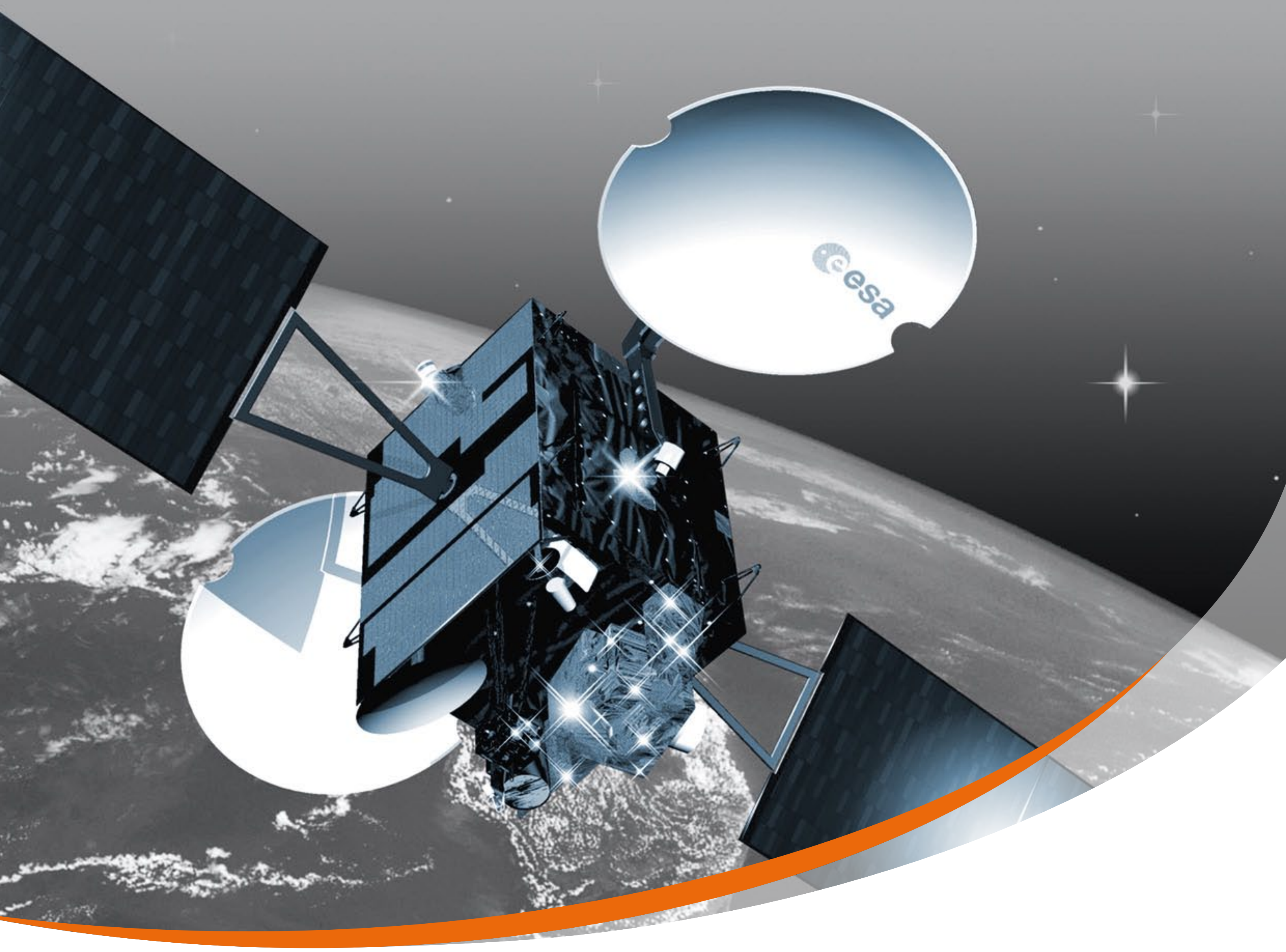
Space Transportation

400 N

400 N BI-PROPELLANT ENGINE

RELIABLE APOGEE AND DEEP SPACE MANEUVERS



All the space you need

ASTRIUM
AN EADS COMPANY

400 N Bi-Propellant Engine

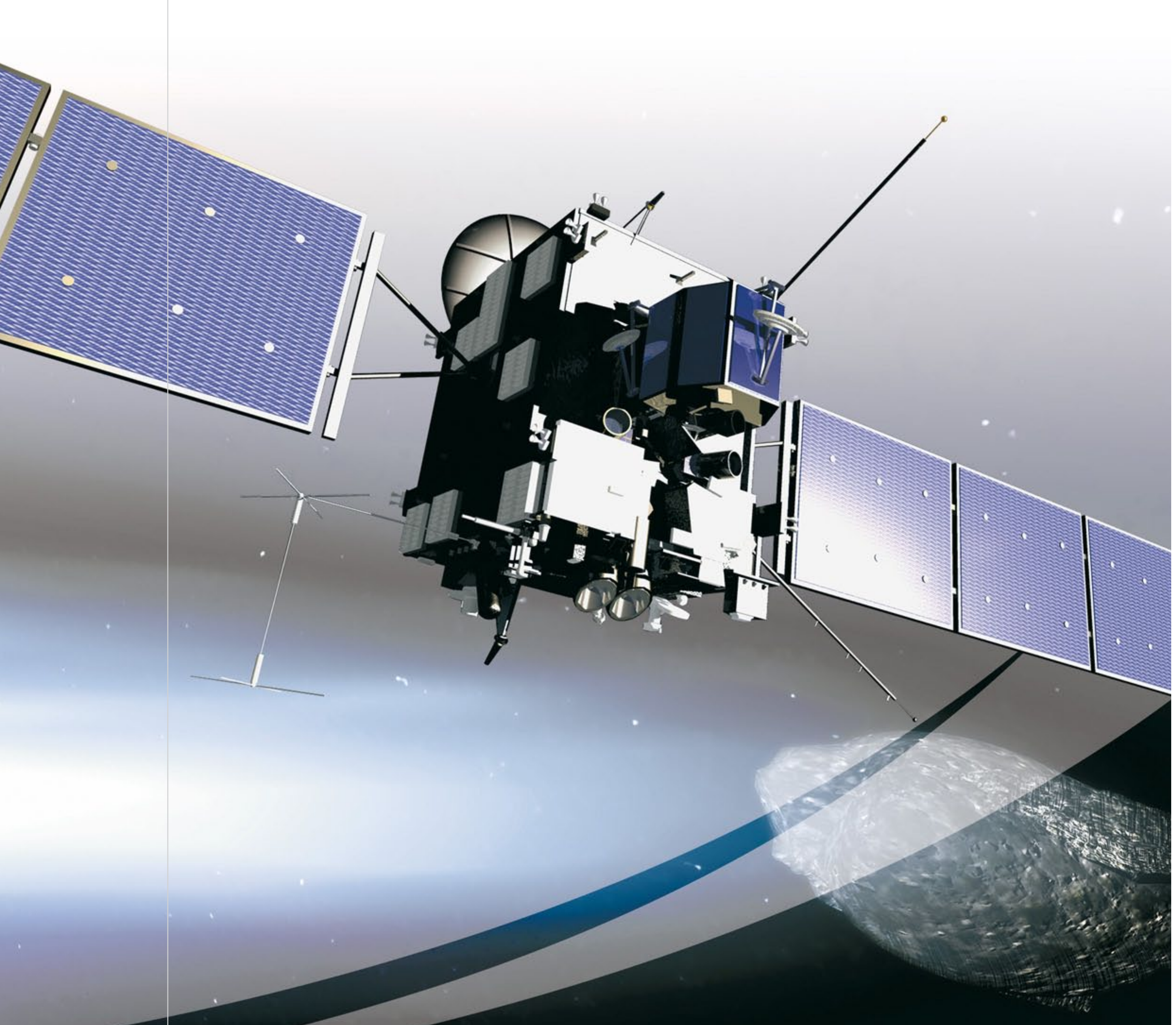
Heritage

The 400 N engine is a small rocket engine for apogee orbit injection of geostationery satellites and for trajectory and planetary orbit maneuvers of deep space probes.

It can look back on more than 40 years use in space. Over 80 units have controlled international scientific and commercial spacecraft to date.

