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Liquid Hydrogen Turbopump ALS Advanced Development Program

Contract NAS 8-37593
Interface Control Document DR-28
Volume I - Hot Fire Unit
8 October 1990

Prepared For:
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Propulsion Division

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LIQUID HYDROGEN TURBOPUMP
ALS
ADVANCED DEVELOPMENT PROGRAM

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The Requirement for Use of International System of Units Has
Been Waived for This Document

RPT/D0413.55-TP

PAGE REVISION LOG	AEROJET PROPULSION DIVISION	DOCUMENT NO. DR-28

Interface Control Document ALS ADP Liquid Hydrogen Turbopump - Hot Fire Unit	AS OF: 8 October 1990	SUPERSEDING: 12 January 1989

Note: The current revision is denoted by a vertical line in the outer margin adjacent to the affected text.

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RPT/D0413.55-McD

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1.0 GENERAL

1.1 SYSTEM DESCRIPTION

The system to be provided by Aerojet Propulsion Division consists of six elements:

- One turbopump hot fire test article.
- One test cart on which the turbopump is mounted.
- Four spools to connect the pump and turbine inlets and outlets with the test facility supply and exhaust ducts.

The Liquid Hydrogen (LH_2) Turbopump features a two-stage impeller pump with a pre-stage inducer driven by a two-stage turbine. The single shaft is supported by duplex rolling element bearings and by damping seals. The turbine is driven by a facility gas generator which is treated in this document as an integral part of the Component Test Facility (CTF)

The turbopump test article will be supplied mounted on a test cart. This is the system configuration addressed in this ICD, and the system which will be connected to the CTF located at the National Aeronautics and Space Administrations (NASA) Stennis Space Center (SSC). The spools will remain loose items of the system until final duct connection is completed.

Primary interfaces between the CTF and the turbopump test cart assembly include pump inlet and discharge, turbine inlet and discharge, and test cart-to-test facility mounts.

Secondary interfaces include purge, chilldown, vent, and bleed lines; and instrumentation connections. These are all located at fluid and instrumentation panels integral with the test cart.

The following is the Equipment Responsibility List associated with this ICD:

1.0 General, (cont.)

Part No.	Item	Responsibility
TBD	Turbopump Test Article	Aerojet
TBD	Test Cart	Aerojet
TBD	Pump Inlet Spool	Aerojet
TBD	Pump Discharge Spool	Aerojet
TBD	Turbine Inlet Spool	Aerojet
TBD	Turbine Discharge Spool	Aerojet
TBD	Turbopump Instrumentation	Aerojet
TBD	Pump Discharge Duct	NASA-CTF
TBD	Turbine Inlet Duct	NASA-CTF
TBD	Turbine Discharge Duct	NASA-CTF
TBD	Gas Generator Assembly	Rocketdyne
TBD	Test Cart Tracks and Foundations	NASA-CTF
TBD	Liquid Hydrogen Supply and Disposal	NASA-CTF
TBD	Instrumentation not on/in Turbopump	NASA-CTF
TBD	Facility Bleed, Drain, Chilldown, and Purge Lines with Valving	NASA-CTF
TBD	Test Cart Lifting/Handling Gear	NASA-CTF
TBD	Data Acquisition and Management	NASA-CTF
TBD	Test Sequencer	NASA-CTF
TBD	Turbine Exhaust Flow Control Orifice	NASA-CTF
TBD	Turbine Inlet Flow Control Orifice	NASA-CTF
TBD	Pump Discharge Flow Control Orifice	NASA-CTF

1.2 SCOPE

This interface Control Document is submitted as Data Requirement (DR) 28 of the Advanced Launch System (ALS), Advanced Development Program (ADP) Liquid Hydrogen Turbopump. This program is being performed by Aerojet Propulsion Division for the Marshall Space Flight Center (MSFC), NASA, under Contract No. NAS 8-37593.

The purpose of this document is to define the interface criteria for the Turbopump Test Article and the Component Test Facility located at NASA, SSC. TPA ICD Volume II is submitted for the Cold Gas Drive Turbopump Test Article, which is generally similar but incorporates certain changes, particularly in fluid requirements and in instrumentation needs. For the purposes of this ICD, the

1.0 General, (cont.)

"test article" consists of the Hot Fire Drive Turbopump mounted on its Test Cart, readied for installation in the CTF. It should be emphasized that the LH_2 turbopump program is still in its early concept design phase. Design of the turbopump, test cart, and spools are subject to revisions until successful conclusion of the Detail Design Review (DDR).

1.3 LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ADP	Advanced Development Program
ALS	Advanced Launch System
AT	Aerojet TechSystems
CTF	Component Test Facility
DAS	Data Acquisition System
FS1	Fire Switch 1 (One)
GH2	Gaseous Hydrogen
GPM	Gallons per Minute
GSE	Ground Support Equipment
ICD	Interface Control Document
LH2	Liquid Hydrogen
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NPSH	Net Positive Suction Head
PR	Turbine Inlet Pressure to Turbine Exit Pressure Ratio
PTI	Pressure at Turbine Inlet
Q/N	Flow-to-Speed Ratio
RPM	Revolutions per Minute
SSC	Stennis Space Center
STE	Special Test Equipment
TBD	To be determined
TTI	Temperature at Turbine Inlet

1.0 General, (cont.)

1.4 TERMINOLOGY

1.4.1 Axis Location

The axis location of an interface connect point is the position of the connect point relative to the turbopump X, Y, and Z axes for the turbopump in a basic aligned position mounted on its test cart, unless otherwise specified.

1.4.2 Test Article System Dry Weight

The weight of the turbopump and test cart combination readied for installation in the CTF and without fluids, shipping fixtures, or closures. This excludes duct connection spool weights.

1.4.3 Test Article Line Maintenance

Turbopump and/or test cart maintenance activity that can be accomplished while the test article is installed in the CTF.

1.4.4 Test Article System

The test article system consists of all hardware within the test article envelope.

1.4.5 Test Article Wet Weight

The weight of the turbopump, test cart, and spools combination including fluids contained in the turbopump and spools prior to the initiation of a test run.

1.4.6 Interface Connect Point

An interface connect point is defined as a test article-to-CTF connection point specifically provided by or required by the test article.

1.4.7 Interface Number

A reference number which identifies each interface connect point.

2.0 APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

Refer to Table 2.1.

2.2 NON-GOVERNMENT DOCUMENTS

TBD

TABLE 2.1
Government Documents

DOD-D-1000B	Drawing Engineering and Associated Lists
DOD-STD-100C	Military Standard Engineering Drawing Practices
MIL HDBK 5E	Military Standardization Handbook, Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-STD-975F	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts Lists
MM 2314.2	Data Management Operating Procedures
MM 8020.6A	MSFC Cost/Schedule Performance Criteria (C/LSPC) with Implementing Provisions
MMI 1711.2D	Mishap Reporting and Investigation
MMI 4000.4	Procurement Management of Propellants/Pressurants
MMI 5310.2	Alerts and Saf-Alerts Reporting of NASA Parts, Materials, and Safety Problems
MMI 5330.4	Deviation Approval Request Requirements
MMI 6400.2A	Packaging, Handling, and Moving of Program Critical Hardware
MMI 8010.5	MSFC Baseline Design Review
MSFC Dwg. 85M03885	Guidelines for Performing Failure Mode, Effects and Criticality Analysis (FMECA), on the Space Shuttle
MSFC HDBK 527E	Materials Selection List for Space Hardware Systems
MSFC HDBK 1249	NDE Guidelines for Fracture Control
MSFC HDBK 1453	Fracture Control Program Requirements
MSFC SPEC 250	Protective Finishes for Space Vehicles, Structures, and Associated Flight Equipment, General Specification for
MSFC SPEC 522A	Design Criteria for Stress Corrosion Cracking
MSFC SPEC 560 (Latest Rev)	Specification - Welding
MSFC SPEC 655	Control of Standard Weld Filler Metal
MSFC STD 504B	Specification - Welding, Aluminum Alloys
MSFC STD 505A	Structural Strength Program Regulations
MSFC STD 506B	Standard Materials and Processes Control
NHB 1440.4A	Specifications and Standards for NASA Engineering Data Micro-reproduction System
NHB 1700.1 (V1)	Basic Safety Requirements
NHB 1700.1 (V3)	Systems Safety
NHB 5300.4 (1B)	Quality Program Provisions for Aeronautical and Space System Contractors
NHB 5300.4 (1D-2)	Safety, Reliability, Maintainability, & Quality Provisions for the SSP
NHB 6000.1C	Requirements for Packaging, Handling, & Transportation of Aeronautics and Space System Equipment and Assoc. Co.
NHB 7320.1B	Facilities Engineering Handbook
SOP 5300.1	Critical Items List and Hazard List
SPR 019	MSFC Problem Assessment System (PAS)

3.0 PHYSICAL INTERFACE (SHIPPING, HANDLING, STORAGE, AND INSTALLATION)

3.1 INSTALLATION ENVELOPE DIMENSIONS AND ORIENTATION

The turbopump test cart assembly/description is included as Figures 3.1 and 3.2. The turbopump coordinate axes definition and spool piece/facility interface coordinates is shown in Figure 3.3. The system coordinate axis are oriented per the right hand rule and relative to the pump.

- The Z axis is coincident with the center line of the turbopump. The positive direction is up.
- The X axis is coincident with the center line of the turbine inlet and perpendicular to the Z axis.
- The Y axis is perpendicular to the X & Z axis.

3.1.1 Test Cart Description

Purpose of TPA GSE Test Cart. The test cart shall be so designed and constructed so as to provide a means for performing the following tasks. See Figures 3.1 and 3.2.

- The cart shall provide a safe and stable platform for moving the turbopump between manufacturing, maintenance or test operations.
- The cart shall exhibit physical dimensions compatible with those of the designated SSC turbopump test cell so as to provide ease of installation and test operations.
- The cart shall exhibit a robust design and be constructed of a suitable materials so as to provide reliable and maintenance free operation.

