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**TEST PLAN
BRAYTON ISOTOPE POWER SYSTEM
GROUND DEMONSTRATION SYSTEM
(BIPS-GDS)**

76-311752

June 13, 1976

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TEST PLAN
BRAYTON ISOTOPE POWER SYSTEM
GROUND DEMONSTRATION SYSTEM
(BIPS-GDS)

76-311752

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B17331 (Abbreviations & Acronyms) 3 Sheets
Test Log: B17373

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TEST PLAN
BRAYTON ISOTOPE POWER SYSTEM
GROUND DEMONSTRATION SYSTEM
(BIPS-GDS)

1. INTRODUCTION

This test plan, prepared by AiResearch Manufacturing Company of Arizona, defines the overall test program for the Brayton Isotope Power System (BIPS) Ground Demonstration System (GDS), hereinafter referred to as the GDS. The GDS is being designed, fabricated, and tested under ERDA Contract E(04-3) 1123.

An abbreviation and acronym table (B17331) is attached for reference to terms used herein.

It is important to note that the GDS system tests are the culmination of years of design, development and testing of the system components, materials and processes. The major components for the GDS test were designed, fabricated and, to an extent, tested under separate NASA contracts. Facility requirements, component and material testing and handling procedures are detailed in other documents.

This document describes the test plan to evaluate the performance of these government furnished components when integrated as a complete, prototypical, flight configuration while operating in projected flight situations.

1.2 Purpose

The purpose of this test plan is to provide an overall outline of all testing to be accomplished on the GDS. Included in this test plan are administrative requirements, instrumentation accuracies, instrumentation, equipment definitions, system test setup, and facility installation. The test program will enable collection of sufficient data to establish material, component, and system design integrity.

The data will also be used to establish and evaluate component and system performance and reliability characteristics, verification of proper system component integration prior to initiation of Phase II, and flight system (FS) development.

AIRPHX Configuration Control Document (CCD) 75-311274, latest revision, defines components of the GDS and FS configurations.

1.2 Scope

This test plan covers the following:

- o Detailed test objectives for material, component, and system testing
- o Evaluation of loop component system performance
- o Controls and instrumentation definition
- o Definition of performance parameters to be measured
- o Definition of test data use
- o Listing of special tools, test equipment, facilities, and instrumentation
- o Assessment of quality, reliability, and safety factors

As outlined in the Integrated Program Plan (IPP) AIRPHX Report No. 75-311574, detailed component and materials testing will be accomplished prior to system integration to verify material and component reliability and integrity. These tests will be performed by AIRPHX, major subcontractors, and governmental agencies. For testing conducted at AIRPHX, detailed development and system test procedures will be prepared to define testing to be performed.

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Test procedures for the GDS system testing, which will be performed in a vacuum chamber, will be prepared in advance of test initiation and submitted to ERDA for review. These tests will include:

- o System checkout
- o Performance
- o Endurance

The overall testing objective outlined herein will be to successfully demonstrate GDS capability to achieve the design requirements specified in AIRPHX System Design Specification SC-76-311742.

1.3 System Commonality

Due to the high degree of commonality between the GDS and FS, successful completion of test requirements for materials, components, and the GDS, will produce a high confidence level for successful testing of the FS. GDS and FS similarities and differences are shown on Table 1-1. Major differences will be that the FS will utilize an isotope heat source instead of the electrical heat source and a cylindrical space radiator in place of the HRHX heat exchanger used for the GDS.

Table 1-1

SIMILARITIES AND DIFFERENCES
BETWEEN THE BIPS GDS AND THE BIPS FS

<u>SUB-SYSTEM</u>	<u>CONFIGURATION</u>	<u>MATERIALS</u>	<u>PERFORMANCE</u>	<u>WEIGHT</u>
MINI BRU	Identical except for instrumentation (Added for GDS tests)	Identical	Identical	Identical (38 pounds)
MBR	Similar except for instrumentation (Added for GDS tests) and size (MBR used in GDS tests is oversize since it has been optimized for three HSAs rather than two). The same basic design can be incorporated into a smaller version optimized for the 2 HSA flight system.	Identical	FS optimized for 2 capsule operation; GDS optimized for 3 capsules	Less for flight system (134/106 pounds)
HSA	Identical except for: 1) Instrumentation (added for GDS tests), 2) EHS power leads (for GDS), 3) Gas management valve (used only in HSA for FS for venting helium generated by isotope decay), and 4) Auxiliary cooling valve (used for venting cover gas from insulation - the GDS will utilize system which will permit reinjection of cover gas; FS ACV will be one-shot mechanism, probably actuated by radio command).	Identical except for external support housing and end domes (stainless steel for GDS; Beryllium for FS) and as noted under "configuration"	Identical	Similar; FS predicted to be somewhat lighter, primarily because Beryllium will replace stainless steel for housing.
RADIATOR	GDS will utilize a liquid to gas HRHX to simulate the space radiator of the FS	GDS HRHX - copper; FS - radiator - aluminum or Beryllium or Lockalloy	HRHX will simulate space radiator	(FS ~ 80 pounds) in Beryllium
CONTROLS	GDS: All circuits breadboarded; circuit boards to be plug-in type; no hybridizing; ease of accessibility and reliability prime considerations. Parasitic load and load drivers convection cooled. FS: All circuits hybridized; packaged for minimum volume, weight. All cooling by radiation	TBD	Identical	Flight System lighter due to hybridizing electronic components (FS ~ 10 pounds)
BELLOWS AND DUCTS	Identical except HRHX ducting for GDS different from radiator ducting of FS. FS has two more low temperature bimetallic joints. (HRHX inlet/outlet ducting). GDS has 15 more weld joints than FS.	Identical	Identical	Basic system without cooler and radiator identical. (FS ~ 27 pounds)
STRUCTURE	Identical except GDS uses vac tank support in place of radiator for FS. Radiator/ component support structure interface ring is identical to FS interface ring.	GDS uses all aluminum. FS uses Lockalloy and Beryllium	Identical	FS lighter structure (FS ~ 32 pounds)
INSULATION	Identical except for additional instrumentation penetrations	Identical	6 to 8% higher thermal loss in GDS (300 to 400 watts) due to instrumentation penetrations.	Identical (18 pounds)

