
3	DC Buses Current	11 AMP	Shunt	06707	Simpson	0-25	±1% FSV	(2)	
	DC Parasitic Load Supply Current	0-15 AMP	Shunt	06705	Simpson	0-15	±1% FSV	(2)	
I40;A,B,C,N	AC Alternator Output Current	8.7 AMP/L	CT-200/5 w 8 PT Current Exducer	237A970G03V12-841	Westinghouse	0-25 AMP	±1.2% FSV ±1% FSV	(2)	3 current transformers and exducers required.
2	AC Alternator Field Current (DC)	1.4 AMP	Shunt	06703	Simpson	0-5 AMP	±1% FSV	(2)	
I140;A,B,C	Facility AC Current	--	CT-200/5 Current Exducer	V12-841	Westinghouse	--	±2% FSV	(2)	3 current transformers and exducers required.
0	DC Buses Voltage	120V	--	--	--	0-150V	±0.5 FSV	(2), (8)	
v31	DC Parasitic Load Supply Voltage	120V	--	--	--	0-150 V	±0.5 FSV	(2), (8)	
0	AC Alternator Output Voltage	110VLL	Voltage Exducer	VE2-841	Westinghouse	0-150V	±1% FSV	(2), (8)	
2	AC Alternator Field Voltage	15.8V	--	--	--	0-50V	±0.3% FSV (2) ±1% FSV (3)	(2), (3), (8) (2), (8)	Signal condition only.
40;A,B,C	Facility AC Voltage	120/208V	Voltage Exducer	VE2-841	Westinghouse	0-150V	±1% FSV	(2), (8)	* tcn measured.
30	DC Buses Power Output	1.3 KW	--	--	--	0-3 KW	--	(2), (3)	I30 x V30 = KW30.
KW31	DC Parasitic Load Power Draw	1.8 KW	--	--	--	0-3 KW	--	(2), (3)	I31 x V31 = KW31.
40	AC Alternator Power Output	1.5 KW	Hall Effect Multiplier	VP2-840	Westinghouse	--	±2% FSV	(2)	
40/140	Facility AC Power		Hall Effect	VP2-840	Westinghouse	--	±2% FSV	(2), (3)	
120	Facility Coolant Loop Flow							(2), (8)	
1	Mini-BRU Compressor Inlet Gas Flow	21 lb/min				0/50 lb/min	±0.4 lb/min	(2)	
									NOTE: All current, voltage and power exducers to be calibrated for 1733 Hz.

PART NO.	CUSTOMER CODE AND APPLICATION	REMARKS
241000-1	ERDA - BRAYTON ISOTOPE POWER SYSTEM GROUND DEMONSTRATION SYSTEM	AS SHOWN

REVISIONS	DATE	APPROVED
1		
2		
3		
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9		
10

ITEM	NAME	DESCRIPTION	ZONE
6	GAS MANAGEMENT VALVE PORT	BOSS PER MS33649-12	C5
5	SYSTEM MOUNT PADS	AS SHOWN	C8
4	HRHX COOLANT OUTLET	FITTING PER MS33656-10	H5
3	HRHX COOLANT INLET	FITTING PER MS33656-10	C5
2	VACUUM TANK OUTLET	CONFORMS TO 150* 5 INCH BLIND PIPE FLANGE MODIFIED	G4
1	VACUUM TANK INLET	CONFORMS TO 150* 5 INCH BLIND PIPE FLANGE MODIFIED	C4
INSTALLATION CONNECTIONS			

1. FORM/POSITION TOLERANCING PER AIRSEARCH SC6000.
2. ALL DIMENSIONS ARE COLD.
3. SEE PL241000-1 FOR SYSTEM ASSEMBLY PART NUMBER.
4. UNTOLERANCED DIMENSIONS TO BE $\pm .06$.

