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Advanced Transportation System Studies

Technical Area 3

Alternate Propulsion Subsystem Concepts

NAS8-39210

DCN 1-1-PP-02147

Final Report

DR-4

Volume I – Executive Summary

April 2000

Prepared for
NASA Marshall Space Flight Center

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Rocketdyne
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TA3-0320a1

**Alternate Propulsion Subsystem Concepts
Database
Version 1.3**

5 April 1993

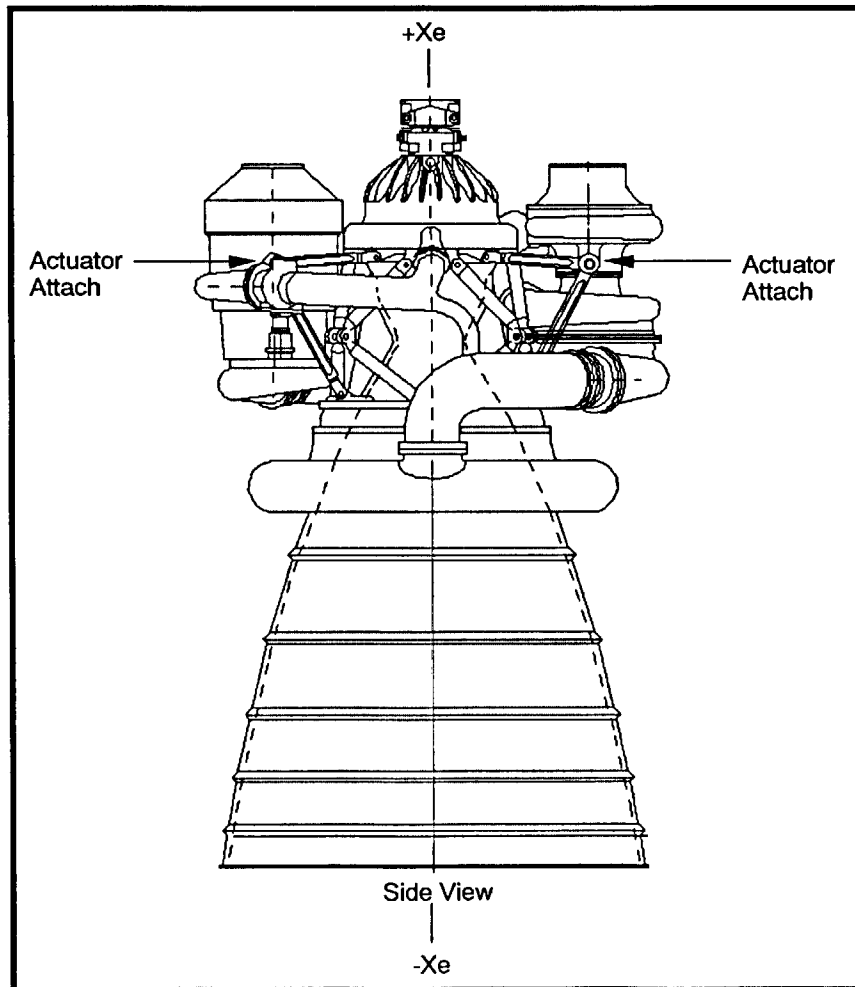
**NASA
Marshall Space Flight Center
Program Development
Huntsville, Alabama 35812**

