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May 2008

ATK Space Propulsion Products Catalog

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Dear Customer:

ATK would like to take this opportunity to provide you with the latest version of our Space Propulsion Products Catalog to help you address your future propulsion requirements. This catalog describes flight-proven motors and development motors in our product line.

If the current production motors contained in this book do not address your specific needs, we have the capability to modify designs to meet your particular motor performance requirements. The practicality of tailoring motor performance has been demonstrated many times in derivatives of earlier design configurations (many examples exist in the STAR™, Orion, and CASTOR® series, for instance).

ATK continues to invest in the development of new products and capabilities. Ongoing activities include extensive work with controllable solid-propulsion systems, which use proportional valves to control performance, and liquid and electric propulsion for small spacecraft.

ATK looks forward to serving your propulsion needs with demonstrated high-reliability, low-cost, and high-performance propulsion subsystems. Please direct any inquiries to Jen Crock, Space Motor Program Management, at (410) 392-1027 or Barry Gregg, director, Space Motor Business Development, at (302) 521-4209. Thank you for your interest in ATK products.

Very truly yours,

Michael R. Lara
Vice President, Programs
ATK Tactical Propulsion and Controls

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ACRONYM LIST

ACS	Attitude control system — A thruster system used to maintain spacecraft/ missile positioning and orientation. Also referred to as a reaction control system (RCS) in some applications
AKM	Apogee kick motor — A motor used to circularize the orbit of a spacecraft, often to GEO
ASAS	Advanced Solid Axial Stage — ASAS is used as a designation for a family of enhanced performance motors that generally incorporate common technologies such a high-strength graphite composite cases, high performance propellants, advanced ordnance, and/or thrust vector control nozzles with electromechanical actuation. These motors are identified by primary diameter, case length, and TVC content. For example, ASAS 21-120V would be a 21-in. diameter motor with a 120-in. case and TVC nozzle
BIT	Built-in test — A feature of electronic devices that allows their operability to be confirmed via a signal provided in response to a test command/query
CaLV	Cargo launch vehicle — A function of the new Ares V launch vehicle
CLV	Crew launch vehicle — A function of Ares I, the human-rated member of the Ares family
CSC	Conical shaped charge — An ordnance product typically used as part of upper stage destruct systems to satisfy range safety requirements
CTPB	Carboxyl terminated polybutadiene — A type of polymer used as a propellant binder
EOSA	Electro-optical safe and arm — A class of safe-and-arm device based on isolation of the unit and primary initiation functions using laser systems and fiber optics to reduce weight and eliminate sensitivity to electrostatic energy that results from use of long wiring runs for ordnance systems typically used in launch vehicles
EPDM	Ethylene propylene diene monomer — A class of elastomeric rubber insulation materials typically used to insulate motor cases
ESA	Electronic safe and arm — A class of safe-and-arm device based on use of semiconductor bridge initiator technology. ESA designs provide capabilities for reporting health status of the ordnance system and incorporating specific safety and command/control protocols
ETA	Explosive transfer assembly — ETAs are used as part of a space motor ignition train, generally to transfer the initiation signal from a safe-and-arm device to another ordnance component such as a TBI. May be further identified as an FETA = flexible ETA, or RETA = rigid ETA

GEM	Graphite epoxy motor — ATK developed GEM designs for the Delta II launch vehicle. Designed to take advantage of proven, off-the-shelf technologies, the GEM system provides increased performance and heavier lift capability
GEO	Geostationary orbit — 22,600 miles out from the earth is an orbital location where satellites remain over a fixed point on the earth
GPS	Global positioning system — A satellite constellation providing precise navigation and location data for military and commercial users
GSE	Ground support equipment — Equipment used to support motor integration with the spacecraft and/or launch vehicle and to provide associated final motor checks
HEW	Head end web — A type of grain design in which the propellant completely covers and is generally bonded to the motor head end
HTPB	Hydroxyl terminated polybutadiene — A type of polymer used as a propellant binder
LEO	Low earth orbit — A position reached by the Space Shuttle and many launch systems prior to orbital adjustments that are typically made using PKM and AKM propulsion
MER	Mars Exploration Rover — Designation for the 2003-2004 NASA missions to Mars that landed the Spirit and Opportunity rovers
NSI	NASA standard initiator
PKM	Perigee kick motor — A motor typically used to raise a satellite into elliptical orbit
RAD	Rocket-assisted deceleration — Designation for motors used to decelerate payloads such as the Mars RAD motors
RPM	Revolutions per minute — Used to designate spin rates used to stabilize spacecraft. Note that the cited spin rates are the highest levels to which the design was tested or analyzed, not necessarily its maximum spin capability
RSRM	Reusable solid rocket motor — Designation used for the Space Shuttle boosters
S&A	Safe and arm — Used to designate an electronic or electromechanical device that inhibits ordnance functions to provide enhanced safety
SCB	Semiconductor bridge — The SCB chip is used in a line of initiators that provides fast and repeatable function times using low initiation energy
SRM	Solid rocket motor
STS	Space Transportation System — The Space Shuttle
TBI	Through bulkhead initiator — Part of a space motor ignition train

TLI	Trans-Lunar Injection — Designation for a motor system used to inject a satellite into a lunar orbit. This specific designation applies to the STAR 37FM-based TLI stage used for the Lunar Prospector spacecraft
TCR	ATK line of resins and preimpregnated composite materials available in combination with a variety of fibers for industrial, commercial, and aerospace applications
TIRS	Transverse impulse rocket system — Designation for motors used to stabilize the lander during descent as part of the Mars Exploration Rover mission
TVA	Thrust vector actuation — refers to the system used to actuate a TVC nozzle
TVC	Thrust vector control — refers to a type of movable nozzle
UWARS	Universal water activated release system — A program that uses a qualified SCB initiator produced by Elkton

Introduction

ATK's space propulsion and ordnance products outlined in this catalog reflect more than 45 years of experience providing high-performance and reliable propulsion for the aerospace industry. This catalog presents technical information on ATK many product lines: Orion, CASTOR®, CASTOR 120®, GEM (graphite epoxy motor), SRMU (solid rocket motor upgrade), the Space Shuttle RSRM (reusable solid rocket motor) and its derivative motors, the STAR™ series of space motors and integrated upper stages, ASAS™ (advanced solid axial stage), and space launch structures.

Solid rocket motor technology provides excellent reliability, tailorable ballistic

RSRM Boosters Lift the Space Shuttle

GEM and STAR Propulsion Power Delta II

CASTOR and Orion Motors Boost Taurus

performance, and low costs for many space, upper-stage, and missile defense applications. Introduction of high-strength composite materials has further enhanced performance for many classes of motors. In addition, ATK motors with thrust vector control nozzles and attitude control systems provide significant upgrades in solid propulsion system capabilities.

STAR 48 Motor and Magellan Satellite Begin Journey to Venus

Lunar Prospector (STAR 37 Integrated Stage)

CASTOR IVB Test

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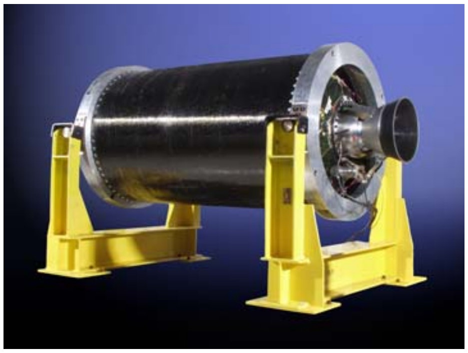
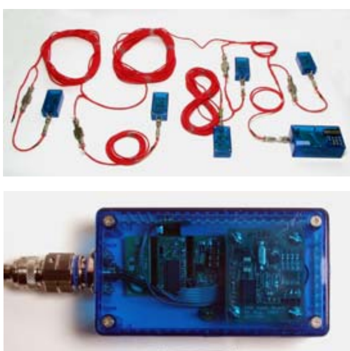
Sometimes existing designs must be modified, stretched, offloaded, or scaled-up to achieve performance goals and/or to accommodate structural interfaces established for specific missions. As a result, ATK routinely modifies our products to meet evolving customer needs through detailed design, analysis, and testing of new propulsion systems that maintain the heritage of prior, flight-proven designs.



Rapid Vectoring Nozzle (RAVEN) Demonstration Motor

ASAS 21-120 Motor Test

Our ordnance products have also established excellent flight reliability records in both motor ignition and destruct system applications. Current electronic safe-and-arm technology can be applied by ATK to reduce ordnance weight and cost and to precisely control ordnance events for your propulsion systems.



Addressable Bus Ordnance System

ESA

Conical Shaped Charge (destruct ordnance)

As an addition to this new catalog, we have included an overview of ATK's integrated stage capabilities. ATK has a broad range of capabilities, including simple stage hardware and stage/vehicle integration support, to more complex three-axis stabilized, inertially guided vehicle designs. ATK now offers fully autonomous single or multiple stage stacks and all of the required avionics hardware, flight software, and mission design and management services.

In addition to hardware, ATK routinely provides a variety of support services, including engineering design trades, launch and integration support, field handling training, aging and surveillance, demilitarization, testing, and analysis. These services help support mission assurance goals leading to successful flight. We also routinely provide shipping containers and ground support equipment for use with the motors. To accommodate new environments or structural interfaces, we can define and support delta-qualification of components and/or complete motor assemblies. ATK can also design skirts and interstages and provide heaters, thermal blankets, and flight termination ordnance to adapt our products to your needs.

Shipping Container

Lunar Prospector Size With Lifting Beam Tooling for Stage/Motor Handling

This catalog contains data sheets that summarize the principle design and performance characteristics of each motor or system. The information provided in the data sheets will permit initial evaluation of our current products in reference to your mission requirements. We encourage you to involve us in these evaluations and welcome the opportunity to provide optimal solutions for your mission needs.

Inquiries regarding specific product lines should be directed to our business development representatives as listed below. In addition to the products noted in this catalog, ATK can provide reliable space structures, aerospace tanks, and hypersonic propulsion technology. For information about these and other ATK products, please visit our website at www.atk.com.

Products	Contact No.	Contact E-mail Address
STAR, ASAS, and CASTOR I and II Motors; STAR™ Stages; Ordnance	Phone: (410) 392-1430 Fax: (410) 392-1205	starmotors@atk.com
Orion, CASTOR IV and 120, GEM, SRMU, and RSRM Motors	Phone: (435) 863-2699 Fax: (435) 863-8658	businessdevelopment@atk.com
Space Structures	Phone: (801) 775-1262 Fax: (801) 775-1207	composite.structures@atk.com
Tanks	Phone: (323) 722-0222 Fax: (323) 721-6002	psi.tank@atk.com
Hypersonic Propulsion Technology	Phone: (631) 737-6100 Fax: (631) 737-6121	GASL.Marketing@atk.com

ORION MOTOR SERIES

AFFORDABLE, LOW-RISK LAUNCH CAPABILITIES

ATK developed the Orion solid rocket motors that propel Orbital Sciences Corporation's Pegasus and Pegasus XL (extended length), and Taurus launch vehicles.

Pegasus® XL

The Pegasus XL is the world's leading launch system for deployment of small satellites into low-Earth orbit. This system uses three Orion series boosters. Because it is aircraft-launched, Pegasus can be launched from virtually anywhere in the world.

It is launched horizontally from an aircraft at an altitude of 40,000 ft. Approximately 5 sec after release, Stage 1 Orion motor initiation occurs, lifting Pegasus into orbit hundreds of miles above the Earth in approximately 10 minutes.

Propulsion efficiency, along with use of advanced materials and avionics technologies, enables Pegasus to deliver approximately twice the payload (up to 1,000 lb) of an equivalent ground-based vehicle to orbit.

Taurus®

ATK builds all four of the solid rocket motors for the Taurus ground-launch vehicle, developed by Orbital Sciences Corporation. Taurus fills the cost and performance gap between Pegasus and much larger, more expensive launch vehicles.

Using proven Orion rocket motors, Taurus delivers satellites of up to 5,000 lb into low-Earth orbit or up to 900 lb into geosynchronous transfer orbit. The Taurus upper-stage solid propulsion rocket motors are essentially the same as the proven Pegasus rocket motors, with slight modifications to accommodate heavier loads. All Orion motors feature graphite-epoxy wound composite cases and hydroxyl-terminated polybutadiene (HTPB) solid propellant.

Orion Series

The Orion family of motors was originally designed for the three stages of the Pegasus launch vehicle. Modifications to the original three Orion motors have accommodated additional applications and enhanced performance for the Taurus, Pegasus XL, Minotaur, Hyper-X, and more recently, the Taurus Lite and Taurus XL launch vehicles.

The multiple configurations and applications currently existing demonstrate that these flight-proven motors are readily adaptable to a wide range of launch scenarios (e.g., ground-start, air-start, silo-launched, etc.).

The current major vehicle applications and variants for Orion motors are shown in the table below. The following figure shows an overview of components of the Orion motor series.

Flight-Proven Orion Motor Configurations

Vehicle	Orion Motor			
	First Stage	Second Stage	Third Stage	Fourth Stage
Pegasus	50S	50	38	
Pegasus XL	50S XL	50 XL	38	
Taurus	50ST	50T	38	
Taurus XL	50S XLT	50 XLT	38	
Taurus Lite	50S XLG	50 XL	38	
Minotaur			50 XL	38
Hyper-X	50S			

Motor Identification Key

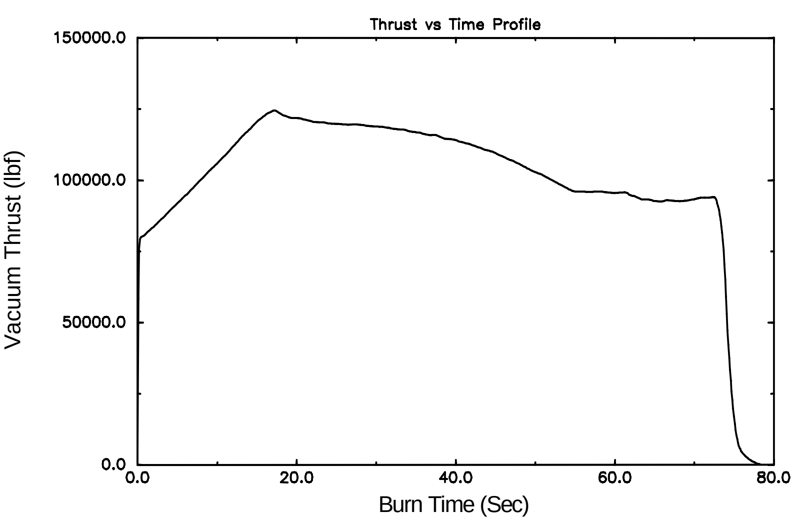
Example **Orion** **50** **S** **XL** **G** **T**

- SRM class
- SRM diameter (in)
- Stretch
  - *With "S" denotes Stage 1*
  - *Without "S" denotes Stage 2*
- XL or Std motor length
  - *"XL" denotes extra length (otherwise standard length)*
- Nozzle configuration
  - *"G" denotes ground-launched (truncated exit cone)*
- Thicker skirt
  - *"T" denotes thicker skirt (increased structural capacity)*

ORION 50S

AIR-IGNITED, FIXED NOZZLE

The Orion 50S was developed as a low-cost, high-performance first stage for the Pegasus launch vehicle. The 50S configuration, shown above incorporating a saddle attachment, has a fixed nozzle and is air ignited after a 5-sec freefall drop from around 40,000 ft. The Orion 50S has launched 10 Pegasus satellite missions into successful orbit, some of which were Pegsat, Microsat, SCD-1 (Brazil's first data collection satellite), Alexis, and Space Test Experiment Platform (STEP)-2. This motor, with some additional modifications, has also been used as a booster in Hyper-X flights to support scramjet flight-testing.



MOTOR DIMENSIONS

Motor diameter, in.	50
Motor length, in.	349

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec	75.3
Average chamber pressure, psia	813
Total impulse, lbf-sec	7,877,000
Burn time average thrust, lbf	104,564

NOZZLE

Housing material	Aluminum
Exit diameter, in.	56.056
Expansion ratio, average	35.3

WEIGHTS, LBM

Total loaded	29,554
Propellant	26,814
Case	1,660
Nozzle	545
Other	36
Burnout	2,098

TEMPERATURE LIMITS

Operation	50°-100°F

PROPELLANT DESIGNATION

QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

Flight proven, production

Current production focused on XL version

*Pegasus standard first stage

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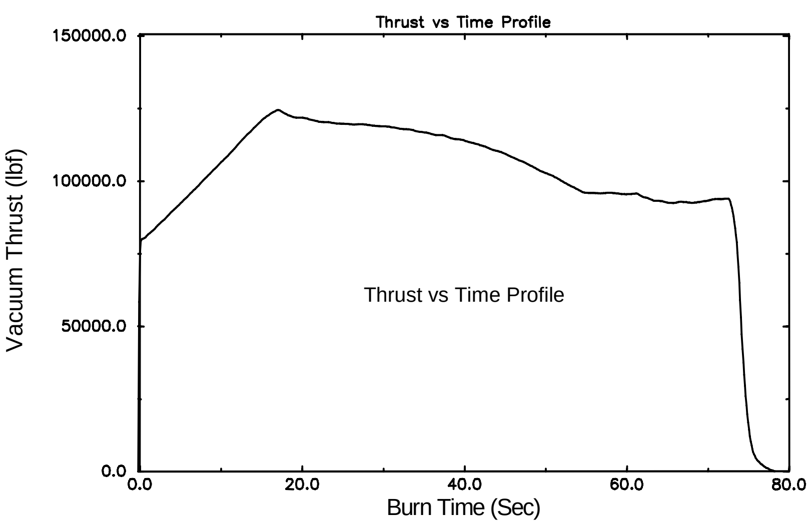
ORION 50ST

AIR-IGNITED, VECTORABLE NOZZLE

Another version, Orion 50ST, incorporates a ± 3-deg moveable nozzle for the air-ignited, Taurus Stage 1. This version has flown on all six Taurus missions (both Air Force and commercial versions), such as the Multi-Spectral Thermal Imager (MTI), Orbview-4, Korea Multi-Purpose Satellite (KOMPSAT), etc.



MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 333

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 75
Average chamber pressure, psia 850
Total impulse, lbf-sec 7,677,000
Burn time average thrust, lbf 102,162

NOZZLE

Housing material ....Aluminum
Exit diameter, in. 47.63
Expansion ratio, average 26.7

WEIGHTS, LBM

Total loaded 29,554
Propellant 26,801
Case 1,660
Nozzle 545
Other 36
Burnout 2,098

TEMPERATURE LIMITS

Operation ....50°-100°F

PROPELLANT DESIGNATION

....QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

....Flight-proven, production

***** Taurus standard first stage

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ORION 50S XL

AIR-IGNITED, FIXED NOZZLE

A performance upgrade of the Orion 50S, the Orion 50S XL, is 55.4 inches longer and contains 6,500 lbm more propellant. To date, this fixed-nozzle XL version has performed successfully on 25 Pegasus XL launch vehicle missions, such as the Solar Radiation and Climate Experiment (SORCE), Fast Auroral Snapshot (FAST), High Energy Solar Spectroscopic Imager (HESSI), Orbview-3, and Transition Region and Coronal Explorer (TRACE).

MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 404

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 69.1
Average chamber pressure, psia 1,073
Total impulse, lbf-sec 9,737,000
Burn time average thrust, lbf 140,802

NOZZLE

Housing material ....Aluminum
Exit diameter, in. 56.06
Expansion ratio, average 34.3

WEIGHTS, LBM

Total loaded 35,656
Propellant 33,121
Case 1,923
Nozzle 545
Other 83
Burnout 2,408

TEMPERATURE LIMITS

Operation ....50°-100°F

PROPELLANT DESIGNATION

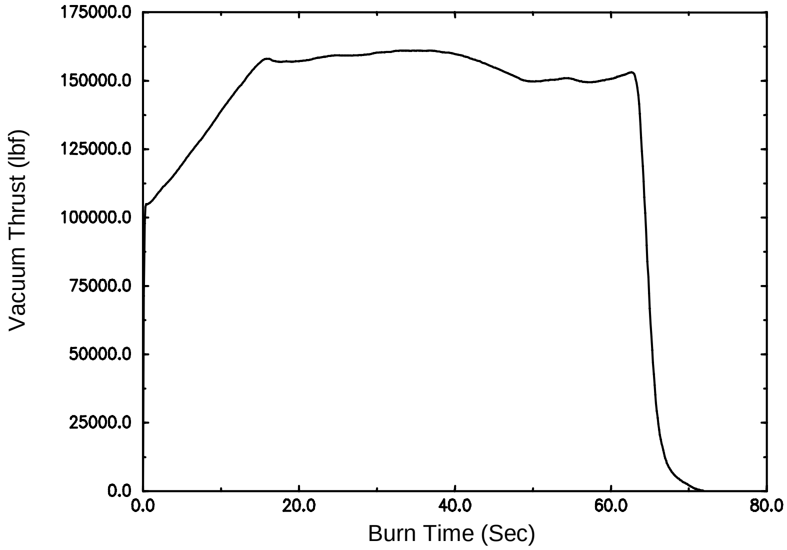
....QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

....Flight-proven, production

*****Pegasus XL first stage

Thrust vs Time Profile



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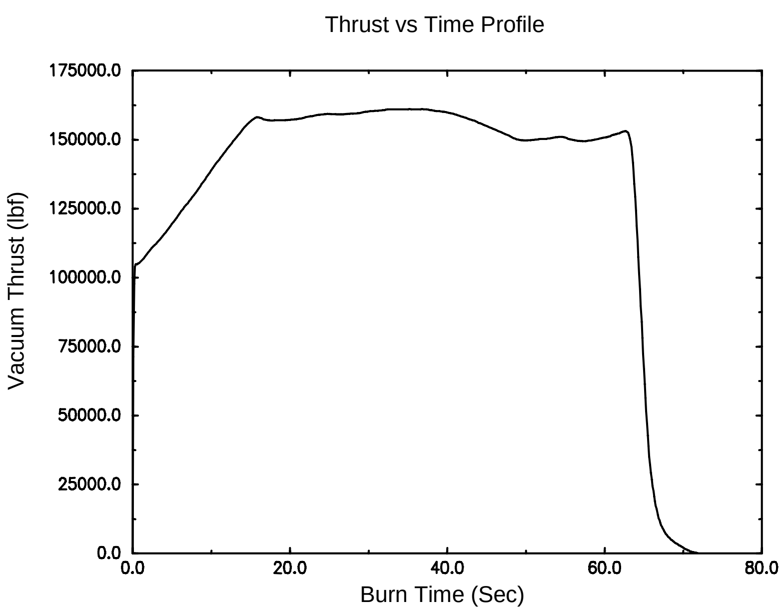
ORION 50S XLT

AIR-IGNITED, VECTORABLE NOZZLE

Vectorable nozzle configurations of Orion 50S XL have also been added to support versatility and new applications. One configuration, Orion 50S XLT, will be used as a first-stage motor on the enhanced Taurus XL vehicle, which launched in May 2004. This version incorporates a ± 5-deg moveable nozzle and thicker skirts.



MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 389

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 68.4
Average chamber pressure, psia.......................1,084
Total impulse, lbf-sec.................................9,466,000
Burn time average thrust, lbf..........................138,230

NOZZLE

Housing material..Aluminum
Exit diameter, in. 47.63
Expansion ratio, average 24.8

WEIGHTS, LBM

Total loaded 35,672
Propellant 33,121
Case 1,923
Nozzle 545
Other 83
Burnout 2,408

TEMPERATURE LIMITS

Operation ....36°-100°F

PROPELLANT DESIGNATION

.....................QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

....Flight-proven, production

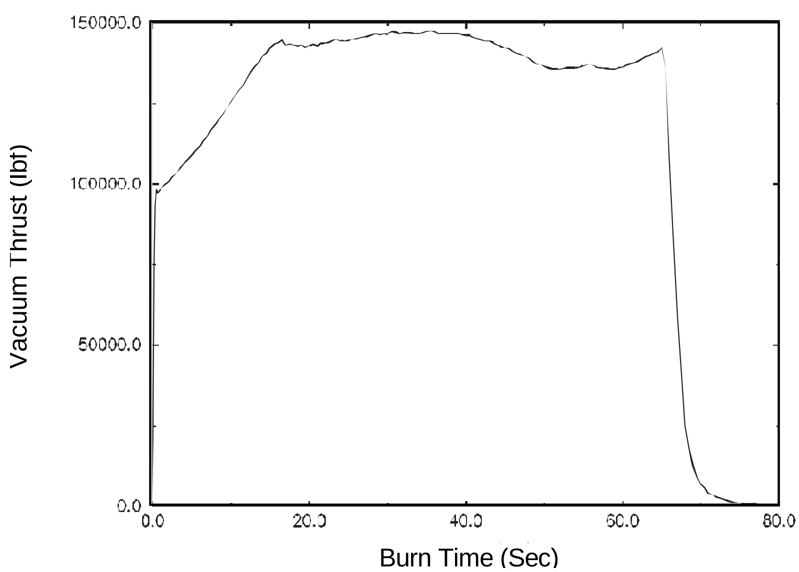
*Taurus XL first stage

ORION 50S XLG

GROUND-IGNITED, VECTORABLE NOZZLE

A ground ignited, vectorable nozzle configuration with ± 5-deg vector capability has also been developed: Orion 50S XLG. This motor was first flown on the Taurus Lite vehicle, February 2003, as the ground-ignited first stage.

Thrust vs Time Profile



MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 372

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 68.4
Average chamber pressure, psia 1,084
Total impulse, lbf-sec 9,052,000
Burn time average thrust, lbf 132,193

NOZZLE

Housing material ....Aluminum
Exit diameter, in. 36.00
Expansion ratio, average 14.2

WEIGHTS, LBM

Total loaded 35,720
Propellant 33,121
Case 1,923
Nozzle 593
Other 83
Burnout 2,456

TEMPERATURE LIMITS

Operation ....50°-100°F

PROPELLANT DESIGNATION

....................QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

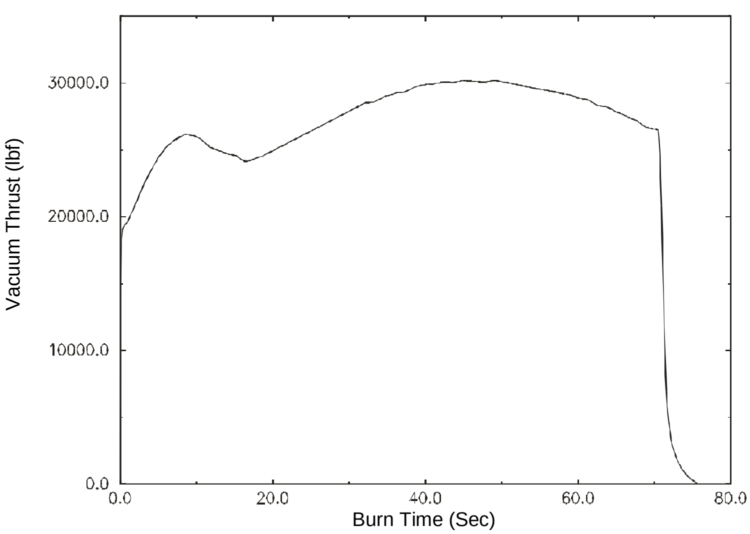
....................Flight-proven, production

*Taurus Lite first stage

ORION 50 (50T)

AIR-IGNITED, VECTORABLE NOZZLE

The Orion 50 was developed as a low-cost, high-performance second stage for the Pegasus launch vehicle. It incorporates a moveable nozzle with ± 5-deg vector capability. The motor was designed for upper stage applications but can readily accommodate lower expansion ratios, such as for ground-launch application, using a truncated nozzle. The Orion 50 has propelled 10 satellite missions into successful orbit, for example: Pegsat, Microsat, SCD-1 (Brazil's first data collection satellite), Alexis, and Space Test Experiment Platform (STEP)-2. A nearly identical version with slightly enhanced skirts, the Orion 50T, has also flown successfully on six Taurus launch vehicle flights.



MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 105

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 75.6
Average chamber pressure, psia 810
Total impulse, lbf-sec 1,949,000
Burn time average thrust, lbf 25,754

NOZZLE

Housing material .....Aluminum
Exit diameter, in. 33.862
Expansion ratio, average 52.1

WEIGHTS, LBM

Total loaded 7,428
Propellant 6,669
Case 472
Nozzle 225
Other 64
Burnout 715

TEMPERATURE LIMITS

Operation .....50°-100°F

PROPELLANT DESIGNATION

.....QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

.....Flight-proven, production

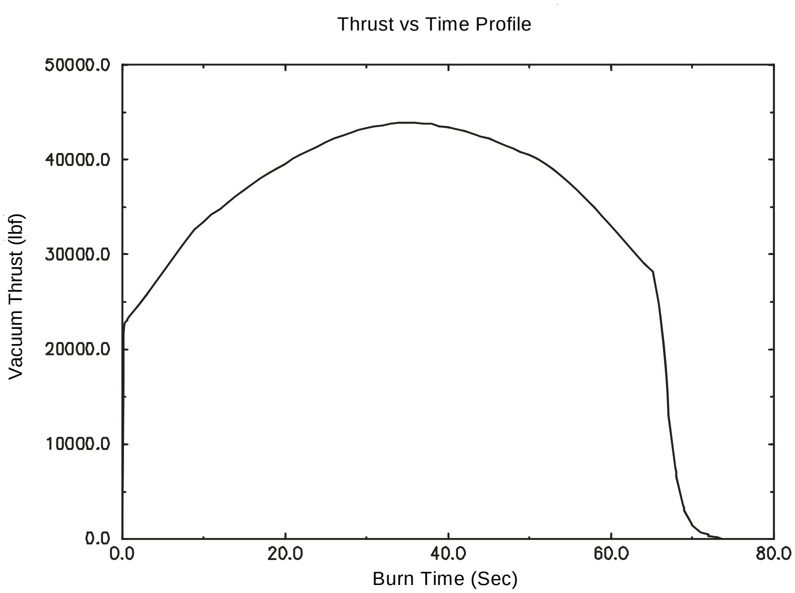
Current production focused on XL length

*Pegasus and Taurus standard second stage

ORION 50 XL (50 XLT)

AIR-IGNITED, VECTORABLE NOZZLE

A flight-proven, extended-length version is also available. The Orion 50 XL is 18-in. longer and contains almost 2,000 lbm more propellant than the Orion 50. It flew on the 1995 STEP-3 mission as the second stage of the Pegasus XL. Including that mission, the Orion 50 XL has now flown on 25 Pegasus XL missions. It has also flown twice as the third-stage motor for the Air Force's Minotaur launch vehicle as part of the Orbital/Suborbital Program, and as the second stage on the Taurus Lite vehicle. In addition, a nearly identical version with heavier skirts, the Orion 50 XLT, launched in May 2004 as a second-stage motor on the enhanced Taurus XL launch vehicle.



MOTOR DIMENSIONS

Motor diameter, in. 50
Motor length, in. 122

MOTOR PERFORMANCE (60°F NOMINAL)

Burn time, sec 69.7
Average chamber pressure, psia 991
Total impulse, lbf-sec 2,518,000
Burn time average thrust, lbf 36,096

NOZZLE

Housing material .....Aluminum
Exit diameter, in. 33.862
Expansion ratio, average 43.5

WEIGHTS, LBM

Total loaded 9,520
Propellant 8,650
Case 551
Nozzle 240
Other 79
Burnout 824

TEMPERATURE LIMITS

Operation .... 50°-100°F (36°-100°F for Taurus XL)

PROPELLANT DESIGNATION

.....QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

.....Flight-proven, production

*Pegasus Xl second stage, Minotaur third stage

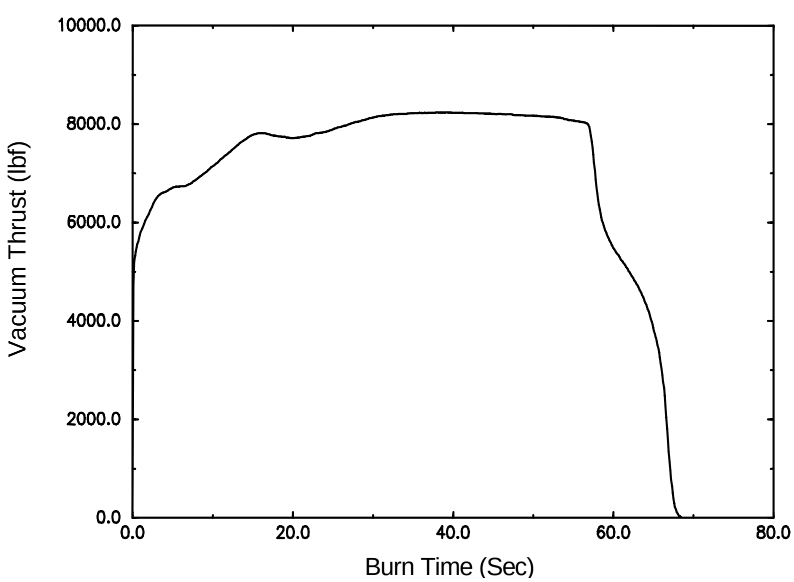
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

ORION 38

AIR-IGNITED, VECTORABLE NOZZLE
UPPER-STAGE BOOSTER

The Orion 38 was developed as a low-cost, high-performance third stage for the Pegasus launch vehicle, and incorporates a ± 5-deg vectorable nozzle. It also functions as the standard third-stage motor for other launch vehicles such as the Pegasus XL, Taurus, Taurus XL, and Taurus Lite launch vehicles; and as the fourth stage of the Air Force's Minotaur vehicle. This motor has performed successfully in 44 flights in over a decade of use.

Thrust vs Time Profile



MOTOR DIMENSIONS

Motor diameter, in. 38
Motor length, in. 53

MOTOR PERFORMANCE (70°F NOMINAL)

Burn time, sec 67.7
Average chamber pressure, psia 572
Total impulse, lbf-sec 491,000
Burn time average thrust, lbf 7,246

NOZZLE

Housing material ....Aluminum
Exit diameter, in. 20.72
Expansion ratio, average 49.3

WEIGHTS, LBM

Total loaded 1,966
Propellant 1,699
Case 133
Nozzle 91
Other 46
Burnout 243

TEMPERATURE LIMITS

Operation ....50°-100°F

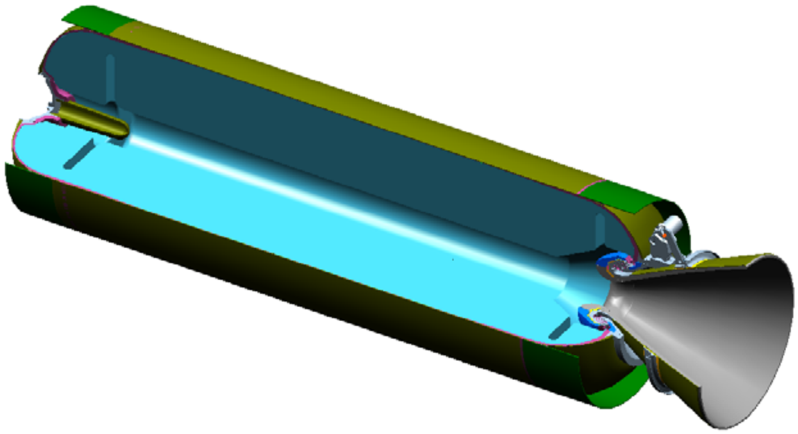
PROPELLANT DESIGNATION

....QDL-1, HTPB polymer, 19% aluminum

PRODUCTION STATUS

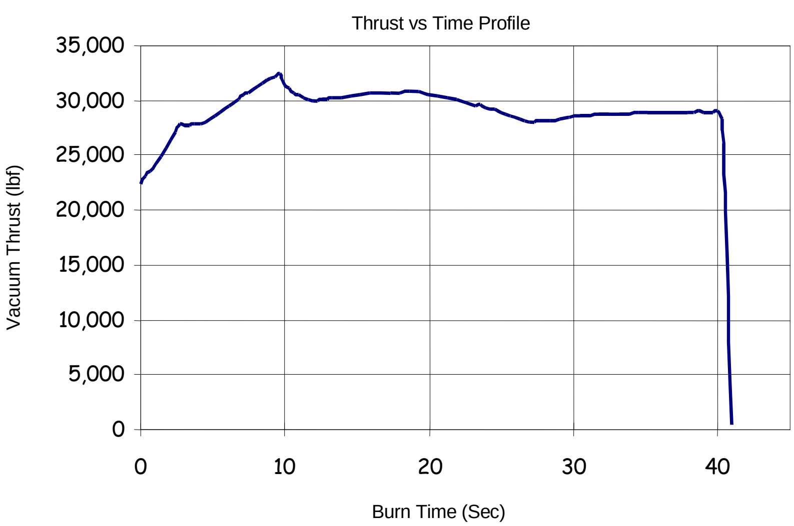
....Flight-proven, production

ORION 32



VECTORABLE NOZZLE IN-LINE BOOSTER

The Orion 32 is a low-cost, high-performance derivative of an existing upper-stage motor. This development motor is 121 in. long and nominally designed as a second-stage motor. A longer version (up to 255 in.) for potential first stage application and a reduced length version (down to 70 in.) are also in design evaluation. This motor configuration has not flown; however, all components, except skirts, are flight-proven.



MOTOR DIMENSIONS

Motor diameter, in.	32
Motor length, in.	121

MOTOR PERFORMANCE (70°F NOMINAL)

Burn time, sec	41
Average chamber pressure, psia	660
Total impulse, lbf-sec	1,186,000
Burn time average thrust, lbf	28,800

NOZZLE

Housing material	Aluminum
Exit diameter, in.	24.9
Expansion ratio, average	23

WEIGHTS, LBM

Total loaded	4,721
Propellant	4,280
Case	217
Nozzle IgniterTVA	1251534
Other	49
Burnout	418

TEMPERATURE LIMITS

Operation	20°-100°F

PROPELLANT DESIGNATION

.....................QDL-2, HTPB polymer, 20% aluminum

PRODUCTION STATUS .... In design

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

CASTOR® MOTOR SERIES

LOW-COST, HIGH-RELIABILITY BOOSTERS

The CASTOR motor family was originally developed in the mid to late 1950s to support the NASA Scout and Little Joe vehicles. In 1969, the CASTOR IV was developed to provide first-stage propulsion for the Athena H and was later adapted as a strap-on booster for Delta II. The CASTOR IVA, IVA-XL, and IVB have since replaced the CASTOR IV motor.

ATK currently manufactures a complete line of first- and second-stage and strap-on solid rocket motors. The CASTOR I-IV family has a combined total of over 1,900 flights and a demonstrated reliability of 99.95%.

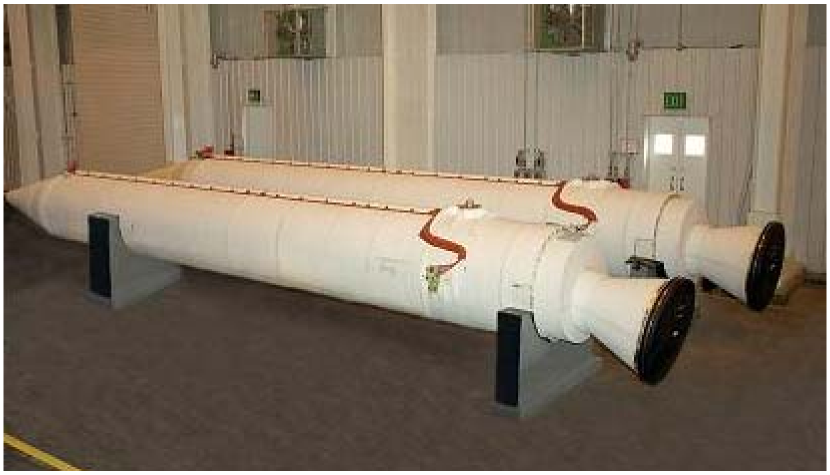
Over 50% of the U.S. space launches carry commercial satellites, and these motors, listed below, are designed to provide low-cost, high-reliability access to space.

- CASTOR IVA, high-performance strap-on propulsion launch vehicles
- CASTOR IVA-XL, 8-foot extended length version with 30% greater launch capability
- CASTOR IVB, TVC version with first stage, second stage, or strap-on booster application

ATK used the base technology from four generations of first-stage ballistic missile boosters and the technology and experience from the CASTOR series as a starting point for the CASTOR motor.

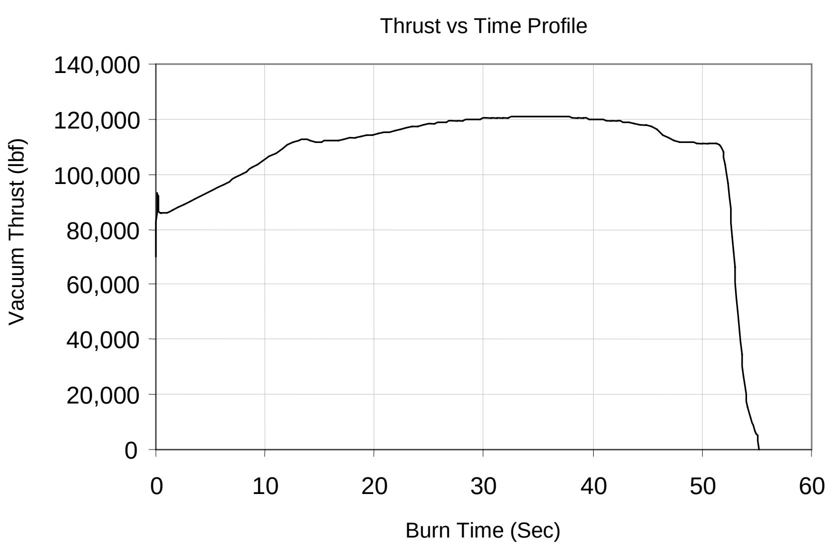
Development of the CASTOR 120 motor began in 1989. The CASTOR 120 was designed, using proven technology, to meet the need for a medium-sized, reliable, solid rocket booster. The primary goals of the program were to achieve a >0.999 reliability rating and a 50% cost reduction. CASTOR 120 motors serve as stage one of the Lockheed Martin Athena I and stages one and two on Athena II. Orbital Sciences' Taurus vehicle uses it as an initial-stage (Stage 0) booster. The motor has flown as the primary booster for the Athena II Lunar Prospector mission, the Taurus Orbview mission, and the Athena I NASA Starshine, among others.

CASTOR IVA



FIXED NOZZLE

Under NASA, the CASTOR IVA motor was first developed in the early 1980s. By switching to HTPB propellant, NASA was able to improve Delta II performance by 11%. Development and qualification motors were fired in 1983. Three additional qualification tests were conducted. Each Delta vehicle carried nine CASTOR IVA strap-on motors until 1993. The straight nozzle version powered Orbital Sciences' Prospector suborbital vehicle and two motors flew on the Conestoga in October 1995. CASTOR IVA motors have flown on the Lockheed Martin Atlas IIAS since it first flew in 1993. The four strap-on boosters on the Atlas IIAS increase payload capacity by 1,500 lb. Two boosters are ground lit at ignition and two are air lit. The motors are jettisoned from the vehicle after burnout.



MOTOR DIMENSIONS

Motor diameter, in. 40.10
Motor length, in. 363.4

MOTOR PERFORMANCE (73°F VACUUM)

Burn time, sec 55.2
Average chamber pressure, psia..........................704
Total impulse, lbf-sec.................................5,967,688
Web time average thrust, lbf.........................112,019

NOZZLE

Housing material ....4130 steel
Exit diameter, in. 32.15
Expansion ratio, average 8.3

WEIGHTS, LBM

Total loaded 25,737
Propellant...22,286
Case 1,880
Nozzle 510
Other...1,061
Burnout 3,239

TEMPERATURE LIMITS

Operation ....+30°-100°F

PROPELLANT DESIGNATION

................TP-H8299, HTPB polymer, 20% aluminum

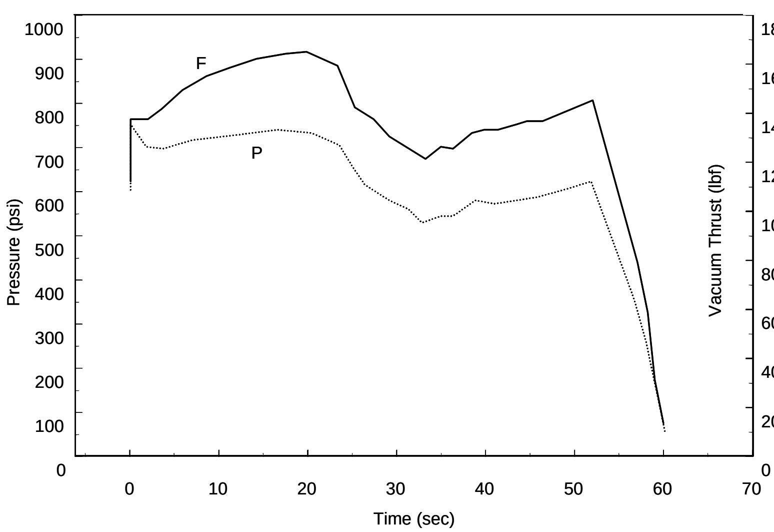
PRODUCTION STATUS ....Flight proven

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

CASTOR IVA-XL

FIXED NOZZLE

The CASTOR IVA-XL motor, an 8-foot extension of the CASTOR IVA motor, was first tested in 1992. Successful qualification tests followed in 1992 and 1993. A more recent demonstration motor test was conducted in 1999. The Japanese H-IIA launch vehicle uses modified CASTOR IVA-XL motors with 6-degree canted nozzles as their solid strap-on boosters (SSB). The H-IIA can use two or four SSBs depending on mission requirements and vehicle configuration. The first CASTOR IVA-XL SSB motors flew on the H-IIA vehicles in 2002.