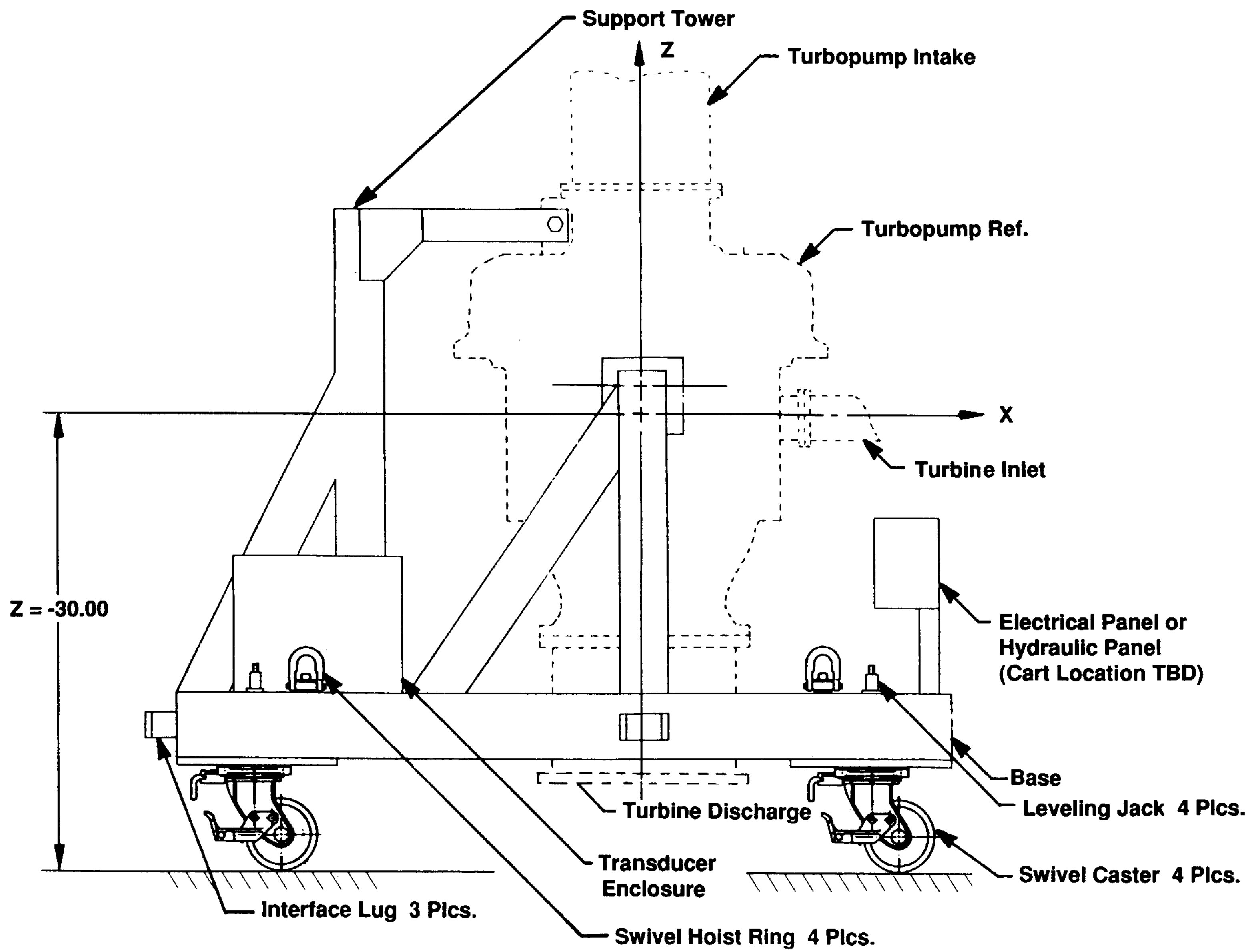

Figure 3.1 Test Cart Description

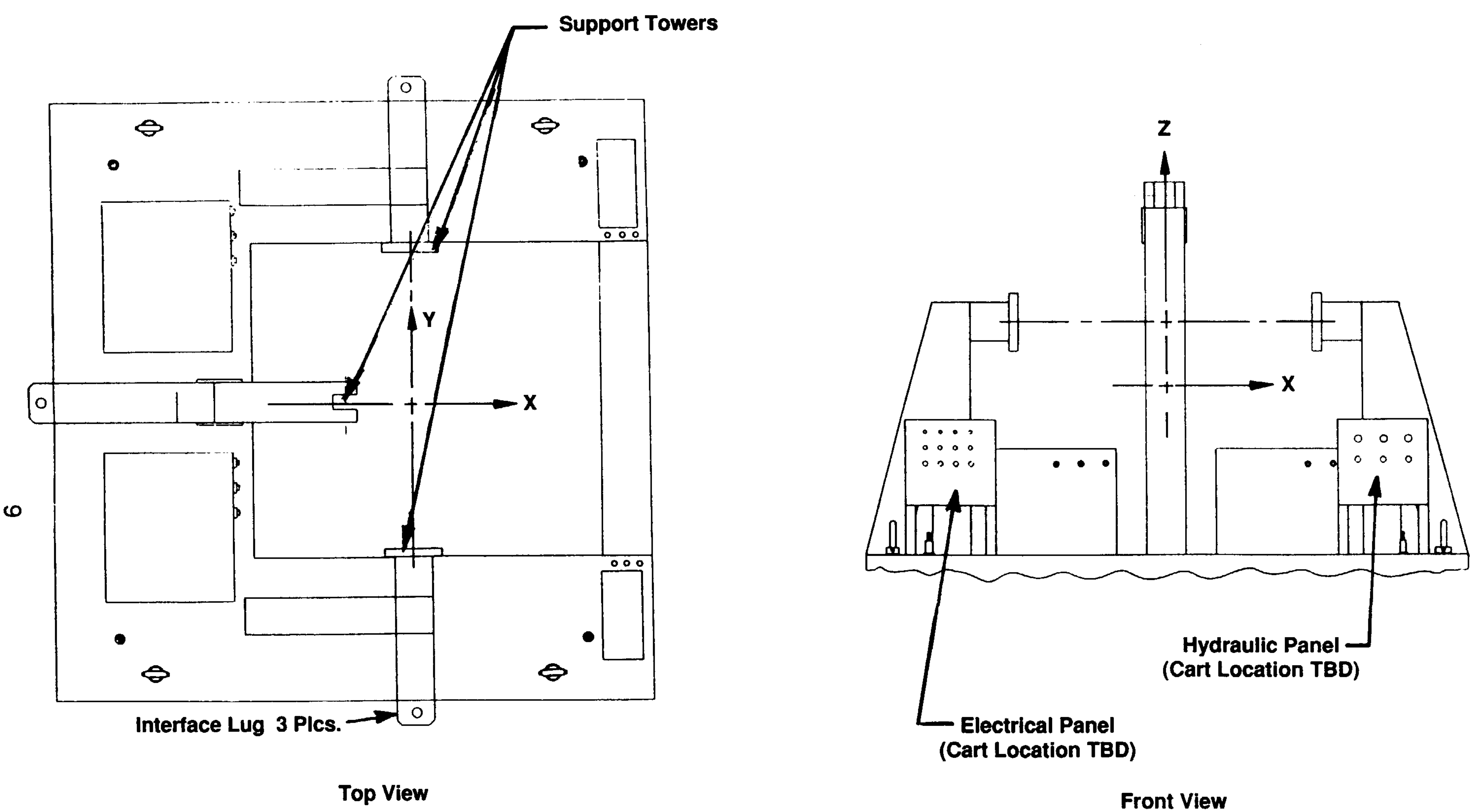

Figure 3.2 Test Cart Description

Note: Pump Intake, Discharge, and Turbine Intake and Discharge Supplied With 1 Foot Long Spools. Required Orifices Will Be Mounted Between Turbopump and Spools.

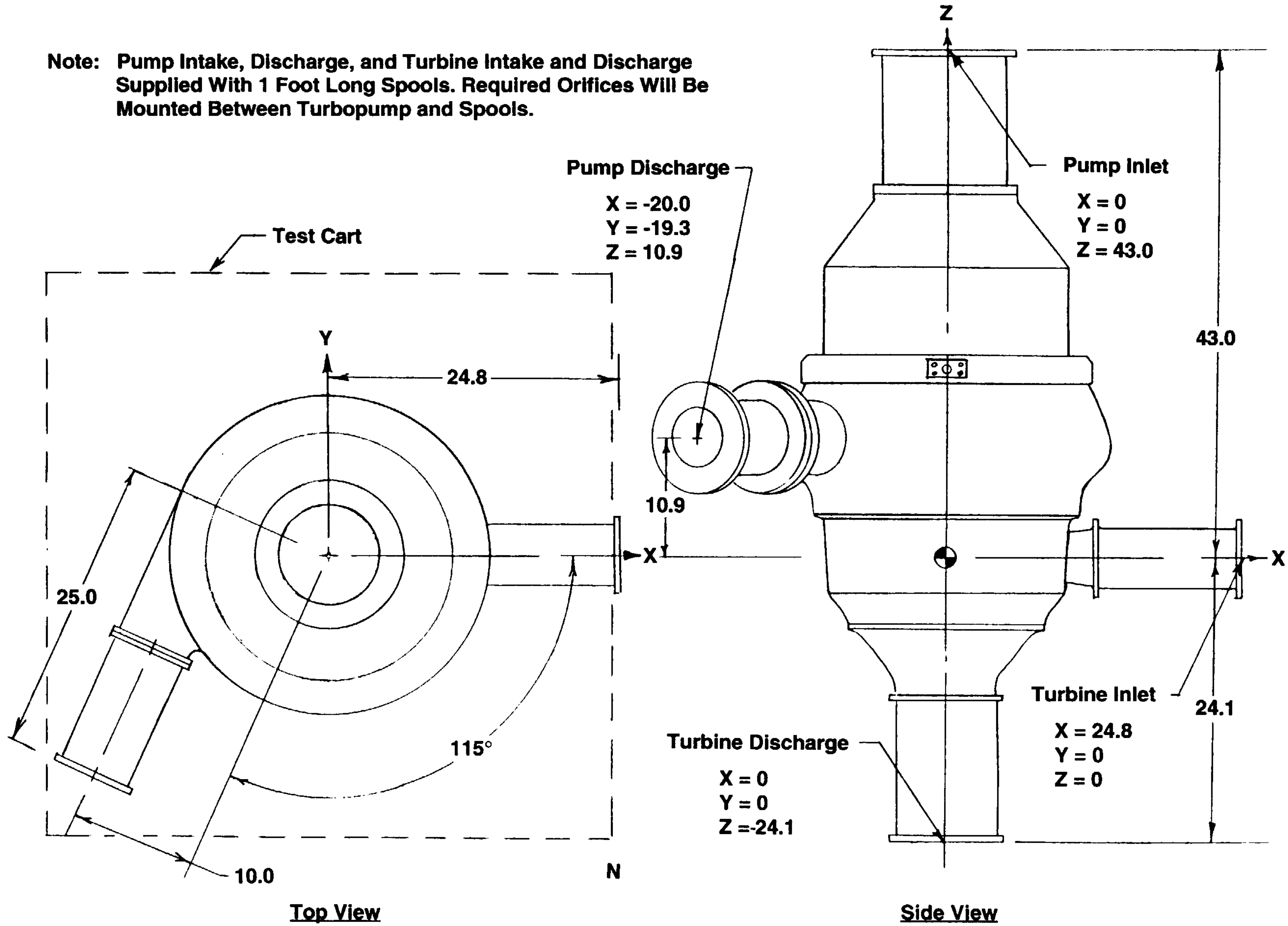

Figure 3.3 Turbopump Coordinate Axes Definition and Spool Piece/Facility Interface Coordinates

- The cart shall function as turbopump test fixture to the extent the combined turbopump and cart shall be capable of being mechanically secured to the test cell so as to provide a reliable and safe installation.

3.1.2 Cart Functional Characteristics

The test cart shall demonstrate the following functional characteristics.

- The turbopump shall be secured to the cart through three mounting brackets. These brackets shall engage the pump section at the designated points shown in Figures 3.1 and 3.2.
- The turbopump shall be secured in a vertical position so as to simulate the same installation method used on the engine.

3.1.3 Mechanical Design

The test cart shall demonstrate the following mechanical design characteristics.

- The cart surface dimensions shall be 48 inches by 48 inches. Located at the center of the surface shall be a clear aperture having a diameter of not less than 32 inches. This aperture shall serve to provide access for installing turbine discharge spool.
- The cart shall be equipped with a removable brace located on the cart edge adjacent to the turbine inlet line. This removable brace will serve to provide additional access area during installation of the cart in the test cell.
- The cart shall be equipped with bearing type wheels to provide ease in moving the cart and turbopump. The cart side, opposite the turbine inlet line, shall be equipped with a

removable tow ring for attachment to a powered towing device. Each wheel is equipped with a brake. Each wheel assembly will be so constructed so as to allow its removal or tie-down to the cart during test operations. Each jack screw shall be equipped with a nut and lock washer for securing jack screw to cart.

- The cart shall be equipped with four hoist rings, located at each corner, suitable for attachment to two, two-point lifting bridle slings and spreader bar. Bridle slings and spreader bar must be capable of safely lifting 6000 pounds and exhibit a safety factor of 2. Facility hoist requirements for lifting and moving the combined turbopump and cart weight shall not be less than 8000 pounds. During test operations each hoist ring is secured to the surface of the cart by a captive clamp.

- The cart shall be equipped with four leveling jacks to be located at each corner. The jacks shall provide a means for adjusting the height and leveling cart on the test cell.