**Rocketdyne Division
Rockwell International
6633 Canoga Avenue
Canoga Park CA 91303**

Continue

Figure 27. Propulsion System Database Opening Screen

STME Propulsion System

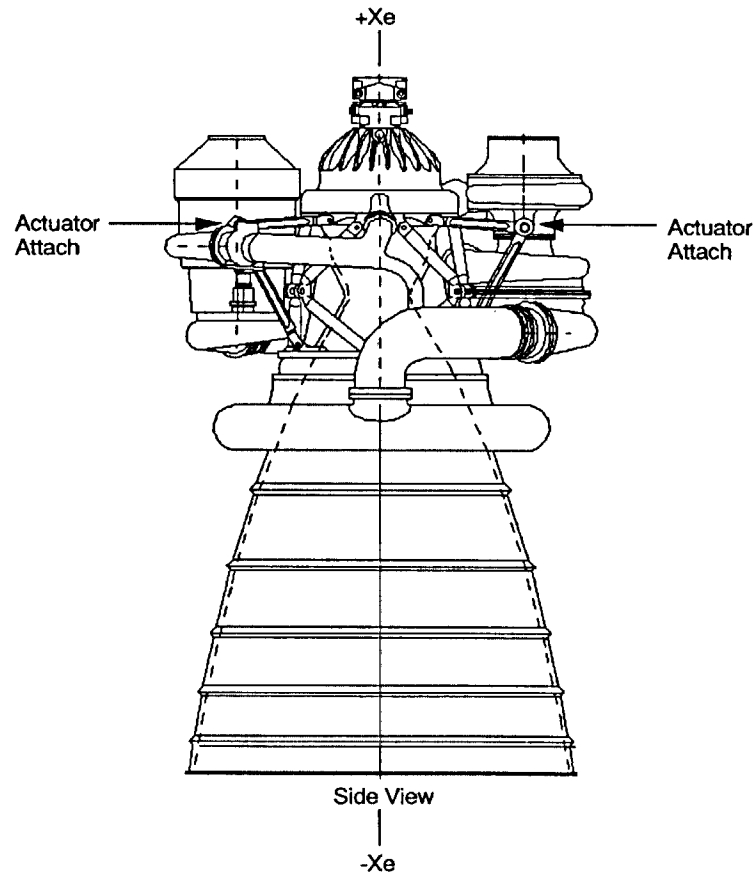


56

- **Nominal Thrust (lbf)**
 - Sea Level **552,980**
 - Vacuum **650,000**
- **Specific Impulse (sec)**
 - Sea Level **364.5**
 - Vacuum **428.5**
- **Chamber Pressure (psia)
(Nozzle Stagnation)** **2,250**
- **Engine Mixture Ratio** **6.000**
- **Expansion Ratio** **45.00**
- **Length (in)** **161.00**
- **Weight (lbm)** **9,100**

Advanced Propulsion Subsystem Concepts Database

Engine Name: Space Transportation Main Engine
Class of Engine: Cryogenic Liquid Chemical



16

Background Information

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid

Chemical

Background

The STME was designed to support propulsion requirements of the National Launch System (NLS). The NLS concept provides a lift capacity for a family of launch vehicles with a wide range of payload sizes (approximately 20,000 lbs and above) and missions. NLS family members may consist entirely of liquid propulsion units or combinations of liquid units and solid rocket motors.

The STME is capable of operating in either a NLS booster or core propulsion application. In either mode, the STME starts prior to vehicle liftoff. In the booster mode, the operation of some STME's will be terminated and detached from the vehicle with other elements while other STME's continue to operate.

In the core mode, the STME will continue to operate after booster (solid or liquid) separation until orbital (or near orbital) conditions are reached.

The STME is a pump fed liquid oxygen and liquid hydrogen engine that has been designed for high reliability and low cost. It employs a gas generator power cycle to drive separate LO2 and LH2 turbopump assemblies. Gas generator propellants are tapped-off the engine propellant system and burned to provide fuel rich gas to drive the turbines. Turbine exhaust gas is used to cool the engine nozzle extension. The engine is capable of operating at two discrete thrust levels, 100% and 70%. Engine start is accomplished by use of vehicle propellant tank head pressures. No helium spin start or solid start cartridge is required. The engine provides oxygen and hydrogen gases for propellant tank pressurization.

Comments

References

Source: STME Technical Information Document , 6 Jan 1993; ICD, Working Draft, Attachment J-3, 18 Sept 1992; Draft Contract End Item Specification, Phase C/D, Revision 10, Attachment J-2, 26 May 1992

Date: Entered as of 31 March 1993

Entered by: Dan Levack

May 14, 1993

Propulsion System General Data

Creation Date	Modification Date	Record Number
3/18/93	3/31/93	1

Engine Name	Space Transportation Main Engine	
Class of Engine	Cryogenic Liquid	Chemical
Propulsion Type	Thermodynamic Expansion of Hot Gas	
Acronym	STME	
Application	Booster Engine	
Manufacturer	Consortium (Aerojet, Pratt & Whitney, Rocketdyne)	
Program Status	Detailed Study	
Manrated		
IOC/Date Studied (Month/Year)	12/1992	
Mixture Ratio – Engine/ Thrust Chamber	6.000	6.993

