

Fluid (Gas and Liquid) Properties

LO2 Temperature in Tank	90 K
LH2 Temperature in Tank	20 K
LO2 Density	1141 kg/m ³
LH2 Density	70.8 kg/m ³
LO2 Specific heat C _v	1669 J/kg-K
LH2 Specific heat C _v	9668 J/kg-K
GO2 Specific heat C _p	919.1 J/kg-K
GH2 Specific Heat C _p	14340 J/kg-K
GH2 Gamma value	1.483 ---
SSME vertical acceleration (T/M)	14.9 m/s ²

LO2 Tankage

GO2 Pressure above liquid surface	246 kPa
LO2 Tankage height above MOV	40 m
LO2 Hydrostatic head before MOV	1127 kPa
LO2 Total head before MOV	1373 kPa
LO2 Pressure after MOV	689 kPa
LO2 Temperature after MOV	90 K

LH2 Tankage

GH2 Pressure above liquid surface	225 kPa
LH2 Tankage height above fuel valve	27 m
LH2 Hydrostatic head before fuel valve	47 kPa
LH2 Total head before fuel valve	272 kPa
LH2 Pressure after fuel valve	207 kPa
LH2 Temperature after fuel valve	20 K

LPOTP		
Pump Section	Liquid or gas flows through pump?	Liquid
Inlet	LO2 Pressure at pump inlet	698 kPa
	LO2 Temperature entering pump	90 K
	LO2 Mass flow rate through pump	401 kg/s
	LO2 Pressure Increase across pump	2.1 MPa
	LPOTP Pump efficiency	0.632 ---
Outlet	LO2 Pressure exiting pump	2789 kPa
	LO2 Temperature exiting pump	91 K
	LPOTP Pump power	1168 kW
Turbine Section	Liquid or gas flows through turbine?	Liquid
Inlet	LO2 Temperature entering turbine	100 K
	LO2 Pressure entering turbine	29.6 MPa
	LO2 Mass flow rate through turbine	77.2 kg/s
	LPOTP Turbine efficiency	0.644 ---
Outlet	LO2 Pressure exiting turbine	2789 kPa
	LO2 Temperature exiting turbine	103 K
	LPOTP Turbine power	1168 kW
LPFTP		
Pump Section	Liquid or gas flows through pump?	Liquid
Inlet	LH2 Pressure at pump inlet	207 kPa
	LH2 Temperature entering pump	20 K
	LH2 Mass flow rate through pump	67.1 kg/s
	LH2 Pressure Increase across pump	1.60 MPa
Outlet	LH2 Pressure exiting pump	1807 kPa

LH2 Temperature exiting pump		21 K
LPFTP Pump efficiency		0.674 ---
LPFTP Pump power		2.24 MW
Turbine Section	Liquid or gas flows through turbine?	Gas
Inlet	GH2 Pressure at turbine inlet	32500 kPa
	GH2 Temperature at turbine inlet	269 K
	GH2 Mass flow rate through turbine	13.6 kg/s
	LPFTP Turbine efficiency	0.536 ---
Outlet	GH2 Pressure ratio across turbine	1.30 ---
	GH2 Pressure at turbine outlet	25000 kPa
	GH2 Temperature at turbine outlet	257 K
	LPFTP Turbine power	2.34 MW
HPFTP		
Pump Section	Liquid or gas flows through pump?	Liquid
	LH2 Pressure drop between LPFTP outlet and HPFTP inlet	398 kPa
	LH2 Pressure at pump inlet	1409 kPa
	LH2 Mass flow rate through pump	67.1 kg/s
	LH2 Pressure increase across pump	41.7 MPa
	LH2 Pressure exiting pump	43109 kPa
	HPFTP Pump efficiency	0.758 ---
	LH2 Temperature entering pump	21 K
	LH2 Temperature exiting pump	41 K
	HPFTP Pump power	52.1 MW
HP LH2 Flow Splits	LH2 Percentage from HPFTP going to thrust chamber cooling	20.3 %
	LH2 Mass flow rate for thrust chamber cooling	13.6 kg/s
	LH2 Temperature entering thrust chamber cooling	40 K
	LH2 Pressure entering thrust chamber cooling	43109 kPa