MOTOR DIMENSIONS

Motor diameter, in. 40.10
Motor length, in. 457.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec 59.4
Average chamber pressure, psia 612
Total impulse, lbf-sec 8,148,000
Web time average thrust, lbf 137,120

NOZZLE

Housing material .... 4130 steel
Exit diameter, in. 48.3
Expansion ratio, average 15.6

WEIGHTS, LBM

Total loaded 33,031
Propellant 28,906
Case 2,505
Nozzle 644
Other 976
Burnout 3,653

TEMPERATURE LIMITS

Operation .... +30°-100°F

PROPELLANT DESIGNATION

.... TP-H8299, HTPB polymer, 20% aluminum

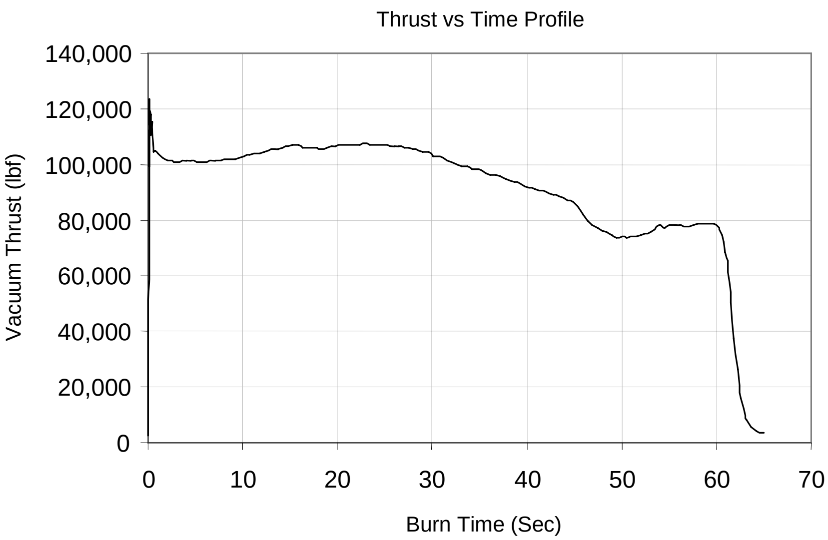
PRODUCTION STATUS .... Flight proven

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

CASTOR IVB

FIXED NOZZLE IN LINE BOOSTER

The CASTOR IVB motor was the first in the series of CASTOR IVA motors to incorporate TVC and a regressive thrust-time trace for aerodynamic pressure considerations. It was developed for the European Space Agency's MAXUS sounding rockets and first flew in 1991. CASTOR IVB motors have provided first-stage boost on all MAXUS flights. CASTOR IVB motors have served as first-stage motors for three U.S. Army's Theater Critical Measurement Program launches in 1996 and 1997; for U.S. Air Force's ait-2 (launched from Kodiak, Alaska in 1999); for Spain's Capricornio in 1997; and served as first and second stages for the Conestoga launch vehicle in 1995.



MOTOR DIMENSIONS

Motor diameter, in. 40.10
Motor length, in. 353.7

MOTOR PERFORMANCE (73°F VACUUM)

Burn time, sec 65.0
Average chamber pressure, psia 459
Total impulse, lbf-sec 5,876,710
Web time average thrust, lbf 95,162

NOZZLE

Housing material .... 4130 steel
Exit diameter, in. 35.52
Expansion ratio, average 8.0

WEIGHTS, LBM

Total loaded 25,441
Propellant 21,990
Case 1,644
Nozzle 709
Other 1,098
Burnout 3,254

TEMPERATURE LIMITS

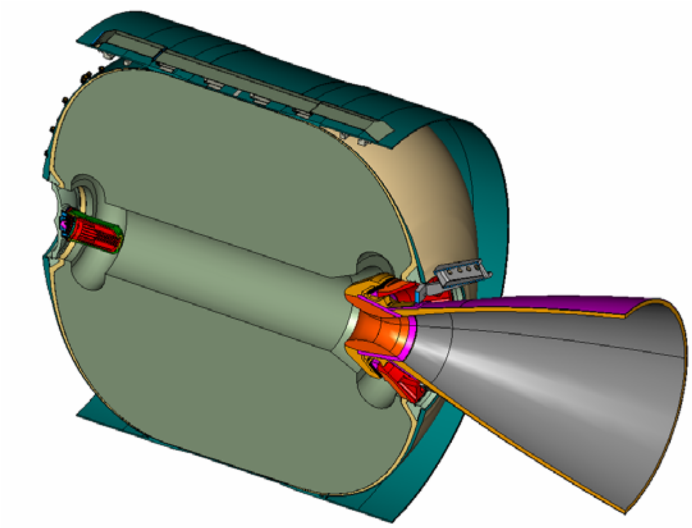
Operation .... +30°-100°F

PROPELLANT DESIGNATION

.... TP-H8299, HTPB polymer, 20% aluminum

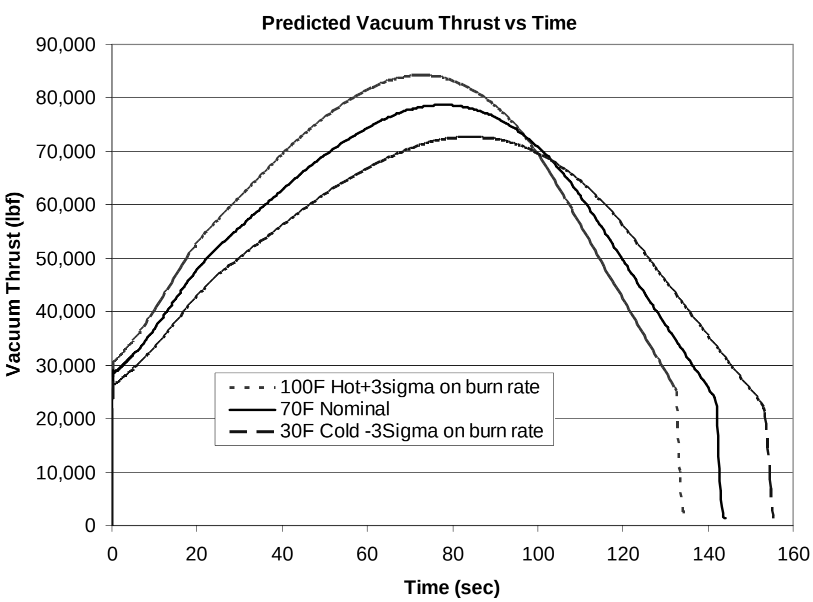
PRODUCTION STATUS .... Flight proven

CASTOR 30



VECTORABLE NOZZLE IN-LINE UPPER STAGE BOOSTER

The CASTOR 30 is a low cost, robust, state-of-the-art upper stage motor. This development motor is 138 in. long and nominally designed as an upper stage that can function as a second or third stage depending on the vehicle configuration. The design of the CASTOR 30 uses all flight proven technology and materials.



MOTOR DIMENSIONS

Motor diameter, in.	92
Motor length, in.	138

MOTOR PERFORMANCE (73°F VACUUM)

Burn time, sec	143
Average chamber pressure, psia	762
Total impulse, lbf-sec	8.34M
Web time average thrust, lbf	58,200

NOZZLE

Housing material	Aluminum
Exit diameter, in.	47.5
Expansion ratio, average	50

WEIGHTS, LBM

Total loaded	30,998
Propellant	28,300
Case	899
Nozzle/Igniter/TVA	748
Other	1,051

TEMPERATURE LIMITS

Operation	+30°-100°F

PROPELLANT DESIGNATION

.... Modified TP-H8299, HTPB polymer, ... 20% aluminum

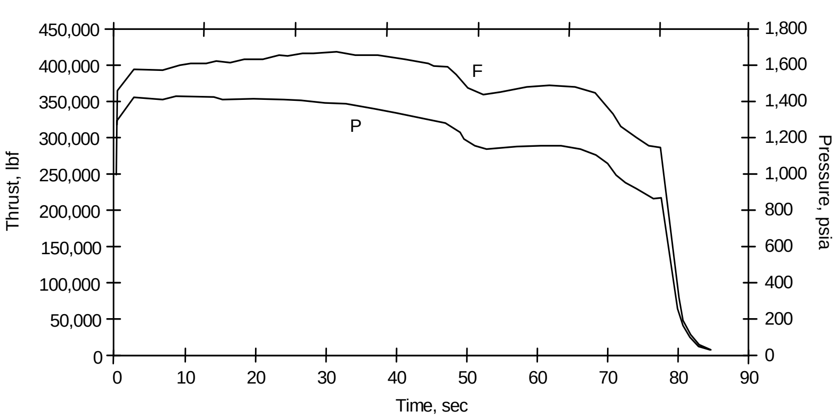
PRODUCTION STATUS .... In-design

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

CASTOR 120

VECTORABLE NOZZLE

The CASTOR 120 was designed, using proven technology, to meet the need for a medium-sized, reliable, solid rocket booster. The CASTOR 120 motor can also be configured as a strap-on booster with a moveable nozzle and a cold gas blowdown system TVC. The TVC system can be removed and the nozzle fixed. The grain can be tailored to reduce thrust during max-Q pressure for high initial thrust or for a regressive thrust to reduce acceleration.



MOTOR DIMENSIONS

Motor diameter, in.	93.0
Motor length, in.	302

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec	79.5
Average chamber pressure, psia	1,246
Total impulse, lbf-sec	30,140,000
Burn time average thrust, lbf	379,000

NOZZLE

Housing material	Carbon phenolic
Exit diameter, in.	59.7
Expansion ratio, average	16.3

WEIGHTS, LBM

Total loaded	117,014
Propellant	108,038
Case	3,329
Nozzle	1,939
Other	3,708
Burnout	8,690

TEMPERATURE LIMITS

Operation	+30°-100°F

PROPELLANT DESIGNATION TP-H1246

PRODUCTION STATUS

.... Flight proven, production

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

GEM MOTOR SERIES

THE MOST RELIABLE, LOWEST COST BOOSTERS

ATK developed the GEM for the Delta II launch vehicle for the U.S. Air Force and Boeing. GEM-40 boosters increased the launch capability of the Delta II. GEMs have demonstrated through qualification and flight that they are the most reliable, lowest cost boosters available.

The GEM-46 is a larger derivative of the highly reliable GEM-40 designed for use on the Delta III. The second generation GEM motor has increased length, diameter, and vectorable nozzles on three of the six ground-start motors. More recently, the motor has also been used on the Delta II Heavy.

More recently, the GEM-60 motors were developed for the Delta IV Evolved Expendable Launch Vehicle. This third generation 70-foot GEM motor provides auxiliary lift-off capability for the Delta IV Medium-Plus (M+) vehicle.

State-of-the-art automation, robotics, and process controls are used to produce GEMs. Cases are filament wound by computer-controlled winding machines using high-strength graphite fiber and durable epoxy resin. ATK is the largest producer of filament wound rocket motors in the world. Critical processes (e.g., case bond application, propellant mixing, motor casting) are performed using an extensive network of computerized and robotic facilities ensuring accurate control of manufacturing. The delivered products are consistent, reliable, repeatable, high quality, competitively priced, and delivered on time.

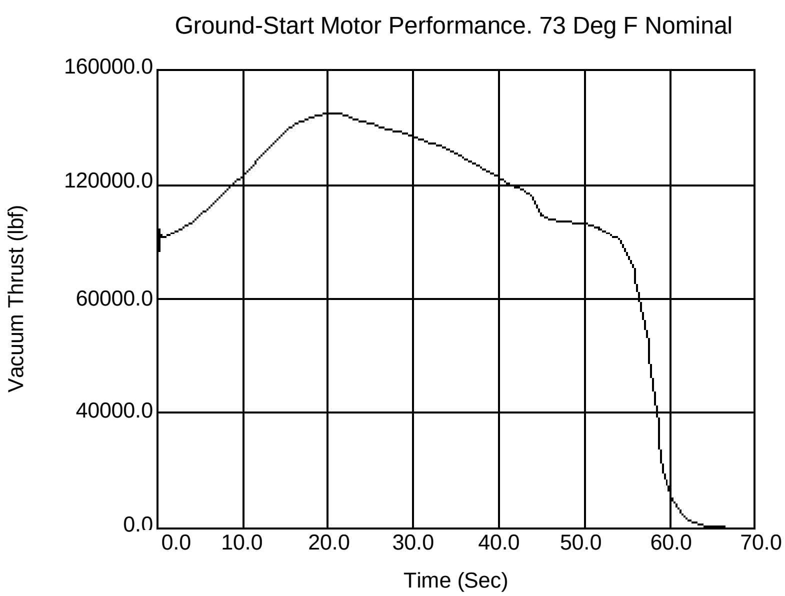
The GEM family of motors includes:

- GEM-40, Delta II Boosters
- GEM-46, Delta III Boosters
- GEM-60, Delta IV Boosters

GEM-40

FIXED NOZZLE, GROUND-IGNITED

The GEM-40 is a strap-on booster system that was developed to increase the payload-to-orbit capability of the Delta II launch vehicle. GEM-40 has flown on Delta II vehicles since 1991. The motors can be flown in different configurations depending on the payload requirements; for example, the Delta vehicle may require three, four, or nine strap-on motors. Motors are ground-ignited when the three- or four-motor configuration is used. A nine-motor configuration ignites six motors on the ground and three in the air. The GEM-40 features a graphite epoxy case and a 10-deg canted, fixed nozzle assembly. The GEM-40 motor is available for ground- and air-ignition (with extended length nozzle) for strap-on or in-line booster configurations.



MOTOR DIMENSIONS

Motor diameter, in.	40
Motor length, in.	435

MOTOR PERFORMANCE (70°F NOMINAL)

Burn time, sec	63.3
Average chamber pressure, psia	818
Total impulse, lbf-sec	7,107,800
Burn time average thrust, lbf	112,200

NOZZLE

Housing material	4130 steel
Exit diameter, in.	32.17
Expansion ratio, average	10.6

WEIGHTS, LBM

Total loaded	28,671
Propellant	25,942
Case	1,602
Nozzle	559
Other	568
Burnout	2,469

TEMPERATURE LIMITS

Operation	30°-100°F

PROPELLANT DESIGNATION

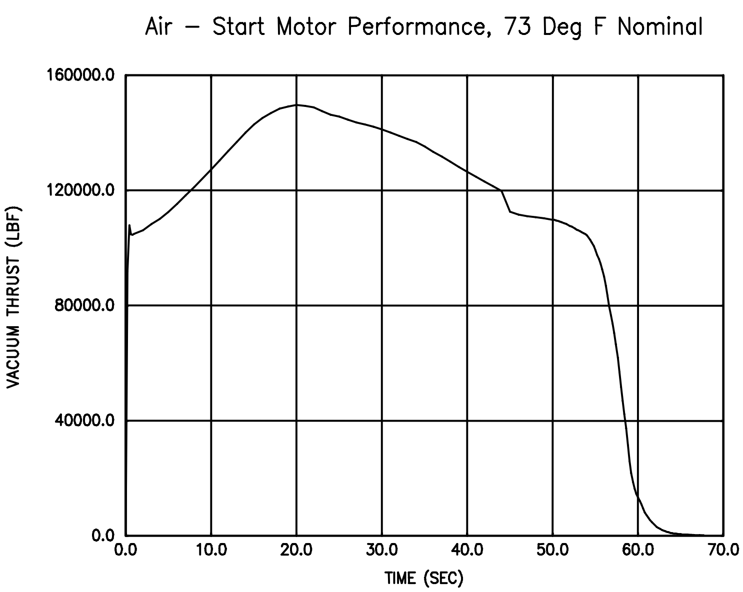
....QDL-1, 88% solids HTPB

PRODUCTION STATUS..................... Production

GEM-40

FIXED NOZZLE, AIR-IGNITED

The GEM-40 is a strap-on booster system that was developed to increase the payload-to-orbit capability of the Delta II launch vehicle. GEM-40 has flown on Delta II vehicles since 1991. The motors can be flown in different configurations depending on the payload requirements; for example, the Delta vehicle may require three, four, or nine strap-on motors. Motors are ground-ignited when the three- or four-motor configuration is used. A nine-motor configuration ignites six motors on the ground and three in the air. The GEM-40 features a graphite epoxy case and a 10-deg canted, fixed nozzle assembly. The GEM-40 motor is available for ground- and air-ignition (with extended length nozzle) for strap-on or in-line booster configurations.



MOTOR DIMENSIONS

Motor diameter, in. 40
Motor length, in. 449.1

MOTOR PERFORMANCE (73°F NOMINAL)

Burn time, sec...63.3
Average chamber pressure, psia..........................818
Total impulse, lbf-sec.................................7,351,000
Burn time average thrust, lbf.........................116,050

NOZZLE

Housing material.......................................4130 steel
Exit diameter, in. 39.80
Expansion ratio, average....................................16.3

WEIGHTS, LBM

Total loaded..28,950
Propellant 25,960
Case 1,521
Nozzle 689
Other...780
Burnout 2,649

TEMPERATURE LIMITS

Operation ....30°-100°F

PROPELLANT DESIGNATION

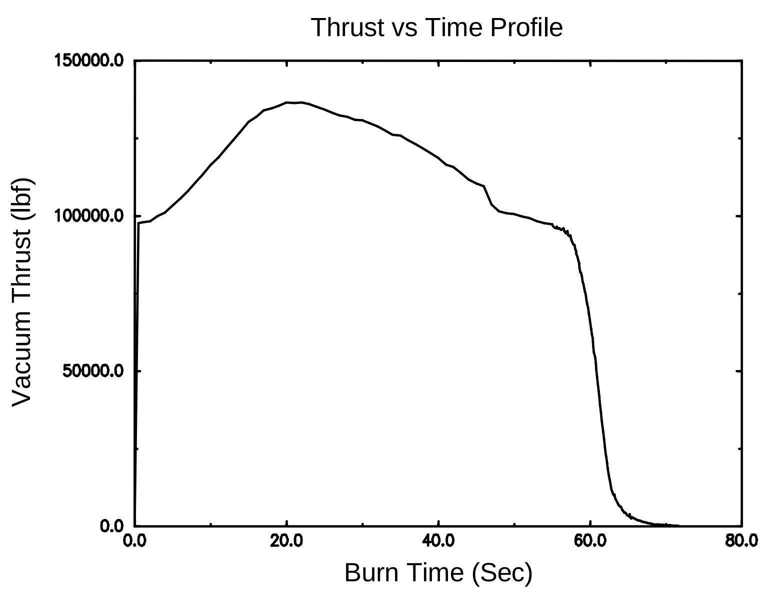
....QDL-1, 88% solids HTPB

PRODUCTION STATUS..................... Production

GEM-40 VN

VECTORABLE NOZZLE, GROUND-IGNITED,
IN-LINE MOTOR

The GEM-40 VN booster is derived from the successful GEM-40 booster. GEM-40 VN maintains the same loaded motor configuration as the current GEM-40 with a design modification to the nozzle assembly to provide 6-deg thrust-vector capability. Air-ignition with extended length nozzle can readily be provided. GEM-40 VN can be used in both in-line and strap-on booster applications. A version of this motor has been developed and qualified for use on the BV/BV+ (Boost Vehicle/Boost Vehicle Plus) configuration for the GMD missile interceptor program.



MOTOR DIMENSIONS

Motor diameter, in. 40
Motor length, in. 425.1

MOTOR PERFORMANCE (70°F NOMINAL)

Burn time, sec 64.6
Average chamber pressure, psia 795
Total impulse, lbf-sec 6,950,000
Burn time average thrust, lbf 107,625

NOZZLE

Housing material .... 4340 steel
Exit diameter, in. 32.3
Expansion ratio, average 9.0

WEIGHTS, LBM

Total loaded 28,886
Propellant 25,960
Case 1,516
Nozzle 934
Other 236
Burnout 2,607

TEMPERATURE LIMITS

Operation .... 55°-65°F

PROPELLANT DESIGNATION

.... QDL-1, 88% solids HTPB

PRODUCTION STATUS .... Flight proven

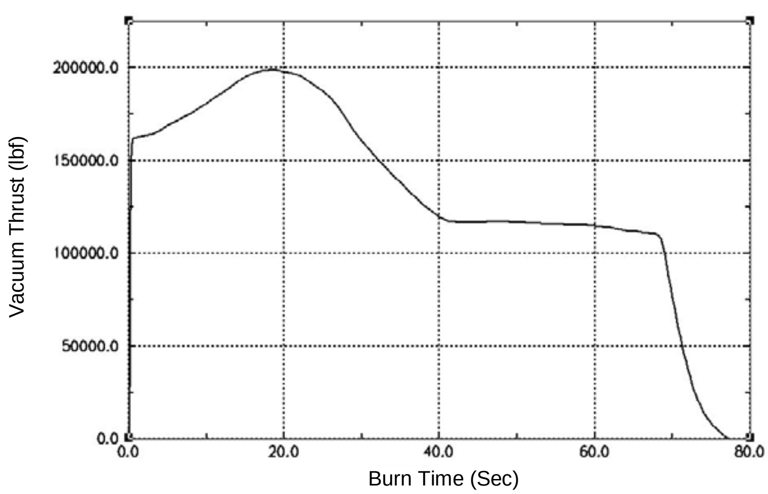
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

GEM-46

FIXED NOZZLE, GROUND-IGNITED

The 46-in.-diameter GEM motor is a strap-on booster system developed to increase the payload-to-orbit capability of the Delta launch vehicles. GEM-46 motors have lofted the Delta II Heavy and the Delta III launch vehicles. On the Delta II Heavy vehicle configuration, nine fixed-nozzle GEM-46 motors are strapped onto the core vehicle: six are ground-ignited and three air-ignited. Nine GEM-46 strap on motors are also used on the Delta III vehicle. The motor configuration for the Delta III includes three fixed-nozzle ground-ignited motors, three vectorable-nozzle ground-ignited motors, and three fixed-nozzle air-ignited motors. The GEM-46 features a graphite-epoxy motor case and a moveable nozzle assembly with a ±5-deg cant.

Thrust vs Time Profile



MOTOR DIMENSIONS

Motor diameter, in. 46
Motor length, in. 495.1

MOTOR PERFORMANCE (73°F NOMINAL)

Burn time, sec 75.9
Average chamber pressure, psia 955
Total impulse, lbf-sec 10,425,000
Burn time average thrust, lbf 137,300

NOZZLE

Housing material .... 4340 steel
Exit diameter, in. 39.93
Expansion ratio, average 13.8

WEIGHTS, LBM

Total loaded 41,590
Propellant 37,180
Case 2,636
Nozzle 903
Other 871
Burnout 4,050

TEMPERATURE LIMITS

Operation .... 30°-100°F

PROPELLANT DESIGNATION

.... QEM, 87% solids HTPB

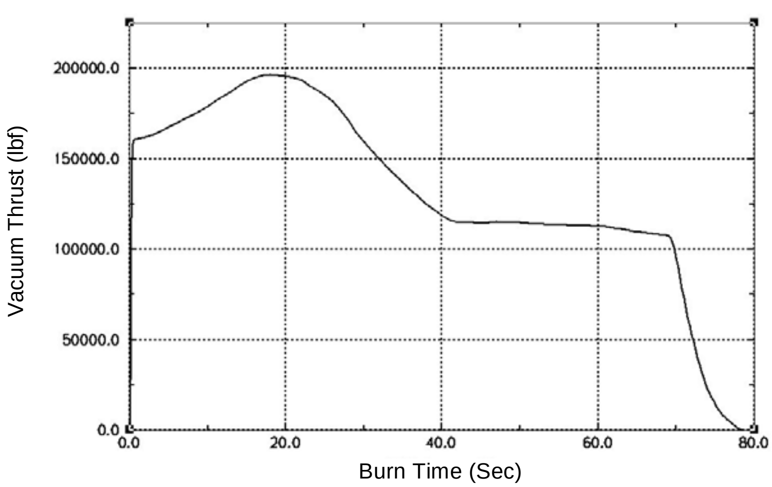
PRODUCTION STATUS .... Production

GEM-46

VECTORABLE NOZZLE, GROUND-IGNITED

The 46-in.-diameter GEM motor is a strap-on booster system developed to increase the payload-to-orbit capability of the Delta launch vehicles. GEM-46 motors have lofted the Delta II Heavy and the Delta III launch vehicles. On the Delta II Heavy vehicle configuration, nine fixed-nozzle GEM-46 motors are strapped onto the core vehicle: six are ground-ignited and three air-ignited. Nine GEM-46 strap on motors are also used on the Delta III vehicle. The motor configuration for the Delta III includes three fixed-nozzle ground-ignited motors, three vectorable-nozzle ground-ignited motors, and three fixed-nozzle air-ignited motors. The GEM-46 features a graphite-epoxy motor case and a moveable nozzle assembly with a ±5-deg cant.