Propellants	
Oxidizer	Liquid Oxygen
Fuel	Liquid Hydrogen

Engine Design Life (Flights)	1
Restart Capability	No
Engine Cycle	Gas Generator
Nominal Chamber Pressure	2,250
Expansion Ratio	45.00
TVC Method	Gimbal

Dimensions	
Maximum Length (inches)	161.00
Maximum Width (inches)	101.22
Engine Mass (lbm)	9,100.00

Engine Thrust Data, lbf		
	<u>Sea Level</u>	<u>Vacuum</u>
Nominal	552,980	650,000
Maximum		
Minimum	357,980	455,000

May 14, 1993

Engine Performance 1

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid

Chemical

Propellants

Oxidizer

Liquid Oxygen

Fuel

Liquid Hydrogen

Mixture Ratio - Engine/Thrust Chamber

6.000

6.993

Nominal Chamber Pressure

2,250

Expansion Ratio

45.00

Engine Design Life (Flights)

1

Engine Restarts

Design

0

Demonstrated

Engine Thrust Data

Sea Level

Vacuum

Nominal

552,980

650,000

Maximum

Minimum

357,980

455,000

Thrust data in units of lbf

Engine Starts

Design

11

Demonstrated

Throttle Ratio, Percent

Sea Level

Vacuum

Maximum

Minimum

64.70

70.00

Engine Reliability, sec

Design

5,500

Demonstrated

Specific Impulse Data

Sea Level

Vacuum

@Nominal Thrust

364.54

428.50

@Maximum Thrust

@Minimum Thrust

336.74

428.00

Specific impulse data in units of seconds

Nozzle Data

Type

Bell

Length (in)

116.00

Diameter (in)

91.67

Throat Area (sq. in)

146.61

Exit Area (sq. in)

6,597.45

Expansion Ratio

45.00

Engine Performance 2

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid

Chemical

Engine Mass (lbm)

Total Mass w/TVC

Total Mass wo/TVC

TVC

Method

Mass (lbm)

Max Gimbal Angle (deg)

Max Gimbal Rate (deg/s)

Engine Cycle

Type

Pressures

Oxidizer Turbopump

Min Pump Inlet

Turbine Inlet

Fuel Turbopump

Min Pump Inlet

Turbine Inlet

Pressures in psia

Envelope

Length

Nominal

Stowed

Extended

Maximum Gimbal

Diameter

Nozzle Exit

Maximum

Maximum Gimbal

Envelope Dimensions in Inches

Engine Component Masses

Component	Allocations	Controls	
Turbomachinery		Controller	35
Oxygen Turbopump	1570	Sensors	35
Fuel Turbopump	1718	Valves/Actuators	214
		Interconnects	17
		Pneumatic System	18
Combustion Devices		Propellant Feed	
Main Injector	1228	Ducts	323
Combustion Chamber	1601	Miscellaneous (System Hardware)	353
Nozzle	1729	Support Devices	
Gas Generator	92	Gimbal System	136
Igniter - CC	7	Heat Exchanger	19
Igniter - GG	7		
		Engine Total	9100