The thruster has experienced multiple refinements in the course of its 40 years life and innovation for further product improvement still continues.

The engines are equipped with propellant valves from either Astrium or foreign supplier, depending on customer's request. The engine is an All European Product when equipped with the Astrium valve.



400 N Bi-Propellant Engine

400 N Thruster in Space

More than 80 spacecraft are equipped with apogee engines of EADS Space Transportation to date, and further will follow. (* Spacecraft will be launched in the near future)

SPACECRAFT	LAUNCH	SPACECRAFT	LAUNCH	SPACECRAFT	LAUNCH
SYMPHONIE	1974	AMSAT	2000	Galaxy 17	2007
SYMPHONIE	1975	CLUSTER II	2000	Star One C1	2007
TV-SAT 1	1987	CLUSTER II	2000	Chinasat 9	2008
TDF-1	1988	EUTELSAT W4	2000	CIEL2	2008
DFS COPERNICUS	1989	HISPASAT 1C	2000	Star One C2	2008
GALILEO	1989	ARTEMIS	2001	Turksat 3A	2008
TELE-X	1989	Atlantic Bird 2	2001	W2A	2009
TV-SAT 2	1989	EURASIASAT	2001	MILSAT-A	2009
DFS COPERNICUS	1990	Eurobird	2001	Palapa D	2009
EUTELSAT2-F1	1990	SICRAL	2001	SICRAL 1B	2009
TDF-2	1990	ASTRA 1K	2002	Thor-6	2009
EUTELSAT2-F2	1991	Atlantic Bird 1	2002	W7	2009
EUTELSAT2-F3	1991	EUTELSAT W5	2002	W3B	2010
DFS COPERNICUS	1992	Hispasat 1D	2002	MILSAT-B	2010
EUTELSAT2-F4	1992	HOT BIRD 6	2002	Nilesat 201	2010
EUTELSAT2-F5	1994	MSG FM1	2002	RASCOM-2	2010
TUERKSAT 1A	1994	Stellat	2002	W3C	2011
TUERKSAT 1AR	1994	STENTOR	2002	Alphasat PFM	*
TUERKSAT 1B	1994	AMC-9, GE-12	2003	AMOS 4	*
HOT BIRD 1	1995	AMOS 2	2003	Apstar7A	*
AMOS 1	1996	MARS EXPRESS	2003	Apstar7B	*
Arabsat 2A	1996	Apstar 6	2005	ARSAT	*
Arabsat 2B	1996	FM01, GEi1	2005	ARSAT 2	*
CLUSTER I	1996	GEi2	2005	AthenaFidus	*
TUERKSAT 1C	1996	MSG FM2	2005	CESASAT	*
NAHUEL 1A	1997	Syrakus 3A	2005	ExoMars Orbiter	*
SIRIUS 2 FM1	1997	Venus Express	2005	MSG FM3	*
THAICOM 3	1997	HB7A, APA2	2006	MSG FM4	*
AMC-5, GE-5	1998	Koreasat 5	2006	Sicral2	*
EUTELSAT W2	1998	Syrakus 3B FM2	2006	SmallGEO	*
SINOSAT	1998	THAICOM 5	2006	W3D	*
Arabsat 3A	1999	Chinasat 6B	2007	W6A	*
EUTELSAT W3	1999	FM02, RC1	2007	Yamal 402	*

400 N Bi-Propellant Engine

Design Description

400 N The 400 N bi-propellant engine uses the storable propellants Monomethyl-hydrazine as fuel and pure Di-Nitrogen-Tetroxide N2O4 or Mixed Oxides of Nitrogen (MON-1, MON-3) as oxidizer. It is designed for long term steady state operation. It operates in a wide pressure range at regulated pressure mode.

The Combustion chamber and a part of the nozzle are made of a Platinum alloy. That does not require surface coating, thereby allowing operational wall temperatures up to 1,600° C (2,900° F) and thus maximum engine performance.

The uncoated surface is absolutely resistant against oxidization and thus invulnerable to mishandling, by application of testsensors or by pulse cycles.

The main criterion for selecting the adequate model for a specific application is the available volume in the spacecraft for accommodating the engine.

Trimming orifices upstream of the valves provide for individual adjustment of the propellant flow, according to the designed system pressure.