Thrust vs Time Profile



MOTOR DIMENSIONS

Motor diameter, in.	46
Motor length, in.	493.9

MOTOR PERFORMANCE (73°F NOMINAL)

Burn time, sec	76.9
Average chamber pressure, psia	915
Total impulse, lbf-sec	10,400,000
Burn time average thrust, lbf	135,200

NOZZLE

Housing material	4340 steel
Exit diameter, in.	36.93
Expansion ratio, average	13.8

WEIGHTS, LBM

Total loaded	42,196
Propellant	37,180
Case	2,636
Nozzle	1,264
Other	2,380
Burnout	4,656

TEMPERATURE LIMITS

Operation	30°-100°F

PROPELLANT DESIGNATION

.... QEM, 87% solids HTPB

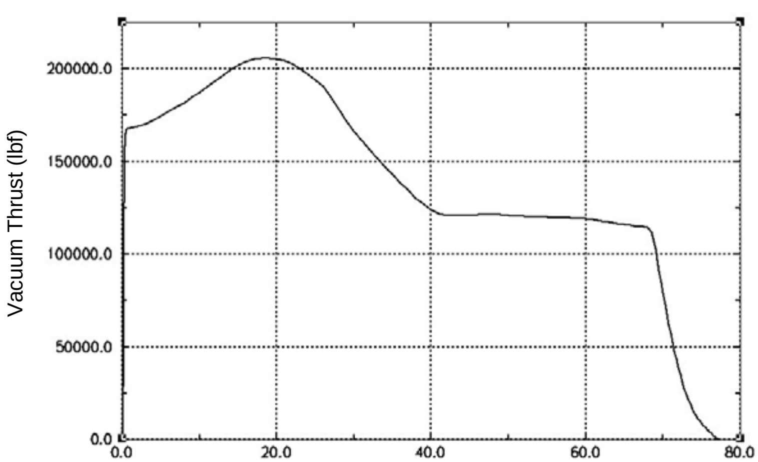
PRODUCTION STATUS..................... Production

GEM-46

FIXED NOZZLE, AIR-IGNITED

The 46-in.-diameter GEM motor is a strap-on booster system developed to increase the payload-to-orbit capability of the Delta launch vehicles. GEM-46 motors have lofted the Delta II Heavy and the Delta III launch vehicles. On the Delta II Heavy vehicle configuration, nine fixed-nozzle GEM-46 motors are strapped onto the core vehicle: six are ground-ignited and three air-ignited. Nine GEM-46 strap on motors are also used on the Delta III vehicle. The motor configuration for the Delta III includes three fixed-nozzle ground-ignited motors, three vectorable-nozzle ground-ignited motors, and three fixed-nozzle air-ignited motors. The GEM-46 features a graphite-epoxy motor case and a moveable nozzle assembly with a ±5-deg cant.

Thrust vs Time Profile



Burn Time (Sec)

MOTOR DIMENSIONS

Motor diameter, in.	46
Motor length, in.	511.2

MOTOR PERFORMANCE (73°F NOMINAL)

Burn time, sec	75.9
Average chamber pressure, psia	955
Total impulse, lbf-sec	10,803,000
Burn time average thrust, lbf	142,300

NOZZLE

Housing material	4340 steel
Exit diameter, in.	49.25
Expansion ratio, average	24.6

WEIGHTS, LBM

Total loaded	42,039
Propellant	37,180
Case	2,636
Nozzle	1,268
Other	955
Burnout	4,397

TEMPERATURE LIMITS

Operation	30°-100°F

PROPELLANT DESIGNATION

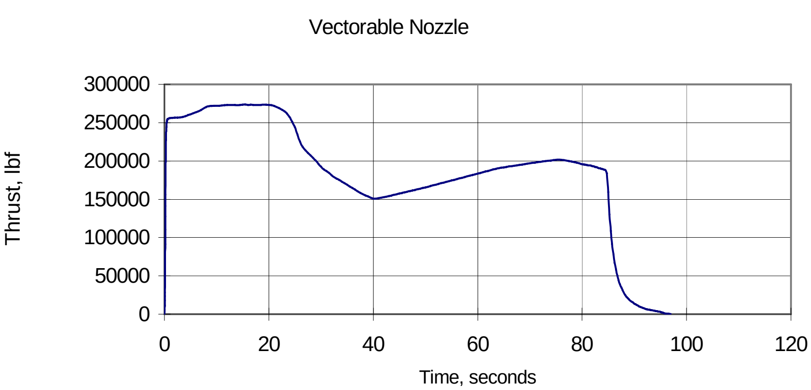
.... QEM, 87% solids HTPB

PRODUCTION STATUS .... Production

GEM-60

VECTORABLE NOZZLE

The 60-in.-diameter GEM motor is a strap-on booster system developed to increase the payload-to-orbit capability of the Delta IV M+ launch vehicles. Two and four strap-on motor configurations of the GEM-60 can be flown on the Delta IV M+ vehicles. The motor features a ± 5 deg canted, moveable nozzle assembly. This motor is a third-generation GEM with both fixed and vectorable nozzle configurations. The Delta IV launch vehicle family's inaugural flight occurred in November 2002 and was the first flight of the Air Force's Evolved Expendable Launch Vehicle Program.



MOTOR DIMENSIONS

Motor diameter, in. 60
Motor length, in. 518

MOTOR PERFORMANCE (73°F NOMINAL)

Burn time, sec 90.8
Average chamber pressure, psia 818
Total impulse, lbf-sec 17,950,000
Burn time average thrust, lbf 197,539

NOZZLE

Housing material .... 4340 steel
Exit diameter, in. 43.12
Expansion ratio, average 11.0

WEIGHTS, LBM

Total loaded 74,158
Propellant 65,471
Case 3,578
Nozzle 2,187
Other 2,922
Burnout 8,346

TEMPERATURE LIMITS

Operation ....30°-100°F

PROPELLANT DESIGNATION

.... QEY, 87% solids HTPB

PRODUCTION STATUS .... Production

SOLID ROCKET MOTOR UPGRADE (SRMU)

The SRMU was developed for the U.S. Air Force and Lockheed Martin to increase the launch capability of the new Titan IVB Space Launch Vehicle. This vehicle supplies access to space for critical national security as well as for civil payloads and can be launched from the East and West Coasts. SRMU motor segments are manufactured using state-of-the-art automation, robotics, and process controls for a consistent, reliable, high-quality product.

The SRMU increases the launch capability of the new Titan IVB Space Launch Vehicle. Designed to take advantage of proven, off-the-shelf technologies, the SRMU system provides 25% increased performance and heavier lift capability than the boosters used on earlier configurations.

The SRMU is a three-segment, 10.5-ft-diameter solid rocket motor. A flight set consists of two SRMUs. When fully assembled, each SRMU is approximately 112 ft tall and weighs over 770,000 lb. With the SRMU, the Titan IVB low-earth-orbit payload exceeds 47,000 lb and its geosynchronous orbit payload capability ranges up to 12,700 lb.

SRMU motor segments are manufactured using state-of-the-art automation, robotics, and process controls. Cases are filament wound with computer-controlled winding machines using a composite of high-strength fiber and durable epoxy resin. SRMUs are then cast and finished using an extensive network of computers and robotics, which enables highly accurate control of critical manufacturing processes for a consistent, reliable, high-quality product.

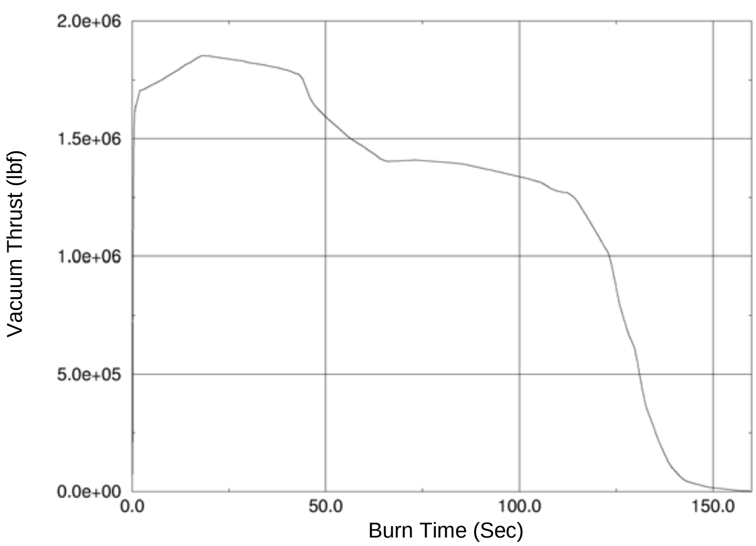
In 1997, Titan IVB launched the Cassini spacecraft and the Huygens Probe on an international mission to study Saturn. Weighing roughly 13,000 lb, the Cassini spacecraft is one of the largest ever launched. The spacecraft entered Saturn's orbit on July 1, 2004.

SRMU

STRAP-ON BOOSTER/SEGMENT

With the solid rocket motor upgrade (SRMU), the Titan IVB low-earth-orbit payload exceeds 47,800 lb and its geosynchronous orbit payload capability ranges up to 12,700 lb (east coast launch), and the low-earth polar orbit capability ranges up to 38,000 lb (west coast launch). The SRMU successfully flew its first mission in 1997 with subsequent missions flown for the Air Force's Milstar and Defense Support Program satellites, the National Reconnaissance Organization's military intelligence satellites, and NASA's Cassini satellite, etc. The SRMU is a three-segment solid rocket motor, manufactured in segments, shipped to the launch site, and stacked at the site.

Thrust vs Time Profile



MOTOR DIMENSIONS

Motor diameter, in.	126
Motor length, in.	1,349

MOTOR PERFORMANCE (70°F NOMINAL)

Burn time, sec	135.7
Average chamber pressure, psia	859.5
Total impulse, lbf-sec	195,476,128
Burn time average thrust, lbf	1,440,502

NOZZLE

Housing material	4340 steel with graphite epoxy overwrap
Exit diameter, in.	128.6
Expansion ratio, average	15.7

WEIGHTS, LBM

Total loaded	776, 038
Propellant	695,427
Case	35,075
Nozzle	14,706
Other	30,830
Burnout	80,611

TEMPERATURE LIMITS

Operation	25°-100°F

PROPELLANT DESIGNATION

QDT, 88% solids HTPB

PRODUCTION STATUS .... Production

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

REUSABLE SOLID ROCKET MOTOR (RSRM)

In 1974, NASA chose ATK to design and build the solid rocket motors that would boost the fleet of orbiters from the launch pad to the edge of space. With the maiden flight of *Columbia* (STS-1) in 1981, a new era in space exploration had begun.

The RSRM is the largest solid rocket motor ever to fly and the only solid rocket motor rated for human flight. It was the first booster designed for reuse; reusability of the RSRM case is one of the most important cost-saving factors in the nation's space program. The boosters provide 80% of the thrust needed to launch NASA's Space Shuttle. Each RSRM consists of four solid propulsion segments, TVC and an aft exit cone assembly. After burnout at about 2 min, the boosters are separated pyrotechnically and fall into the Atlantic for recovery. The motors are cleaned, disassembled and returned to Utah for refurbishment and reloading. Motor segments are designed for reuse on up to 20 flights. The RSRMs were also designed to be used as strap-on boosters for other heavy-lift launch vehicle applications.

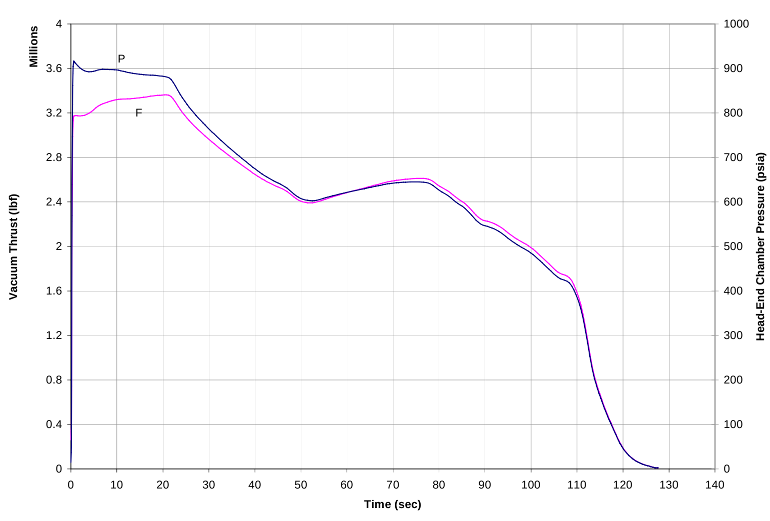
RSRM

NASA SPACE SHUTTLE MOTOR

Each motor is just over 126-ft long and 12-ft in diameter. The entire booster (including nose cap, frustum, and forward and aft skirts) is approximately 149-ft long. Of the motor's total weight of 1,252,000 lb, propellant accounts for 1,107,000 lb.

Each launch requires the boost of two RSRMs. From ignition to end of burn, each RSRM generates an average thrust of 2,600,000 lb and burns for approximately 123.6 sec. By the time the twin RSRMs have completed their task, the Space Shuttle orbiter has reached an altitude of 24 nautical miles and is traveling at a speed in excess of 3,000 miles per hour.

Engineers direct approximately 110,000 quality control inspections on each RSRM flight set. RSRMs are also static tested as part of the quality assurance and development process.



MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 1,513.49

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec 122.2
Average chamber pressure, psia 620.1
Total impulse, lbf-sec 297,001,731
Web time average thrust, lbf 2,430,456

NOZZLE

Housing material D6AC
Exit diameter, in. 149.64
Expansion ratio, average 7.72

WEIGHTS, LBM

Total loaded 1,255,334
Propellant 1,106,059
Case 98,748
Nozzle 23,942
Other 26,585
Burnout 144,206

TEMPERATURE LIMITS

Operation .... +40º-90ºF

PROPELLANT DESIGNATION

.... TP-H1148, PBAN polymer, 86% solids

PRODUCTION STATUS

.... Flight proven, production

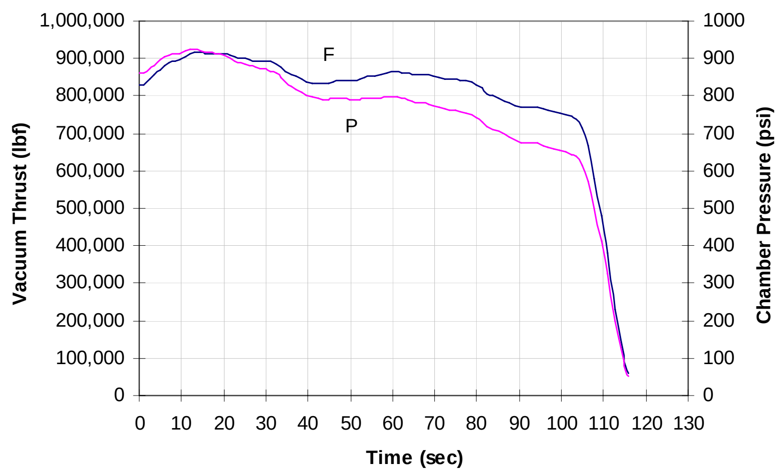
RSRM DERIVATIVES

VECTORABLE NOZZLE STRAP-ON BOOSTER

TRSRM derivative boosters have the demonstrated reliability of the human-rated Space Shuttle system. Examining recovered RSRM hardware and using RSRM program history allows for continuous reliability assessments of production hardware. Sustained RSRM production provides cost savings and a reliable, long-term source of derivative boosters. Finally, a complete family of booster stacks in increments as small as a quarter segment allows customized and efficient payload matching. These derivative motors can be used as a first-stage motor or a strap-on booster.

1 SEGMENT RSRM

FIXED/VECTORABLE NOZZLE



MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 499.6

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec..115.8
Average chamber pressure, psia......................750.8
Total impulse, lbf-sec..............................92,978,688
Burn time average thrust, lbf.........................802,989

NOZZLE

Housing material... D6AC
Exit diameter, in. 93.8
Expansion ratio, average.................................10.75
WEIGHTS, lbm ....
Total loaded 404,601
Propellant 336,231
Case 30,867
Nozzle 16,000
Other..21,503
Burnout 66,072

TEMPERATURE LIMITS

Operation ....+40º-90ºF

PROPELLANT DESIGNATION

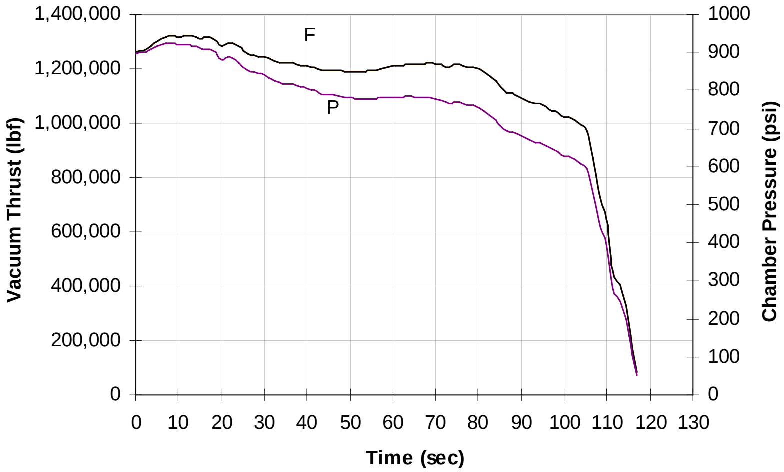
.... TP-H1148, PBAN polymer, 86% solids

PRODUCTION STATUS

.... Concept based on a production motor

1.5-SEGMENT RSRM

FIXED/VECTORABLE NOZZLE



MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 697.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec 117.0
Average chamber pressure, psia 741.6
Total impulse, lbf-sec 132,700,522
Burn time average thrust, lbf 1,134,183

NOZZLE

Housing material D6AC
Exit diameter, in. 113.3
Expansion ratio, average 11.8
WEIGHTS, lbm ....
Total loaded 558,993
Propellant 476,496
Case 41,666
Nozzle 16,000
Other 24,831
Burnout 79,286

TEMPERATURE LIMITS

Operation .... +40º-90ºF

PROPELLANT DESIGNATION

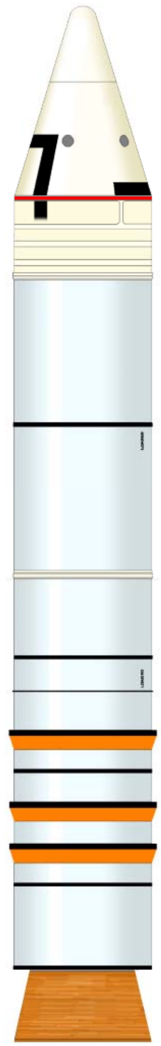
.... TP-H1148, PBAN polymer, 86% solids

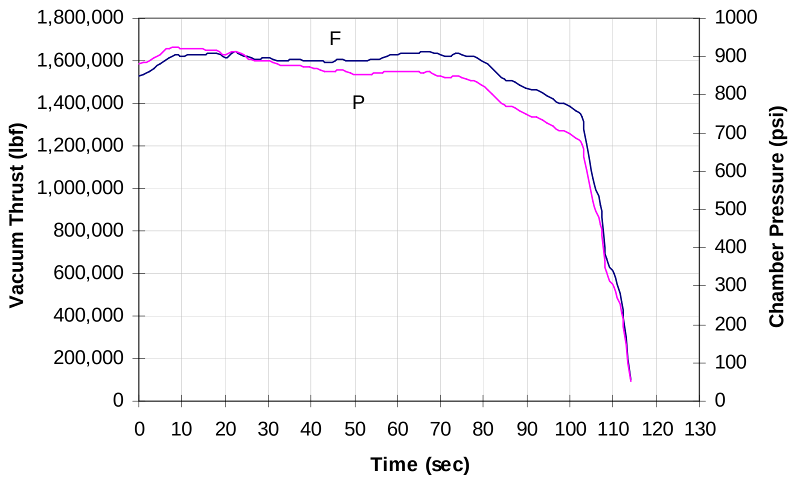
PRODUCTION STATUS

.... Concept based on a production motor

2-SEGMENT RSRM

FIXED/VECTORABLE NOZZLE





MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 860.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec...114.1
Average chamber pressure, psia......................798.7
Total impulse, lbf-sec............................170,800,701
Burn time average thrust, lbf......................1,497,451

NOZZLE

Housing material... D6AC
Exit diameter, in. 118.7
Expansion ratio, average...................................10.4
WEIGHTS, lbm ....
Total loaded 715,659
Propellant 619,003
Case 52,465
Nozzle 16,000
Other...28,191
Burnout 93,075

TEMPERATURE LIMITS

Operation ....+40º-90ºF

PROPELLANT DESIGNATION

.... TP-H1148, PBAN polymer, 86% solids

PRODUCTION STATUS

.... Concept based on a production motor

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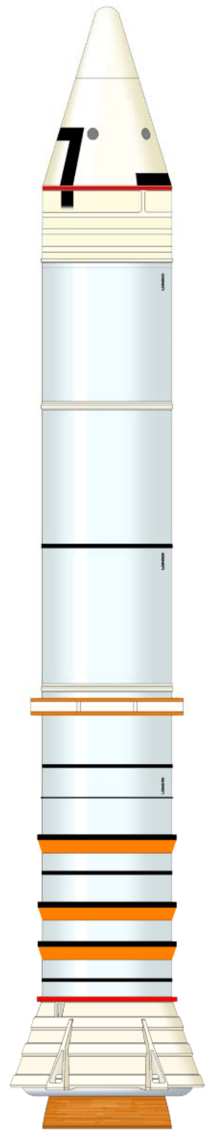
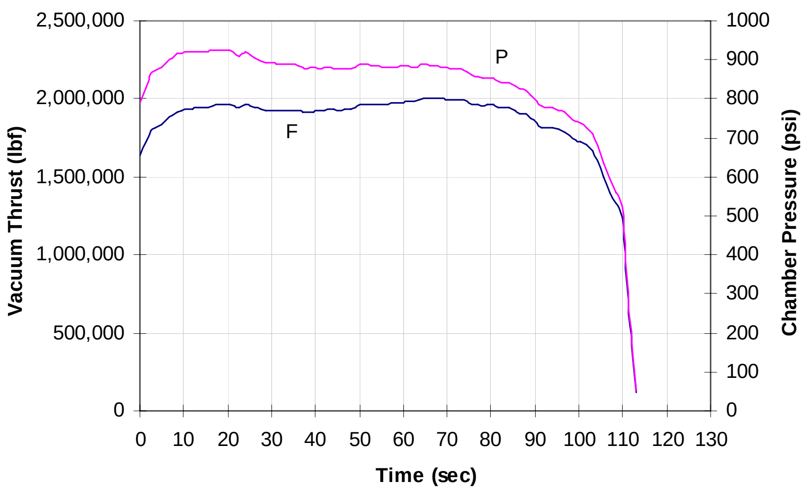
Export Authority ITAR 125.4(b)(13)

2.5 SEGMENT RSRM

FIXED/VECTORABLE NOZZLE





MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 1,037.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec..113.2
Average chamber pressure, psia......................831.8
Total impulse, lbf-sec............................209,304,469
Burn time average thrust, lbf......................1,849,898

NOZZLE

Housing material... D6AC
Exit diameter, in. 133.7
Expansion ratio, average....................................11.1
WEIGHTS, lbm ....
Total loaded 867,215
Propellant 758,990
Case 62,716
Nozzle 17,000
Other..28,509
Burnout 103,487

