RD00-164-1

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

The Boeing Company
Rocketdyne
6633 Canoga Avenue
Canoga Park, California 91303

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TA3–0320a1

May 14, 1993

Engine Performance 1

Print | Reports

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	

Engine Reliability, sec

Design	5,500
Demonstrated	

Throttle Ratio, Percent

	Sea Level	Vacuum
Maximum		
Minimum	64.70	70.00

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

Specific Impulse Data

	Sea Level	Vacuum
@Nominal Thrust	364.54	428.50
@Maximum Thrust		
@Minimum Thrust	336.74	428.00

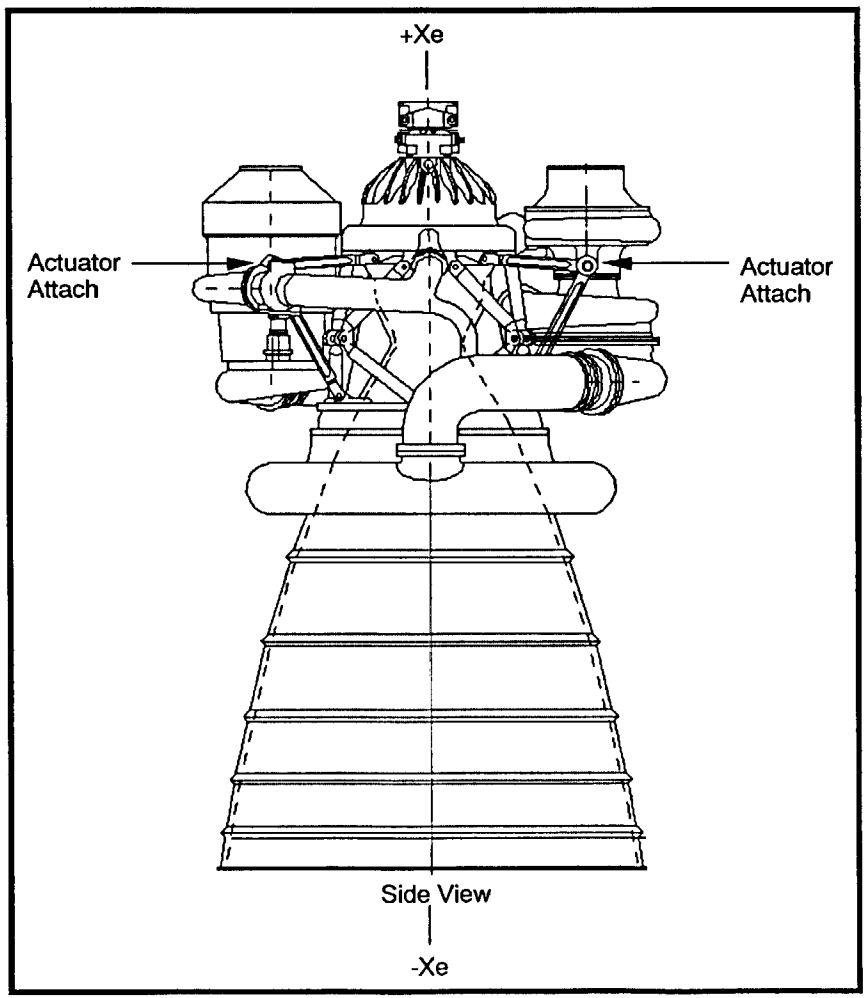
Specific Impulse data in units of seconds

Figure 31. Typical Report Page Layout

Figure 32.