The application of heaters and thermistors for thermal control is provided on request.

Two almost identical engine models are available off the shelf. The only model difference is the size of the expansion nozzle: Model S400-15 is equipped with a larger nozzle and operates therefore at a 1% higher efficiency than model S400-12.

Engine Model S 400-12

Engine Model S 400-15

400 N Bi-Propellant Engine

Characteristics

CHARACTERISTICS	MODEL S400-12	MODEL S400-15
Thrust, Nominal	420 N	425 N
Thrust Range	340 … 440 N	340 … 440 N
Specific Impulse at Nominal Point	318 s	321 s
Flow Rate, Nominal	135 g/s	
Flow Rate, Range	110 … 142 g/s	
Mixture Ratio, Nominal	1.65	
Mixture Ratio, Range	1.50 … 1.80	
Chamber Pressure, Nominal	10 bar	
Inlet Pressure Range	12.5 … 18.5 bar	
Throat Diameter (inner)	16.4 mm	
Nozzle End Diameter (inner)	244 mm	292 mm
Nozzle Expansion Ratio (by area)	220	330
Mass, Thruster with Valve	3.60 kg	4.30 kg
Chamber-Throat Material	Platinum Alloy	
Nozzle Material	Nimonic	
Injector Type	Double Cone Vortex	
Cooling Concept	Film & Radiative	
Propellants, Fuel	MMH	
Oxidizer	N2O4, MON-1, MON-3	
Valve	Solenoid Single Seat, Double Coil Voltage 21 to 27 V, Power 35W per coil Bi-stable	
Mounting I/F to S/C	Valve flange with 4 through-holes of 6.6 mm diameter	
Tubing I/F	per MS 33656-4	
Valve Lead Wires	AWG 24 per MIL-W-81381	
Thruster heater and Thermal Sensor	On request	
Qualified single burn life	1.1 hours	2.04 hours
Qualified accumulated burn life	8.3 hours	12.8 hours planned
Qualified cycle life	100 cycles	144 cycles planned

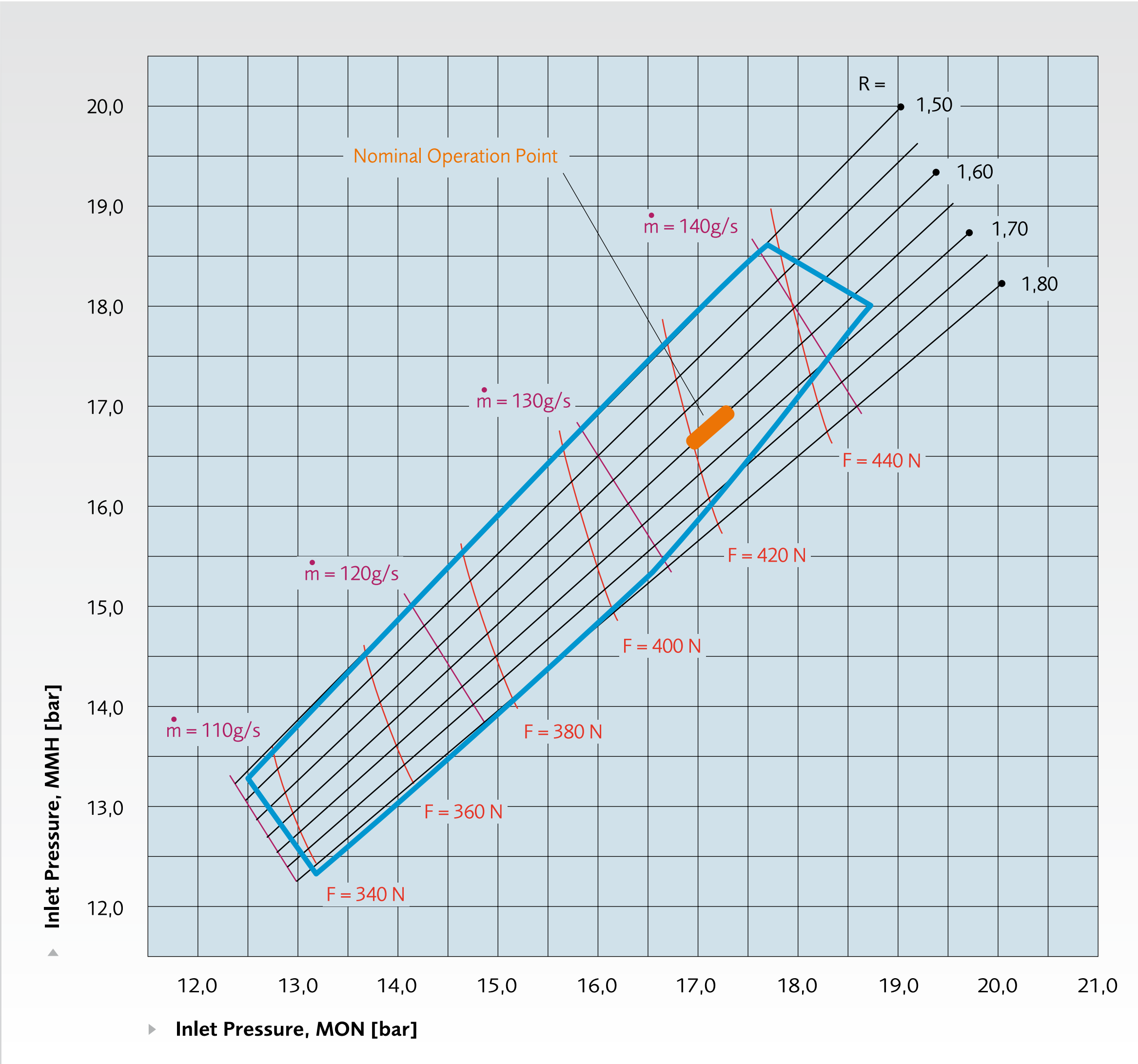
Conversion Factors: 1 mm = 0.0394 inch · 1 kg = 2.2 lb · 1 N = 0.22 lb · 1 bar = 14.22 psi