3.1.4 Method of Construction and Materials

The cart shall be constructed of stainless steel. Stainless steel has been selected because of lower cost and its ability to retain structural integrity at cryogenic temperatures. The cart base shall be all welded construction. Turbopump mounting brackets shall be welded assemblies and be attached to the base with attaching hardware. All spools, pump intake, pump discharge, turbine intake and turbine discharge shall be constructed of stainless steel and pipe with welded flanges.

3.1.5 Cart Turbopump Instrumentation

All Aerojet instruments/sensors required to monitor performance and control turbopump operation, during test operations, shall be integral to the cart. The cart shall have integral to its structure the following instrumentation capabilities. (See also Figure 3.2). The electrical and sensor interface panel shall be capable of handling 78 individual sensor outputs. Refer to Table 4.1 for listing of instrumentation.

- The cart shall be equipped with two instrument/sensor enclosures for protection of those instruments not directly attached to turbopump, such as Taber pressure transducers. The panels, on each enclosure, shall be attached to the base of the cart. The transducer shall be installed in such a manner that all sensor input lines shall be external to the housing that will enclose the instruments.

- Each enclosure shall be capable of accommodating at least 25 transducers.

- Operating power for transducers shall be provided by a regulated power supply located within one enclosure. Primary power for the power supply will require 28 volts dc.

- Each enclosure shall be constructed in such a manner so as to protect instruments from test environment.

- Instrument output signals shall be managed through individual shielded cable. Each cable shall terminate on an electrical interface panel (location on Cart TBD). Electrical connectors are defined in Section 4.4.2.

- Instruments/sensors requiring close proximity to the turbopump shall be mounted directly to the assembly.

3.1.6 Hazardous Environment Safety Design

Because of the hazardous test environment the cart shall incorporate the following safety design requirements.

TABLE 4.1
Master Measurements List

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ALS HOT FIRE TEST ARTICLE

MASTER MEASUREMENTS LIST

ALS HOT FIRE TEST ARTICLE

No.	STA	MEASUREMENT		LOCATION	Q	SUB	ATC NOMEN	MEASUREMENT FUNCTION: RED LINE	PER-FORM	CON-TROL	DIAG	TRANSDUCER RANGE	SAMPLE RATE	C D N NUMBER	MODEL NUMBER	REMARKS - INTERFACE PANEL
1	9	PRESS., STATIC	*	PMP IN	1			X	X	X		0-100 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
2	9	PRESS., STATIC		PMP IN	1	2		X	X	X		0-100 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
3	9	PRESS., STATIC	*	MAIN PMP DISCH	1				X	X		0-5000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
4	9	PRESS., STATIC		MAIN PMP DISCH	1	2			X	X		0-5000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
5	9	PRESS., STATIC	*	TURB IN	1			X	X	X		0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
6	9	PRESS., STATIC		TURB IN	1	2		X	X	X		0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
7	9	PRESS., STATIC	*	TURB DISCH	1				X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
8	9	PRESS., STATIC		TURB DISCH	1	2			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
9	9	PRESS., STATIC	*	PMP 1ST STG DISCH	1				X			0-1000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
10	9	PRESS., STATIC	*	PMP 1ST STG DISCH	1				X			0-1000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
11	9	PRESS., STATIC	*	PMP 1ST STG DISCH	1	3			X			0-1000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
12	9	PRESS., STATIC	*	PMP 2ND STG DISCH	1				X			0-2000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
13	9	PRESS., STATIC	*	PMP 2ND STG DISCH	1				X			0-2000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
14	9	PRESS., STATIC	*	PMP 2ND STG DISCH	1	3			X			0-2000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
15	9	PRESS., STATIC	*	PMP 3RD STG DISCH	1			X	X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
16	9	PRESS., STATIC	*	PMP 3RD STG DISCH	1			X	X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
17	9	PRESS., STATIC	*	PMP 3RD STG DISCH	1	3			X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
18	9	PRESS., STATIC	*	THRUST BAL CAV	1				X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
19	9	PRESS., STATIC	*	THRUST BAL CAV	1				X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
20	9	PRESS., STATIC	*	THRUST BAL CAV	1				X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
21	9	PRESS., STATIC	*	THRUST BAL CAV	1	4			X			0-2000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
22	9	PRESS., STATIC	*	PMP BRG CAV IN	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
23	9	PRESS., STATIC	*	PMP BRG CAV OUT	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
24	9	PRESS., STATIC	*	TURB BRG CAV IN	1	1			X			0-1000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
25	9	PRESS., STATIC	*	TURB BRG CAV OUT	1	1			X			0-1000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
26	9	PRESS., STATIC	*	TURB NOZZLE OUT	1				X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
27	9	PRESS., STATIC		TURB NOZZLE OUT	1				X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
28	9	PRESS., STATIC		TURB NOZZLE OUT	1	3			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
29	9	PRESS., STATIC	*	LABYRNTH OUT	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
30	9	PRESS., STATIC	*	TURB 2ND STG STATOR HUB	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
31	9	PRESS., STATIC		TURB 2ND STG STATOR TIP	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
32	9	PRESS., STATIC		TURB 2ND STG ROTOR OUT	1				X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
33	9	PRESS., STATIC		TURB 2ND STG ROTOR OUT	1	2			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
34	9	PRESS., STATIC		PMP 2ND STG IN	1	1			X			0-2000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
35	9	PRESS., STATIC		NO. 4 DAMPER OUT	1	1			X			0-3000 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
36	9	PRESS., STATIC		INDUCER OUT	1	1			X			0-500 PSIG	100 Hz		TBD (4)	10 PIN CONNECTOR MS3116P-12-10S MALE
37	9	TEMPERATURE	*	PMP IN	1	1		X	X			30-60 °R	100 Hz		TBD (4)	RTD - 6 PIN CONNECTOR 71-432300-6S MALE
38	9	TEMPERATURE	*	MAIN PMP DISCH	1	1			X			30-80 °R	100 Hz		TBD (4)	RTD - 6 PIN CONNECTOR 71-432300-6S MALE
39	9	TEMPERATURE	*	TURB IN	1			X	X			500-1800 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
40	9	TEMPERATURE	*	TURB IN	1	2		X	X			500-1800 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
41	9	TEMPERATURE	*	TURB DISCH	1	1			X			500-1400 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
42	9	TEMPERATURE	*	PMP BRG OUT	1	1		X	X		X	30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
43	9	TEMPERATURE		PMP BRG IN	1	1			X			30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
44	9	TEMPERATURE	*	TURB BRG OUT	1	1		X	X		X	30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE

NOTES:
1) IF MEASUREMENT FUNCTION IS MARKED 'RED-LINE', THE SENSOR MUST BE LOCATED NO FURTHER THAN 12 INCHES FROM PUMP BOSS.
2) ALL SIGNAL CONDITIONING TO BE PROVIDED BY SSC (THERE ARE NO SPECIAL SIGNAL CONDITIONING REQUIREMENTS AT THIS TIME).
3) THE 'SUB' COLUMN INDICATES THE SENSOR SUBTOTAL BY PARAMETER FOR DAS PROCESSING. SENSOR GRAND TOTAL = 81 OF WHICH 49 (INDICATED BY '*' IN MEASUREMENT COLUMN) REQUIRE SSC DATA REDUCTION.
4) INSTRUMENTATION SELECTION TO BE COMPATABLE WITH SSC CTF DAS ICD.

TABLE 4.1 (Cont.)
Master Measurements List

ALS HOT FIRE TEST ARTICLE — MASTER MEASUREMENTS LIST — ALS HOT FIRE TEST ARTICLE

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No.	STA	MEASUREMENT	LOCATION	Q	SUB	ATC NOMEN	MEASUREMENT FUNCTION: RED LINE	MEASUREMENT FUNCTION: PER-FORM	MEASUREMENT FUNCTION: CON-TROL	MEASUREMENT FUNCTION: DIAG	TRANSDUCER RANGE	SAMPLE RATE	C D N NUMBER	MODEL NUMBER	REMARKS - INTERFACE PANEL
45	9	TEMPERATURE	TURB BRG IN	1	1			X			30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
46	9	TEMPERATURE	TURB SL D/S CAV	1	1			X			30-150 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
47	9	TEMPERATURE	THRUST BAL SUMP	1	1			X			30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
48	9	TEMPERATURE	PMP 2ND STG DISCH	1	1			X			30-80 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
49	9	TEMPERATURE	PMP 1ST STG DISCH	1	1			X			40-70 °R	100 Hz		TBD (4)	T/C - 3 PIN CONNECTOR MS3116P-8-3S MALE
50	9	SPEED *	PMP SHAFT	1			X	X	X	X	0-30,000 RPM	20K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
51	9	SPEED *	PMP SHAFT	1	2		X	X	X	X	0-30,000 RPM	20K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
52	10	FLOW *	PMP IN	1				X		X	0-24,000 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
53	10	FLOW *	PMP IN	1	2			X		X	0-24,000 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
54	10	FLOW *	GG LOX	1				X		X	0-180 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
55	10	FLOW *	GG LOX	1	2			X		X	0-180 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
56	10	FLOW *	GG FUEL	1				X		X	0-3500 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
57	10	FLOW *	GG FUEL	1	2			X		X	0-3500 GPM	SSC ?		TBD (4)	SSC FACILITY MEASMT INCLUDING DATA REDUCTION
58	9	ACCELEROMETER, X AXIS *	PMP CASE	1			X			X	0-10 G's P-P	5K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
59	9	ACCELEROMETER, Y AXIS *	PMP CASE	1			X			X	0-10 G's P-P	5K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
60	9	ACCELEROMETER, X AXIS *	PMP CASE	1			X			X	0-10 G's P-P	5K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
61	9	ACCELEROMETER, Y AXIS *	PMP CASE	1			X			X	0-10 G's P-P	5K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
62	9	ACCELEROMETER, Z AXIS *	PMP CASE	1	5		X			X	0-10 G's P-P	5K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
63	9	DISPLACEMENT, X AXIS *	SHAFT, PMP END	1			X			X	0-0.010 IN.	5K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
64	9	DISPLACEMENT, Y AXIS *	SHAFT, PMP END	1			X			X	0-0.010 IN.	5K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
65	9	DISPLACEMENT, X AXIS *	SHAFT, TURB END	1			X			X	0-0.010 IN.	5K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
66	9	DISPLACEMENT, Y AXIS *	SHAFT, TURB END	1			X			X	0-0.010 IN.	5K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
67	9	DISPLACEMENT, Z AXIS *	SHAFT, TURB END	1	5		X			X	0-0.010 IN.	5K Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
68	9	STRAIN	PMP HSG, FORWARD	1						X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
69	9	STRAIN	PMP HSG, FORWARD	1	2					X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
70	9	STRAIN	PMP HSG, AFT	1						X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
71	9	STRAIN	PMP HSG, AFT	1	2					X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
72	9	STRAIN	DIFFUSER/PMP HSG	1	1					X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
73	9	STRAIN	TURBINE HOUSING	1						X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
74	9	STRAIN	TURBINE HOUSING	1	2					X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
75	9	STRAIN	DIAPHRAM SEAL	1						X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
76	9	STRAIN	DIAPHRAM SEAL	1	2					X	±0.004 IN/IN	100 Hz		TBD (4)	6 PIN CONNECTOR 71-432300-6S MALE
77	9	PRESSURE, HIGH FREQ	PMP IN	1	1					X	0-100 PSIG	20K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
78	9	PRESSURE, HIGH FREQ	PMP DISCH	1	1					X	0-5000 PSIG	20K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
79	9	PRESSURE, HIGH FREQ	TURB IN	1	1					X	0-3000 PSIG	20K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
80	9	PRESSURE, HIGH FREQ	TURB DISCH	1	1					X	0-500 PSIG	20K Hz		TBD (4)	MINI COAX CONNECTORS BNC MALE
81	9	TORQUE	BREAKAWAY TORQUE	1						X	0-500 IN-LBS	N/A		TBD (4)	NOT APPLICABLE
82															
83															
84															
85															
86															
87															
88															
89															

NOTES:
1) IF MEASUREMENT FUNCTION IS MARKED 'RED-LINE', THE SENSOR MUST BE LOCATED NO FURTHER THAN 12 INCHES FROM PUMP BOSS.
2) ALL SIGNAL CONDITIONING TO BE PROVIDED BY SSC (THERE ARE NO SPECIAL SIGNAL CONDITIONING REQUIREMENTS AT THIS TIME).
3) THE 'SUB' COLUMN INDICATES THE SENSOR SUBTOTAL BY PARAMETER FOR DAS PROCESSING. SENSOR GRAND TOTAL = 81 OF WHICH 49 (INDICATED BY '*' IN MEASUREMENT COLUMN) REQUIRE SSC DATA REDUCTION.
4) INSTRUMENTATION SELECTION TO BE COMPATABLE WITH SSC CTF DAS ICD.