GH2 Temperature exiting thrust chamber cooling	269 K
GH2 Pressure exiting thrust chamber cooling	32500 kPa
LH2 Percentage from HPFTP going to expansion nozzle cooling	42.4 %
LH2 Mass flow rate for expansion nozzle cooling	28.5 kg/s
GH2 Temperature entering expansion nozzle cooling	40 K
GH2 Pressure entering expansion nozzle cooling	43109 kPa
GH2 Temperature exiting expansion nozzle cooling	265 K
GH2 Pressure exiting expansion nozzle cooling	35200 kPa
LH2 Percentage from HPFTP bypassing thrust chamber and nozzle	37.3 %
LH2 mass flow rate bypassing thrust chamber and nozzle	25.0 kg/s
Resulting GH2 pressure after expanding bypass LH2 to GH2	35200 kPa
Resulting GH2 temperature after expanding bypass LH2 to GH2	28 K
GH2 Combined total mass flow rate going to preburners	53.5 kg/s
GH2 Temperature going to preburners	154 K
GH2 Pressure going to preburners	35200 kPa
Preburner GH2 Percentage of rejoined GH2 flows going to HPFTP preburner	68 %
GH2 Mass flow rate entering preburner	36.4 kg/s
GH2 Temperature entering preburner	154 K
GH2 Pressure entering preburner	35200 kPa
Preburner O/F mass ratio	0.970 ---
LO2 Mass flow rate entering preburner from LO2 boost pump	35.3 kg/s
LO2 Temperature entering preburner from LO2 boost pump	100 K
LO2 Pressure entering preburner from LO2 boost pump	50200 kPa
Preburner product gas mass flux	71.7 kg/s
Preburner product gas Y_H2	0.446 ---
Preburner product gas Y_H2O	0.554 ---
Preburner product gas temperature	1117 K
Preburner product gas pressure	35500 kPa
Preburner product gas gamma value	1.35 ---

Preburner product gas C _p value	8088 J/kg-K
Preburner product gas MW value	3.97 g/mol

Turbine Section	Liquid or gas flows through turbine?	Gas
	HPFTP Turbine power	47.2 MW
	Turbine inlet gas temperature	1117 K
	Turbine inlet gas pressure	35500 kPa
	Turbine pressure ratio p _{in} / p _{out}	1.52 ---
	Turbine outlet gas pressure	23355 kPa
	Turbine outlet mass flux	71.7 kg/s
	Turbine isentropic efficiency	0.770 ---
	Turbine outlet gas temperature	1029 K

HPOTP

Pump Section	Liquid or gas flows through pump?	Liquid
	LO2 Pressure at pump inlet	2.8 MPa
	LO2 Mass flow rate through pump	401 kg/s
	LO2 Pressure exiting pump	29.6 MPa
	HPOTP Pump efficiency	0.681 ---
	LO2 Temperature entering pump	93 K
	LO2 Temperature exiting pump	100 K
	HPOTP Pump power	13.8 MW

Boost Pump	Liquid or gas flows through pump?	Liquid
	LO2 Pressure entering boost pump	29.6 MPa
	LO2 Temperature entering boost pump	100 K
	LO2 Pressure exiting boost pump	50.2 MPa
	Boost pump efficiency	0.803 ---
	LO2 Temperature exiting boost pump	103 K
	LO2 Mass flow rate through boost pump	48.3 kg/s
	Boost pump power	1.1 MW

Preburner	GH2 Percentage of rejoined GH2 flows going to HPOTP preburner	32	%
	GH2 Mass flow rate entering preburner	17.1	kg/s
	GH2 Temperature entering preburner	154	K
	GH2 Pressure entering preburner	35200	kPa
	Preburner O/F mass ratio	0.668	---
	LO2 Mass flow rate entering preburner from LO2 boost pump	11.3	kg/s
	LO2 Temperature entering preburner from LO2 boost pump	103	K
	LO2 Pressure entering preburner from LO2 boost pump	50.2	MPa
	Preburner product gas mass flux	28.4	kg/s
	Preburner product gas Y_H2	0.549	---
	Preburner product gas Y_H2O	0.451	---
	Preburner product gas temperature	836	K
	Preburner product gas pressure	34400	kPa
	Preburner product gas gamma value	1.37	---
	Preburner product gas C_p value	9073	J/kg-K
	Preburner product gas MW value	3.36	g/mol