TEMPERATURE LIMITS

Operation ....+40º-90ºF

PROPELLANT DESIGNATION

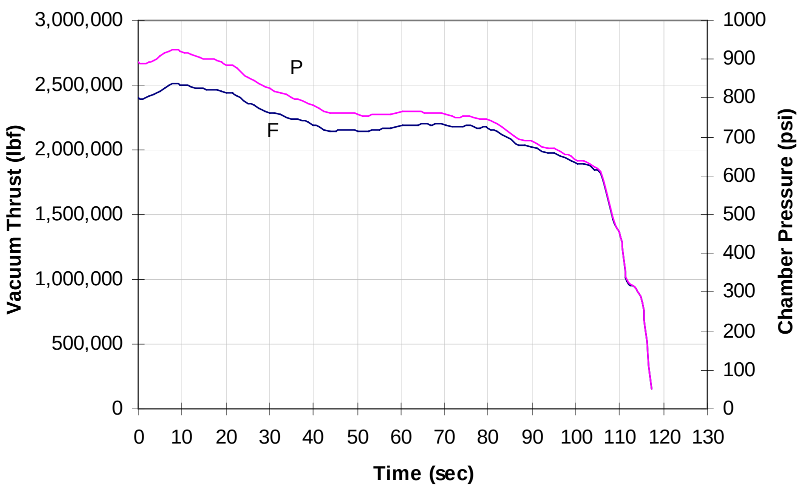
.... TP-H1148, PBAN polymer, 86% solids

PRODUCTION STATUS

.... Concept based on a production motor

3-SEGMENT RSRM

FIXED/VECTORABLE NOZZLE



MOTOR DIMENSIONS

Motor diameter, in.	146.1
Motor length, in.	1,197.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time, sec	117.4
Average chamber pressure, psia	738.0
Total impulse, lbf-sec	246,270,861
Burn time average thrust, lbf	2,097,755

NOZZLE

Housing material	D6AC
Exit diameter, in.	139.8
Expansion ratio, average	9.3
WEIGHTS, lbm	
Total loaded	1,028,632
Propellant	900,348
Case	73,515
Nozzle	18,000
Other	36,769
Burnout	123,135

TEMPERATURE LIMITS

Operation	+40º-90ºF

PROPELLANT DESIGNATION

........................Tp-H1148, Pban polymer, 86% solids

PRODUCTION STATUS

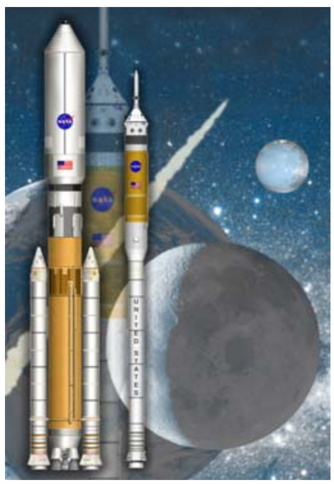
.... Concept based on a production motor

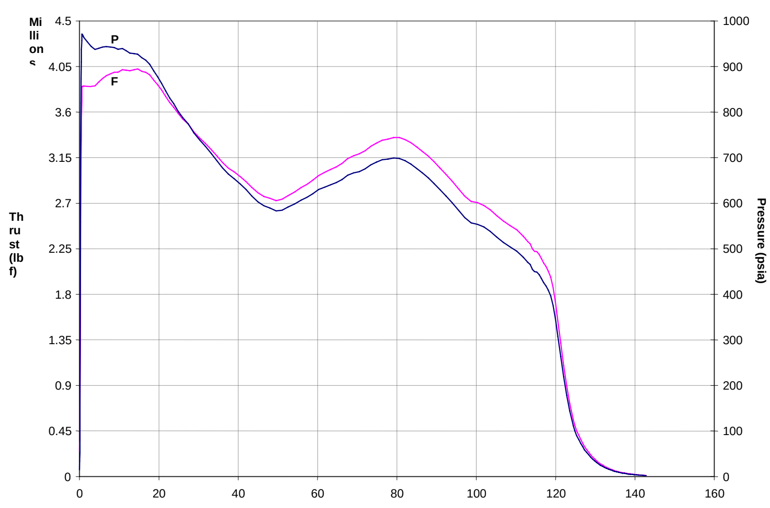
5-SEGMENT RSRM

The Crew Exploration Vehicle (CEV) will be shaped like an Apollo-era capsule. It will be larger, however, and hold up to six astronauts. It will be used initially to ferry astronauts to the International Space Station. Missions to the moon and Mars will come later.

The CEV will be powered aloft by the crew launch vehicle (CLV): Ares I. ATK's five-segment solid rocket booster, which will generate a maximum thrust of 3.5 million pounds, has been selected to provide first-stage propulsion. The two-stage CLV will have the capability to deliver 55,000-pound payloads to low Earth orbit.

The cargo lift vehicle (CaLV), Ares V, is scheduled to be operational in 2018. It will be capable of delivering 300,000 lb to low Earth orbit, more payload than any launch system ever built. Two ATK five-segment solid rocket boosters (each capable of generating 3.5M lb of maximum thrust) and five Space Shuttle main engines will provide first-stage propulsion. Because Ares V will share its major propulsion elements with today's Space Shuttle and its successor, the CLV, reliability will be significantly increased and development costs reduced.





MOTOR DIMENSIONS

Motor diameter, in. 146.1
Motor length, in. 1864.7

MOTOR PERFORMANCE (60°F VACUUM)

Burn time, sec 131.9
Average chamber pressure, psia 625.8
Total impulse, lbf-sec 381,367,646
Burn time average thrust, lbf 2,890,923

NOZZLE

Throat Housing material D6AC
Exit diameter, in. 152.55
Expansion ratio, average 6.55

WEIGHTS, lbm ....

Total loaded 1,616,123
Propellant 1,427,807
Case 127,843
Nozzle 24,029
Other 36,444
Burnout 181,480

TEMPERATURE LIMITS

Operation .... +40º-90ºF

PROPELLANT DESIGNATION

.... HTPB polymer, 88% solids

PRODUCTION STATUS .... Conceptual motor

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Export Authority ITAR 125.4(b)(13)

STAR™ MOTOR SERIES

PERFORMANCE, CAPABILITY, INTERFACE TAILORING, AND TECHNICAL SUPPORT SERVICES FOR STAR MOTORS

ATK's STAR, ASAS, Orion, CASTOR, GEM, and RSRM motors span a significant range of impulse capability. Specific applications often require design tailoring and technical support to best achieve mission goals.

The sections that follow describe how ATK tailors ballistic performance, provides mission specific capabilities, and/or delivers technical support for STAR series space motors. Similar performance tailoring and support can be provided for our other products.

Tailor Ballistic Performance. Specific examples include efforts to achieve the following goals:

- Increase propellant loading and thus total impulse by stretching motor length
- Cut back or off-load the propellant grain to reduce propellant weight and total impulse
- Limit peak thrust/acceleration levels on the payload/spacecraft by altering propellant formulations and/or grain geometry and/or operating pressure
- Modify the nozzle to adjust throat erosion and thrust profiles
- Incorporate an exit cone extension (e.g., a gas-deployed skirt) to enhance expansion ratio and overall performance
- Minimize performance variation by machining propellant grains to precise weight tolerances and by providing thermal systems to maintain propellant grain temperature
- Incorporate mission-specific propellants that provide desired energy levels, environmental compatibility, and/or exhaust characteristics

Provide Desired Mission-Specific Capabilities. ATK is pleased to support our customers with designs that will meet mission-specific conditions. This includes incorporation of additional capabilities and/or providing design compliance with customer-specified flight envelopes, interfaces, and environments. Examples include the following:

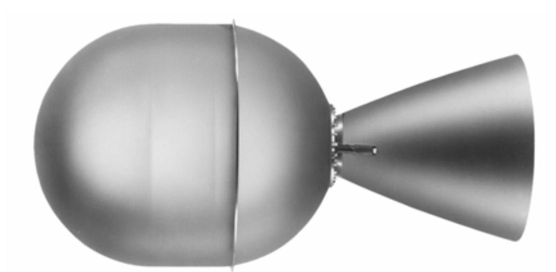
- Use of alternative case materials (steel, aluminum, titanium, composite)

- Qualification to new environments
- Use of proven materials to ensure space storability
- Exit cone length truncation or shortening to fit within a restricted envelope
- Provision of active thrust vector control (TVC) for vehicle steering
- Incorporation of a reaction control system (RCS) for motor and stage pointing
- Furnishing of thermal protection of spacecraft structures from the heat of motor operation through postfiring heat soak
- Provision of thermal management, using heaters and/or blankets prior to operation
- Integration of motors/stages with spin and de-spin motors and collision avoidance systems
- Design of stages with associated command timers and/or avionics and power systems and related software to enable autonomous stage operation
- Integration of advanced ordnance components for motor initiation, stage separation, and flight termination
- Accommodation of specific spacecraft structural interfaces including incorporation of tabs, skirts, and/or complete interstage structures fabricated from metal or composite material
- Movemment or modification of attachment features as required to mate with space-craft/payload

Technical Support. ATK can provide technical alternatives and support for design and flight efforts, including the following:

- Inert mass simulators for system ground tests
- Technical trades on critical design parameters needed for overall system design
- System engineering data and analysis support including performance modeling
- Test and analysis to demonstrate operational capability under new environmental conditions (temperatures, spin conditions, space aging, etc.)
- Logistic, personnel, and technical support for motor shipping, packaging, and integration with the spacecraft or launch vehicle at the launch site including, but not limited to, preparing field handling manuals and providing ground support equipment (GSE) for the motor (e.g., turnover stands, handling stands, and leak test equipment)

ATK has the experience to modify our basic motor designs and can design completely new motors at minimum risk to support specific flight applications (see following figure). We are also prepared to provide required technical support for all of our motor, ordnance, and stage products.



STAR 30BP

STAR 30E

STAR 30BP Motor Was Stretched 7 in. to Yield the STAR 30E

Documentation and Field Support. ATK has prepared and provided to various customers documentation and field support for launches from Cape Canaveral Air Force Station (CCAFS) Kennedy Space Center, Vandenberg AFB, Tanegashima Space Center, Xi Chang, Wallops Flight Facility, Fort Churchill, San Marcos Test Center, Kwajelin Test Center, China Lake Test Center, and Kourou. For most programs, ATK prepares the documents; hold a training session with the responsible ground crew; participate in auditing and modifying the documents to comply with on-site equipment, facilities, and safety practices; and prepare the final documents prior to delivery of the first flight motor in the field, thereby facilitating safe and efficient handling of the first flight system. ATK can also be enlisted to review and assess customer-prepared procedures for the safe handling of our rocket motors.

Field Support. ATK has the trained personnel to lead, instruct, and assist ground crews for receipt, maintenance, inspection, checkout, and assembly of motors and ordnance items. Training or instructional sessions are often of value to customers and launch range personnel and can be conducted at ATK or on-site.

Instructional Field Handling Documentation. The table below lists the procedural documents that can be prepared at customer request for each motor. Many motor programs have adopted these materials for use in the field as supplemental information in the preparation of vehicle stage or spacecraft propulsion units for inspection, buildup, and assembly at the various launch sites.

Typical Instructional Documentation

Document Type	Description
Engineering Instruction	Describes proper unpacking, handling, storage, and maintenance of the rocket motor in the field (safety precautions)
X-ray Inspection Procedure	Establishes radiographic inspection procedure to be used for preflight evaluation using launch site facilities
Inspection Procedures	Delineates proper use of equipment and procedures for verification of motor component integrity
Safe-and-Arm (S&A) Checkout Procedure	Describes electrical checkout of “live” S&A devices
Ordnance Assembly Procedure	Delineates proper procedure for checkout and of installation of squibs, through-bulkhead initiators, explosive transfer assemblies, and S&A devices
Motor Final Inspection and Assembly Procedure	Delineates inspection and preflight buildup of the rocket motor. This procedure can contain many or all other instructional documents for field support and surveillance
Safety Plan	Provides information on the proper safety procedures for handling of explosive devices
Handling Equipment Maintenance Procedures	Describes conduct of periodic proof or load tests to verify equipment adequacy. Delineates proper procedures for maintenance of equipment
Motor Flight Instrumentation Installation and Checkout	Describes proper procedures for installation and checkout of items such as pressure transducers, strain gauges, etc. Delineates precautions and need for testing following installation
Other Instruction	Many systems have unique requirements for ancillary equipment or ordnance items. Procedures can be prepared to meet almost any system need (e.g., spin balancing)

Motor Ground Support Equipment (GSE). In addition to shipping containers, we can provide a variety of GSE for use in handling, inspection, and assembly of the rocket motor and ordnance devices. ATK also designs mission-specific equipment for installation of the motor into the spacecraft or stage. Typical GSE available includes the following:

- Shipping containers
- Turnover stands
- Inert mass simulators
- Leak test equipment

In-Transit Instrumentation. Space motors are sensitive to temperature, humidity, and shock loads. Monitoring of the environmental conditions during transportation of space motors is critical. Several standard and proven devices are available. We can also accommodate special problems, such as long periods of transit. Some of the items readily available are:

- Temperature recorders
- Shock indicators
- Humidity indicators

Generally, ATK personnel have monitored all activities during development, qualification, and lot acceptance testing of ATK motors at various test sites in the United States, Japan, French Guiana, and China. We strongly recommend this support for every flight program. We can provide trained personnel to monitor activities at the launch site or in customer test facilities and to assist in resolution of problems.

Postflight Analysis. Analysis of flight data can help identify trends in motor performance and thus eliminate potential problems. Further, evaluation during a program helps enhance the predictability of flight performance. For example, comparison of ground data with other flight data may enable the customer to reduce the weight of fuel for velocity trimming and RCS, allowing for potential of enhanced spacecraft usable weight on subsequent launches.

Typical postflight analysis that ATK can support includes the following:

- Ballistic performance
- Acceleration profile
- Derived nonaxial (lateral) thrust data
- Motor temperatures
- Residual thrust
- Other (dependent on flight instrumentation)

Motor Data. A summary of STAR motor performance is presented in the following table. The pages that follow contain data sheets for the various STAR motor configurations.

STAR Motor Performance and Experience Summary

STAR Designation	Model Number	Nominal Diameter in.	Nominal Diameter cm	Total Impulse, lbf-sec	Effective Specific Impulse, lbf-sec/lbm	Propellant Weight lbm	Propellant Weight kg	Propellant Mass Fraction	Tests	Flights
3	TE-M-1082-1	3.18	8.08	281	266.0	1.05	0.48	0.42	26	1
3A	TE-M-1089	3.18	8.08	65	241.2	0.27	0.12	0.14	2	3
4G	TE-M-1061	4.45	11.30	595	269.4	2.16	0.98	0.65	2	0
5*	TE-M-500	5.05	12.83	895	189.0	3.8	1.72	0.87	4	11
5A	TE-M-863-1	5.13	13.02	1,289	250.8	5.0	2.27	0.49	6	3
5C/CB	TE-M-344-15/-16	4.77	12.11	1,249	262.0	4.62	2.10	0.47	245	846
5D	TE-M-989-2	4.88	12.39	3,950	256.0	15.2	6.89	0.68	13	3
5E	TE-M-1046	4.88	12.39	2,372	–	9.5	4.31	0.50	2	4
6	TE-M-541-3	6.2	15.75	3,077	287.0	10.7	4.85	0.80	47	238
6A*	TE-M-542-3	6.2	15.75	2,063	285.3	7.2	3.27	0.72		
6B	TE-M-790-1	7.3	18.54	3,686	269.0	13.45	6.10	0.60	8	18
8	TE-M-1076-1	8.06	20.47	7,430	272.9	27.12	12.30	0.71	26	6
9	TE-M-956-2	9.0	22.86	9,212	289.1	31.8	14.42	0.78	1	0
10*	TE-M-195	10.0	25.40	6,600	251.0	26.3	11.93	0.68	46	Classified
12*	TE-M-236	12.0	30.48	10,350	252.0	40.3	18.28	0.66	160	349
12A*	TE-M-236-3	12.1	30.73	13,745	270.0	50.2	22.77	0.67	6	Classified
12GV	TE-M-951	12.24	31.58	20,669	282.4	72.6	32.9	0.79	5	2
13*	TE-M-458	13.5	34.29	18,800	273.0	68.3	30.98	0.87	7	2
13A*	TE-M-516	13.5	34.29	21,050	286.5	73.0	33.11	0.87	5	9
13B	TE-M-763	13.6	34.54	26,050	285.0	90.9	41.23	0.88	1	2
13C*	TE-M-345-11/12	13.5	34.29	18,200	218.0	66.5	30.16	0.80	125	131
13D*	TE-M-375	13.5	34.29	17,200	223.0	63.0	28.58	0.81	10	2
13E*	TE-M-385	12.7	32.26	14,200	211.0	55.4	25.13	0.82	65	48
13F*	TE-M-444	13.5	34.29	21,190	240.0	73.5	33.34	0.83	5	9
15G	TE-M-1030-1	15.0	38.1	50,210	281.8	175.5	79.61	0.85	11	10
17	TE-M-479	17.4	44.20	44,500	286.2	153.5	69.63	0.88	6	4
17A	TE-M-521-5	17.4	44.20	71,800	286.7	247.5	112.26	0.89	10	7
20 Spherical*	TE-M-251	20.0	50.80	66,600	234.0	253	114.76	0.93	1	1
20	TE-M-640-1	19.7	50.04	173,560	286.5	601.6	273.20	0.91	10	32
20A*	TE-M-640-3	19.7	50.04	184,900	291.9	630.0	285.76	0.91	2	0
20B*	TE-M-640-4	19.8	50.29	174,570	289.1	601.6	272.88	0.89	6	5
24	TE-M-604	24.5	62.23	126,000	282.9	440.6	199.85	0.92	9	6
24A*	TE-M-604-2	24.5	62.23	112,400	282.4	393.8	178.62	0.92		
24B*	TE-M-604-3	24.5	62.23	126,230	282.9	441.4	200.22	0.92		
24C	TE-M-604-4	24.5	62.23	138,000	282.3	484.0	219.54	0.92		
25*	TE-M-184-3	24.5	62.23	134,720	240.0	477.6	216.64	0.92	11	0
26	TE-M-442	26.0	66.04	138,500	271.0	508.5	230.65	0.86	4	14
26C	TE-M-442-2	26.1	66.29	139,800	272.1	511.4	231.97	0.88		
26B	TE-M-442-1	26.1	66.29	142,760	271.7	524.0	237.68	0.91	1	8

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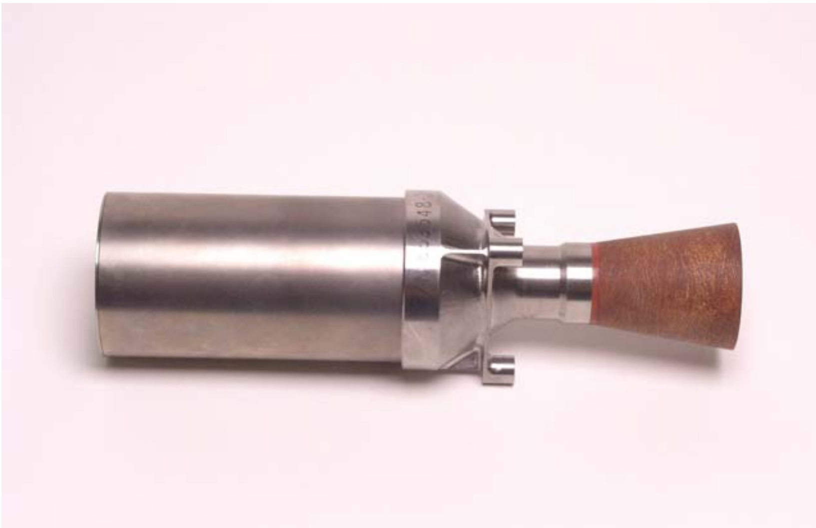
STAR Designation	Model Number	Nominal Diameter in.	Nominal Diameter cm	Total Impulse, lb_f-sec	Effective Specific Impulse, lb_f-sec/lb_m	Propellant Weight lb_m	Propellant Weight kg	Propellant Mass Fraction	Tests	Flights
27	TE-M-616	27.3	69.34	213,790	287.9	735.6	333.66	0.92	18	31
27H	TE-M-1157	27.3	69.34	219,195	291.4	810.9	367.82	0.92	1	0
30*	TE-M-700-2	30.0	76.20	300,940	293.0	1,021.7	463.44	0.94	4	0
30A*	TE-M-700-4	30.0	76.20	302,350	294.7	1,021.0	463.12	0.94		
30B*	TE-M-700-5	30.0	76.20	328,200	293.0	1,113.0	504.85	0.94	14	29
30BP	TE-M-700-20	30.0	76.20	328,455	292.3	1,113.6	505.12	0.93	5	23
30C	TE-M-700-18	30.0	76.20	376,095	286.4	1,302.5	590.80	0.94	4	22
30C/BP	TE-M-700-25	30.0	76.20	383,270	291.8	1,302.5	590.80	0.93	0	4
30E	TE-M-700-19	30.0	76.20	407,550	290.4	1,392.0	631.40	0.93	3	11
31	TE-M-762	30.1	76.45	840,000	293.5	2,835.0	1285.94	0.93	6	17
37*	TE-M-364-1	36.8	93.47	356,200	260.0	1,123.0	509.38	0.90	50	6
37B*	TE-M-364-2	36.8	93.47	417,900	291.0	1,440.0	653.17	0.91	1	21
37C*	TE-M-364-18	36.8	93.47	608,600	285.5	2,125.0	963.88	0.92	1	8
37D*	TE-M-364-3	36.8	93.47	417,900	266.0	1,440.0	653.17	0.91	14	18
37E*	TE-M-364-4	36.8	93.47	654,200	283.6	2,290.0	1038.73	0.93	13	75
37F*	TE-M-364-19	36.8	93.47	549,536	286.0	1,909.3	866.04	0.93	8	10
37FM	TE-M-783	36.8	93.47	685,970	289.8	2,350.1	1065.99	0.93	5	25
37FMV	TE-M-1139	36.8	93.47	685,970	289.8	2350.1	1065.99	0.93	0	0
37G*	TE-M-364-11	36.8	93.47	671,809	289.9	2,348.0	1065.04	0.92	4	0
37GV	TE-M-1007-1	35.2	89.41	634,760	293.5	2,364.0	1072.29	0.92	1	0
37N*	TE-M-364-14	36.8	93.47	357,500	290.0	1,232.0	558.83	0.90	1	8
37S*	TE-M-364-15	36.8	93.47	420,329	287.3	1,449.5	657.48	0.92	2	24
37X*	TE-M-714-1	36.8	93.47	685,148	295.6	2,350.7	1066.26	0.93	1	0
37XF*	TE-M-714-6	36.7	93.22	571,470	290.0	1,950.4	884.69	0.93	9	9
37XFP	TE-M-714-16/17	36.7	93.22	570,040	290.0	1,948.2	883.69	0.92	3	41
37XFPV	TE-M-988-1	36.7	93.22	570,040	290.0	1,948.2	883.69	0.91	1	0
37Y*	TE-M-714-2	36.8	93.47	701,000	297.0	2,360.0	1070.48	0.93	2	0
40*	TE-M-186-2	40.1	101.85	443,026	207.0	1,995.0	904.92	0.92	10	0
48*(short)	TE-M-711-3	49.0	124.46	1,269,610	286.6	4,405.0	1998.08	0.95	18	29
48*(long)	TE-M-711-8	49.0	124.46	1,296,300	292.9	4,405.0	1998.08	0.94		
48A (short)	TE-M-799-1	49.0	124.46	1,528,400	283.4	5,357.2	2429.99	0.94	1	0
48A (long)	TE-M-799	49.0	124.46	1,563,760	289.9	5,357.2	2429.99	0.94		
48B (short)	TE-M-711-17	49.0	124.46	1,275,740	286.0	4,431.2	2009.96	0.94	3	97
48B (long)	TE-M-711-18	49.0	124.46	1,303,700	292.1	4,431.2	2009.96	0.94		
48V	TE-M-940-1	49.0	124.46	1,303,700	292.1	4,431.2	2009.96	0.93	2	0
63D	TU-936	63.0	160.02	2,042,450	283.0	7,166.5	3250.67	0.93	5	3
63F	TE-M-963-2	63.1	160.27	2,816,700	297.1	9,401.6	4264.50	0.93	4	2
75	TE-M-775-1	75.0	190.50	4,797,090	288.0	16,541.7	7503.20	0.93	1	0
92	–	93.0	236.22	10,120,100	287.7	34,879	15,820.85	0.94	0	0

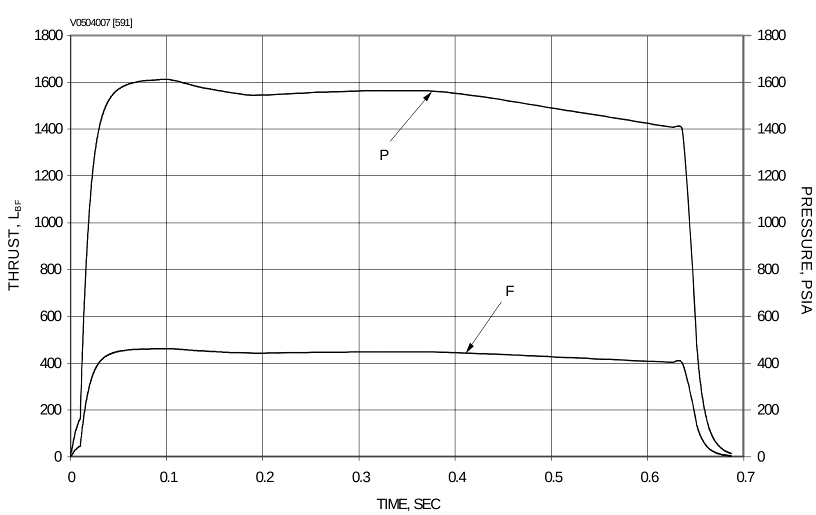
*STAR motors that have been replaced by other motor configurations

STAR 3

TE-M-1082-1



The STAR 3 motor was developed and qualified in 2003 as the Transverse Impulse Rocket System (TIRS) for the Mars Exploration Rover (MER) program for the Jet Propulsion Laboratory (JPL) in Pasadena, CA. Three TIRS motors were carried on each of the MER landers. One of the TIRS motors was fired in January 2004 to provide the impulse necessary to reduce lateral velocity of the MER Spirit lander prior to landing on the Martian surface. The motor also has applicability for spin/despin and separation systems.