- The turbopump and cart shall be electrically grounded to facility ground.
- All electrical connector carrying transducer operating power shall be potted.
- All electrical interface panel connectors shall be of explosion proof design.
- All signal and power cable shall be shielded and electrically grounded.

3.1.7 Cryogenic Interface Panel

The cart shall incorporate an interface panel, (location on cart TBD), for means of connecting externally supplied purge, chilldown and bleed to the turbopump. Attached to the rear of the panel shall be a means for distributing the lines to the designated turbopump components. Bleed lines shall be 1 inch nominal and purge lines 1/2 inch nominal. See Figure 3.2. Panel interface fittings shall be cryogenic type stainless steel, threaded and equipped with captive protective covers.

3.1.8 Cart/Turbopump Shipping and Storage

A special shipping container shall be used for safe transporting of the cart and turbopump. The container shall be constructed of a durable material and shall be considered as reusable. The interface lugs located on the cart shall be used for securing the cart to the shipping container. The turbopump shall be shipped without spools installed. All open turbopump ports shall be sealed with a bolted closure to eliminate the introduction of moisture and dirt. Prior to shipment the turbopump shall be purged using dry nitrogen. The four spools shall be stored and shipped in a separate container. During shipping or extended storage, the turbopump shall remain in the enclosure. When installed in the CTF, a trickle purge system (300 cc per min max.) shall be capable of maintaining the turbopump under a constant purge pressure of 12 ± 2 psig.

3.1.9 Fuel Turbopump Test Cart Footprint

Figure 3.4 described the Fuel Turbopump Test Cart Footprint in the test cell. Table 3.1 described the loads and moments that the turbopump could impose on the test cell structure. These loads and moments are not to be construed as loads the structure could impose on the turbopump.

3.1.10 SSC Test Cell Interface

The cart shall be designed and constructed to interface and operate in the planned SSC Turbopump Test Cell. The proposed cart design complies with the specified SSC envelope. See Figure 3.3. The following are the cart design requirements for interfacing with the test cell.

3.2 DUCTS AND LINES REQUIREMENTS FOR INTERFACING CART WITH TEST CELL

3.2.1 Turbine Inlet, Discharge, Purge, and Drainline Interconnects

Refer to Figure 3.5 for number and line sizes.

3.2.1.1 Holes, Bolt Patterns, Fasteners, Materials, Surface Finish, and Surface Preparation

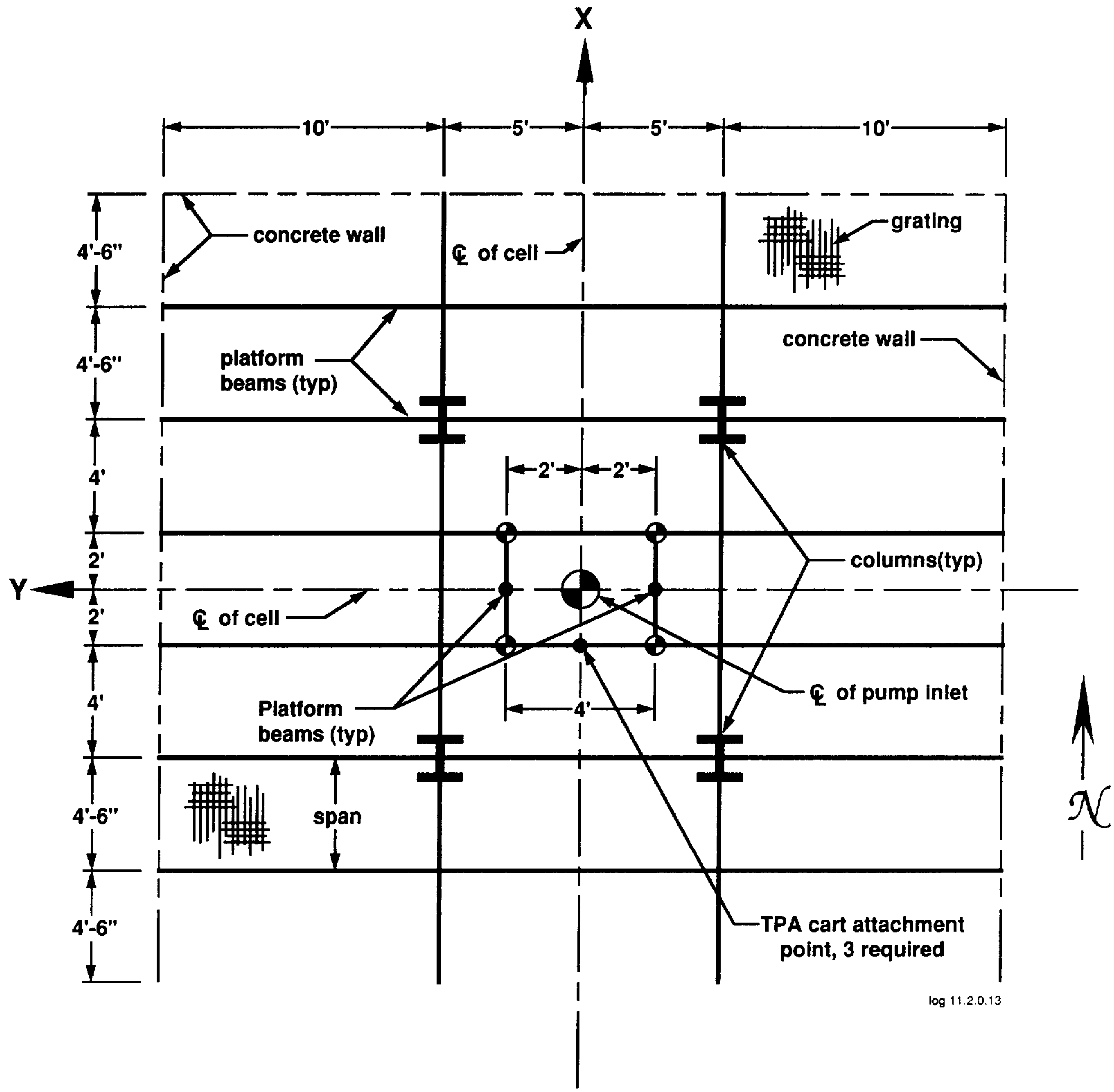
TBD

3.2.2 Propellant Inlet, Discharge and Bleedline Interconnects

Refer to Figure 3.5 for number and line sizes.

3.2.2.1 Holes, Bolt Patterns, Fasteners, Materials, Surface Finish, and Surface Preparation

TBD



Structural Interface Points for CTF

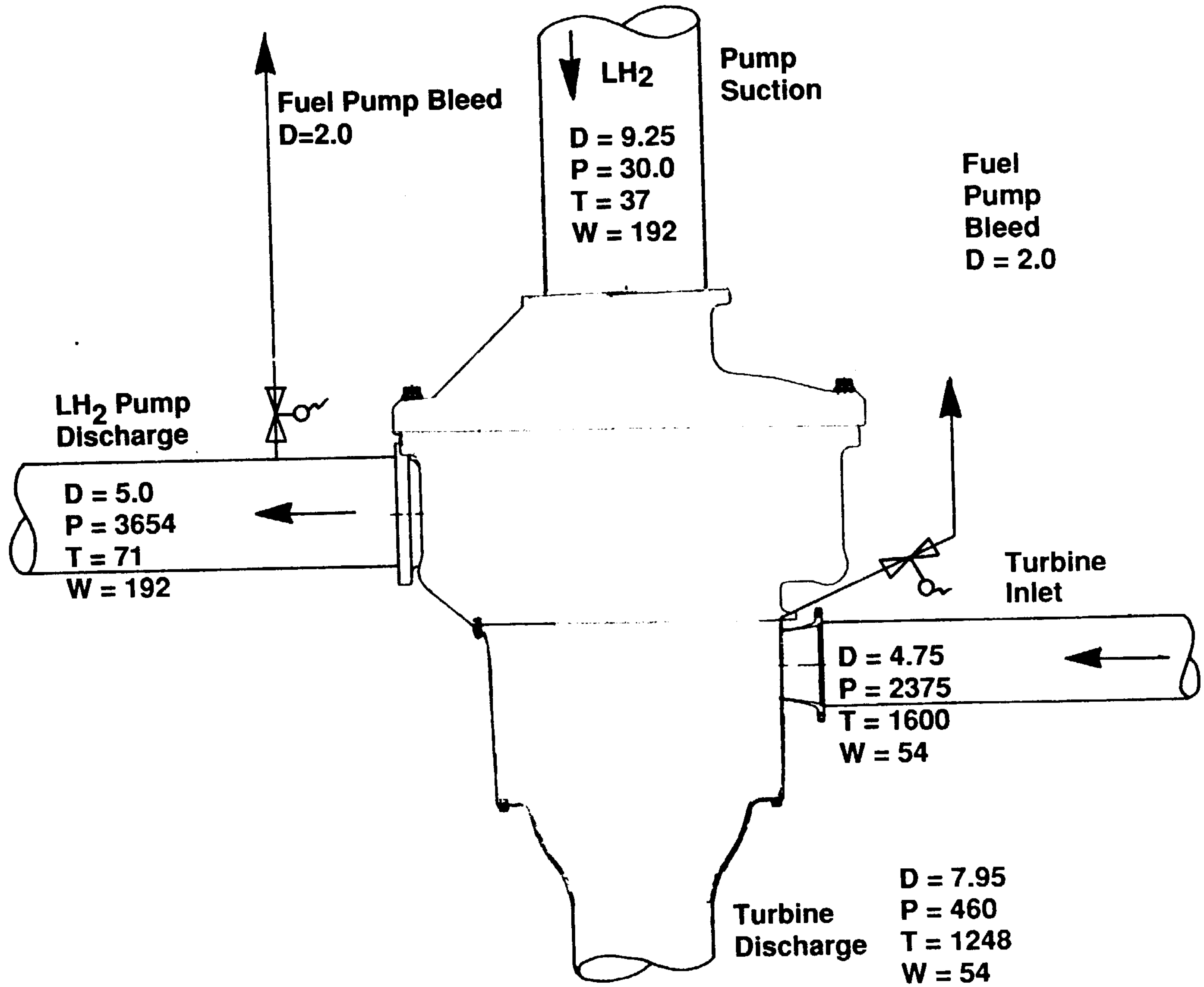
Figure 3.4. Pump Test Cart

TABLE 3.1

TURBOPUMP LOADS IMPOSED ON THE TEST STAND*

Direction	Loads
Fx	± 100,000 lbs
Fy	± 50,000 lbs
Fz	± 100,000 lbs
Mxx	250,000 in-lbs
Myy	250,000 in-lbs
Mzz	250,000 in-lbs

* Static forces caused by duct loads.