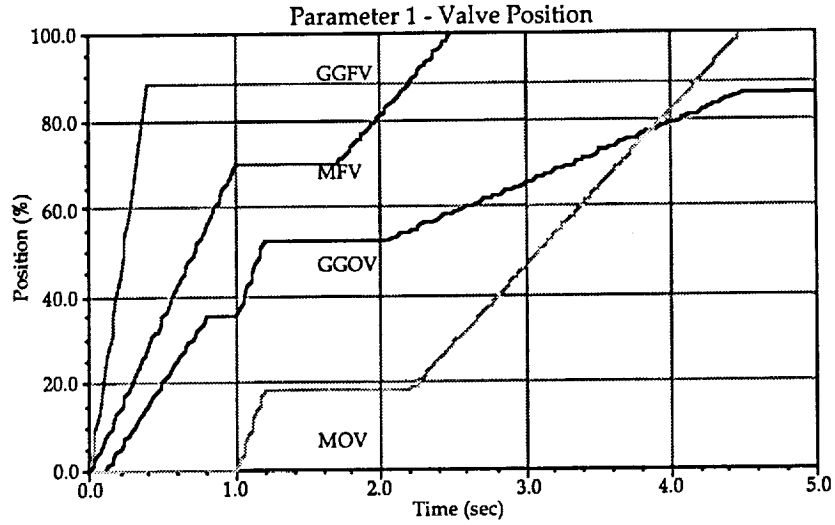
Start-Up/Shutdown Sequences

Engine Name: Space Transportation Main Engine

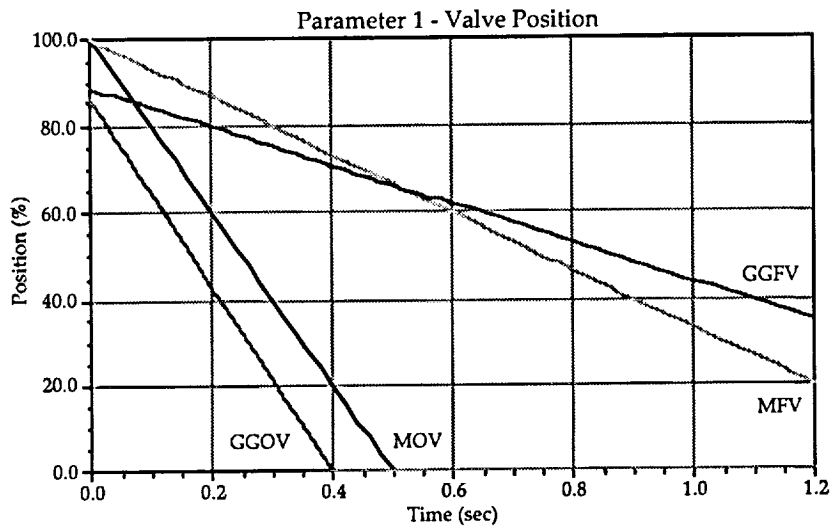
Class of Engine: Cryogenic Liquid

Chemical

StartUp Sequence



Shutdown Sequence



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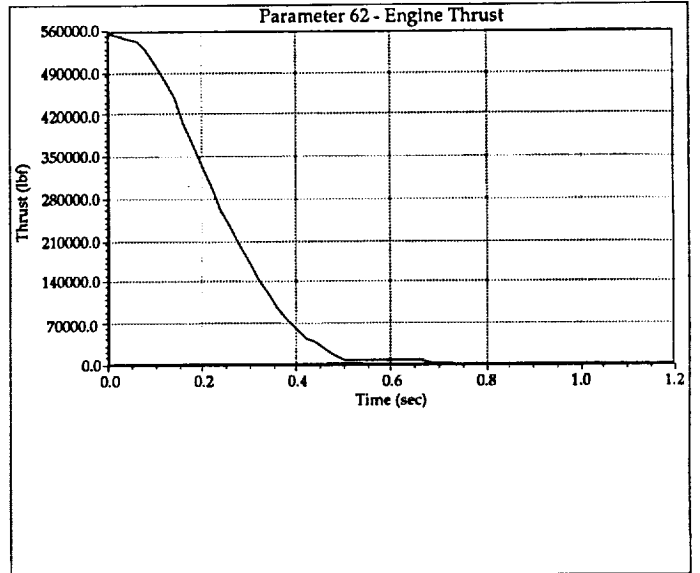
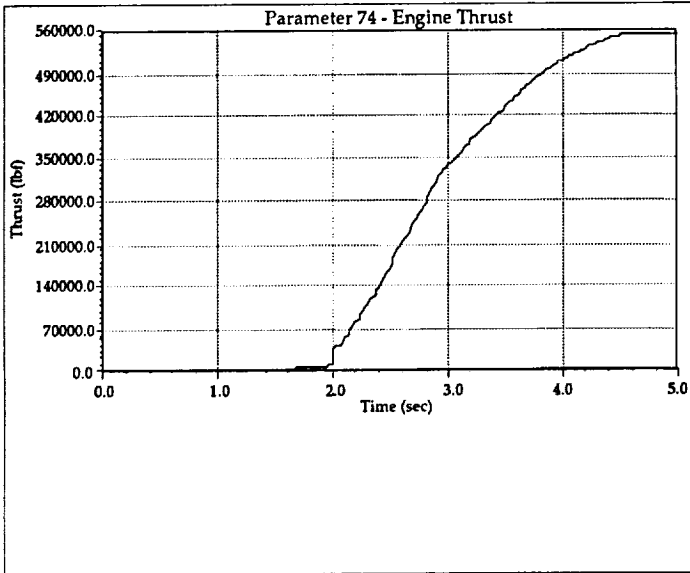
Start-Up/Shutdown Profiles