- NOTES:
- (1) Although intended to be "identical" in many instances, lessons learned from GDS, performance and endurance tests may lead to changes in flight system components and/or configuration.
 - (2) For test purposes, GDS will incorporate a number of additional valves, gas supply systems, and protective devices.
 - (3) GDS loop will contain two turbine bypass shutoff valves and a pressure relief valve for development testing protection; FS will not.
 - (4) GDS loop will contain a one-way check valve in compressor inlet to eliminate the possibility of reverse flow during startup. Possibility of removing check valve from FS will be investigated during GDS testing.
 - (5) GDS loop will not be as well sealed as the FS because of extensive instrumentation and greater number of potential leak paths. For this reason, an He-Xe tank will be connected to GDS loop. A pressure regulator will control inlet pressure into closed loop and provide replenishment of working fluid to compensate for leakage. The FS will be sealed after initial charging.
 - (6) Flight monitoring system will be included in GDS to a limited degree. Transducers selected for flight, and some associated electronics, will be included in GDS test.

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2. GENERAL REQUIREMENTS

2.1 Administrative Requirements

2.1.1 Test Procedures

Individual test procedures will be prepared and submitted to the ERDA for review of all GDS testing. The test procedures will provide: test description, representative test setup schematics, data parameters to be recorded, a detailed step-by-step test sequence of the test, accept-reject criteria, and any test or administrative requirement unique to the particular test.

In addition, development test procedures will be prepared for internal AiResearch tests pertaining to materials/component development testing.

2.1.2 Procedure Format

The format for individual system test procedures will include a detailed test description, in tabular form, for ease of implementation. Certain basic information, such as administrative requirements, is included in this test plan and therefore, will not be repeated in individual test procedures, except by reference to this test plan. Refer to AIRPHX Specification Requirements Summary Report No. 76-311737 for detail format information.

2.1.3 Test Witnessing

The test program will be subject to witnessing by ERDA, AIRPHX personnel, and cognizant subcontractor personnel (AIRLA, GE, and TECO). ERDA will be notified prior to initiation of tests.

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2.1.4 Test Log

A test log will be provided to record all test results, including test incidents, in chronological order. The applicable component/system part numbers, serial numbers, date of test, test procedure, accumulated test time, and all pertinent incidents will be recorded on the log. AIRPHX Form B17373 (attached) will be used for this log.

2.1.5 Test Data

Raw test data will be made available to ERDA representatives after testing, if requested. Raw test data applicable to major system components will also be made available to the cognizant subcontractor, if requested.

2.1.6 Data Check

Upon completion of each system test, all data will be checked to ascertain that the correct procedure was followed, the GDS functioned properly, and required data were recorded.

2.1.7 Photographs

Photographs will be taken of major components prior to assembly into the GDS, and of the GDS system as installed in the vacuum chamber, prior to test initiation. Dependent upon inspection after test completion, final photographs will be taken for inclusion in the test reports, if deemed beneficial.

2.1.8 Test Reports

Upon completion of GDS system tests, test reports will be prepared detailing test results and any recommendations considered appropriate. Adequate test data, recordings, photographs, and pertinent test documentation will be included in each test report.

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2.1.9 Malfunctions and Failures

Every test program event including malfunctions and failures of any kind will be recorded in the Test Log. Should any malfunction or failure of the test article occur, the Engineering Project will be informed immediately. ERDA and cognizant subcontractors will also be informed and disposition will be coordinated as required. A summary of any malfunctions and failures will be included in the Final Test Report.

2.2 Technical Requirements

2.2.1 Pre-Test Inspection

Prior to test initiation, the GDS will be subjected to detailed inspection in accordance with AIRPHX Inspection Procedure 76-311744. Inspection will include a visual check of all instrumentation and equipment connections to ascertain that the system is connected properly, and that the desired data, (i.e., flow, temperature, pressure, pressure drop, and power output) will be recorded.

2.2.2 Pre-Test Checkout

A pre-test checkout will be conducted on the facility and equipment to include the following as a minimum:

- o Vacuum pumps and vacuum gages
- o Test chamber gas management system
- o HSA gas management system
- o Chamber seal annulus vacuum system
- o GDS shutdown system
- o GDS alarm system
- o Instrumentation
- o Heater electrical supply

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- o HSA EHS alarm and shutdown
- o HRHX coolant supply
- o Working fluid management system
- o Starting system

Where an expendable supply of gases are to be used [i.e., argon, krypton, and the working fluid, Xe-He mixture (MW = 83.8)], the amount of gas will be adequate to ensure that the test can be performed without interruption. Prior to first operation of the Mini-BRU (including the starting system), a detailed pre-test checkout will be performed to ensure that all systems are operating properly.