Units	
Diameter,D	Inches
Pressure,P	psia
Temperature,T	˚R
Flow Rate,W	lb/sec

Figure 3.5 Fuel Pump Fluid Interface Conditions

3.2.3 Ducts and Lines Interface Loads

3.2.3.1 Limit Loads, Deflections, and Alignment

The CTF shall install the primary interface lines so that loads not greater than TBD are transmitted to the turbopump at both the ambient-non-operating and pump/turbine operating condition. Each of the primary interface lines (pump inlet and discharge, turbine inlet and discharge) will have a minimum length line extending from the turbopump that has no changes in geometry (Table 3.2).

TABLE 3.2

INTERFACE LINES MINIMUM LENGTH

Interface Line	Min Length
Pump Inlet	5 diameters
Pump Discharge	5 diameters
Turbine Inlet	5 diameters
Turbine Discharge	4 diameters

4.0 ELECTRICAL PANEL INTERFACE

4.1 LAYOUT AND CONNECTORS

Connection to turbopump instrumentation shall be performed through the panel located on the Test Cart (Figures 3.1 and 3.2). The panel contains all electrical inputs and outputs necessary for instrumenting the test article. Electrical connections shall be grouped (input and output) and each connection shall be individually identified. All instruments shall have dedicated connectors attached to the panel, a shielded cable and instrument connector. All shields shall be grounded at the signal conditioner. All panel connectors will be provided with protective covers.

4.2 SPECIFICATIONS

TBD

4.3 INSTRUMENTATION

4.3.1 Static Data

Refer to Master Measurements List (Table 4.1). The Component Test Facility shall be responsible for general signal conditioning. Aerojet shall be responsible for special signal conditioning.

4.3.2 High Frequency Data

Refer to Master Measurements List (Table 4.1). The Component Test Facility shall be responsible for general signal conditioning. Aerojet shall be responsible for special signal conditioning.

4.4 DATA ACQUISITION INTERFACE

4.4.1 Data Requirements

Data related requirements shall be compiled into a document for each test series and presented to SSC for approval. The instrumentation shall be compatible with SSC CTF Data Acquisition System.

4.4.2 Facility Test Cell Receptacle Box Connectors

The Receptacle Box (RB) connectors for general purpose low speed data acquisition shall be MS3116P-12-10S (or equivalent) type with ten pins for bridge sensors, government part number 71-432300-6S (or equivalent) type with six pins for Rosemount RTD's, and MS3116P-3S (or equivalent) type with three pins for thermocouples. The thermocouple connectors will have the Chromel and Alumel pins to support K type thermocouples as standard. The RB connectors for high speed data acquisition shall be mini coax BNC or general purpose 10 pin female MS3116P-12-10S (or equivalent) type. See Figures 4.1, 4.2, and 4.3 for pins assignments for both the ten pin, six pin and three pin connectors.

4.4.3 Accuracy

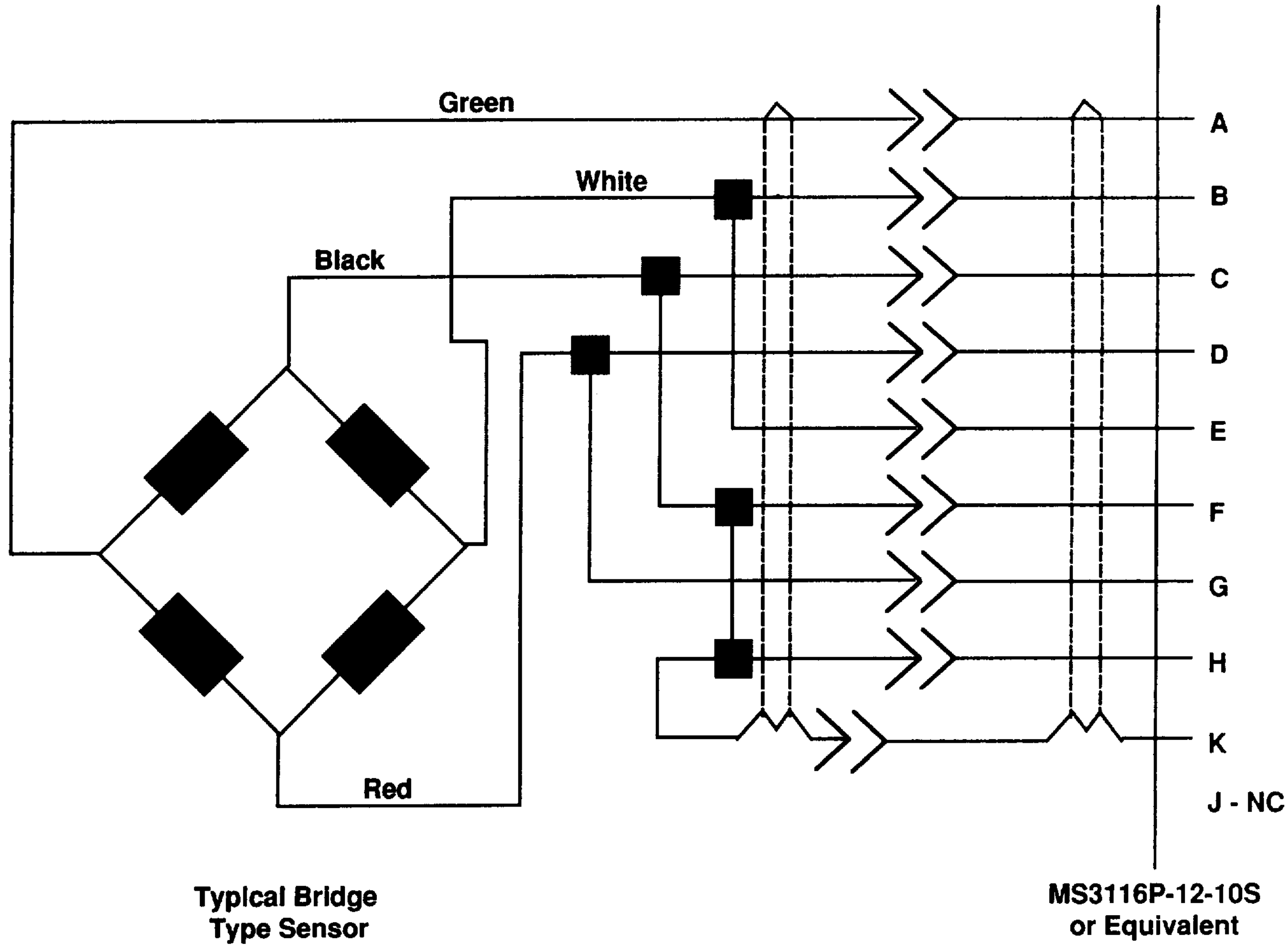
The data acquisition system (DAS) shall have an accuracy of at least +/- 0.1 percent full scale of amplified range, exclusive of the sensor and its wiring. Analog to Digital conversion shall have a minimum of 14 bit (1 in 16,384) resolution.

4.4.4 Low Speed Data Acquisition Channels

The low speed DAS shall have signal conditioning for bridge sensors, Rosemount RTB's, and K type thermocouples, and standard voltage inputs. Strain gauges will be typically 350 ohms with 10 volts excitation. The data acquisition rate for the low speed DAS is 100 samples per second average per channel. The total throughput for all channels combined is 10,000 samples per second. The sample rate per channel can be varied up to 1,000 samples per second, as long as the total throughput does not exceed 10,000 samples per second total.

4.4.5 High Speed Data Acquisition Channels

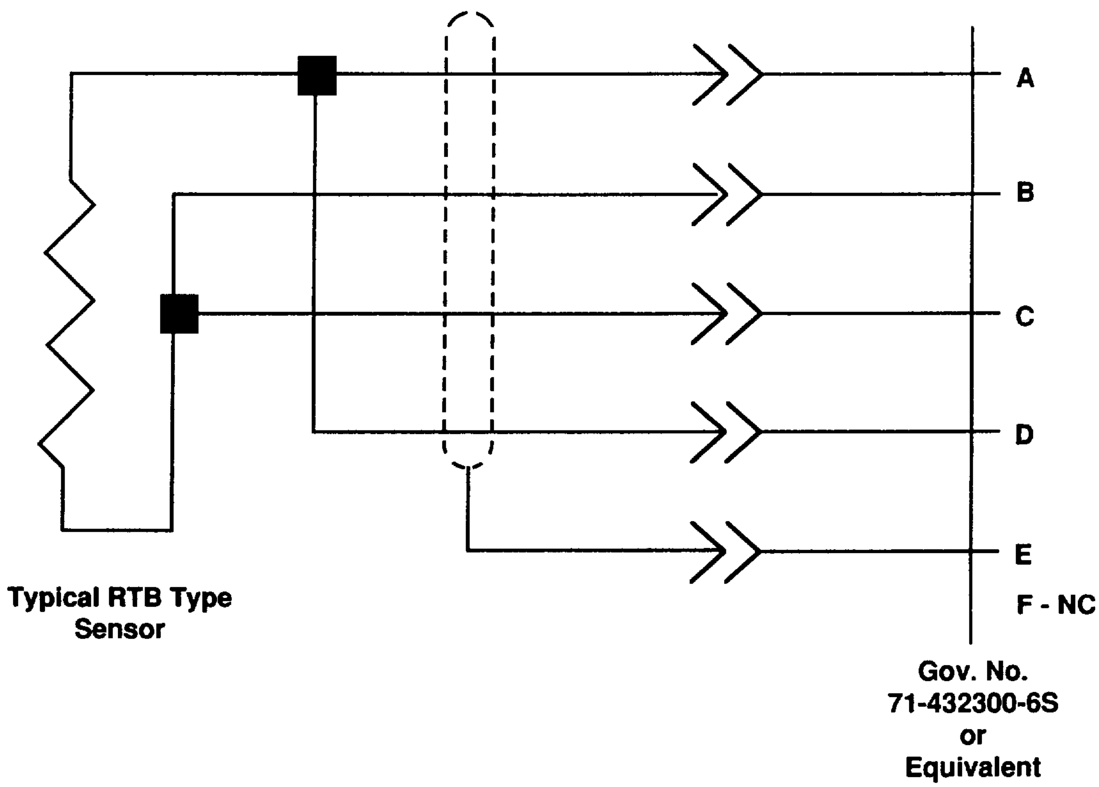
The high speed DAS shall have signal conditioning for 100 total piezoelectric and frequency type sensor inputs for the TP, GG, and any facility requirements. The data acquisition rate for the high speed DAS is 50,000 samples



Pin Connections
A = + Signal
B = - Signal
C = - Excitation
D = + Excitation
E = Calibration
F = Calibration
G = + Sense
H = - Sense
J = Not Defined
K = Guard