MOTOR DIMENSIONS

Motor diameter, in.	3.18
Motor length, in.	11.36

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	0.62/0.66
Ignition delay time, sec	0.12
Burn time average chamber pressure, psia	1,502
Maximum chamber pressure, psia	1,596
Total impulse, lbf-sec	281.4
Propellant specific impulse, lbf-sec/lbm	266.0
Effective specific impulse, lbf-sec/lbm	266.0
Burn time average thrust, lbf	435
Maximum thrust, lbf	461

NOZZLE

Initial throat diameter, in.	0.461
Exit diameter, in.	2.072
Expansion ratio, initial	20.2:1

WEIGHTS, LBM

Total loaded	2.55
Propellant	1.06
Case assembly	0.40
Nozzle assembly	0.58
Total inert	1.49
Burnout	1.49
Propellant mass fraction	0.42

TEMPERATURE LIMITS

Operation	-40º-104°F
Storage	-65º-140°F

PROPELLANT DESIGNATION TP-H-3498

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

NOTE: Offload configuration delivering 171 lb_f-sec of total impulse also qualified

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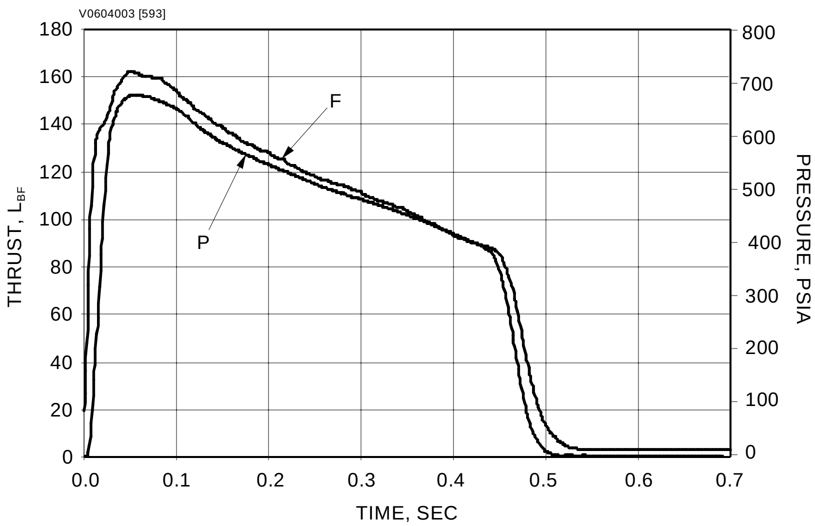
STAR 3A	TE-M-1089

The STAR 3A was developed and qualified in 2003 as an offloaded and shortened version of the STAR 3 used for JPL's Mars Exploration Rover (MER) transverse impulse rocket system (TIRS). It has a shorter case and truncated exit cone to accommodate a lower propellant weight and smaller available volume. The STAR 3A is ideally suited for separation, spin/despin, deorbit, and small satellite applications.



MOTOR DIMENSIONS

Motor diameter, in. 3.18
Motor length, in. 7.5

MOTOR PERFORMANCE (95°F VACUUM)

Burn time/action time, sec 0.44/0.49
Ignition delay time, sec 0.007
Burn time average chamber pressure, psia 520
Maximum chamber pressure, psia 676
Total impulse, lbf-sec 64.4
Propellant specific impulse, lbf-sec/lbm 241.2
Effective specific impulse, lbf-sec/lbm 241.2
Burn time average thrust, lbf 138
Maximum thrust, lbf 180

NOZZLE

Initial throat diameter, in. 0.46
Exit diameter, in. 1.1
Expansion ratio, initial 5.7:1

WEIGHTS, LBM

Total loaded 1.96
Propellant (including igniter) 0.27
Total inert 1.70
Burnout 1.70
Propellant mass fraction 0.14

TEMPERATURE LIMITS

Operation .... -40º-104°F
Storage .... -65º-140°F

PROPELLANT DESIGNATION TP-H-3498

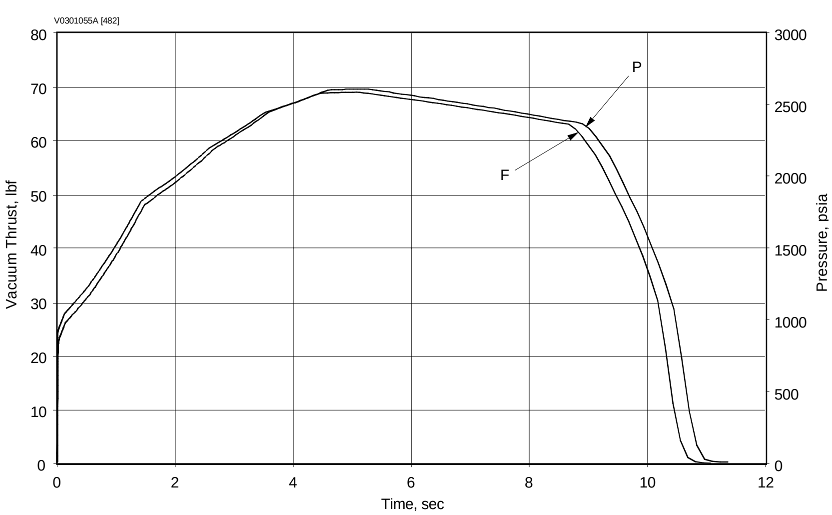
CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

STAR 4G

TE-M-1061

This STAR motor was developed and tested in January 2000 under a NASA Goddard Space Flight Center program for a low-cost, high mass fraction orbit adjust motor for use in deploying constellations of very small satellites (nanosatellites). The first static test of the STAR 4G prototype motor was conducted 8 months after program start. The motor is designed to operate at high chamber pressure and incorporates a noneroding throat insert to maximize specific impulse.



MOTOR DIMENSIONS

Motor diameter, in. 4.45
Motor length, in. 5.43

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 10.3/10.8
Ignition delay time, sec 0.035
Burn time average chamber pressure, psia 2,185
Maximum chamber pressure, psia 2,600
Total impulse, lbf-sec 595
Propellant specific impulse, lbf-sec/lbm 275.6
Effective specific impulse, lbf-sec/lbm 269.4
Burn time average thrust, lbf 58
Maximum thrust, lbf 69

NOZZLE

Initial throat diameter, in. 0.15
Exit diameter, in. 1.13
Expansion ratio, initial 56.8:1

WEIGHTS, LBM

Total loaded 3.30
Propellant 2.16
Heavyweight Nano ESA 0.17
Case assembly 0.49
Nozzle assembly 0.46
Total inert 1.12
Burnout 1.07
Propellant mass fraction 0.65

TEMPERATURE LIMITS

Operation .... 40º-90°F
Storage .... 40º-100°F

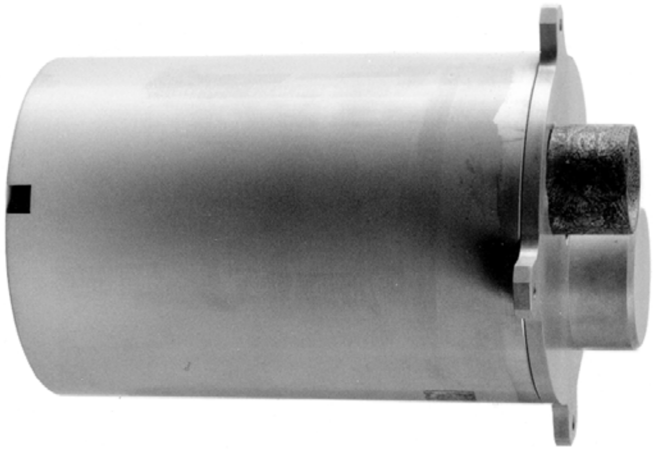
PROPELLANT DESIGNATION TP-H-3399

CASE MATERIAL .... Graphite-epoxy composite

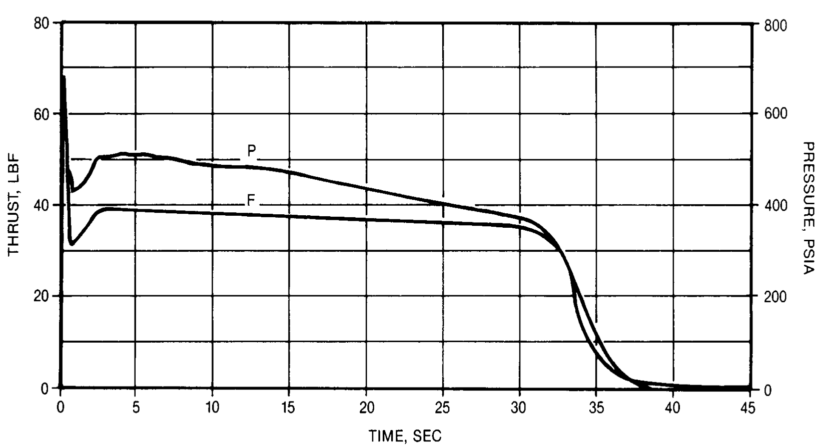
PRODUCTION STATUS .... Development

STAR 5A

TE-M-863-1



The STAR 5A rocket motor was qualified in 1988 to provide a minimum acceleration and extended burn delta-V impulse. With a low-average thrust and a unique off-center nozzle design, the motor can be utilized in many nonstandard geometric configurations for small payload placement or spin-up applications. The STAR 5A first flew in 1989 from the Space Shuttle.



MOTOR DIMENSIONS

Motor diameter, in. 5.13
Motor length, in. 8.84

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 32.0/35.6
Ignition delay time, sec 0.04
Burn time average chamber pressure, psia 453
Maximum chamber pressure, psia 516
Total impulse, lbf-sec 1,289
Propellant specific impulse, lbf-sec/lbm 255.3
Effective specific impulse, lbf-sec/lbm 250.8
Burn time average thrust, lbf 38
Maximum thrust, lbf 38

NOZZLE

Initial throat diameter, in. 0.24
Exit diameter, in. 1.284
Expansion ratio, initial 28.6:1

WEIGHTS, LBM

Total loaded 10.24
Propellant 5.05
Case assembly 2.02
Nozzle assembly 0.57
Total inert 5.17
Burnout 5.08
Propellant mass fraction 0.49

TEMPERATURE LIMITS

Operation .... -4º-104°F
Storage .... -76º-140°F

SPIN EXPERIENCE, RPM .... Up To 60

PROPELLANT DESIGNATION TP-H-3399

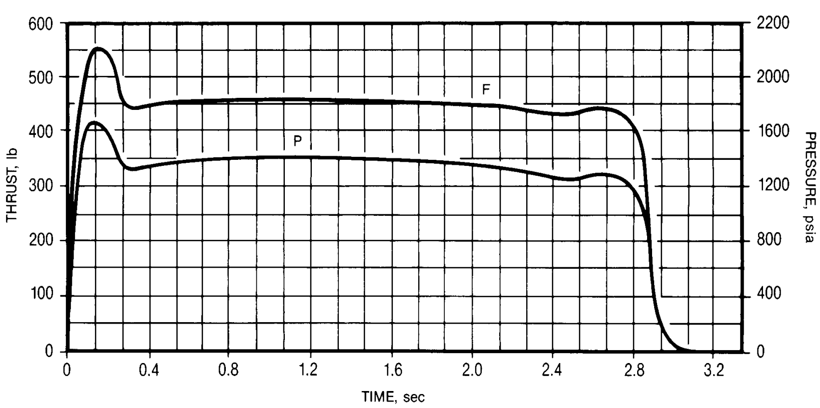
CASE MATERIAL .... Aluminum

PRODUCTION STATUS .... Flight-proven

STAR 5C

TE-M-344-15

The STAR 5C rocket motor was initially designed, developed, qualified, and placed in production (1960-1963) under a contract with Martin Marietta. The STAR 5C is used to separate the second stage from the trans-stage on the Titan II missile and Titan launch vehicle. The current version was qualified for use in 1976, replacing the earlier main propellant grain with TP-H-3062.



MOTOR DIMENSIONS

Motor diameter, in.	4.77
Motor length, in.	13.43

MOTOR PERFORMANCE (60°F VACUUM)

Burn time/action time, sec	2.80/2.94
Ignition delay time, sec	0.015
Burn time average chamber pressure, psia	1,348
Maximum chamber pressure, psia	1,390
Total impulse, lbf-sec	1,252
Propellant specific impulse, lbf-sec/lbm	275.2
Effective specific impulse, lbf-sec/lbm	268.1
Burn time average thrust, lbf	439
Maximum thrust, lbf	455

NOZZLE

Initial throat diameter, in.	0.483
Exit diameter, in.	2.34
Expansion ratio, initial	23.5:1

WEIGHTS, LBM

Total loaded	9.86
Propellant (including igniter propellant)	4.55
Case assembly	4.24
Nozzle assembly	0.40
Total inert	5.28
Burnout	5.16
Propellant mass fraction	0.46

TEMPERATURE LIMITS

Operation	20º-130°F
Storage	-25º-130°F

PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... 4130 steel

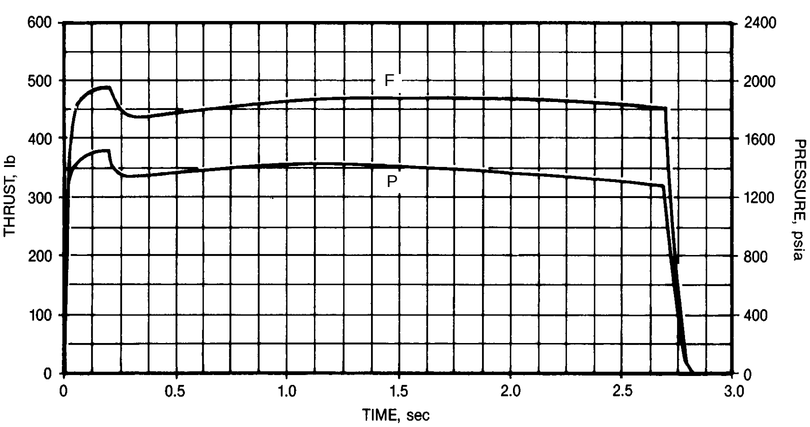
PRODUCTION STATUS .... Flight-proven

STAR 5CB

TE-M-344-16

The STAR 5CB rocket motor was redesigned and requalified to separate the second stage from the upper stage on the Titan IV launch vehicle. The motor incorporates a reduced aluminum content (2% Al) propellant to minimize spacecraft contamination during firing. The case, nozzle, and igniter components are unchanged from the STAR 5C design, but the motor has been qualified (in 1989) for the more severe Titan IV environments. This motor was first flown in 1990.

The STAR 5CB has been adapted for other applications. Mounting lugs and studs can be added to the head-end closure while removing the skirts on either end to accommodate mission specific attachment features.



MOTOR DIMENSIONS

Motor diameter, in. 4.77
Motor length, in. 13.43

MOTOR PERFORMANCE (60°F VACUUM)

Burn time/action time, sec 2.67/2.77
Ignition delay time, sec 0.013
Burn time average chamber pressure, psia 1,388
Maximum chamber pressure, psia 1,434
Total impulse, lbf-sec 1,249
Propellant specific impulse, lbf-sec/lbm 270
Effective specific impulse, lbf-sec/lbm 262
Burn time average thrust, lbf 459
Maximum thrust, lbf 492

NOZZLE

Initial throat diameter, in. 0.483
Exit diameter, in. 2.34
Expansion ratio, initial 23.5:1

WEIGHTS, LBM

Total loaded 9.93
Propellant (excluding 0.03 lbm igniter propellant) 4.62
Case assembly 4.24
Nozzle assembly 0.40
Total inert 5.28
Burnout 5.16
Propellant mass fraction 0.47

TEMPERATURE LIMITS

Operation .... 0º-130°F
Storage .... -35º-172°F

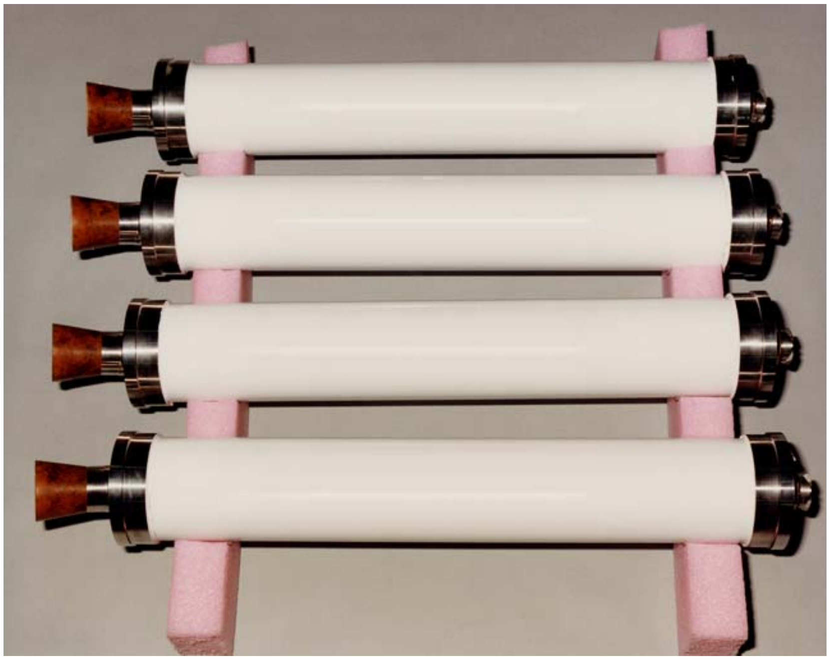
PROPELLANT DESIGNATION TP-H-3237A

CASE MATERIAL .... 4130 steel

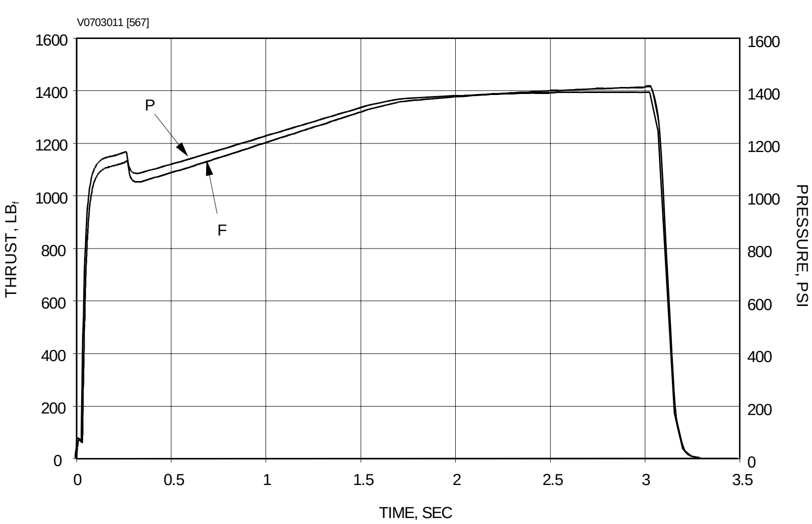
PRODUCTION STATUS .... Flight-proven

STAR 5D

TE-M-989-2



The STAR 5D rocket motor was designed and qualified (1996) to serve as the rocket-assisted deceleration (RAD) motor on the Mars Pathfinder mission for the Jet Propulsion Laboratory (JPL) in Pasadena, CA. The STAR 5D features a titanium case, head-end ignition system, and canted nozzle design and is based on earlier STAR 5 designs. Three of these motors were fired on July 4, 1997, to slow the Pathfinder spacecraft to near-zero velocity before bouncing on the surface of Mars.



MOTOR DIMENSIONS

Motor diameter, in. 4.88
Motor length, in. 32.7

MOTOR PERFORMANCE (-22°F VACUUM)

Burn time/action time, sec 3.03/3.28
Ignition delay time, sec 0.029
Burn time average chamber pressure, psia 1,299
Maximum chamber pressure, psia 1,406
Total impulse, lbf-sec 3,950
Propellant specific impulse, lbf-sec/lbm 259.5
Effective specific impulse, lbf-sec/lbm 256.0
Burn time average thrust, lbf 1251
Maximum thrust, lbf 1,410

NOZZLE

Initial throat diameter, in. 0.869
Exit diameter, in. 2.345
Expansion ratio, initial 7.3:1
Cant angle, deg 17

WEIGHTS, LBM

Total loaded 22.55
Propellant (including igniter propellant) 15.22
Case assembly 5.93
Nozzle assembly 1.40
Total inert 7.33
Burnout 7.12
Propellant mass fraction 0.68

TEMPERATURE LIMITS

Operation .... -67º-158°F
Storage .... -80º-172°F

PROPELLANT DESIGNATION TP-H-3062

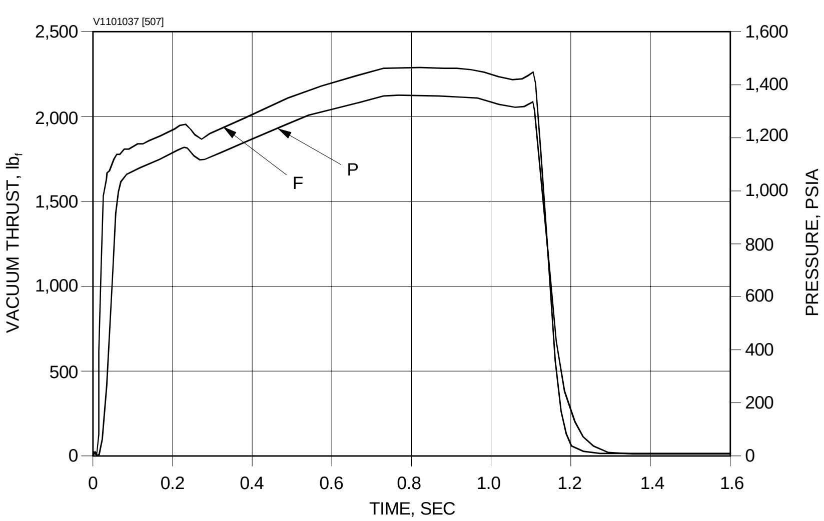
CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

STAR 5E

TE-M-1046

The STAR 5E rocket motor was derived from the STAR 5D by shortening the motor case, opening the throat diameter, and using an alternative propellant formula. This motor, developed for a booster separation application, features a stainless steel case, head-end ignition system, a high-burn-rate propellant, and canted nozzle design. The STAR 5E completed qualification in 1999 for a classified application.