QUANTITY	UNIT	PART NO. OR IDENTIFYING NO.	SYMBOL	DESCRIPTION OR IDENTIFICATION	CODE	MATERIAL AND SPECIFICATION	ZONE
PARTS LIST							
SIGNATURES				DATE	PARTS LIST		
BY <i>[Signature]</i>				3-3-76	AIRSEARCH MANUFACTURING COMPANY OF AMERICA		
CHECKED <i>[Signature]</i>					A DIVISION OF THE AIRSEARCH CORPORATION		
APPROVED <i>[Signature]</i>					SYSTEM INSTALLATION, BIPS - GDS		
MATERIAL AND SPECIFICATION					241001		
SCALE 1/4					1 SHEET OF 2		

DEVELOPMENT SYSTEM PROTECTION & ALARMS

EMERGENCY SHUT DOWN PROVISIONS

CONDITION	START STOP	DEVELOPMENT BACKFILL	BACKFILL CHAMBER	MISCELLANEOUS
WIND-1 (OVERSPEED)	X	X		
TUR-1 OVERSPEED - COMB. INLET		X		
TUR-2,3,4 TURB. INLET		X		
TUR-5 TURB. JOURN. BRS.		X	X	
TUR-6 TURB. INLET BRS. HS		X		
TUR-7,8 COMP. JOURN. BRS.		X	X	
TUR-9,10 HS INLET		X		
TUR-11,12 STARTER	X	X		
TUR-13,14 LEVEL 2 LOW PRESS		X	X	
PL-1,2,3 LEVEL 1	X	X		
PL-4,5 HIGH CHAMBER PRESS.		X	X	

ALARM SYSTEM
AL-1
AL-2
AL-3
AL-4

DATA ACQUISITION

TREND	DIGITAL	DATA
PI-1	PI-1	PI-1
PI-2	PI-2	PI-2
PI-3	PI-3	PI-3
PI-4	PI-4	PI-4
PI-5	PI-5	PI-5
PI-6	PI-6	PI-6
PI-7	PI-7	PI-7
PI-8	PI-8	PI-8
PI-9	PI-9	PI-9
PI-10	PI-10	PI-10
PI-11	PI-11	PI-11
PI-12	PI-12	PI-12
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PI-14	PI-14	PI-14
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PI-98	PI-98	PI-98
PI-99	PI-99	PI-99
PI-100	PI-100	PI-100