2.2.3 Post-Test Inspection

2.2.3.1 External Inspection

Unless a failure occurs that requires teardown inspection and repair, only a GDS external inspection will be conducted between tests. The condition of the mount, structure, instrumentation, and insulation will be visually inspected and recorded.

2.2.3.2 Internal Inspection

Upon completion of all tests requiring Mini-BRU, HSAs, MBR, and ducting usage, or after a premature failure of one of these components, inspection will be made by teardown as required by the teardown procedure. The components will be arranged in an orderly fashion, inspected, and photographed to show components condition.

Critical inspection cards will be completed for all components designated by the Engineering Project, or as defined in the teardown procedures. Advanced notification will be given to ERDA, major subcontractors, and GFE equipment suppliers to permit teardown inspection witnessing.

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2.2.3.3 Material Analyses

Material tests will be made with sample Cb C-103 material plates tack-welded in the GDS duct system at the HSA inlets, turbine plenum inlet, and turbine exhaust. At teardown, these specimens will be removed for evaluation by tensile tests, bend ductility, interstitial analysis, and metallographic analysis, as defined by the teardown procedure.

Destructive tests will include a turbine blade sample, checking of the braze joints in the MBR, as defined in the teardown procedure.

2.2.4 Post-Test Recommendations

A final report will be submitted to ERDA. This report will present test results and recommended go-forward tests, e.g., continued endurance, additional material evaluation, shock, vibration, etc., considered necessary to provide a high confidence level for the FS phase of testing.

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3. FACILITIES AND SERVICES

3.1 Test Facilities

All GDS demonstration tests will be conducted at the AIRPHX Test Facility.

The test facility is independent of other laboratory test facilities and will include all necessary services and support equipment. Included in the facility will be a clean room assembly area, storage and handling area, ground test console area, vacuum dry box, gas management system, and vacuum chamber with associated peripheral equipment.

3.1.1 Test Conditions

Test conditions will be as defined in the individual test procedures.

3.1.2 GDS Installation

3.1.2.1 Test Setup

The GDS will be assembled in accordance with AiResearch Assembly Procedure 76-311748 and installed in the vacuum chamber. GDS installation is shown on Drawing 241001 attached with instrumentation and equipment connections as shown on Drawing 306960 attached.

The interface structure Drawing 241001 provides GDS support that would normally be provided by the space radiator for the FS. The support consists of a bracket system cantilevered from the vacuum chamber fixed end. The movable portion of the vacuum chamber is on tracks to allow access to the cantilevered portion of the GDS.

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The HRHX will be located outside the vacuum chamber to preclude penetration of coolant piping into the test chamber, thus ensuring that no coolant leakage will occur inside the chamber (water leakage could contaminate the refractory material and GDS insulation).

Test setup and instrumentation schematics will be included in each test procedure.

3.1.2.2 Inspection, Cleaning, and Handling

All system components will be subjected to approved inspection, cleaning, and handling procedures, prior to, and during assembly into the GDS.

These procedures shall be as defined in the following AiResearch Documents:

<u>Document Number</u>	<u>Document Title</u>
76-311744	BIPS-GDS General Inspection Procedure
76-311746	BIPS-GDS General Cleaning Procedure
76-311747	BIPS-GDS General Handling Procedure

3.1.2.3 GDS Assembly

The GDS components will be assembled in the contamination control area, prior to installation in the vacuum chamber. Assembly will be in accordance with AiResearch Assembly Procedure 76-311748. During assembly, the appropriate cleaning and handling procedures referenced in Paragraph 3.1.2.2 will be followed.

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3.1.2.4 Pre-Test Checkout

A pre-test checkout will be performed on those items defined in Paragraph 2.2.2, or as specified in the appropriate test procedure. Detail procedures will be followed in a checklist fashion to ensure that all systems are operating properly.

3.1.3 Instrumentation

Instrumentation and equipment listed on Table B17303 attached will be used to measure/record the data required by the test table included in each test procedure. Any special instrumentation or equipment not included on Table B17303 that may be required for a particular test will be specified in the detail test procedure.

3.1.4 Instrumentation Accuracies

Instrumentation accuracies will be within the limits specified on Table B17303.

The AIRPHX Metrology Quality Assurance section provides calibration and certification of all instruments, measuring devices, and tooling used in product testing in accordance with MIL-C-45662A (Calibration System Requirements). Frequency of service, calibration and certification of all equipment and a positive recall system for assurance of continuing accuracy is provided. Records are kept for a period of seven years. Secondary standards are certified by the AIRPHX Primary Standards Laboratory or other independent laboratories, providing traceability to the National Bureau of Standards. Inventory and storage tooling is also controlled by this section.

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3.2 Services

All necessary services required for the GDS test program will be provided in the test facility, Drawing 601990 attached. These services are shown schematically on Drawing 306960. The facility will provide:

- o Energy and fluid requirements for GDS operation, instrumentation, and vacuum facility
- o A clean room and staging area for GDS assembly and instrumentation installation
- o A vacuum chamber and pumping system for space environment simulation
- o Control console, information readout, system test monitoring, recording equipment, automatic failure alarms and shutdowns, as required
- o Working fluid management system
- o Vacuum chamber gas management system

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4. TEST REQUIREMENTS

4.1 General Requirements

The overall test program involves not only GDS testing as a system, but also the development and test of materials and components/subsystems prior to system testing. Therefore, the following categories of testing are discussed:

- o Materials Tests
- o Component/Subsystem Tests
- o System Tests (GDS)
- o General Performance Tests
- o Endurance Test (1000 hrs)

Materials and component/subsystem testing will be conducted by AIRPHX, and a number of subcontractors. All GDS testing will be performed by AIRPHX at Phoenix, after system integration and assembly.