MOTOR DIMENSIONS

Motor diameter, in.	4.88
Motor length, in.	24.04

MOTOR PERFORMANCE (95°F VACUUM)

Burn time/action time, sec	1.08/1.18
Ignition delay time, sec	0.028
Burn time average chamber pressure, psia	1,240
Maximum chamber pressure, psia	1,371
Total impulse, lbf-sec	2,372
Propellant specific impulse, lbf-sec/lbm	249.5
Burn time average thrust, lbf*	2,100
Maximum thrust, lbf*	2,313
*Along nozzle centerline	

NOZZLE

Initial throat diameter, in.	1.16
Exit diameter, in.	2.65
Expansion ratio, initial	5.2:1
Cant angle, deg	17.0

WEIGHTS, LBM

Total loaded	18.90
Propellant	9.51
Total inert	9.39
Propellant mass fraction	0.50

TEMPERATURE LIMITS

Operation	32º-149°F
Storage	-40º-158°F

PROPELLANT DESIGNATION TP-H-3498A

CASE MATERIAL........................... Stainless steel

PRODUCTION STATUS..................Flight-proven

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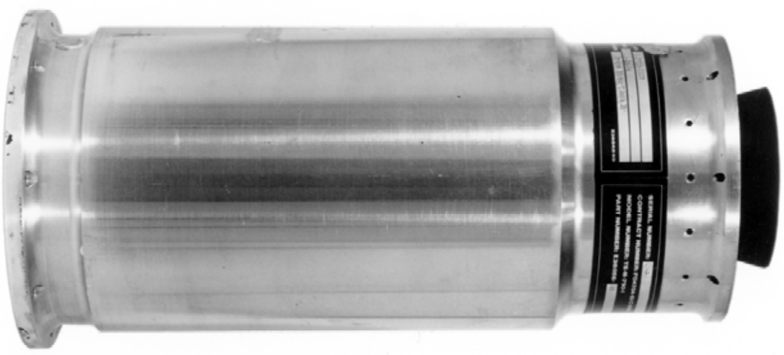
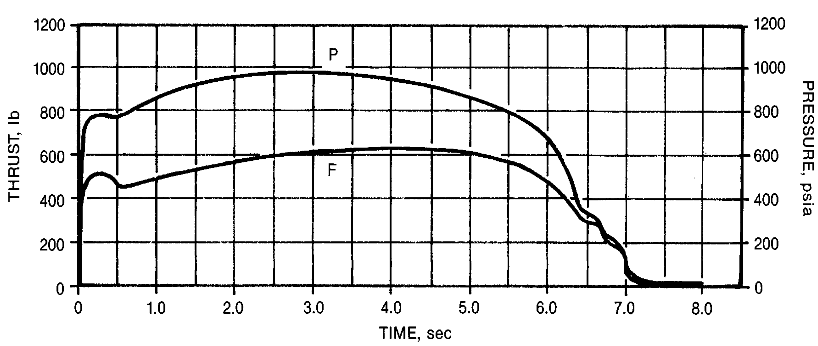
STAR 6B

TE-M-790-1



The STAR 6B rocket motor was developed for spin-up and axial propulsion applications for re-entry vehicles. The design incorporates an aluminum case and a carbon-phenolic nozzle assembly. The STAR 6B was qualified in 1984 and first flew in 1985. The motor is capable of spinning at 16 revolutions per second during firing and is qualified for propellant loadings from 5.7 to 15.7 lb_m.



MOTOR DIMENSIONS

Motor diameter, in. 7.32
Motor length, in. 15.89

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 5.9/7.2
Ignition delay time, sec 0.010
Burn time average chamber pressure, psia.......... 846
Maximum chamber pressure, psia 907
Total impulse, lbf-sec....................................... 3,686
Propellant specific impulse, lbf-sec/lbm................ 274
Effective specific impulse, lbf-sec/lbm 269
Burn time average thrust, lbf................................ 565
Maximum thrust, lbf 634

NOZZLE

Initial throat diameter, in. 0.662
Exit diameter, in. 3.76
Expansion ratio, initial/average.................... 32:1/28:1

WEIGHTS, LBM

Total loaded 22.62
Propellant (including igniter propellant) 13.45
Case and closure assembly................................ 6.02
Nozzle assembly 0.80
Total inert... 9.17
Burnout 8.92
Propellant mass fraction 0.59

TEMPERATURE LIMITS

Operation .... 30º-110°F
Storage .... -20º-160°F

SPIN EXPERIENCE, RPM 960

PROPELLANT DESIGNATION......... TP-H-3237A

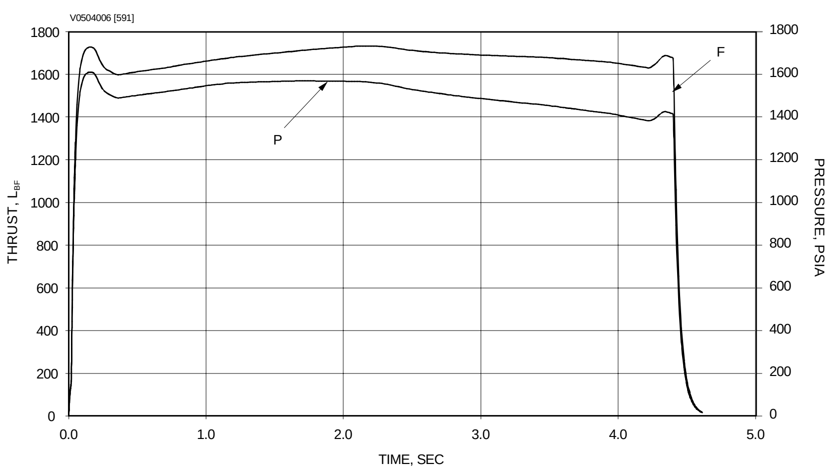
CASE MATERIAL................................... Aluminum

PRODUCTION STATUS.................. Flight-proven

ATK

STAR 8 TE-M-1076-1

The STAR 8 was developed and qualified (2002) as the rocket assisted deceleration (RAD) motor for the Mars Exploration Rover (MER) program for the Jet Propulsion Laboratory (JPL) in Pasadena, CA. The motor is based on the STAR 5D motor technology developed for JPL's Mars Pathfinder program. The STAR 8 first flew in January 2004 when three motors were used to decelerate each of the Spirit and Opportunity rovers for landing at Gusev Crater and Meridiani Planum on Mars.



MOTOR DIMENSIONS

Motor diameter, in.	8.06
Motor length, in.	27.07

MOTOR PERFORMANCE (-22°F VACUUM)

Burn time/action time, sec	4.33/4.51
Ignition delay time, sec	0.025
Burn time average chamber pressure, psia	1,500
Maximum chamber pressure, psia	1,572
Total impulse, lbf-sec	7,430
Propellant specific impulse, lbf-sec/lbm	274.0
Effective specific impulse, lbf-sec/lbm	272.9
Burn time average thrust, lbf	1,681
Maximum thrust, lbf	1,742

NOZZLE

Initial throat diameter, in.	0.879
Exit diameter, in.	4.095
Expansion ratio, initial	21.7:1
Cant angle, deg	17

WEIGHTS, LBM

Total loaded	38.43
Propellant	27.12
Case assembly	6.12
Nozzle assembly	3.69
Total inert	11.31
Burnout	11.20
Propellant mass fraction	0.71

TEMPERATURE LIMITS

Operation	-40º-104°F
Storage	-65º-140°F

PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

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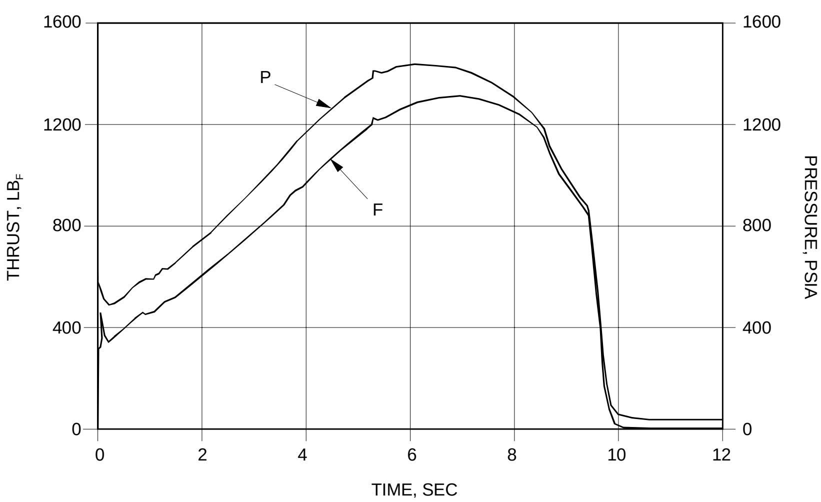
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 9

TE-M-956-2

The STAR 9 rocket motor was developed in 1993 on independent research and development (IR&D) funds to demonstrate a number of low-cost motor technologies. These included an integral aft polar boss/exit cone, two-dimensional carbon-carbon throat, and case-on-propellant manufacturing technique.



MOTOR DIMENSIONS

Motor diameter, in. 9.0
Motor length, in. 19.96

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 9.4/9.8
Ignition delay time, sec 0.01
Burn time average chamber pressure, psia 1,072
Maximum chamber pressure, psia 1,436
Total impulse, lbf-sec 9,212
Propellant specific impulse, lbf-sec/lbm 289.7
Effective specific impulse, lbf-sec/lbm 289.1
Burn time average thrust, lbf 951
Maximum thrust, lbf 1,311

NOZZLE

Initial throat diameter, in. 0.763
Exit diameter, in. 6.52
Expansion ratio, initial 73:1

WEIGHTS, LBM ....

Total loaded 41.0
Propellant (including igniter propellant) 31.8
Case assembly (including igniter inerts) 6.5
Nozzle assembly 2.7
Total inert 9.2
Burnout 9.1
Propellant mass fraction 0.78

TEMPERATURE LIMITS

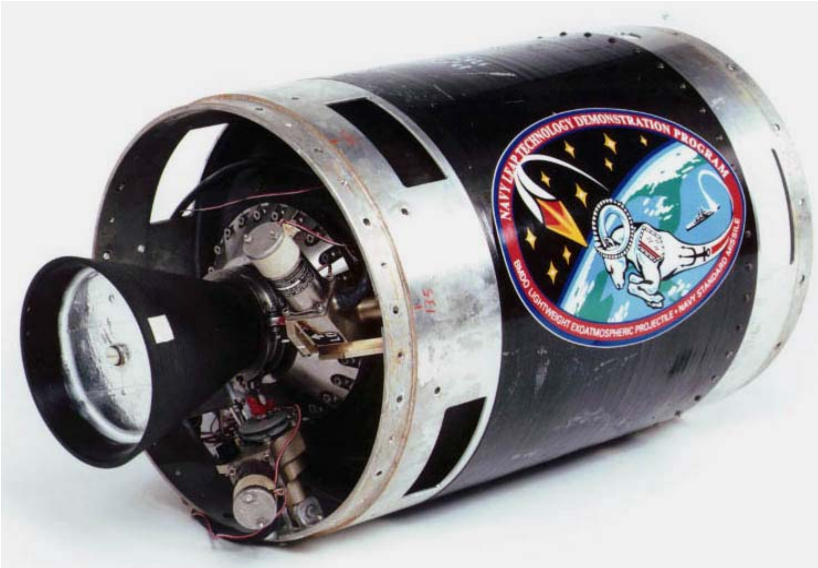
Operation .... 40º-90°F
Storage .... 30º-95°F

PROPELLANT DESIGNATION TP-H-1202

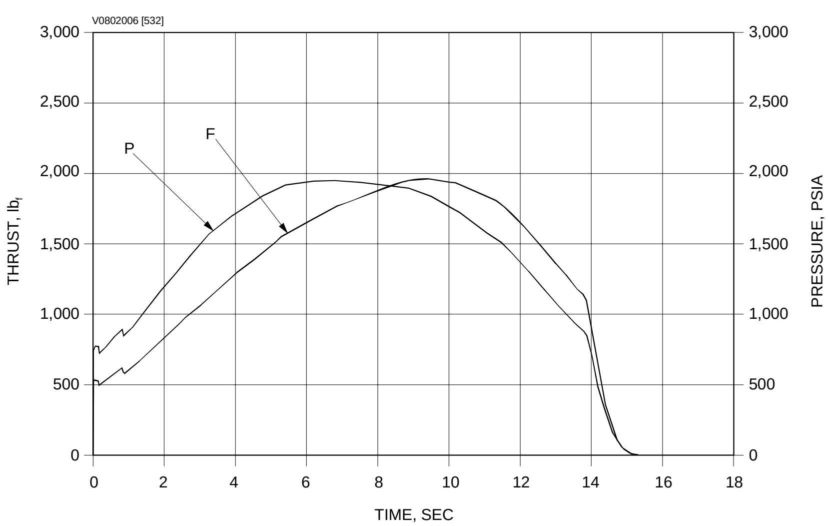
CASE MATERIAL .... Graphite-epoxy composite

PRODUCTION STATUS .... Demonstration

STAR 12GV TE-M-951



The STAR 12GV rocket motor served as the third stage of the U.S. Navy/MDA Terrier Lightweight Exoatmospheric Projectile (LEAP) experiments. The motor first flew in March 1995. The stage has TVC capability, head-end flight destruct ordnance, and utilizes a graphite-epoxy composite case. It is compatible with an aft-end attitude control system (ACS) module. ATK developed the motor design and component technology between 1992-1995 under the ASAS program.



MOTOR DIMENSIONS

Motor diameter, in. 12.24
Motor length, in. 22.5

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 13.9/14.8
Ignition delay time, sec 0.02
Burn time average chamber pressure, psia 1,550
Maximum chamber pressure, psia 1,950
Total impulse, lbf-sec 20,669
Propellant specific impulse, lbf-sec/lbm 284.7
Effective specific impulse, lbf-sec/lbm 282.4
Burn time average thrust, lbf 1,455
Maximum thrust, lbf 1,980

NOZZLE

Initial throat diameter, in. 0.691
Exit diameter, in. 5.26
Expansion ratio, initial 58:1
TVC angle, deg .... ± 5 deg

WEIGHTS*, LBM

Total loaded 92.5
Propellant 72.6
Case assembly 14.3
Nozzle assembly 4.5
Total inert 19.8
Burnout 19.2
Propellant mass fraction 0.79

TEMPERATURE LIMITS

Operation .... 40º-95°F
Storage .... 0º-130°F

PROPELLANT DESIGNATION TP-H-3340A

CASE MATERIAL .... Graphite-epoxy composite

PRODUCTION STATUS .... Flight-proven

*Includes actuators and cables only. Battery and controller weights and ACS are not included

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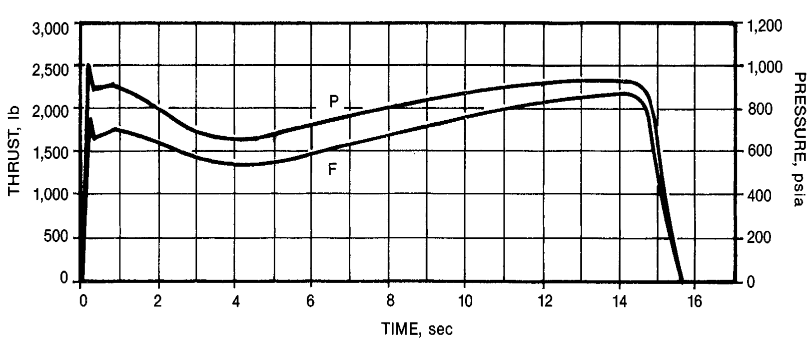
STAR 13B

TE-M-763

The STAR 13B incorporates a titanium case developed for the STAR 13 with the propellant and nozzle design of an earlier STAR 13 apogee motor. The motor design was qualified in 1983 and was used in 1984 to adjust orbit inclinations of the Active Magnetosphere Particle Tracer Experiment (AMPTE) satellite launched from Delta 180 and in 1988 as a kick motor for a missile defense experiment.



MOTOR DIMENSIONS

Motor diameter, in. 13.57
Motor length, in. 25.11

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 14.8/16.1
Ignition delay time, sec 0.02
Burn time average chamber pressure, psia 823
Maximum chamber pressure, psia 935
Total impulse, lbf-sec 26,050
Propellant specific impulse, lbf-sec/lbm 286.6
Effective specific impulse, lbf-sec/lbm 285.0
Burn time average thrust, lbf 1,708
Maximum thrust, lbf 2,160

NOZZLE

Initial throat diameter, in. 1.20
Exit diameter, in. 8.02
Expansion ratio, initial/average 49.8:1/41.0:1

WEIGHTS, LBM

Total loaded 103.7
Propellant 90.9
Case assembly 5.6
Nozzle assembly 3.7
Total inert 12.8
Burnout 12.3
Propellant mass fraction 0.88

TEMPERATURE LIMITS

Operation .... 40º-110°F
Storage .... 40º-110°F

SPIN EXPERIENCE, RPM 120

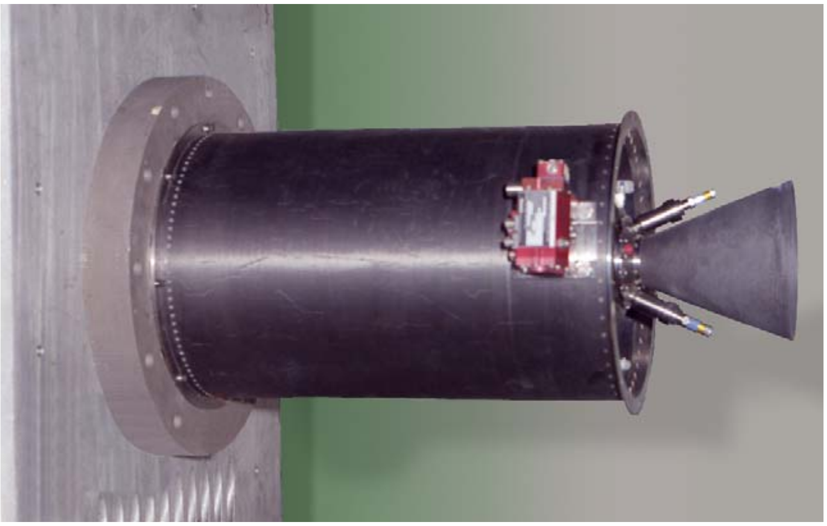
PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

STAR 15G

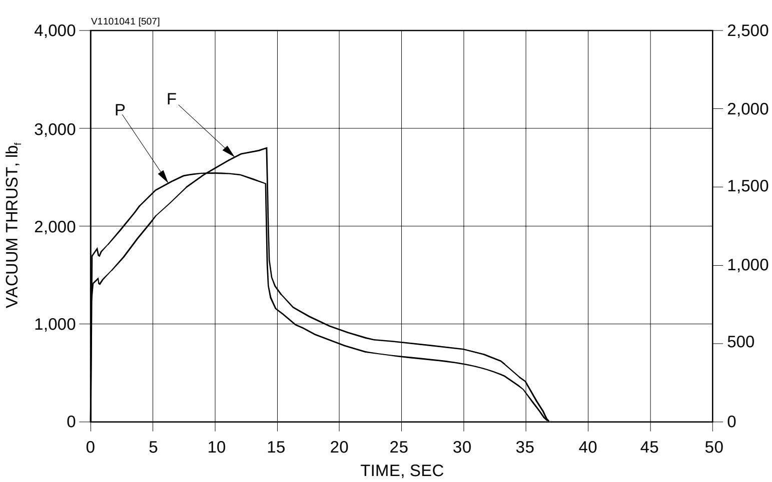
TE-M-1030-1



AN UPPER-STAGE MOTOR

The STAR 15G rocket motor was designed and qualified during 1997 in two different grain design configurations. The motor design was based on the ASAS 15-in. diameter development motor (DM) used to evaluate design features and component and material technology in seven tests between December 1988 and June 1991. ATK employed its Thiokol Composite Resin (TCR) technology on this motor, one of several STAR designs to use a wound graphite-epoxy composite case.

The motor's unique regressive thrust-time profile is an example of propellant grain tailoring to restrict thrust to maintain a low level of acceleration to the payload. An alternative propellant loading of 131 lb_m was also tested during qualification.



MOTOR DIMENSIONS

Motor diameter, in. 15.04
Motor length, in. 31.57

MOTOR PERFOQRMANCE (70°F VACUUM)

Burn time/action time, sec 33.3/36.4
Ignition delay time, sec 0.334
Burn time average chamber pressure, psia 885
Maximum chamber pressure, psia 1,585
Total impulse, lbf-sec 50,210
Propellant specific impulse, lbf-sec/lbm 285.9
Effective specific impulse, lbf-sec/lbm 281.8
Burn time average thrust, lbf 1,470
Maximum thrust, lbf 2,800

NOZZLE

Initial throat diameter, in. 0.97
Exit diameter, in. 8.12
Expansion ratio, initial 70:1

WEIGHTS, LBM

Total loaded (excl. ETA and S&A) 206.6
Propellant (excluding 0.12 lbm of igniter propellant) 175.5
Case assembly 22.6
Nozzle assembly 4.6
Total inert 30.9
Burnout 28.3
Propellant mass fraction 0.85

TEMPERATURE LIMITS

Operation .... 40º-110°F
Storage .... 40º-110°F

SPIN EXPERIENCE, RPM 125

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Graphite-epoxy composite

PRODUCTION STATUS .... Flight-proven

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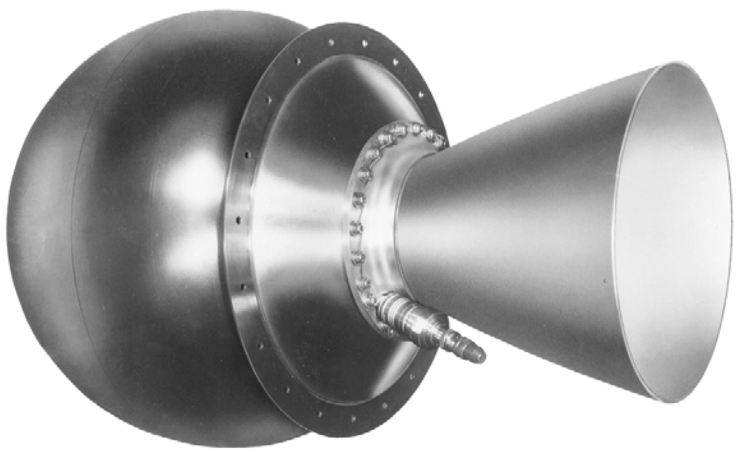
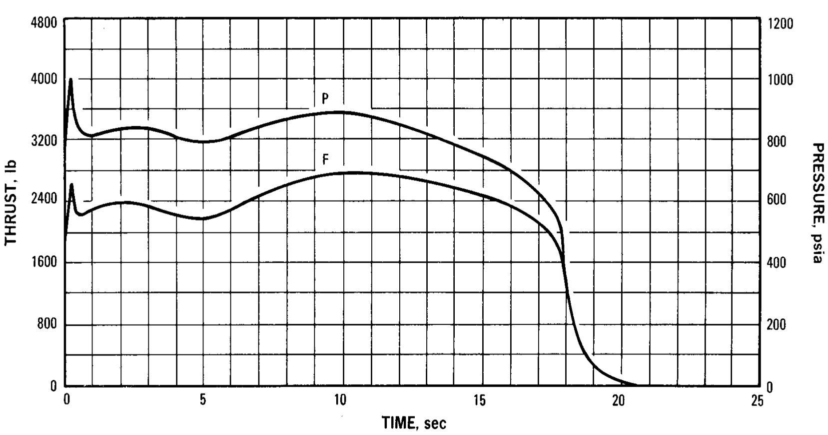
STAR 17

TE-M-479



The STAR 17 motor has served as the apogee kick motor (AKM) for several programs. The STAR 17 features a silica-phenolic exit cone and a titanium case with mounting ring on the aft end that can be relocated as required by the customer.