Turbine Section	Liquid or gas flows through turbine?	Gas
	HPOTP Turbine power	13.8 MW
	Turbine inlet gas temperature	836 K
	Turbine inlet gas pressure	34400 kPa
	Turbine outlet gas pressure	23355 kPa
	Turbine pressure ratio p_in / p_out	1.47 ---
	Turbine outlet mass flux	28.4 kg/s
	Turbine outlet gas temperature	782 K
	Turbine isentropic efficiency	0.650 ---

Main Injectors

GH2 Injectors	GH2-rich product mass flow rate from HPFTP supplied to injectors	71.7	kg/s
	GH2-rich product temperature from HPFTP supplied to injectors	1029	K
	GH2-rich product C_p from HPFTP supplied to injectors	8088	J/kg-K
	GH2-rich product MW from HPFTP supplied to injectors	3.97	g/mol

GH2-rich product pressure from HPFTP supplied to injectors	23355 kPa
GH2-rich product Y_H2 from HPFTP supplied to injectors	0.446 ---
GH2-rich product Y_H2O from HPFTP supplied to injectors	0.549 ---
GH2 Mass flow rate from LPFTP turbine supplied to injectors	13.3 kg/s
GH2 Temperature from LPFTP turbine supplied to injectors	257.0 K
GH2 Pressure from LPFTP turbine supplied to injectors	25000 kPa
GH2 C_p from LPFTP turbine supplied to injectors	14340 J/kg-K
GH2 MW from LPFTP turbine supplied to injectors	2.02 g/mol
Combined GH2-rich mass flow rate from fuel side going to injectors	84.9 kg/s
Combined GH2-rich temperature from fuel side going to injectors	837.7 K
Combined GH2-rich pressure from fuel side going to injectors	23796 kPa
Combined Y_H2 in GH2-rich flow from fuel side going to injectors	0.534 ---
Combined Y_H2O in GH2-rich flow from fuel side going to injectors	0.466 ---
Combined C_p in GH2-rich flow from fuel side going to injectors	9055 J/kg-K
Combined MW of GH2-rich flow from fuel side going to injectors	3.44 g/mol
GH2-rich product mass flow rate from HPOTP supplied to injectors	28.4 kg/s
GH2-rich product temperature from HPOTP supplied to injectors	782 K
GH2-rich product pressure from HPFTP supplied to injectors	23355 kPa
GH2-rich product Y_H2 from HPOTP supplied to injectors	0.549
GH2-rich product Y_H2O from HPOTP supplied to injectors	0.451
GH2-rich product C_p from HPOTP supplied to injectors	9037 J/kg-K
GH2-rich product MW from HPOTP supplied to injectors	3.36 g/mol
Total GH2-rich preburner product mass flow supplied to injectors	113.7 kg/s
Y_H2 in combined GH2-rich preburner flows supplied to injectors	0.538 ---
Y_H2O in combined GH2-rich preburner flows supplied to injectors	0.462 ---
C_p of combined GH2-rich preburner flows to injectors	9069 J/kg-K
Temperature of combined GH2-rich preburner flows to injectors	824 K
MW of combined GH2-rich preburner flows to injectors	3.40 g/mol

Pressure of combined GH2-rich preburner flows to injectors	23684 kPa
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GH2 Pressure drop across injectors	16200 kPa
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GH2 Pressure at exit of injectors	7284 kPa
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LO2 Injectors LO2 mass flow rate from HPOTP supplied to injectors	353 kg/s
LO2 Temperature from HPOTP supplied to injectors	100 K
LO2 Pressure from HPOTP supplied to injectors	29.6 MPa

LO2 Pressure drop across injectors	9000 kPa
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LO2 Pressure at exit of injectors	20600 kPa
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Thrust Chamber