Table 4-1 lists tests and test objectives. The table will be revised/updated as required.

4.1.1 Materials Tests

The BIPS program will use material testing results to establish confidence in material reliability and life potential prior to assembly into the GDS. Major test effort will center around testing and/or development of:

- o Refractory Metals (emphasis on Cb C-103)
- o Superalloys
- o Metal Joining (welds, braze, bimetallic)

BIPS WORKHORSE LOOP AND GDS TESTING SEQUENCE

TABLE 4-1

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A detailed discussion of this study effort is provided in AiResearch Integrated Program Plan, 75-311574, latest issue. The GDS test will provide material examples for the analyzer of Paragraph 2.2.3.3.

4.1.2 Component/Subsystem Tests

Component testing will be conducted on major components, to verify design integrity, prior to assembly into the GDS for system testing. A detailed listing of acceptance test areas is shown on Table 4-2, Acceptance Requirements Matrix.

The component tests are discussed in the Integrated Program Plan, AiResearch Report No. 75-311574.

4.1.3 BIPS Workhorse Loop Testing

Prior to GDS testing, additional component verification testing will be accomplished in a workhorse loop identical to the GDS with the following exceptions:

- o Superalloy turbine plenum and hot ducting.
- o Cb ducting and bellows assemblies will not be used.
- o Two 4000 watt electric heat sources will be used in lieu of the two GDS HSAs.

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TABLE 4-2

ACCEPTANCE REQUIREMENT MATRIX

Component	Acceptance Test Documentation	Acceptance Description	Processing Acceptance Documentation	Processing Acceptance Description	Acceptance Requirements at AIRPHX
1. HSHX	Later	<ul style="list-style-type: none"> Visual and dimensional inspection ΔP test at ambient temperature Leak test, proof pressure test at ambient temperature (3 delivered units) Allowable leakage <10⁻⁹ Std cc He/sec 	Later	<ul style="list-style-type: none"> Partial processing during HSA processing 	<ul style="list-style-type: none"> Final processing after final welding (hot gas flow clean)
2. HSA	Later	<ul style="list-style-type: none"> Visual and dimensional inspection Leak test of HSHX as assembled into HSA. Allowable leakage <10⁻⁹ Std cc He/sec. Leak test of HSA assembly, (HSA structure). Allowable leakage <10⁻⁶ Std cc He/sec. Proof pressure test of HSA HSHX as assembled into HSA Proof pressure test of HSA structure (not definite). 	Later	<ul style="list-style-type: none"> Heat clean (time at temperature and pressure - confirmation acceptance by mass spectrometer, if possible) Leak test of HSA after heat clean Leak test of HSHX (pending leak test method) Visual inspection 	<ul style="list-style-type: none"> Visual inspection for damage, particularly at interfaces Leak test of HSA at ambient temperature Continuity and insulation resistance measurement of instrumentation at connector penetrations
3. EHS (47E302718)	Specification: CP47A14602 Procedure: SI-249247	<ul style="list-style-type: none"> Visual and dimensional inspection Thermal/Vacuum performance EHS circuit resistance measurement Thermocouple continuity 	Later	<ul style="list-style-type: none"> Heat clean (time at temperature and pressure - confirmation acceptance by mass spectrometer, if possible) EHS circuit resistance and instrumentation check after processing 	<ul style="list-style-type: none"> EHS circuit resistance, insulation resistance, and T/C continuity at HSA connector penetrations -- Measurements to be made at ambient temperature
HRHX (GE)	TBD	<ul style="list-style-type: none"> Cold flow Proof Pressure He leak test. Allowable leakage < 10⁻⁷ Std cc He/sec, < 4 Std cc He/sec at 70 psi Flow clean 		<ul style="list-style-type: none"> Pre-Storage cleaning procedure 	<ul style="list-style-type: none"> Visual inspection Heat transfer characteristics Dynamic Response In-Gradient Thermal Cycle
MBR (LA)	TBD	<ul style="list-style-type: none"> Proof pressure He Leak test, Allowable leakage < 10⁻⁷ Std cc He/sec Cold flow 		<ul style="list-style-type: none"> Pre-Storage cleaning procedure 	<ul style="list-style-type: none"> Visual Inspection
MINI BRU (PHX)	TBD	<ul style="list-style-type: none"> Cold spin Alternator/Motor mode Leak test 		<ul style="list-style-type: none"> Cleaning and Storage 	N/A
CONTROLS (PHX)	TBD	TBD		<ul style="list-style-type: none"> Cleaning and Storage 	N/A
DUCTING AND BELLOWS (TBD)	TBD				
INSULATION SYSTEM (TECO)	TBD

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The work horse loop will be operated for approximately three months to:

- o Provide verification testing for the Mini-BRU, HRHX, and MBR.
- o Provide Cb test component contamination data.
- o Shake down the test facility.
- o Develop and verify system operating procedures
- o Evaluate system control techniques.

Operation of the work horse loop will allow "three" capsule running (7200 w) instead of "two" capsule (4800 w) as will be conducted with the GDS test program, since the major components (Mini-BRU, HRHX, and MBR) have design operation capability at 7200 w heat input. During the workhorse loop testing the following tests will be performed:

NOTE:

Prior to workhorse loop testing the loop will be pre-conditioned and the facility checkout will be accomplished in accordance with AiResearch Equipment Facility Specification Report No. 76-311740.