Output for Space Transportation Main Engine (STME) Propulsion System

STME Propulsion System

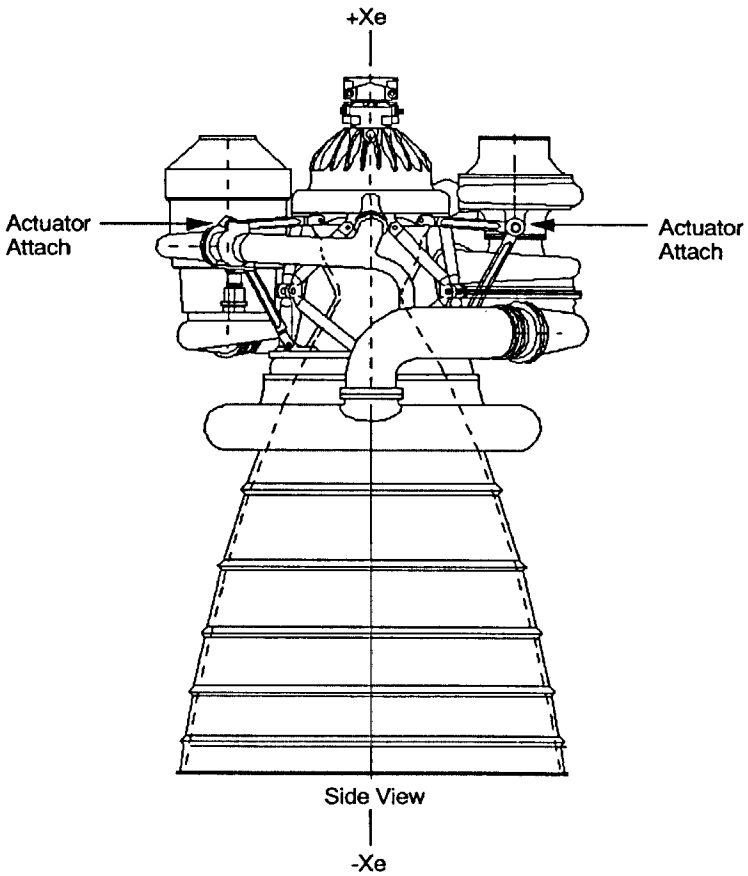


- **Nominal Thrust (lbf)**
  - Sea Level 552,980
  - Vacuum 650,000
- **Specific Impulse (sec)**
  - Sea Level 364.5
  - Vacuum 428.5
- **Chamber Pressure (psia) (Nozzle Stagnation)** 2,250
- **Engine Mixture Ratio** 6.000
- **Expansion Ratio** 45.00
- **Length (in)** 161.00
- **Weight (lbm)** 9,100

5/14/93

Advanced Propulsion Subsystem Concepts Database

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



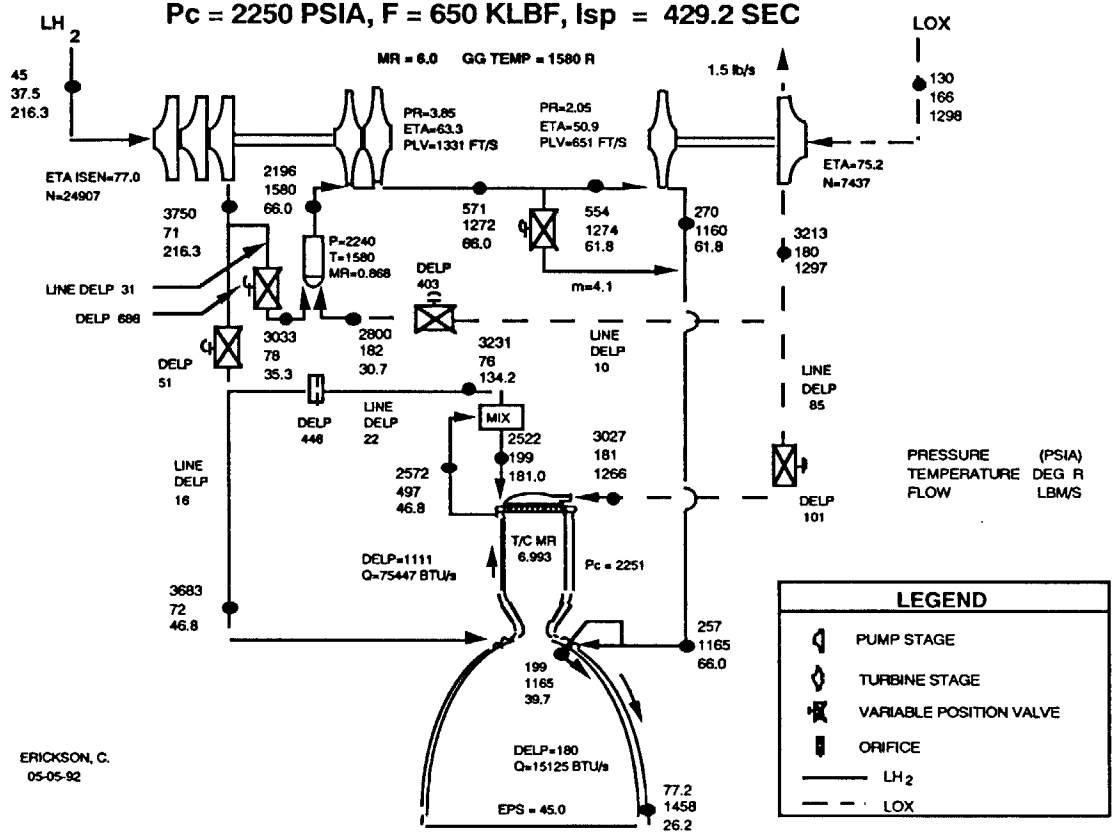
Advanced Propulsion Subsystem Concepts Database