Engine Name: Space Transportation Main Engine

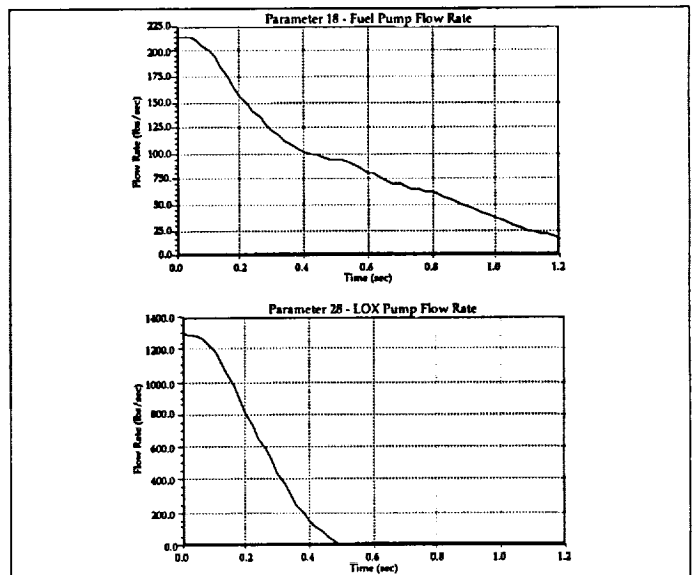
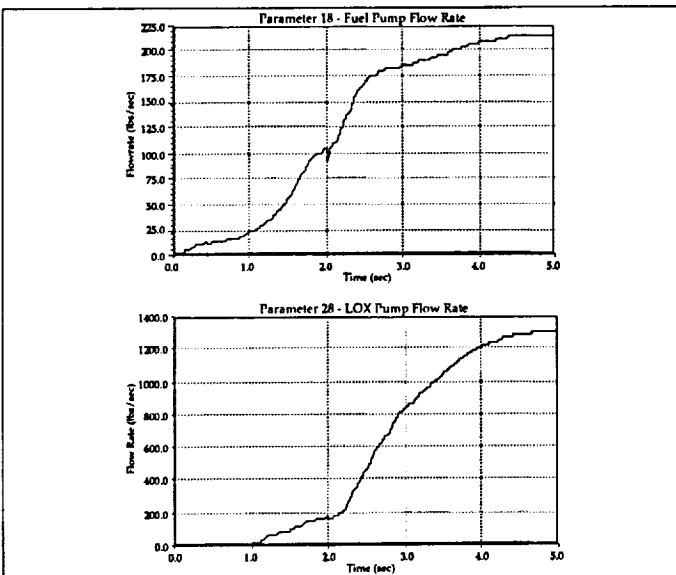
Class of Engine: Cryogenic Liquid