4.1.3.1 Startup and Shutdown Tests

Startup and shutdown testing will be conducted to determine the most effective method of achieving startup and shutdown of the BIPS. Results of these tests will allow determination of the following effects.

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- o Thermal stress on HSHX, Mini-BRU and recuperator
- o HSA operation during shutdown.
- o Reverse flow of working fluid
- o Start method
- o Recuperator and HSHX pre-heat
- o Heat soak-back after shutdown
- o HSA Auxiliary Cooling System Operation
- o Insulation outgassing rate

4.1.3.2 Emergency Shutdown

Emergency shutdown testing will be conducted to determine that overtemperature and overspeed safety controls operate properly, prior to system test initiation.

4.1.3.3 System Performance Mapping

A wide range of heat inputs will be applied to the Workhorse Loop heater to obtain initial performance data over the complete performance range. The limits of the range will be determined at the low power output end by an impending speed droop from the nominal, and at the high end by the loop pressure and turbine inlet temperature or alternator limits. A series of working fluid charges that will encompass the charges required for one-half, one, two, and three HSAs (2.4 kW_t per HSA) heat input in an FS will be used to determine the performance of the BIPS at the beginning of mission (BOM) and end of mission (EOM). The system thermal input will be equal to the hypothetical FS HSA's plus the heat losses attributable to the instrumentation.

- o Compressor inlet temperature effects will be evaluated by varying the coolant temperature and/or HRHX flow.

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- o Turbine inlet temperature effects will be evaluated by changing the gas inventory at constant thermal input. Decreasing the temperature should provide sufficient data to correlate the effect of increased temperature with predicted effects.
- o Speed effects will be evaluated by varying the speed control set point.
- o Characteristics of an all superalloy FS at a turbine inlet temperature of 1300°F (or at conditions determined during current studies).

4.1.3.4 Component Performance Evaluation

Data will be taken and recorded during System Performance Testing (4.1.3.3) to allow a thorough analysis of component performance while operating as a part of the system.

4.1.4 GDS Loop Tests

GDS tests will be performed after completion of the workhorse loop testing. All GDS tests will be conducted in the vacuum chamber capable of maintaining the vacuum level at 10^{-6} torr. System tests will include:

- o Startup and shutdown (Acceptance Tests)
- o Performance
- o Endurance Test (1000-hour)

Detailed test procedures for the above tests will be prepared and submitted to the ERDA for review and approval prior to test initiation. The GDS will be instrumented for measurements to be taken at all key thermodynamic cycle state points, and for selected metal temperatures throughout all testing.

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Testing covered by the detailed procedures is discussed in the following paragraphs, and will follow system pre-conditioning and establishment of operating environment.

4.1.4.1 Startup and Shutdown Tests

Startup and shutdown tests will be conducted utilizing experience obtained during workhorse loop tests (Paragraph 4.1.3). These tests will be conducted to evaluate performance with the two HSA configurations. Characteristics and effects will be established as follows:

- o Thermal transients
- o Duct stresses
- o Structural stresses
- o HSA vent rate

4.1.4.2 Emergency Shutdown Tests

Emergency shutdown tests will be repeated as provided for in Paragraph 4.1.3.2.

4.1.4.3 Argon Atmosphere Test

Simulated storage tests of the FS will be conducted by operating the EHSs with the system in an inert argon atmosphere. Test purpose is to determine that heat transfer properties are adequate to allow stabilized temperatures with acceptable limits.

4.1.4.4 Launch Pad Startup Test

FS launch pad startup and operation into space will be simulated by FS startup under stabilized storage conditions with subsequent chamber evacuation during BIPS-GDS operation. Test objectives are to determine transient characteristics.

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4.1.4.5 Startup in Space Test

The start characteristics and the time required to achieve rated power output in space will be determined by first supplying rated power to the EHSS and allowing thermal output to stabilize. The HSAs will then be vented to the evacuated test chamber and the BIPS will be started.

4.1.4.6 BOM Performance Test

The GDS will be tested at a design thermal input of $4800 W_t$. The initial test conditions will be to the predicted operating point. Provisions will be made for variable loop inventory (i.e., pressure level) to obtain the maximum performance and for fine tuning the system. Compressor inlet temperature will also be varied to obtain the empirical trade-off between system performance and radiator size. Sufficient instrumentation will be provided to evaluate compressor, turbine, recuperator, cooler, and heater performance in the system, and allow effects of performance changes to be readily identified. The operating point established by this testing will be used in the endurance test. Performance tests will include:

- o Compressor inlet temperature effects will be evaluated by varying the coolant temperature and/or flow to the HRHX.
- o Turbine inlet temperature effects will be evaluated by changing the gas inventory at constant thermal input.
- o Speed control effects will be evaluated by varying the speed control set point.

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4.1.4.7 EOM Performance Test

EOM performance testing will be conducted at a reduced power level consistent with predicted EOM value. The procedure with exception of the power level will be in accordance with paragraph 4.1.4.6.

4.1.4.8 Endurance Operation Test

A limited endurance test of 1000 hours will be conducted at the power level of BOM Performance Test (Paragraph 4.1.4.6) to determine the following objectives:

- o To provide verification of proper system/component performance over an extended period of operation.
- o Provide confidence that test facilities and procedures permit trouble free operation of the GDS over extended periods of time.
- o Provide accurate determination of test costs per hour for use in follow-on program phases.
- o Substantiate to a limited degree Failure Modes, Effects and Criticality Analysis (FMECA).