400 N Bi-Propellant Engine

Steady State Operation

ENGINE OPERATION RANGE

Both engine models are qualified to operate within the shown inlet pressure range. The customer may select the adjustment of the actual operation range within these boundaries according to the system requirements.
Nominal operation is defined for propellant mixture ratio R = 1,64 (Oxidizer / Fuel) and for propellant inlet pressure 17 bar.

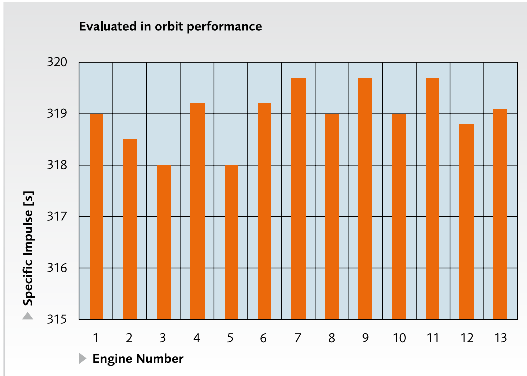


400 N Bi-Propellant Engine

Steady State Operation

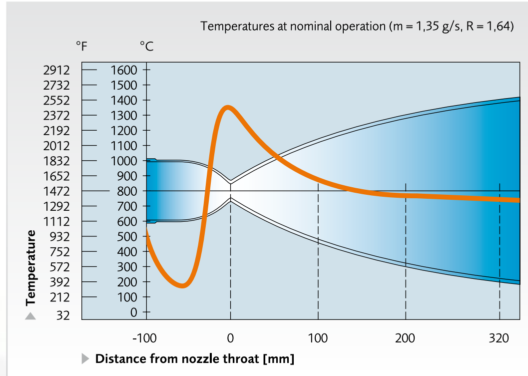
OPERATION IN ORBIT

The evaluation of actual apogee boost maneuvers in space demonstrates the reliable performance of the engine.