Chemical

Thrust Profile



Flowrate Profile



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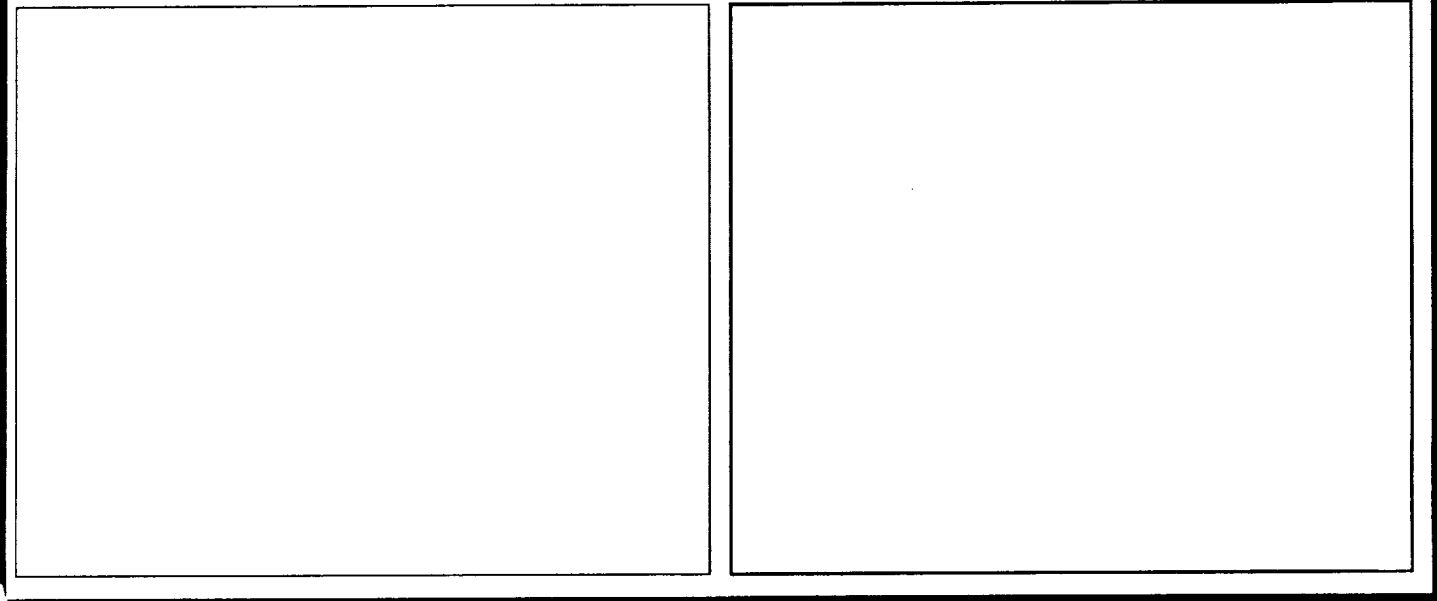
Start-Up/Shutdown Profiles

Engine Name: Space Transportation Main Engine

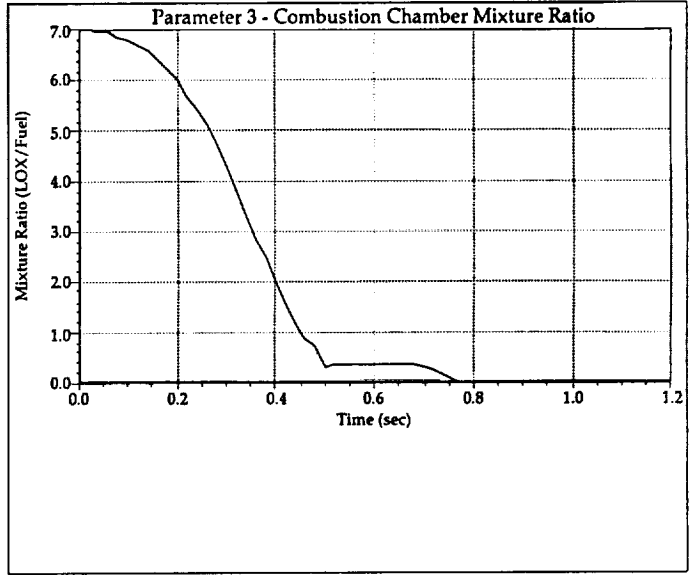
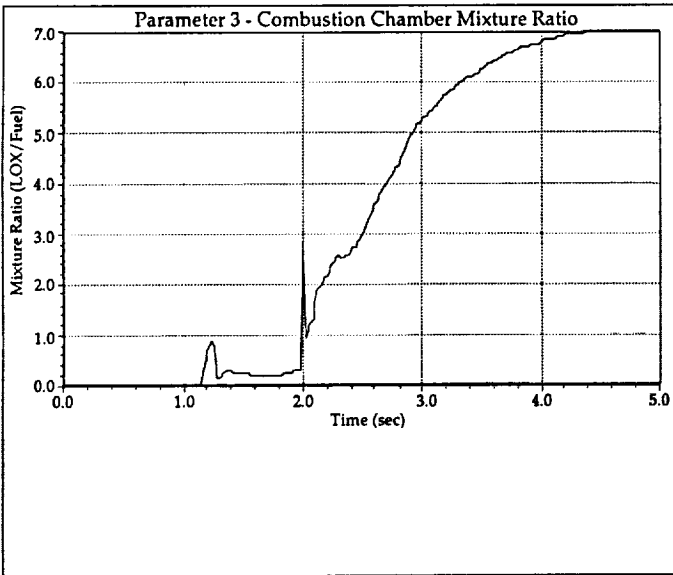
Class of Engine: Cryogenic Liquid