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5. TEST SCHEDULE

The Workhorse Loop and GDS Test Schedule is shown on Figure 5-1.

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	1976												1977												1978															
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O						
MATERIALS/PROCESSES TESTS																																								
COMPONENT FAB																																								
ASSEMBLE WORK-HORSE LOOP																																								
WORK-HORSE LOOP TESTING																																								
ASSEMBLE BIPS-GDS LOOP																																								
BIPS-GDS TESTING PERFORMANCE ENDURANCE																																								

BIPS-GDS TEST PROGRAM SCHEDULE

FIGURE 5-1

NO 1 SHEET 8A-10-ATA9 Dwg

DEVELOPMENT SYSTEM
PROTECTION & ALARMS

EMERGENCY SHUT DOWN PROVISIONS

CONDITION	SPALLS FLAKING CRACKING DISINTEGRATION	DISINTEGRATION EVS ₂	BACKFILL WAS ₂	BACKFILL CHARGER	MISCELL- ANEOUS
NEW-1 (OVERSPEED)	X	X			
TAN-4 OVERTEMP - COMPRESSOR INLET		X			SOOTY IN TAN-4
TAN-6A,B		THRU INLET			
TAN-6	FLUE JOINTS BOW	X		X	
TAN-7S	INLET BEARING	X		X	
TAN-7E	COMPRESSOR BOW	X		X	
TAN-7S,26	NSH#2	X			
TAN-40A,B	STATIC	X	X		
TAN-11A,B LEVEL 2 LOW PRESS		X		X	
TAN-11A,B LEVEL 1	X				
TAN-200 HIGH CHARGE PRESS	THRU	X	X	X	

DATA ACQUISITION

[illegible]

LEGEND

0-17	<u>PENALTY LOOP</u>		
1	COMPRESSOR INLET		
2	COMPRESSOR DISCHARGE		
3-4	ALTERNATOR HX DISCHARGE - DIST "A"		
5-6	ALTERNATOR HX DISCHARGE - DIST "B"		
7	RECUPERATOR H.P. INLET		
8	RECUPERATOR H.P. DISCHARGE		
9-1	RECUPERATOR / HSA FLOW DIVIDER		
2-2-1	HSA "A" INLET		
2-2-2	HSA "A" INLET		
6-0-1	HSA "A" DISCHARGE		
0-0-1	HSA "B" DISCHARGE		
0-0-1	TURBINE INLET FROM HSA "A"		
6-0-2	TURBINE INLET FROM HSA "B"		
6-0-3	TURBINE DISCHARGE		
3-0	RECUPERATOR L.P. INLET		
0-0	RECUPERATOR L.P. DISCHARGE		
0-1	HEATX INLET		
0	HEATX WALL		
0	HEATX DISCHARGE		
0	TURBINE JOURNAL BEARING		
0	COMPRESSOR JOURNAL BEARING		
0	COMPRESSOR JOURNAL BEARING		
0	MINI-BU HOUSING (TUE-DOAN SPR. RECUPERATOR STRUCTURE)		
25, 26	HSA "A", HSA "B"		
0-27	<u>DC ELECTRICAL SYSTEM</u>		
30	DC BUSES		
0	PNEUMATIC LOAD VALVE		
0-29	AC ELECTRICAL SYSTEM		
0	ALTERNATOR OUTPUT		
0	ALTERNATOR INLET		
0	FIELD SUPPLY		
0-30	<u>HYDROGEN MANAGEMENT SYSTEM</u>		
0-31	PERMIT COOLANT LOOP		
0-32	EXHAUST AC ELECTRICAL "		
0-33	SAFETY SPEC. SAMPLER		
0-34	SAFETY SPEC. SAMPLER		
0-35	SAFETY SPEC. SAMPLER		
0-36	SAFETY SPEC. SAMPLER		
0-37	SAFETY SPEC. SAMPLER		
0-38	SAFETY SPEC. SAMPLER		
0-39	SAFETY SPEC. SAMPLER		
0-40	SAFETY SPEC. SAMPLER		
0-41	SAFETY SPEC. SAMPLER		
0-42	SAFETY SPEC. SAMPLER		
0-43	SAFETY SPEC. SAMPLER		
0-44	SAFETY SPEC. SAMPLER		
0-45	SAFETY SPEC. SAMPLER		
0-46	SAFETY SPEC. SAMPLER		
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0-63	SAFETY SPEC. SAMPLER		
0-64	SAFETY SPEC. SAMPLER		
0-65	SAFETY SPEC. SAMPLER		
0-66	SAFETY SPEC. SAMPLER		
0-67	SAFETY SPEC. SAMPLER		
0-68	SAFETY SPEC. SAMPLER		
0-69	SAFETY SPEC. SAMPLER		
0-70	SAFETY SPEC. SAMPLER		
0-71	SAFETY SPEC. SAMPLER		
0-72	SAFETY SPEC. SAMPLER		
0-73	SAFETY SPEC. SAMPLER		
0-74	SAFETY SPEC. SAMPLER		
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0-91	SAFETY SPEC. SAMPLER		
0-92	SAFETY SPEC. SAMPLER		
0-93	SAFETY SPEC. SAMPLER		
0-94	SAFETY SPEC. SAMPLER		
0-95	SAFETY SPEC. SAMPLER		
0-96	SAFETY SPEC. SAMPLER		
0-97	SAFETY SPEC. SAMPLER		
0-98	SAFETY SPEC. SAMPLER		
0-99			

NOMENCLATURE

[illegible]