M15-2-20

Figure 4.1. Ten Pin Connectors - Electrical Connection

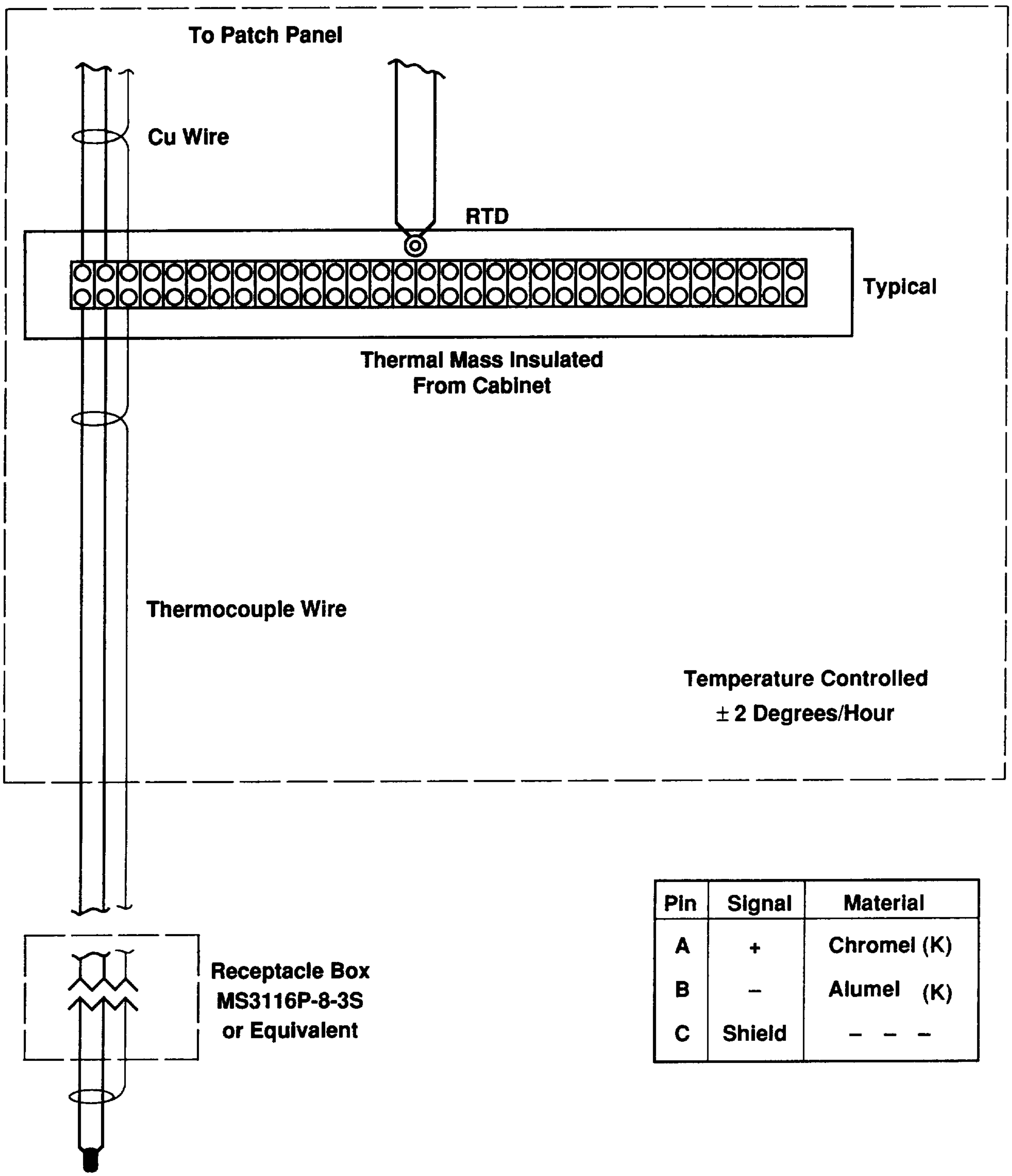


Pin Connections

A = + Signal
B = - Signal
C = - Excitation
D = + Excitation
E = Shield

M15-2-21

Figure 4.2. Six Pin Connectors - Electrical Connection



Pin	Signal	Material
A	+	Chromel (K)
B	–	Alumel (K)
C	Shield	– – –

M15-2-22

Figure 4.3. Three Pin Thermocouple Connectors and Reference Junction Cabinet

per second average per channel. The total throughput for all channels combined is 5 million samples per second. The sample rate per channel can be varied up to 100,000 samples per second, as long as the throughput does not exceed 4 million samples per second total.

4.4.6 Standard Signal Conditioning

Gain is from 1 to 1,000. Filtering to 24 db/octave rolloff, in ten steps minimum. Types of sensors and measurements to be conditioned are; resistive bridges, Rosemount RTB's, K type thermocouples, standard voltages, piezoelectric transducers, and frequency measurements.

4.4.7 Special Signal Conditioning

Special signal conditioning shall be provided by Aerojet.

5.0 MASS PROPERTIES

5.1 TEST ARTICLE SYSTEM DRY WEIGHT

5.1.1 Turbopump Dry Weight is 1600 Pounds

5.1.2 Test Cart and Supporting Equipment Weight is 3700 Pounds

5.2 MOMENTS OF INERTIA

TBD

5.3 CENTER OF GRAVITY

The turbopump center of gravity (CG) is 16 in. from the X axis towards the pump inlet on the turbopump centerline.

6.0 FLUID INTERFACES

Refer to Table 6.1 for the turbopump design point conditions. Table 6.2 contains a preliminary Test Matrix.

6.1 PROPELLANT CONDITIONS

Refer to time lines in Figures 6.1 and 6.2 for propellant pressures and temperatures during chilldown, testing, and post-test.

6.1.1 Prestart Temperature/Pressure Limits (Chilldown)

Prior to FS1, the turbopump shall be bled until all pump internal cavities have been purged of GH2. The maximum start suction LH_2 temperature shall not exceed 40 degrees Rankine. The minimum start suction pressure shall exceed 30 psia.

6.1.2 Operating Conditions (Transient and Steady State)

6.1.2.1 Pump Inlet/Discharge Pressure/Temperature Limits and Flow Rates

The pump inlet pressure shall not exceed 100 psia or the NPSH be less than 281 ft. while the pump is operating at design speed. The pump discharge pressure shall not exceed 4350 psia while the pump is operating at design speed. The flow rates shall be controlled so that the flow-to-speed ratio is not greater than $Q/N = 1.2\left(\frac{Q}{N}\right)_{des}$ or not less than $Q/N = 0.8\left(\frac{Q}{N}\right)_{des}$.

6.2 TURBINE GAS CONDITIONS

Refer to time lines in Figures 6.3, 6.4, and 6.5 for limits on turbine inlet temperature, pressure, and flow during the start and shut-down transients for the nominal test.

TABLE 6.1

TURBOPUMP ASSEMBLY DESIGN POINT
(TEST NO. 5)

Pump

Inlet Pressure	30 psia
Discharge Pressure	3654 psia
Inlet Temp.	37°R
Flow	18,592 gpm
Head	107,560 ft
Speed	28,500 rpm
η	78%
SHP	49,450 SHP
NS	1570
S	37,600

Turbine

Inlet Pressure	2375 psia
Inlet Temp.	1600°R
Discharge Pressure	460 psia
PR	5.16
$\dot{W}$	54 lb/sec
η	58%
Flow Nozzle Area	5.0 sq. in.

TABLE 6.2
Hot-Gas Turbopump Preliminary Test Matrix

Test No.	Pump (Q/N)/ Q/N) des	N/ N des*	Turbine (U/C)/ (U/C) des	Turbine PR/ PR des	Turbine Inlet Pressure (psi) ±10%	Turbine Discharge Pressure (psi) +5 % -15	Pump Discharge Pressure (psi) ± 10%	Turbine Mass Flow (lbm/s) ±15%	Pump Inlet Temp ±1°R (°R)	Pump Inlet PR +10 psia -0	Turbine In Temp °R +0 % -50°R
1	1.0	0.7	0.7	1.0	1050	203	1776	24	37	30	1600
2	1.0	1.0	1.0	1.0	2375	452	3624	54	37	30	1600
3	0.8	1.0	1.0	1.0	2140	415	3660	49	37	30	1600
4	1.1	1.0	1.0	1.0	2400	465	3440	57	37	30	1600
5	1.0	1.0	1.0	1.0	2375	460	3624	54	37	30	1600
6	TBD										
7	TBD										