LEGEND

1	COMPRESSOR INLET	10	COMPRESSOR DISCHARGE
2	COMPRESSOR DISCHARGE	11	COMPRESSOR DISCHARGE
3	COMPRESSOR DISCHARGE	12	COMPRESSOR DISCHARGE
4	COMPRESSOR DISCHARGE	13	COMPRESSOR DISCHARGE
5	COMPRESSOR DISCHARGE	14	COMPRESSOR DISCHARGE
6	COMPRESSOR DISCHARGE	15	COMPRESSOR DISCHARGE
7	COMPRESSOR DISCHARGE	16	COMPRESSOR DISCHARGE
8	COMPRESSOR DISCHARGE	17	COMPRESSOR DISCHARGE
9	COMPRESSOR DISCHARGE	18	COMPRESSOR DISCHARGE
10	COMPRESSOR DISCHARGE	19	COMPRESSOR DISCHARGE
11	COMPRESSOR DISCHARGE	20	COMPRESSOR DISCHARGE
12	COMPRESSOR DISCHARGE	21	COMPRESSOR DISCHARGE
13	COMPRESSOR DISCHARGE	22	COMPRESSOR DISCHARGE
14	COMPRESSOR DISCHARGE	23	COMPRESSOR DISCHARGE
15	COMPRESSOR DISCHARGE	24	COMPRESSOR DISCHARGE
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18	COMPRESSOR DISCHARGE	27	COMPRESSOR DISCHARGE
19	COMPRESSOR DISCHARGE	28	COMPRESSOR DISCHARGE
20	COMPRESSOR DISCHARGE	29	COMPRESSOR DISCHARGE
21	COMPRESSOR DISCHARGE	30	COMPRESSOR DISCHARGE
22	COMPRESSOR DISCHARGE	31	COMPRESSOR DISCHARGE
23	COMPRESSOR DISCHARGE	32	COMPRESSOR DISCHARGE
24	COMPRESSOR DISCHARGE	33	COMPRESSOR DISCHARGE
25	COMPRESSOR DISCHARGE	34	COMPRESSOR DISCHARGE
26	COMPRESSOR DISCHARGE	35	COMPRESSOR DISCHARGE
27	COMPRESSOR DISCHARGE	36	COMPRESSOR DISCHARGE
28	COMPRESSOR DISCHARGE	37	COMPRESSOR DISCHARGE
29	COMPRESSOR DISCHARGE	38	COMPRESSOR DISCHARGE
30	COMPRESSOR DISCHARGE	39	COMPRESSOR DISCHARGE
31	COMPRESSOR DISCHARGE	40	COMPRESSOR DISCHARGE
32	COMPRESSOR DISCHARGE	41	COMPRESSOR DISCHARGE
33	COMPRESSOR DISCHARGE	42	COMPRESSOR DISCHARGE
34	COMPRESSOR DISCHARGE	43	COMPRESSOR DISCHARGE
35	COMPRESSOR DISCHARGE	44	COMPRESSOR DISCHARGE
36	COMPRESSOR DISCHARGE	45	COMPRESSOR DISCHARGE
37	COMPRESSOR DISCHARGE	46	COMPRESSOR DISCHARGE
38	COMPRESSOR DISCHARGE	47	COMPRESSOR DISCHARGE
39	COMPRESSOR DISCHARGE	48	COMPRESSOR DISCHARGE
40	COMPRESSOR DISCHARGE	49	COMPRESSOR DISCHARGE
41	COMPRESSOR DISCHARGE	50	COMPRESSOR DISCHARGE
42	COMPRESSOR DISCHARGE	51	COMPRESSOR DISCHARGE
43	COMPRESSOR DISCHARGE	52	COMPRESSOR DISCHARGE
44	COMPRESSOR DISCHARGE	53	COMPRESSOR DISCHARGE
45	COMPRESSOR DISCHARGE	54	COMPRESSOR DISCHARGE
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47	COMPRESSOR DISCHARGE	56	COMPRESSOR DISCHARGE
48	COMPRESSOR DISCHARGE	57	COMPRESSOR DISCHARGE
49	COMPRESSOR DISCHARGE	58	COMPRESSOR DISCHARGE
50	COMPRESSOR DISCHARGE	59	COMPRESSOR DISCHARGE
51	COMPRESSOR DISCHARGE	60	COMPRESSOR DISCHARGE
52	COMPRESSOR DISCHARGE	61	COMPRESSOR DISCHARGE
53	COMPRESSOR DISCHARGE	62	COMPRESSOR DISCHARGE
54	COMPRESSOR DISCHARGE	63	COMPRESSOR DISCHARGE
55	COMPRESSOR DISCHARGE	64	COMPRESSOR DISCHARGE
56	COMPRESSOR DISCHARGE	65	COMPRESSOR DISCHARGE
57	COMPRESSOR DISCHARGE	66	COMPRESSOR DISCHARGE
58	COMPRESSOR DISCHARGE	67	COMPRESSOR DISCHARGE
59	COMPRESSOR DISCHARGE	68	COMPRESSOR DISCHARGE
60	COMPRESSOR DISCHARGE	69	COMPRESSOR DISCHARGE
61	COMPRESSOR DISCHARGE	70	COMPRESSOR DISCHARGE
62	COMPRESSOR DISCHARGE	71	COMPRESSOR DISCHARGE
63	COMPRESSOR DISCHARGE	72	COMPRESSOR DISCHARGE
64	COMPRESSOR DISCHARGE	73	COMPRESSOR DISCHARGE
65	COMPRESSOR DISCHARGE	74	COMPRESSOR DISCHARGE
66	COMPRESSOR DISCHARGE	75	COMPRESSOR DISCHARGE
67	COMPRESSOR DISCHARGE	76	COMPRESSOR DISCHARGE
68	COMPRESSOR DISCHARGE	77	COMPRESSOR DISCHARGE
69	COMPRESSOR DISCHARGE	78	COMPRESSOR DISCHARGE
70	COMPRESSOR DISCHARGE	79	COMPRESSOR DISCHARGE
71	COMPRESSOR DISCHARGE	80	COMPRESSOR DISCHARGE
72	COMPRESSOR DISCHARGE	81	COMPRESSOR DISCHARGE
73	COMPRESSOR DISCHARGE	82	COMPRESSOR DISCHARGE
74	COMPRESSOR DISCHARGE	83	COMPRESSOR DISCHARGE
75	COMPRESSOR DISCHARGE	84	COMPRESSOR DISCHARGE
76	COMPRESSOR DISCHARGE	85	COMPRESSOR DISCHARGE
77	COMPRESSOR DISCHARGE	86	COMPRESSOR DISCHARGE
78	COMPRESSOR DISCHARGE	87	COMPRESSOR DISCHARGE
79	COMPRESSOR DISCHARGE	88	COMPRESSOR DISCHARGE
80	COMPRESSOR DISCHARGE	89	COMPRESSOR DISCHARGE
81	COMPRESSOR DISCHARGE	90	COMPRESSOR DISCHARGE
82	COMPRESSOR DISCHARGE	91	COMPRESSOR DISCHARGE
83	COMPRESSOR DISCHARGE	92	COMPRESSOR DISCHARGE
84	COMPRESSOR DISCHARGE	93	COMPRESSOR DISCHARGE
85	COMPRESSOR DISCHARGE	94	COMPRESSOR DISCHARGE
86	COMPRESSOR DISCHARGE	95	COMPRESSOR DISCHARGE
87	COMPRESSOR DISCHARGE	96	COMPRESSOR DISCHARGE
88	COMPRESSOR DISCHARGE	97	COMPRESSOR DISCHARGE
89	COMPRESSOR DISCHARGE	98	COMPRESSOR DISCHARGE
90	COMPRESSOR DISCHARGE	99	COMPRESSOR DISCHARGE
91	COMPRESSOR DISCHARGE	100	COMPRESSOR DISCHARGE