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

STEP - REV. 26b @ RPL INLET

Pc = 2250 PSIA, F = 650 KLBF, Isp = 429.2 SEC



May 14, 1993

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

	Sea Level	Vacuum
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

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Nominal Chamber Pressure	2,250
Expansion Ratio	45.00
Engine Design Life (Flights)	1

Engine Thrust Data

	Sea Level	Vacuum
Nominal	552,980	650,000
Maximum		
Minimum	357,980	455,000

Thrust data in units of lbf

Throttle Ratio, Percent

	Sea Level	Vacuum
Maximum		
Minimum	64.70	70.00

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

Engine Restarts

Design	0
Demonstrated	

Engine Starts

Design	11
Demonstrated	

Engine Reliability, sec

Design	5,500
Demonstrated	

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

May 14, 1993

Engine Performance 2

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

Engine Mass (lbm)

Total Mass w/TVC	9,100.0
Total Mass wo/TVC	

TVC

Method	Gimbal
Mass (lbm)	
Max Gimbal Angle (deg)	11.3
Max Gimbal Rate (deg/s)	4.7

Engine Cycle

Type: Gas Generator

Pressures

Oxidizer Turbopump		Fuel Turbopump	
Min Pump Inlet	47	Min Pump Inlet	32
Turbine Inlet	554.0	Turbine Inlet	2,196.0

Pressures in psia

Envelope

Length		Diameter	
Nominal	161	Nozzle Exit	97.0
Stowed		Maximum	101.2
Extended		Maximum Gimbal	
Maximum Gimbal			

Envelope Dimensions in inches

Engine Component Masses

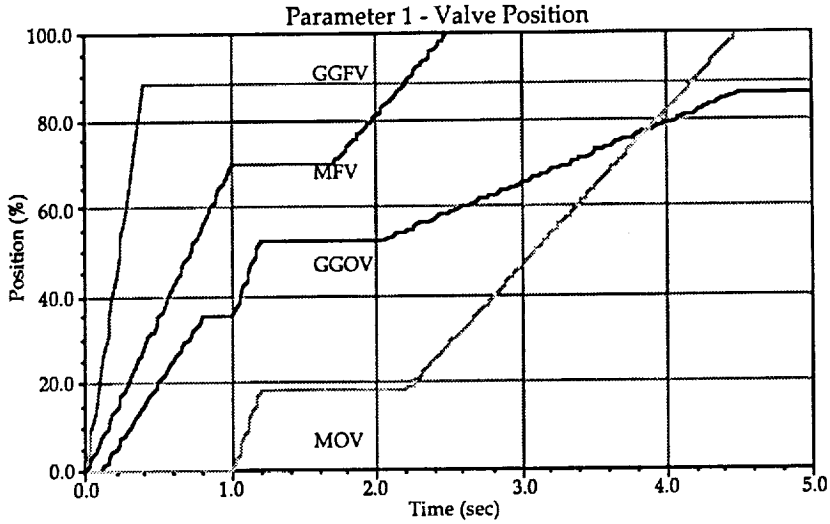
Component Allocations			
Turbomachinery		Controls	
Oxygen Turbopump	1570	Controller	35
Fuel Turbopump	1718	Sensors	35
		Valves/Actuators	214
Combustion Devices		Interconnects	17
Main Injector	1226	Pneumatic System	18
Combustion Chamber	1601		
Nozzle	1729	Propellant Feed	
Gas Generator	92	Ducts	323
Igniter - CC	7	Miscellaneous (System Hardware)	353
- GG	7	Support Devices	
		Gimbal System	136
		Heat Exchanger	19
		Engine Total	9100