•Planned Test Speed May Be Adjusted After Critical Speed Analysis

M16/D3/Fig-2

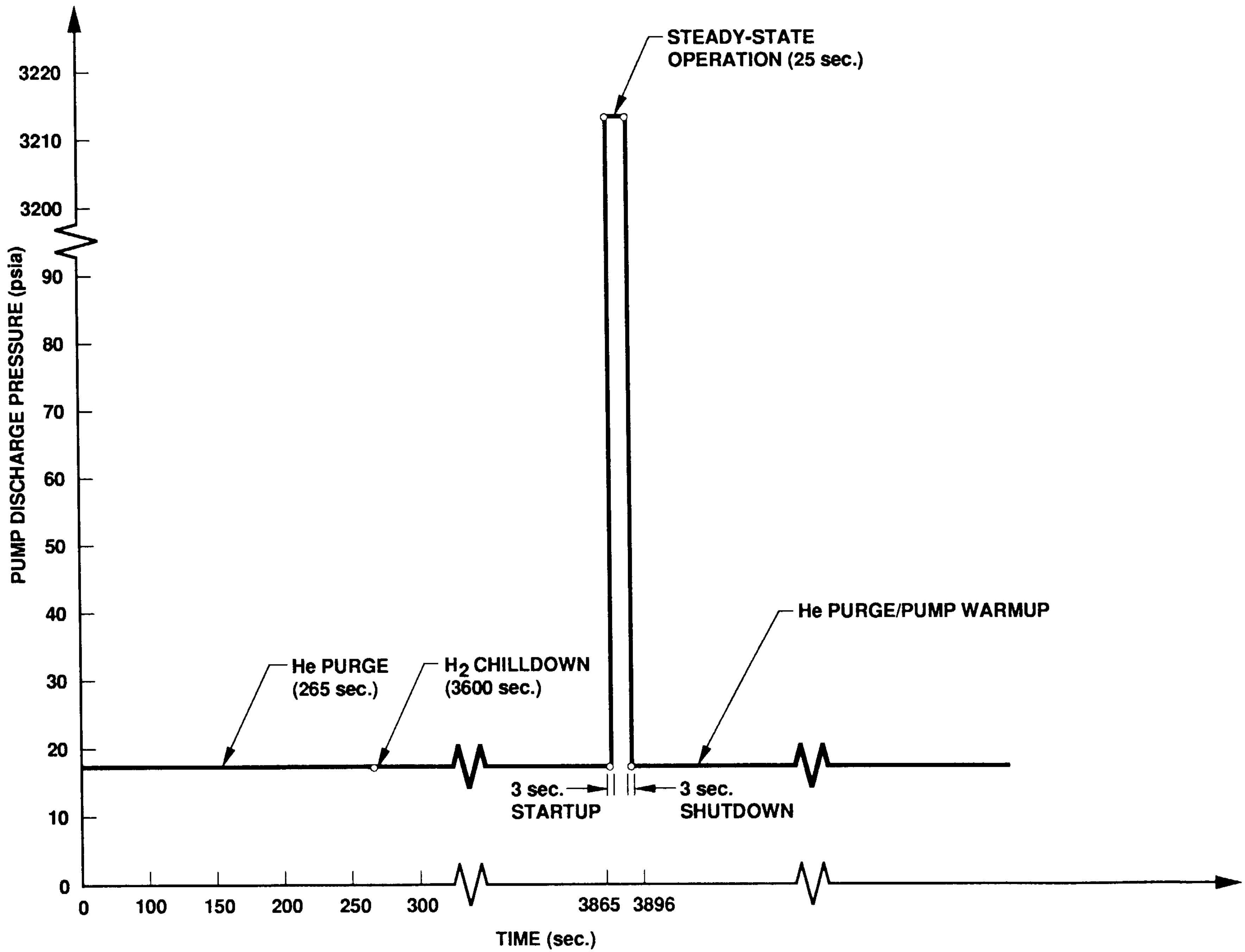


Figure 6.1. Pump Discharge Pressure vs. Time

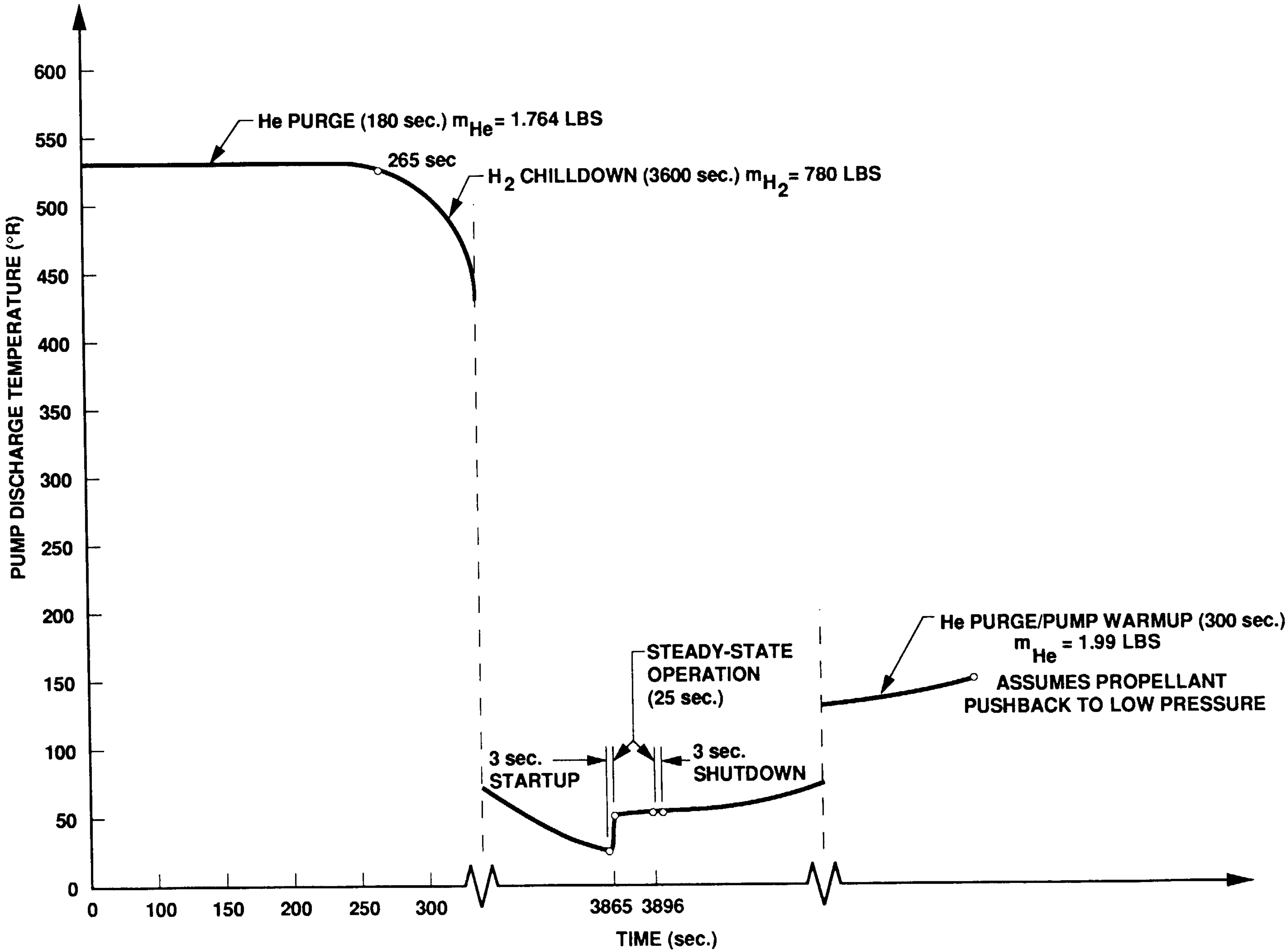


Figure 6.2. Pump Discharge Temperature vs. Time

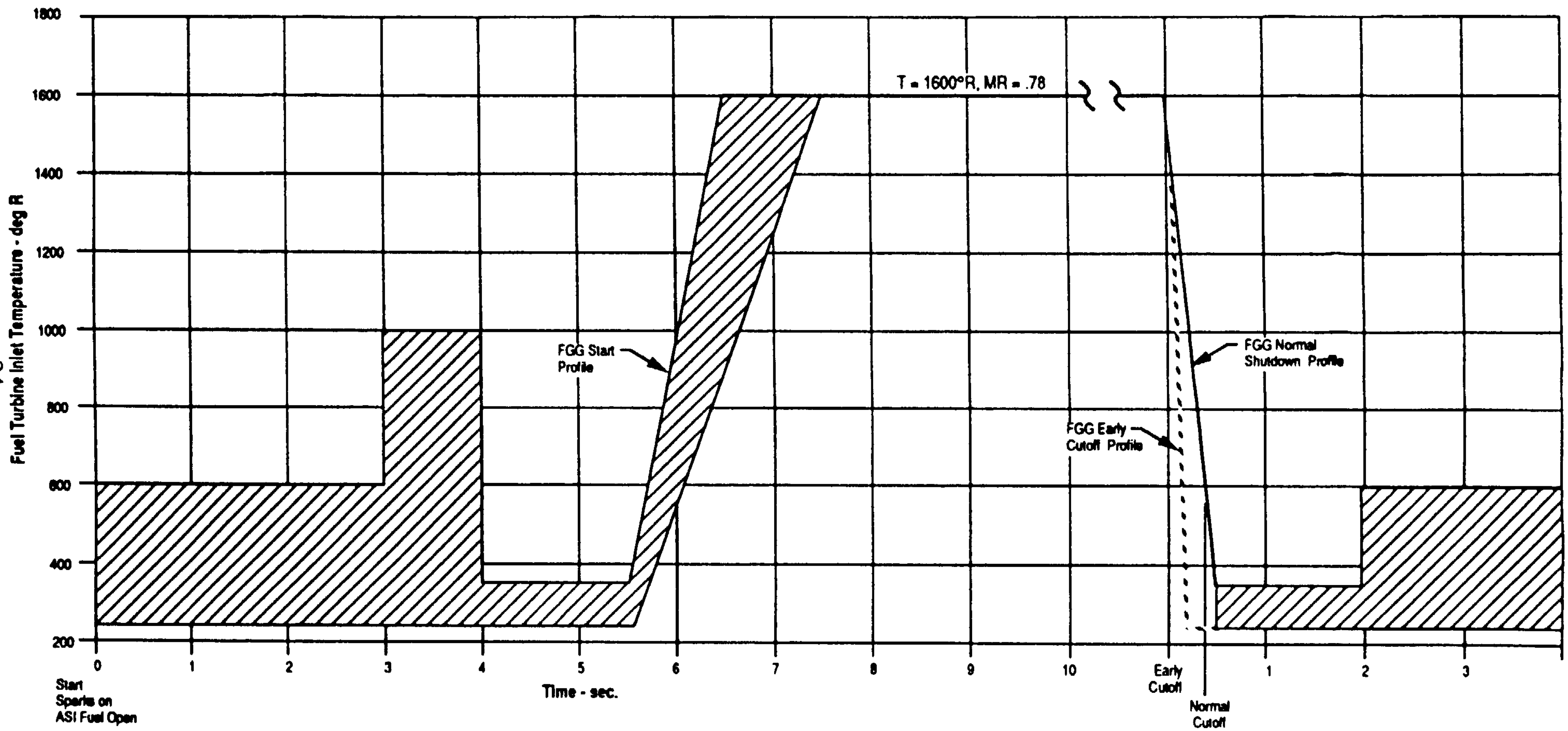


Figure 6.3 Fuel Turbine Inlet Temperature Start and Cutoff Transient

90LS/074-002

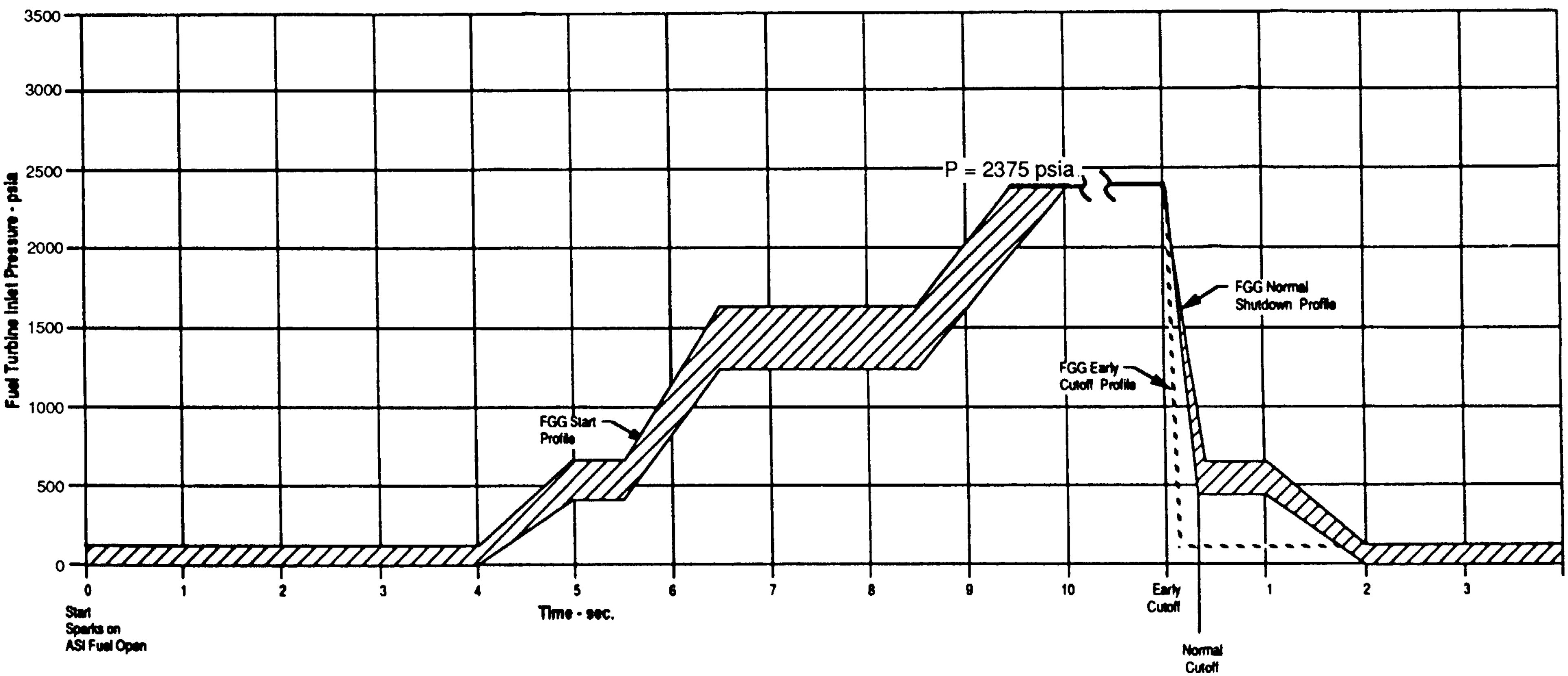


Figure 6.4 Fuel Turbine Inlet Pressure Start and Cutoff Transient

90LS/074-008

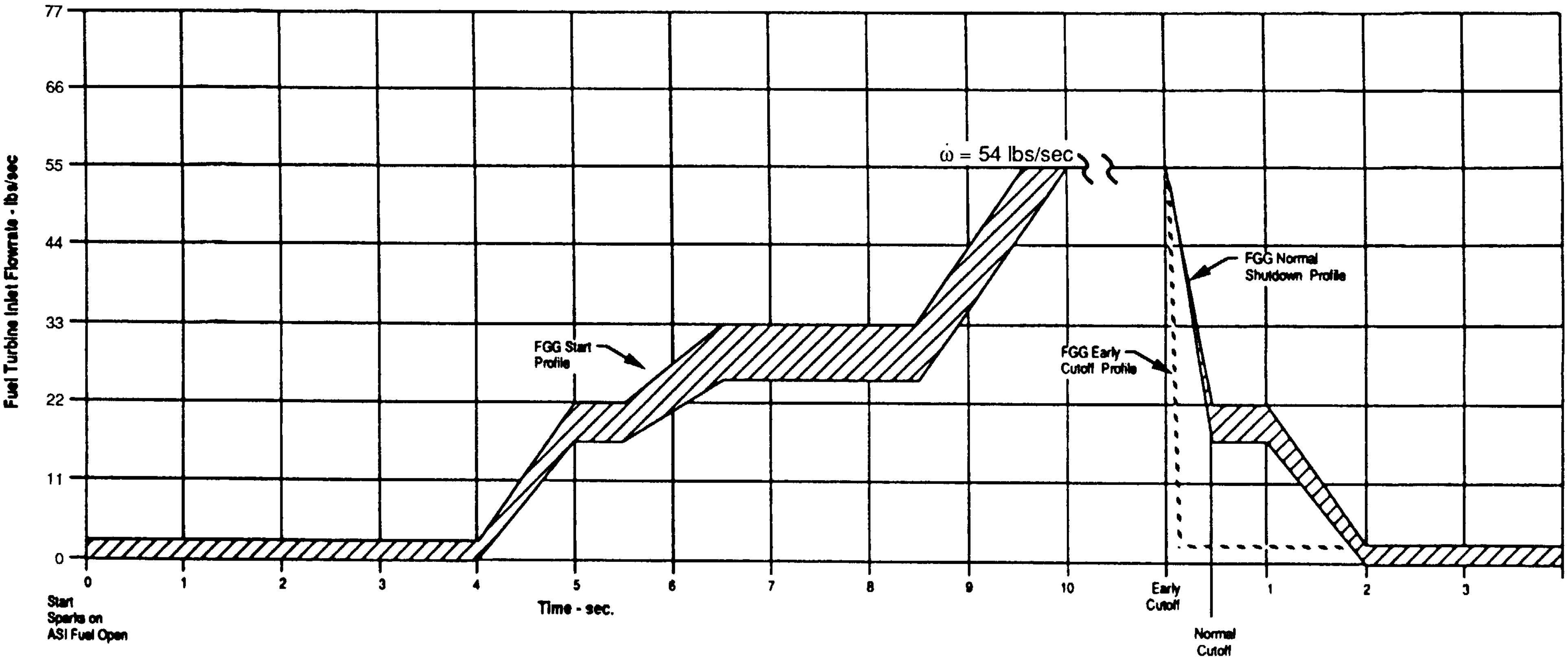


Figure 6.5 Fuel Turbine Inlet Flowrate Start and Cutoff Transient

90LS/074-005

6.2, Turbine Gas Conditions (cont.)

6.2.1 Operating Conditions (Transient and Steady-State)

6.2.1.1 Turbine Inlet/Discharge Pressure/Temperature Limits and Flow Rates

During start transient the maximum temperature shall not exceed 1700 degrees Rankine and shall not be sustained at 1700°R longer than 20 milliseconds. The turbine inlet temperature shall not exceed 1600 degrees Rankine while operating at steady-state. These are local free stream temperatures, not average. The turbine inlet pressure shall not exceed 2636 psia.

6.3 SHUTDOWN CRITERIA (REDLINES)

Parameter	Criteria		Response Time
Speed	MAX	29,000 RPM	25 ms
Q/N	MAX	0.75 GPM/RPM	200 ms
Q/N	MIN	0.48 GPM/RPM	200 ms
NPSH	MIN	310 ft	25 ms
Press. Pump Disch	MAX	4056 psia	200 ms
Temp. Pump Bearing Outlet	MAX	75°R	200 ms
Temp. Turbine Bearing Outlet	MAX	100°R	200 ms
TTI (Transient)	MAX	1700 degrees Rankine	20 ms
TTI (Steady-State)	MAX	1600 degrees Rankine	25 ms
PTI	MAX	2636 Psia	50 ms
Acceleration Pump	MAX	3.0 G_{rms} (@ synchronous)	25 ms
Case to Shaft Displacement (Steady-State)	MAX	0.10 in.	25 ms

Response time is defined as the time from detection of a redline condition to the time of closure of the GG valves (both oxidizer and fuel valves) limiting the max speed to 29,000.

7.0 ENVIRONMENTS

7.1 AMBIENT CONDITIONS

7.1.1 Pressure

The turbopump shall be capable of operating at ambient pressures ranging between 13.5 to 15.0 psia.

7.1.2 Temperature

The turbopump shall be capable of operating at ambient temperatures ranging between 35 and 120 degrees Fahrenheit.

7.1.3 Humidity

The turbopump shall be capable of operating at an ambient relative humidity between 0 and 100%.

7.1.4 Salt Fog

TBD

7.1.5 Electromagnetic

TBD

7.2 INDUCED

7.2.1 Shock

TBD

7.2.2 Vibration

7.2.2.1 Nominal

The turbopump and hot gas drive combination is predicted to produce a nominal steady-state random vibration environment in all three coordinate axes of (refer to Figure 7.1):

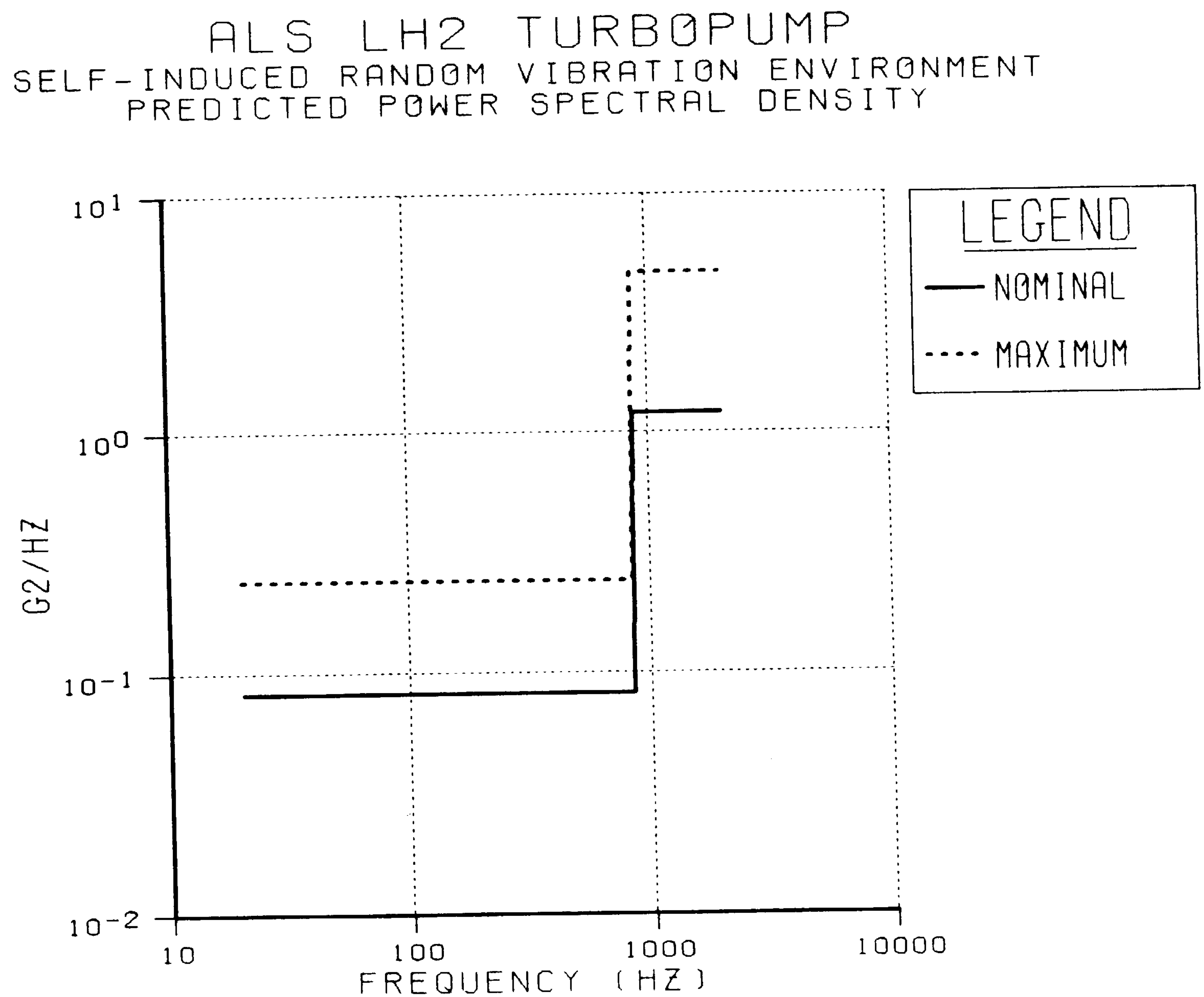


Figure 7.1 Self-Induced Random Vibration Environment

- 20 to 850 Hz at 0.082 $(G_{rms})^2/Hz$
- 850 to 2000 Hz at 1.199 $(G_{rms})^2/Hz$
- Random composite level = 38.0 G_{rms}

The turbopump is predicted to produce nominal sinusoidal vibration levels in all three coordinate axes of:

- 0.5 G_{rms} at 450 Hz and 900 Hz
- Total composite level (random and sine) = 38.0 G_{rms}

These predictions account for combustion phenomena, propellant flow, and synchronous vibration.

7.2.2.2 Maximum

The turbopump and cold gas drive combination is predicted to produce a maximum steady-state random vibration environment in all three coordinate axes of (refer to Figure 7.1):

- 20 to 850 Hz at 0.243 $(G_{rms})^2/Hz$
- 850 to 2000 Hz at 4.673 $(G_{rms})^2/Hz$
- Random composite level = 74.5 G_{rms}

The turbopump is predicted to produce maximum sinusoidal vibration levels in all three coordinate axes of:

- 2.0 G_{rms} at 450 Hz and 900 Hz
- Total composite level (random and sine) = 74.6 G_{rms}

These predictions account for combustion phenomena, propellant flow, and synchronous vibration.

7.0, Environments, (cont.)

7.2.3 <u>EMI/EMC</u>

TBD

7.2.4 <u>Acoustics</u>

TBD

7.2.5 <u>Temperature</u>

TBD

8.0 PROCEDURE INTERFACES - (TBD)

8.1 DELIVERY

8.1.1 Conditioning

8.2 PRE-OPERATION

8.2.1 Maintenance

Provisions shall be made to supply the TPA with regulated GN_2. GN_2 will be used for a TPA trickle purge during non-test periods. Starting with TPA test, GHe will be supplied to the TPA at ambient temperature and at a pressure of 5-10 psig.

8.2.2 Checkout

8.2.3 Conditioning

8.2.4 Installation/Removal

8.2.5 Torque Requirements - Mechanical Connections

8.2.6 Torque Requirements - Electrical Connections

8.2.7 Sealing Requirements - Electrical Connections

8.3 OPERATION

8.3.1 Conditioning

8.4 POST-OPERATION

8.4.1 Checkout

8.4.2 Conditioning

8.4.3 Installation/Removal

8.0, Procedure Interfaces - (TBD), (cont.)

8.5 RECYCLE

8.5.1 Maintenance

8.5.2 Checkout

8.5.3 Refurbishment

8.5.4 Conditioning

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Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DR-28		

4. Title and Subtitle
ALS Liquid Hydrogen Turbopump
Interface Control Document, Hot Fire Unit, Volume I

5. Report Date
8 October 1990

6. Performing Organization Code

7. Author(s)
Colin Faulkner, Program Manager
Bruce Lindley, Lead Designer

8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address
Aerojet Propulsion Division
P.O. Box 13222
Sacramento, CA 95813

11. Contract or Grant No.
NAS 8-37593

13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, DC 20546
NASA MSFC, Huntsville

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Formalizes interfaces between the LH_2 Turbopump test article, the NASA/SSC Component Test Facility Gas Generator. This ICD treats the turbopump/test cart combination as the test article. This ICD refers to the Hot Gas Unit test article. (The cold gas drive variant is covered by another ICD).

17. Key Words (Suggested by Author(s))	18. Distribution Statement
ALS Liquid Hydrogen Turbopump	Unclassified-Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price*
Unclassified	Unclassified	51	

NASA FORM 1626 OCT 86