— LINE SYMBOLS —

- SAMPLING LINES
LIQUID LOOP LINES
ELECTRICAL LINES (ELECTRICITY)
PRIMARY GAS LOOP LINES
AUXILIARY GAS LOOP LINES
- TRAP, VACUUM
TRANSMITTER
DRAIN POINTS
PRESSURE VALVE
RELIEF VALVE
CHECK VALVE
SOLENOID OPERATED VALVE
GATE VALVE
- WELDED JOINT
MATERIAL SAMPLE
INSTRUMENT
THERMOCOUPLE
TRANSDUCER
DEVELOPMENT, TEST ONLY
FLOW VENTURI
DUCT MATERIAL, O.D. WALL THICKNESS & LENGTH
BENDOFF
ORIFICE
DUCT WELD JOINT

GDS WITH CONTROLS AND INSTRUMENTATION

PRELIMINARY
REV A 3-12-76
• B 3-27-76

PRELIMINARY
BIPS GDS PIPING &
INSTRUMENTATION DIAGRAM

306960

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ZONE	LTN	DESCRIPTION	DATE APPROVED
<p>REVISION STATUS OF SHEETS</p>			
REV			
SHEET

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

QUANTITY REQD	PART NO	PART NO OR IDENTIFYING NO	SYM	NOMENCLATURE OR DESCRIPTION	QTY REQD	MATERIAL AND SPECIFICATION	QTY REQD
← PART NUMBER				PARTS LIST			
CCP52-1 GDS FINAL 24001		SIGNATURES DATE 5-3-76		AMERSEARCH MANUFACTURING COMPANY OF AMERICA A DIVISION OF THE AMER-1 CORPORATION 10000 W. 10th Ave., Denver, Colorado 80202			
REQD NEXT ASY USED ON HEAT TREATMENT PROCESS HARDNESS AND BRIN TEMPER AND BRIN		DRW ENGR DESIG TEST SPEC MFG ASSEMBLY INSPECTION MATERIALS FINISHING PACKAGING SHIPPING RECEIVING STORAGE MAINTENANCE REPAIR REMEDIATION DISPOSAL OTHER		DRG TITLE SYSTEM INSTALLATION, BIPS - GDS			
DRG NO 99193		DRG REV 1/4		DRG NO 241001			
SCALE 1/4		WT —		SHEET 1 OF 2

VIEW F-F
VACUUM TANK
MOUNT PAD
4 PLACES
SCALE 1/2

VIEW E-E
TYP 2 PLACES
SCALE 1/2

TABLE B17303
INSTRUMENTATION AND EQUIPMENT LIST
B1P6-QDS TEST

Tag No. (Reference Drawing 306560)	Data Parameter	Nominal Value	Description	Model/ Part Number	Manufacture	Range	Accuracy	Data Usage	Remarks
W1A	Mini-BRU Shaft Speed	55,000 rpm	Monopole		Electro Products	0-100,000 rpm	±10 rpm	(1)	(1) Anadex Readout
W1B	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
W1C	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 Dis- charge 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 Dis- charge 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	0/300°F	±3°F	(2)	
T10.0A	Recuperator Low Pressure Discharge Temperature	212°F	C-A Thermocouple	N/A	AiResearch Design	0/300°F	±3% FSV	(3)	
T10.1:A,B,C	HRHX Inlet Temperature	212°F	C-A Thermocouple	N/A	AiResearch Design	0/300°F	±3°F	(2)	
T12.0:A,B	HRHX Discharge Tempera- ture	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	±3°F	(2), (5)	
T15:A,B	Mini-BRU Compressor Thrust Bearing Tempera- ture	300°F	C-A Thermocouple	N/A	AiResearch Design	0/450°F	±5°F	(2), (5)	
T16:A,B	Mini-BRU Compressor Journal Bearing Tempera- ture	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-X)	Heat Source Heat Ex- changer Core Tempera- ture, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.3 (A-J)	Heat Source Heat Ex- changer Header Tempera- ture, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.4 (A-D)	Heat Source Heat Ex- changer Duct Tempera- ture, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.5 (A-F)	Heat Source Insulation System Cylinder Tempera- ture, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.6 (A-D)	Heat Source Insulation System Flange End Tem- perature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	
T25.7 (A-B)	Heat Source Preload Screw Temperature, "A"		W-Re Thermocouple	N/A	GE Design	50/2000°F	±10°F	(2)	

TABLE B17303
INSTRUMENTATION AND EQUIPMENT LIST
BIPS-QDS TESTS

Tag No. (Reference Drawing 306960)	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-Y)	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 Temper- ature	380°F	C-A Thermocouple	N/A	AiResearch Design	50/450°F	±3°F	(2),(3)	
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	±5% FSV	(2)	
P4B	Recuperator High Pressure Side Inlet Pressure	100 psia	Pressure Transducer	PA220TC150-350	Statham	0/150 psia	±5% FSV	(2)	
P4.1A	Recuperator Low Pressure Side Inlet Pressure	68 psia	Pressure Transducer	PA220TC100-350	Statham	0/100 psia	±5% FSV	(2)	
P4.1B	Recuperator Low Pressure Side Inlet Pressure	68 psia	Pressure Transducer	PA220TC100-350	Statham	0/100 psia	±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)	
P14	Mini-BRU Turbine Journal Bearing Pressure	48 psia	Pressure Transducer	PA220TC-75-350	Statham	0/75 psia	±0.5 psi	(2),(3)	
P15	Mini-BRU Compressor Thrust Bearing Pressure	48 psia	Pressure Transducer	PA220TC-75-350	Statham	0/75 psia	±0.5 psi	(2),(3)	
P16	Mini-BRU Compressor Journal Bearing Pressure	48 psia	Pressure Transducer	PA220TC-25-350	Statham	0/75 psia	±0.5 psi	(2)	