NOMENCLATURE

LETTER	DESCRIPTION	LETTER	DESCRIPTION
A	ALARM	Q	QUANTITY
B	BACKFILL	R	REACTOR
C	CONTROL	S	SEPARATOR
D	DISCHARGE	T	TEMPERATURE
E	ELAPSED	U	UNIT
F	FLOW	V	VALVE
G	GAUGE	W	WATER
H	HAND	X	EXHAUST
I	INDICATOR	Y	YIELD
J	JUNCTION	Z	ZONE
K	KEY	AA	ALARM
L	LEVEL	AB	ALARM
M	MOTOR	AC	ALARM
N	NUMBER	AD	ALARM
O	OPERATOR	AE	ALARM
P	PUMP	AF	ALARM
Q	QUANTITY	AG	ALARM
R	REACTOR	AH	ALARM
S	SEPARATOR	AI	ALARM
T	TEMPERATURE	AJ	ALARM
U	UNIT	AK	ALARM
V	VALVE	AL	ALARM
W	WATER	AM	ALARM
X	EXHAUST	AN	ALARM
Y	YIELD	AO	ALARM
Z	ZONE	AP	ALARM

LINE SYMBOLS

SAMPLING LINES		ORBITAL METALLIC JOINT	AND GAGES
LIQUID LOOP LINES		MATERIAL SAMPLE
ELECTRIC LINES		INSTRUMENT
ELECTRIC LINES		THERMOCOUPLE
ELECTRIC LINES		TRANSDUCER
ELECTRIC LINES		DEVELOPMENT, TEST ONLY
ELECTRIC LINES		RAW VENTURI
ELECTRIC LINES		DUCT MATERIAL, O.D., WALL THICKNESS
ELECTRIC LINES		BRIDGING
ELECTRIC LINES		DEVICE
ELECTRIC LINES		DUCT WELD JOINT	