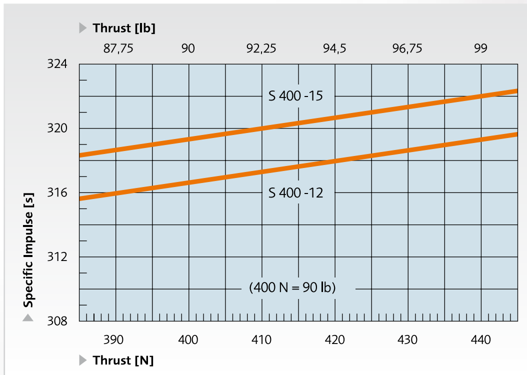
THERMAL BEHAVIOUR

Maximum engine temperatures occur at the nozzle throat. Heat and oxidization resistant platinum alloys are applied in this section wall temperatures up to 1600° C (2900° F) are permissible.



STEADY STATE PERFORMANCE

The specific impulse (Isp) is the measure of engine efficiency. The higher the Isp the lower the propellant consumption for a dedicated mission. The Isp depends on the actual operational conditions. In this diagram both engine models are operated at nominal propellant mixture ratio 1,65. Model S400-15 (nozzle expansion 330:1) performs generally a 3 sec higher Isp than model S400-12 (nozzle expansion 220:1).



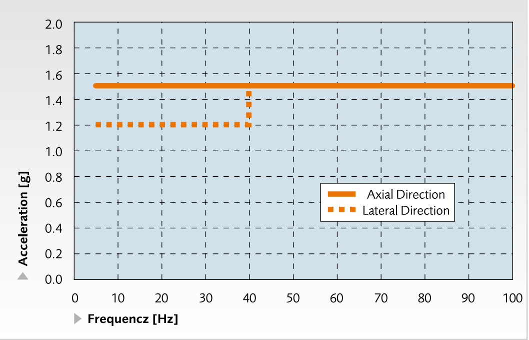
400 N Bi-Propellant Engine

Launch Vibration Loads

The engines are designed to withstand sinus, random and shock loads at the shown levels. These loads represent both, launcher loads and amplification by the spacecraft structure. The loads are applied at the engine's support structure.

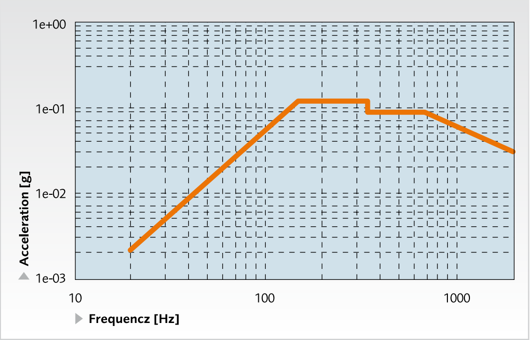
SINUSOIDAL VIBRATION LOADS

Qualification loads. Higher loads may be applied for dedicated missions provided notching is foreseen at critical resonance frequencies of the nozzle.



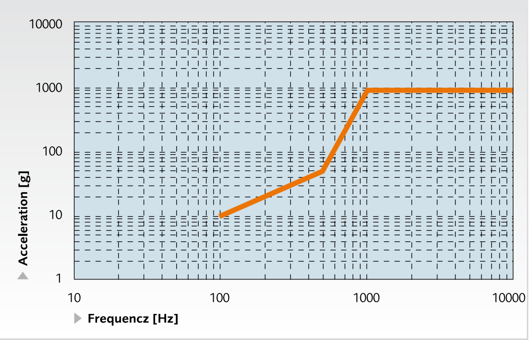
RANDOM VIBRATION LOADS

Qualification loads applied for 3 minutes to each axis.



SHOCK SPECTRUM

Qualification Loads, 1 Shock per axis.