Chemical

Isp Profile



Mixture Ratio Profile



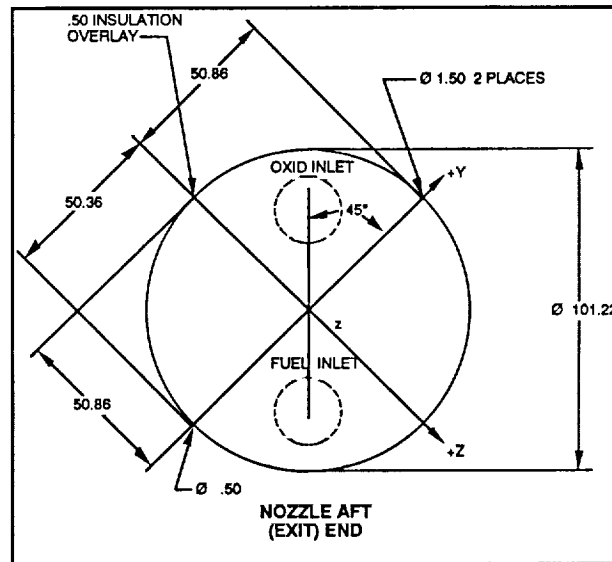
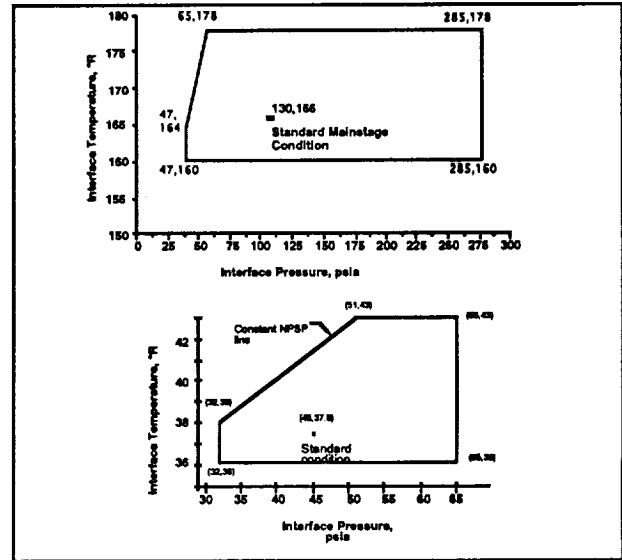
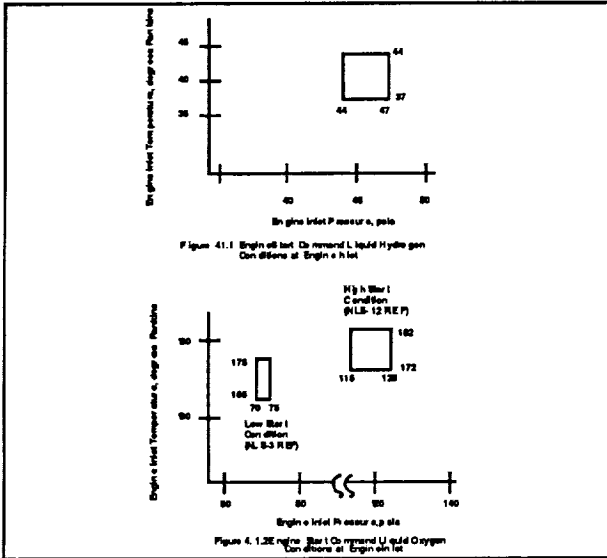
Interfaces

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid

Chemical

Interfaces



May 14, 1993

Technology Development

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid

Chemical

Technology Development