Main combustion chamber (MCC) overall O/F mass ratio	5.98 ---
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Main combustion chamber (MCC) pressure	20.6 MPa
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Mass flow rate of combined GH2-rich preburner flows entering MCC	113.7 kg/s
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Y_H2 in combined GH2-rich preburner flows entering MCC	0.538 ---
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Y_H2O in combined GH2-rich preburner flows entering MCC	0.462 ---
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Temperature of combined GH2-rich preburner flows entering MCC	824 K
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Mass flow rate of LO2 entering MCC	353 kg/s
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Resulting O/F mixture fraction (mass ratio) entering MCC	3.10 ---
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O2/H2 mass flux ratio entering MCC	5.77 ---
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Combustion product gas temperature in combustion chamber	4904 K
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Combustion product gas pressure in combustion chamber	20.6 MPa
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Combustion product gas Cp value in combustion chamber	20121 J/kg-K
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Combustion product gas gamma value in combustion chamber	1.17 ---
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Combustion product gas MW in combustion chamber	10.13 g/mol
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Combustion product gas mass flux exiting combustion chamber	466.7 kg/s
Combustion chamber diameter	45.1 cm
Combustion chamber cross-sectional area A_C	0.160 m ²
Throat diameter	26.2 cm
Throat area A*	0.054 m ²
Ratio of A_C over A*	2.96 ---

Expansion Nozzle

	Nozzle exit diameter	2.304	m
	Nozzle exit area A_e	4.17	m^2
	Nozzle A_e/A*	77.3	---
	Nozzle isentropic efficiency	0.97	---
Frozen flow	Combustion product gas gamma value entering nozzle	1.17	---
Frozen flow	Combustion product gas MW entering nozzle	10.13	g/mol
Frozen flow	M_e from non-isentropic nozzle flow w/ gamma entering nozzle	4.063	---
Frozen flow	p_e/p_t2 from non-isentropic nozzle flow w/ gamma entering nozzle	0.00136	---
Frozen flow	p_e from non-isentropic nozzle flow w/ gamma entering nozzle	27.3	kPa
Frozen flow	T_e from non-isentropic nozzle flow w/ gamma entering nozzle	1867	K
Frozen flow	V_e from non-isentropic nozzle flow w/ gamma entering nozzle	5567	m/s

Shifting Equilibrium	Combustion product gas gamma value exiting nozzle	1.109 ---
Shifting Equilibrium	Combustion product gas MW exiting nozzle	12.62 g/mol
Shifting Equilibrium	M_e from non-isentropic nozzle flow w/ gamma exiting nozzle	4.213 ---
Shifting Equilibrium	p_e from non-isentropic nozzle flow w/ gamma exiting nozzle	26.1 kPa
Shifting Equilibrium	T_e from non-isentropic nozzle flow w/ gamma exiting nozzle	2815 K
Shifting Equilibrium	V_e from non-isentropic nozzle flow w/ gamma exiting nozzle	6042 m/s

Thrust

Sea Level (SL)	Resulting jet thrust (SL)	2820 kN
	Resulting pressure thrust (SL)	-314 kN

Vacuum (vac)	Resulting nominal thrust (SL)	2505 kN
	Nozzle divergence thrust loss	0.80 %
	Resulting divergence-corrected thrust (SL)	2485 kN
	Actual thrust coefficient C_T (SL)	2.23 ---
	Ideal thrust coefficient $(C_T)_{ideal}$ (SL)	2.25 ---
	Resulting nozzle C_T efficiency (SL)	0.991 ---
	Specific Impulse I_{sp} (SL)	543 s
	Resulting jet thrust (vac)	2816 kN
	Resulting pressure thrust (vac)	109 kN
	Resulting nominal thrust (vac)	2926 kN
	Nozzle divergence thrust loss	0.80 %
	Resulting divergence-corrected thrust (vac)	2903 kN
	Actual thrust coefficient C_T (vac)	2.61 ---
	Ideal thrust coefficient $(C_T)_{ideal}$ (vac)	2.63 ---
	Resulting nozzle C_T efficiency (vac)	0.99 ---
	Specific Impulse I_{sp} (vac)	634 s