400 N Bi-Propellant Engine

Engine with Support Structure and Thermal Shield

ENGINE MODULE

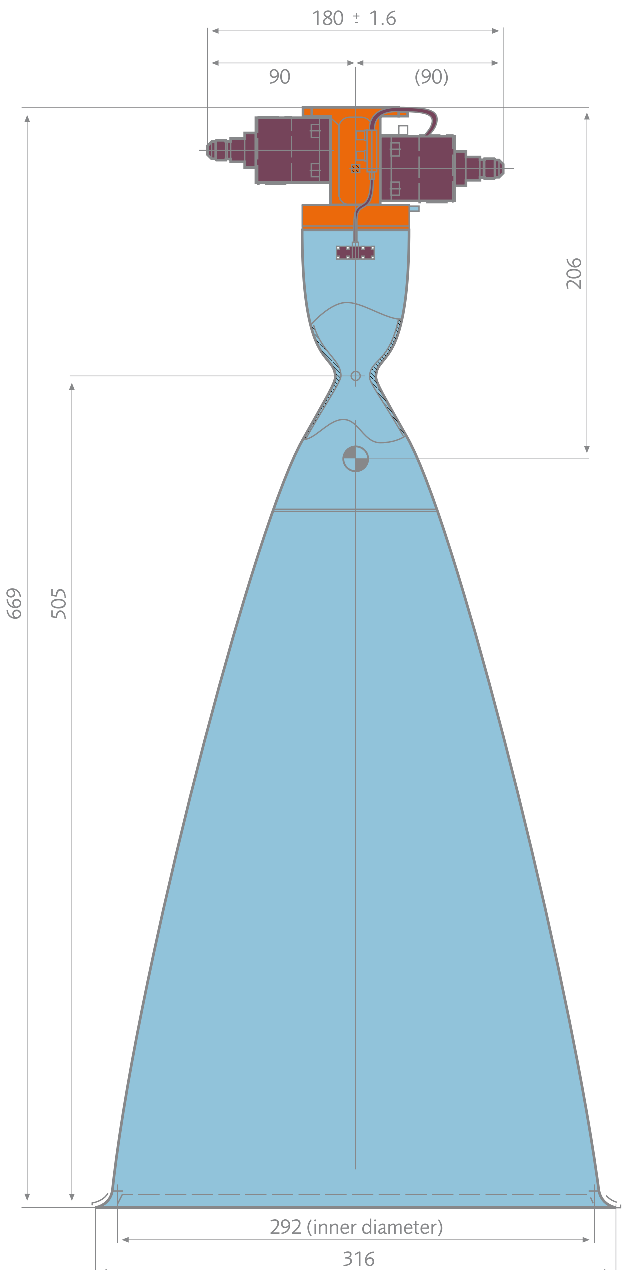
The engine is provided with supporting structure and thermal shield as completely assembled module, on customer request.

400 N Bi-Propellant Engine

Structure Interface

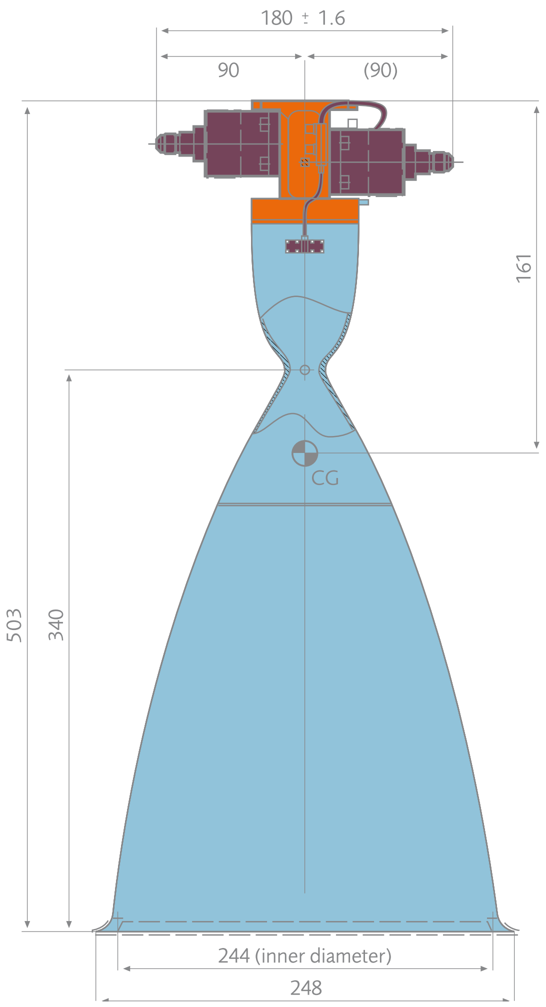
ENGINE DIMENSIONS

Engine Model S 400-15



ENGINE DIMENSIONS

Engine Model S 400-12



ENGINE TOP VIEW

Model S 400-12 and Engine Model S 400-15

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