TABLE B17303
INSTRUMENTATION AND EQUIPMENT LIST
BIPS-QDS TESTS

Tag No. (Reference Drawing 306960)	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	±0.3 psi	(2)	
P _D 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)	
P _D 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)	
P _D 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)	
P _D 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)	
P _D 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)	
P _D 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)	
P _D 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)	
P _D 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)	
I30	DC Buses Current	11 AMP	Shunt	06707	Simpson	0-25	±1% FSV	(2)	
I31	DC Parasitic Load Supply Current	0-15 AMP	Shunt	06705	Simpson	0-15	±1% FSV	(2)	
I40;A,B,C,M	AC Alternator Output Current	8.7 AMP/L	CT-200/5 w 8 PT Current Enducor	237A970003V12-841	Westinghouse	0-25 AMP	±1.2% FSV ±1% FSV	(2)	3 current transformers and enducors required.
I42	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 Enducor	V12-841	Westinghouse	--	±2% FSV	(2)	3 current transformers and enducors required.
V30	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)	
V40	AC Alternator Output Voltage	110VLL	Voltage Enducor	VE2-841	Westinghouse	0-150V	±1% FSV	(2), (8)	
V42	AC Alternator Field Voltage	15.8V	--	--	--	0-50V	±0.5% FSV (2) ±1% FSV (3)	(2), (3), (8) (2), (8)	Signal condition only.
V140;A,B,C	Facility AC Voltage	120/200V	Voltage Enducor	VE2-841	Westinghouse	0-150V	±1% FSV	(2), (8)	6 ton measured.
KW30	DC Buses Power Output	1.3 KW	--	--	--	0-3 KW	--	(2), (3)	I30 x V30 = KW30.
KW31	DC Parasitic Load Power Draw	1.0 KW	--	--	--	0-3 KW	--	(2), (3)	I31 x V31 = KW31.
KW40	AC Alternator Power Output	1.5 KW	Hall Effect Multiplier	V92-840	Westinghouse	--	±2% FSV	(2)	
KW140	Facility AC Power		Hall Effect	V92-840	Westinghouse	--	±2% FSV	(2), (3)	
FI120	Facility Coolant Loop Flow							(2), (8)	
FI1	Mini-BRU Compressor Inlet Gas Flow	21 lb/min				0/50 lb/min	±0.4 lb/min	(2)	NOTE: All current, voltage and power ex-ducers to be calibrated for 1733 Hz.

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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		

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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/GE IHS Technology)
HSA	Heat Source Assembly (Does <u>not</u> include IHS or EHS. 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		O
IMU	Inertial Measurement Unit	OBF	Orbiter Processing System
IUS	Interim Upper Stage	OHA	Operational Hazard Analysis
IVA	Intra Vehicular Activity	ORNL	Oak Ridge National Laboratory
		OMS	Orbital Maneuvering Subsystem
J		P	
JPL	Jet Propulsion Laboratory (Pasadena, California)	PCL	Power Conversion Loop (Use of PCS preferred)
JFC	Johnson Space Center (Houston)	PCM	Pulse Code Modulation
		PCR	Payload Changeout Room
K		PCS I	Power Conversion System (HSA + BRU + MBR + Heat Sink + Controls + Piping and structure)
KB	Keyboard	PCS II	Power Conversion System (HSA + BRU + MBR + Radiator + Controls + Piping and Structure)
Kbaud	Code Elements per Second in 1000's	PGHM	Payload Ground Handling Mechanism
Kbps	Bits per Second in 1000's	PHA	Preliminary Hazard Analysis
KSC	Kennedy Space Center	PLC	Parasitic Load Control System
KW _e	Kilowatts Electrical	P/L	Payload
KW _t	Kilowatts Thermal	PLCC	Payload Control Center
L		PLH	Payload Handling
LASL	Los Alamos Scientific Laboratory	PLM	Payload Management
LCC	Launch Control Center	POP	Perpendicular to Orbit Plane
LES 8/9	Lincoln Experimental Satellite (No. 8 and 9)	PSAR	Preliminary Safety Analysis Report
LF	Load Factor	PSC	Power Supply Console (for RHS)
LH2	Liquid Hydrogen	PSC	Procurement Specification (AiResearch Term)
LiOH	Lithium Hydroxide	PSE	Peculiar Support Equipment
LO2	Liquid Oxygen	PSS	Payload Specialist Station
LPS	Launch Processing System	PSSR	Preliminary System Safety Review
M		PICS	Plutonium Isotope Containment Shield
M	Meters		Q
MARSCOM	Materials Review and Selection Committee	QA	Quality Assurance
MBR	Mini-Brayton Recuperator		
Mini-BRU	350 to 2100 Watts Electrical Brayton Rotating Unit		
MCC	Mission Control Center		
MDM	Multiplexer-Demultiplexer		

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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		

BIPS—GDS TEST LOG

E.W.O. No.		Date	Test Cell or Station No.
Assembly No.		Model No.	Unit Serial No.
Development Engineer		Technician	Grp. Ldr.
Test Type		Test Schedule	Modification

TIME	START	STOP	Event	O.C.

SUMMARY: Total Running Time _____ hrs. _____ min.		Total Manual Starts _____	Ref. Data Page _____
		Total Automatic Starts _____	Engineering _____