Start-Up/Shutdown Sequences

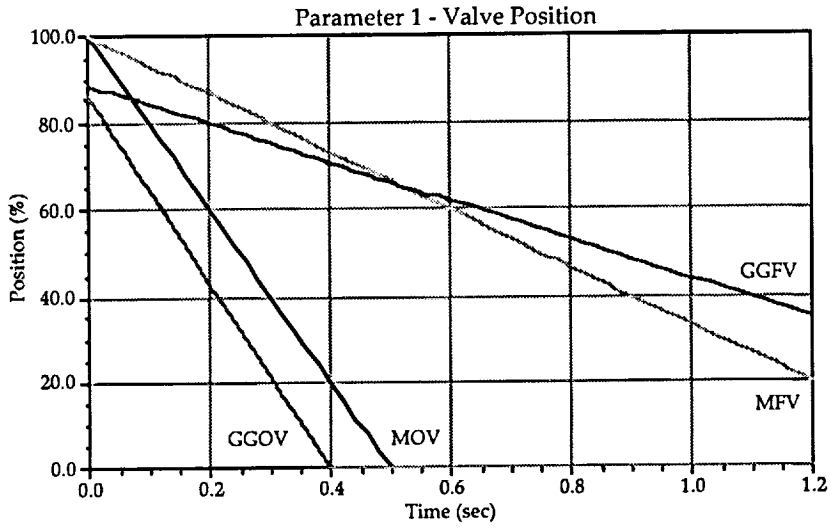
Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

StartUp Sequence



Shutdown Sequence



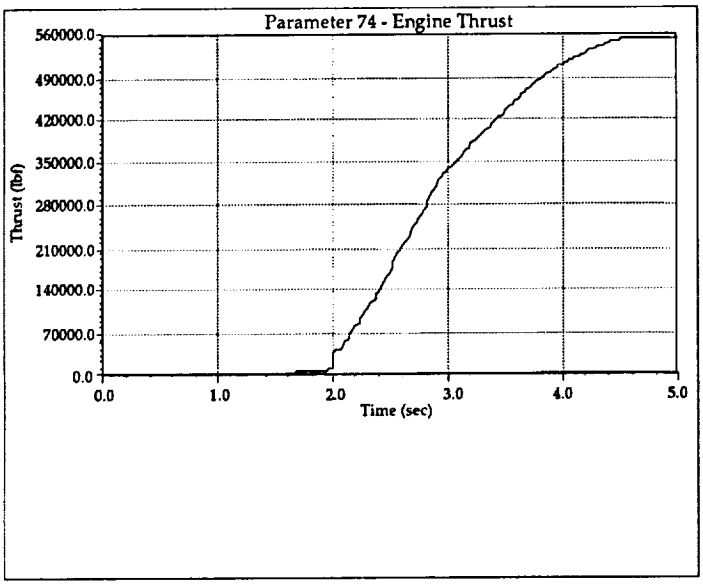
May 14, 1993

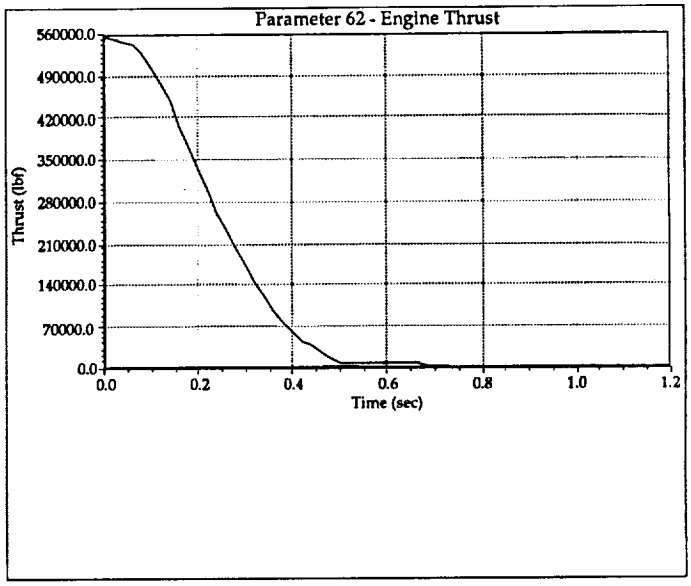
Start-Up/Shutdown Profiles

Engine Name: Space Transportation Main Engine

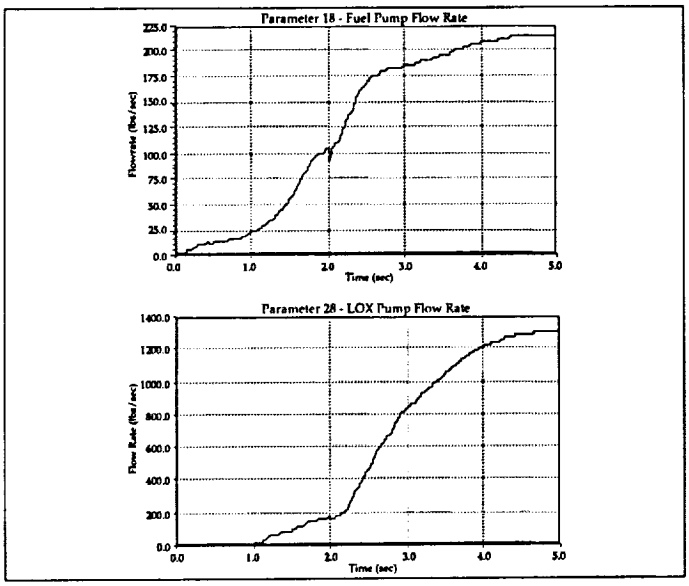
Class of Engine: Cryogenic Liquid Chemical

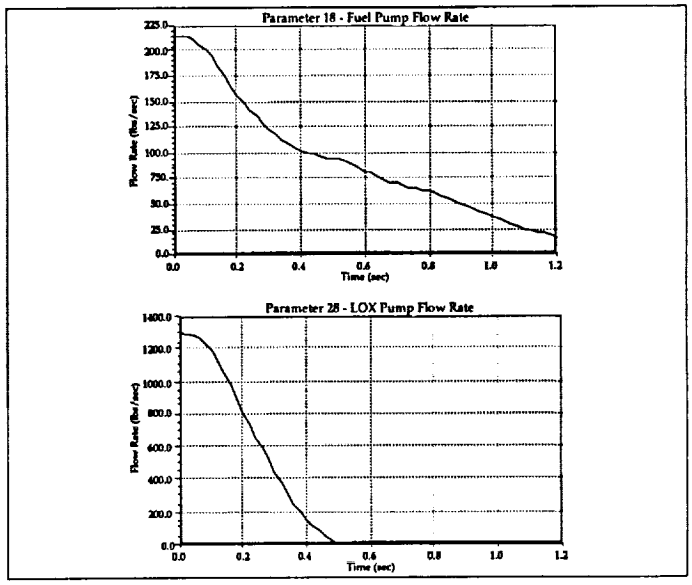
Thrust Profile





Flowrate Profile





May 14, 1993

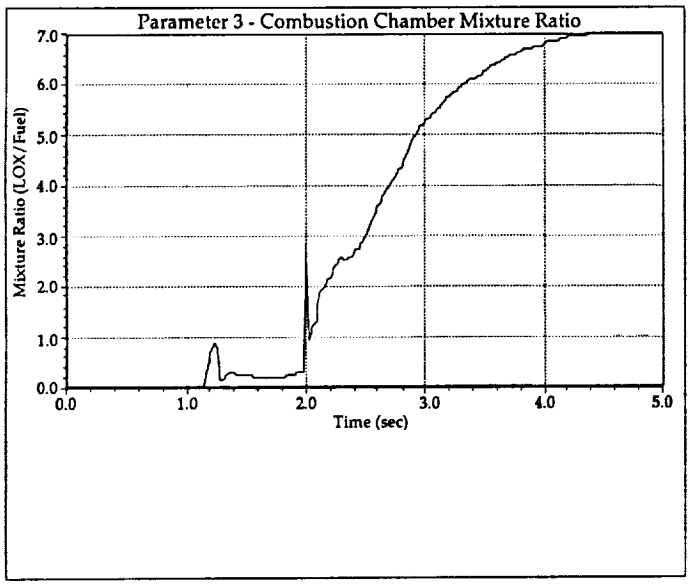
Start-Up/Shutdown Profiles

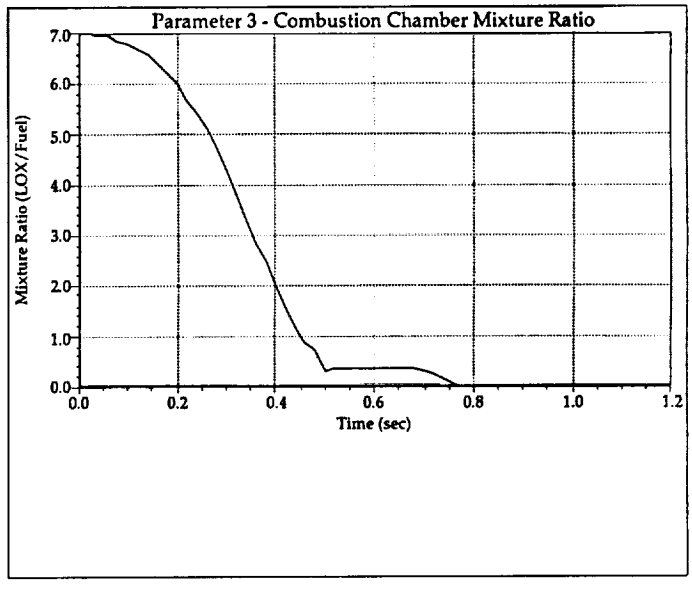
Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

Isp Profile

Mixture Ratio Profile



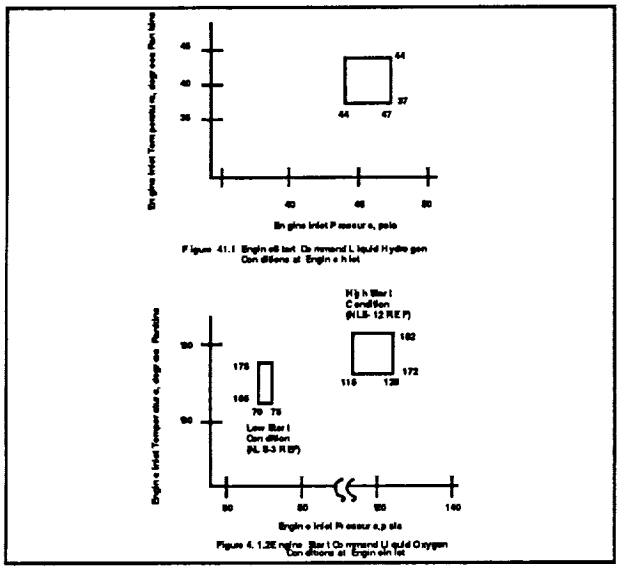


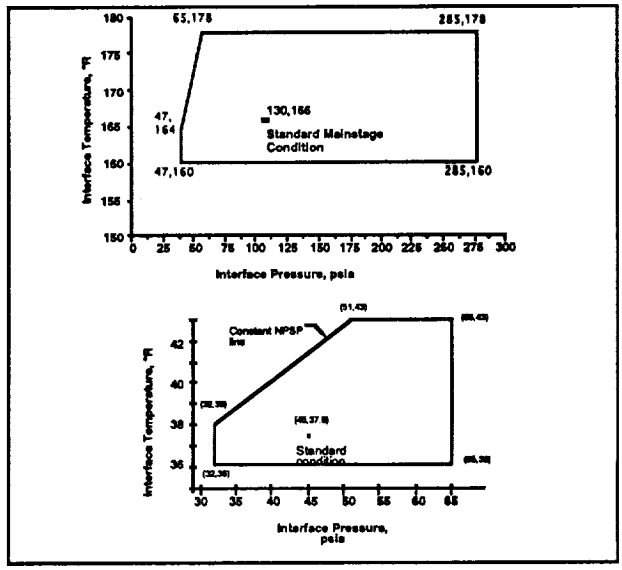
Interfaces

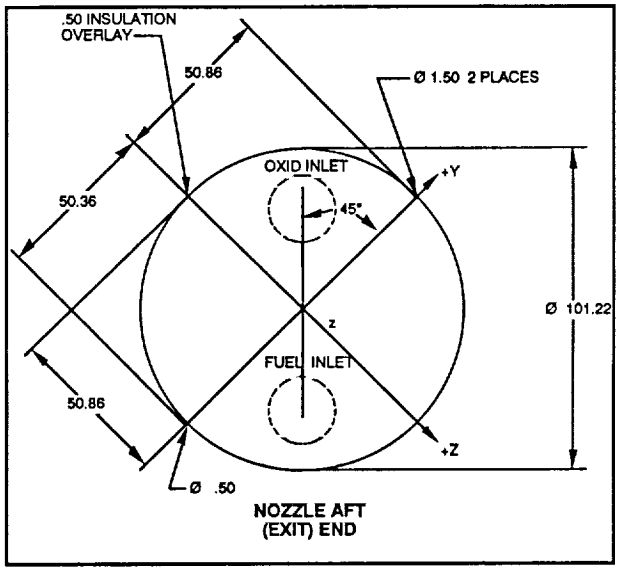
Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

Interfaces







Technology Development

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

Technology Development

May 14, 1993

Advanced Development Plan

Engine Name: Space Transportation Main Engine

Class of Engine: Cryogenic Liquid Chemical

Advanced Development Plan