The STAR 17 motor was developed and qualified in six tests conducted at ATK and AEDC through March 1967. The initial STAR 17 flight was on Delta 57 in July 1968 from the Western Test Range (WTR). Subsequent launches have been conducted from Eastern Test Range (ETR) on Delta and on the Atlas vehicle from WTR.



MOTOR DIMENSIONS

Motor diameter, in. 17.4
Motor length, in. 27.06

MOTOR PERFORMANCE (70°F VACUUM).....

Burn time/action time, sec 17.6/18.6
Ignition delay time, sec 0.060
Burn time average chamber pressure, psia....803
Maximum chamber pressure, psia 1,000
Total impulse, lbf-sec....44,500
Propellant specific impulse, lbf-sec/lbm....290.0
Effective specific impulse, lbf-sec/lbm 286.2
Burn time average thrust, lbf....2,460
Maximum thrust, lbf 2,775

NOZZLE

Initial throat diameter, in. 1.372
Exit diameter, in. 10.69
Expansion ratio, initial....60.7:1

WEIGHTS, LBM

Total loaded 174.3
Propellant....153.5
Case assembly 8.8
Nozzle assembly 7.0
Total inert....20.8
Burnout 18.8
Propellant mass fraction 0.88

TEMPERATURE LIMITS

Operation .... 0º-120°F
Storage .... 0º-120°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION....TP-H-3062

CASE MATERIAL....Titanium

PRODUCTION STATUS....Flight-proven

Approved for Public Release
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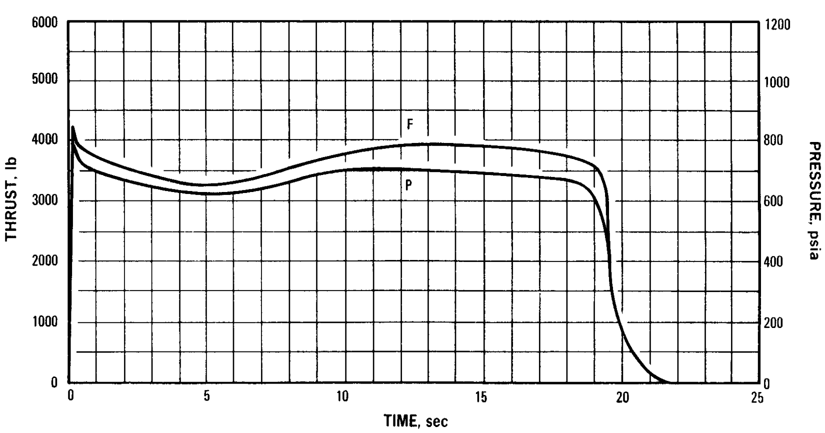
Export Authority ITAR 125.4(b)(13)

STAR 17A

TE-M-521-5

The STAR 17A motor is an apogee kick motor (AKM) used for the interplanetary monitoring platform (IMP) and other small satellites. The motor utilizes an extended titanium case to increase total impulse from the STAR 17 and has been used for various missions in launches from Delta and Atlas vehicles between 1969 and 1977. The STAR 17A motor was qualified in the -5 configuration for IMP H&J.



MOTOR DIMENSIONS

Motor diameter, in.	17.4*
Motor length, in.	38.64

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	19.4/20.6
Ignition delay time, sec	0.070
Burn time average chamber pressure, psia	670
Maximum chamber pressure, psia	700
Total impulse, lbf-sec	71,800
Propellant specific impulse, lbf-sec/lbm	290.1
Effective specific impulse, lbf-sec/lbm	286.7
Burn time average thrust, lbf	3,600
Maximum thrust, lbf	3,900

NOZZLE

Initial throat diameter, in.	1.884
Exit diameter, in.	13.75
Expansion ratio, initial	53.2:1

WEIGHTS, LBM

Total loaded	277
Propellant	247.5
Case assembly	13.1
Nozzle assembly	10.3
Total inert	29.5
Burnout	26.5
Propellant mass fraction	0.89

TEMPERATURE LIMITS

Operation	0º-110°F
Storage	0º-110°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

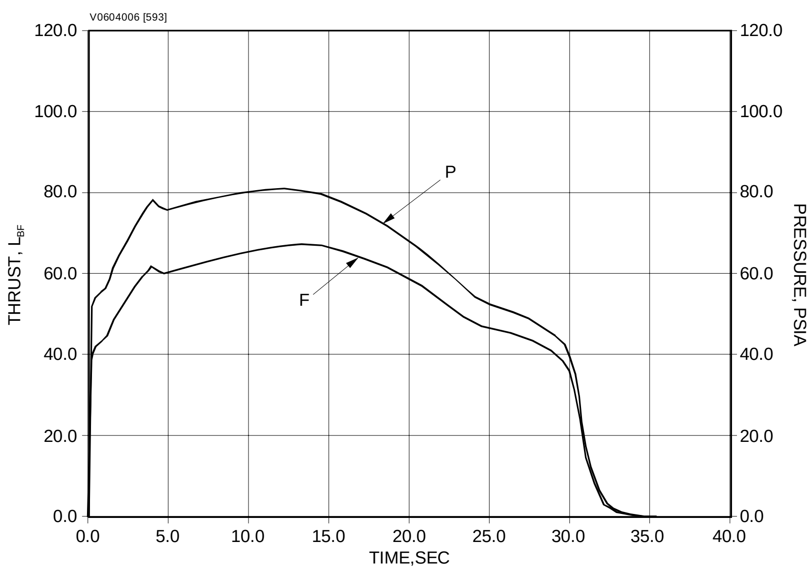
*The diameter extends to 18.38 in. at the location of the attachment flange

STAR 20

TE-M-640-1

The STAR 20 Altair III rocket motor was developed as the propulsion unit for the fourth stage of the Scout launch vehicle. The filament-wound, fiberglass-epoxy case contains a 16% aluminum carboxyl-terminated polybutadiene (CTPB) propellant grain. The lightweight, external nozzle is a composite of graphite and plastic that is backed by steel. The STAR 20 Altair III was developed in testing between 1972 and 1978 with flights from WTR, San Marcos, and Wallops beginning with Scout 189 in August 1974.

ATK also developed a modified version of the STAR 20. The STAR 20B design increased case structural capability over the standard STAR 20 to support launch from an F-15 aircraft for the ASAT program. The STAR 20B ASAT motor was qualified during testing in 1982-1983 to support flights between January 1984 and September 1986.



MOTOR DIMENSIONS

Motor diameter, in. 19.7
Motor length, in. 58.5

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 27.4/31.5
Ignition delay time, sec 0.04
Burn time average chamber pressure, psia 654
Maximum chamber pressure, psia 807
Total impulse, lbf-sec 173,560
Propellant specific impulse, lbf-sec/lbm 288.5
Effective specific impulse, lbf-sec/lbm 286.5
Burn time average thrust, lbf 5,500
Maximum thrust, lbf 6,720

NOZZLE

Initial throat diameter, in. 2.3
Exit diameter, in. 16.5
Expansion ratio, initial 50.2:1

WEIGHTS, LBM

Total loaded 662.3
Propellant (including igniter propellant) 601.6
Case assembly 24.3
Nozzle assembly 12.5
Total inert 60.7
Burnout 58.6
Propellant mass fraction 0.91

TEMPERATURE LIMITS

Operation .... 40º-100°F
Storage .... 30º-110°F

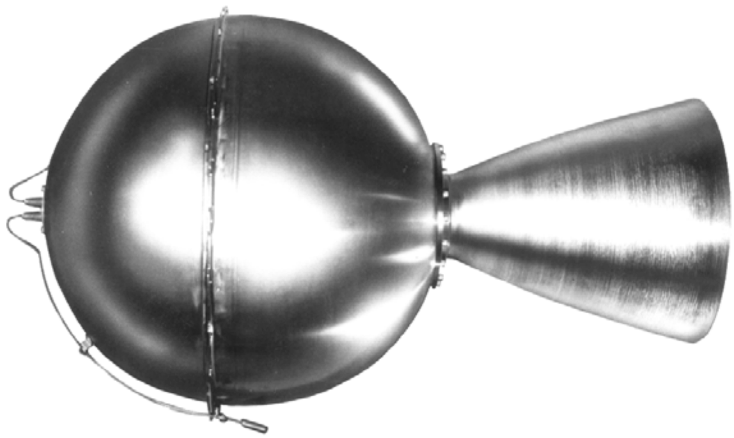
SPIN EXPERIENCE, RPM 180

PROPELLANT DESIGNATION TP-H-3062

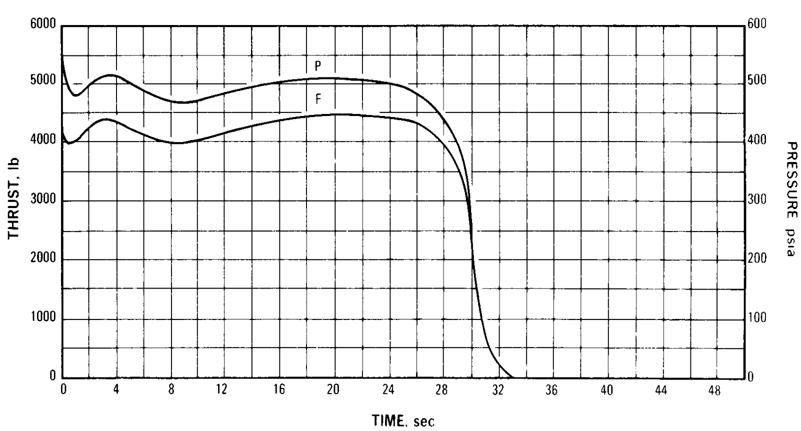
CASE MATERIAL .... Fiber glass-epoxy composite

PRODUCTION STATUS .... Flight-proven

STAR 24 TE-M-604



The STAR 24 rocket motor was qualified in 1973 and flown as the apogee kick motor (AKM) for the Skynet II satellite. The motor assembly uses a titanium case and carbon-phenolic exit cone. Different versions of this motor have been qualified for the Pioneer Venus mission (1978). The initial STAR 24 flight was in 1974 on Delta 100. The STAR 24 motor has flown from both ETR and WTR.



MOTOR DIMENSIONS

Motor diameter, in. 24.5
Motor length, in. 40.5

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 29.6/31.1
Ignition delay time, sec 0.03
Burn time average chamber pressure, psia 486
Maximum chamber pressure, psia 524
Total impulse, lbf-sec 126,000
Propellant specific impulse, lbf-sec/lbm 286.0
Effective specific impulse, lbf-sec/lbm 282.9
Burn time average thrust, lbf 4,170
Maximum thrust, lbf 4,420

NOZZLE

Initial throat diameter, in. 2.42
Exit diameter, in. 14.88
Expansion ratio, initial/average 37.8:1/36.7:1

WEIGHTS, LBM

Total loaded 481.0
Propellant (including igniter propellant) 440.6
Case 13.0
Nozzle assembly 13.1
Total inert 40.4
Burnout 35.6
Propellant mass fraction 0.92

TEMPERATURE LIMITS

Operation .... 0º-110°F
Storage .... 20º-110°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

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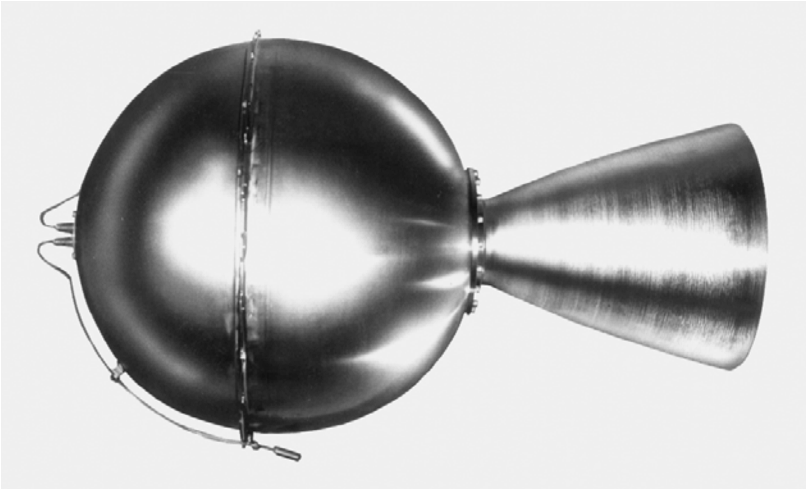
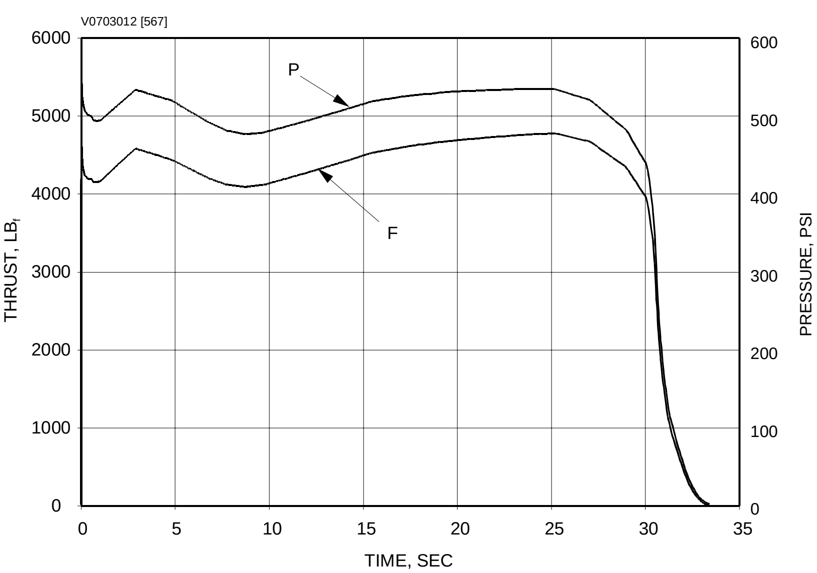
STAR 24C

TE-M-604-4



The STAR 24C was designed and qualified (in 1976) for launch of NASA's International Ultraviolet Experiment (IUE) satellite in January 1978 from ETR on Delta 138. It operates at a slightly higher chamber pressure than earlier STAR 24 motors. The STAR 24C has an elongated cylindrical section and a larger nozzle throat to accommodate increased propellant loading.



MOTOR DIMENSIONS

Motor diameter, in. 24.5
Motor length, in. 42.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 28.0/29.6
Ignition delay time, sec 0.03
Burn time average chamber pressure, psia 544
Maximum chamber pressure, psia 598
Total impulse, lbf-sec 138,000
Propellant specific impulse, lbf-sec/lbm 285.1
Effective specific impulse, lbf-sec/lbm 282.3
Burn time average thrust, lbf 4,650
Maximum thrust, lbf 4,800

NOZZLE

Initial throat diameter, in. 2.443
Exit diameter, in. 14.88
Expansion ratio, initial 37.1:1

WEIGHTS, LBM

Total loaded 527.5
Propellant (including 1.2 lbm igniter propellant) 484.0
Case 14.1
Nozzle assembly 13.1
Total inert 43.5
Burnout 38.7
Propellant mass fraction 0.92

TEMPERATURE LIMITS

Operation .... 0º-110°F
Storage .... 20º-110°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION TP-H-3062

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

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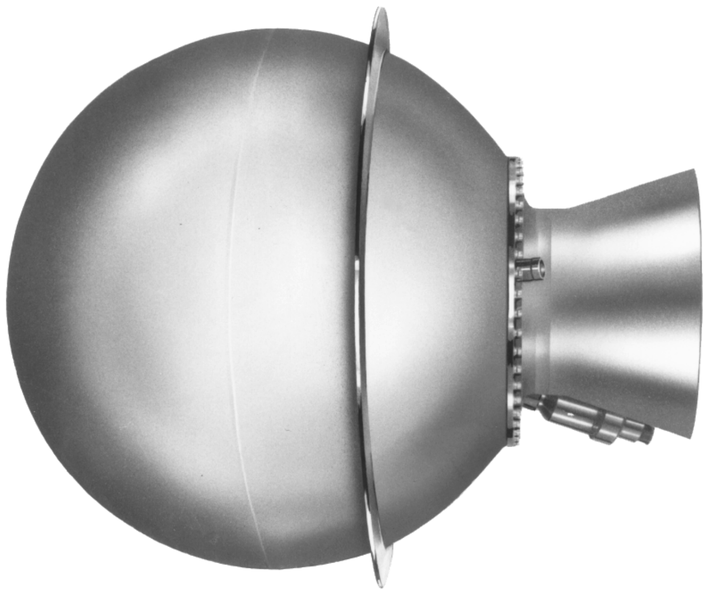
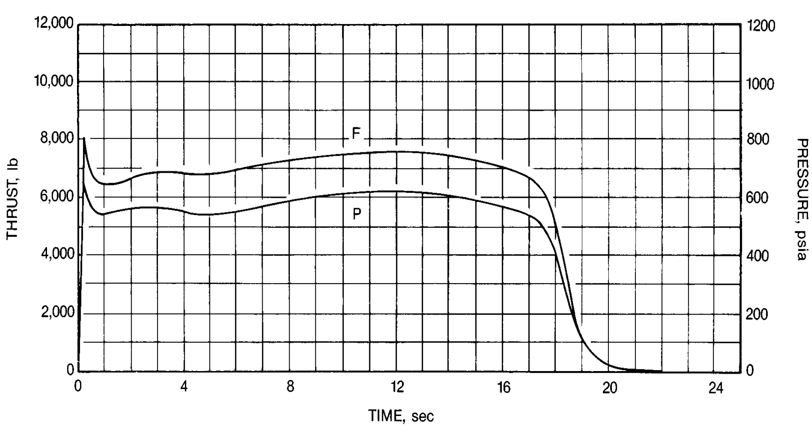
Export Authority ITAR 125.4(b)(13)

STAR 26

TE-M-442



The STAR 26 was qualified in 1964 for flight as an upper stage in the Sandia National Laboratories Strypi IV vehicle. Similar in design to its predecessor, the STAR 24, this motor offers a higher thrust.



MOTOR DIMENSIONS

Motor diameter, in.	26.0
Motor length, in.	33.0

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	17.8/19.0
Ignition delay time, sec	0.06
Burn time average chamber pressure, psia	575
Maximum chamber pressure, psia	650
Total impulse, lbf-sec	138,500
Propellant specific impulse, lbf-sec/lbm	272.4
Effective specific impulse, lbf-sec/lbm	271.0
Burn time average thrust, lbf	7,500
Maximum thrust, lbf	8,000

NOZZLE

Initial throat diameter, in.	3.06
Exit diameter, in.	12.50
Expansion ratio, initial	16.7:1

WEIGHTS, LBM

Total loaded	594.0
Propellant (including 1.2 lbm igniter propellant)	508.5
Case assembly	39.6
Nozzle assembly	23.3
Total inert	85.5
Burnout	83.0
Propellant mass fraction	0.86

TEMPERATURE LIMITS

Operation	50º-90°F
Storage	40º-120°F

SPIN EXPERIENCE, RPM....400

PROPELLANT DESIGNATION....TP-H-3114

CASE MATERIAL.... D6AC steel

PRODUCTION STATUS....Flight-proven

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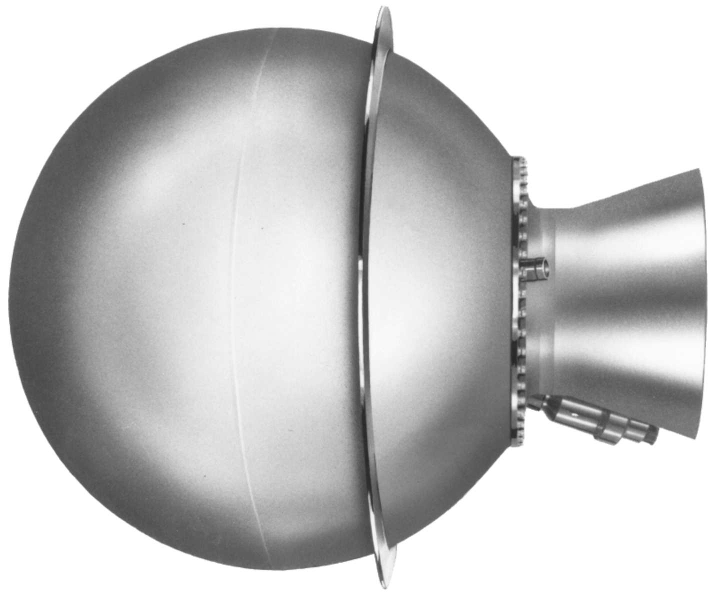
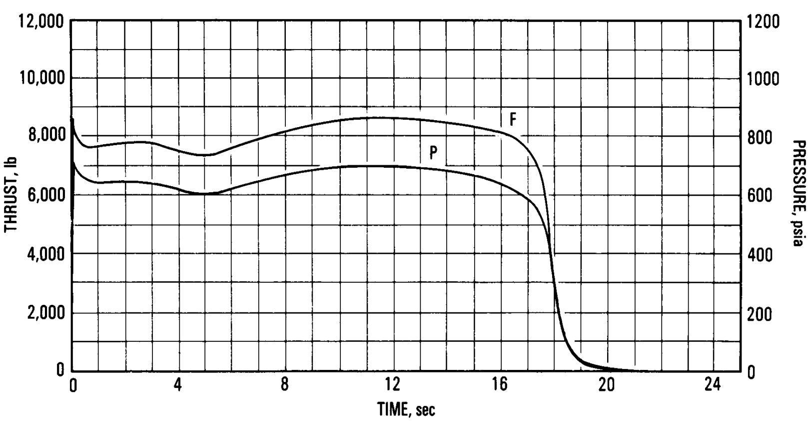
Export Authority ITAR 125.4(b)(13)

STAR 26B

TE-M-442-1



The STAR 26B is a version of the STAR 26 lightened by utilizing a titanium case. This weight savings has allowed increased propellant loading, resulting in extended performance. The STAR 26B was qualified in a 1970 test and was flown as an upper stage on the Burner IIA spacecraft for Boeing and the USAF beginning in 1972.



MOTOR DIMENSIONS

Motor diameter, in. 26.1
Motor length, in. 33.1

MOTOR PERFORMANCE (70°F VACUUM,

Isp based on Burner IIA flight data) ....
Burn time/action time, sec 17.8/18.6
Ignition delay time, sec 0.06
Burn time average chamber pressure, psia.......... 623
Maximum chamber pressure, psia 680
Total impulse, lbf-sec.................................... 142,760
Propellant specific impulse, lbf-sec/lbm............. 272.4
Effective specific impulse, lbf-sec/lbm 271.7
Burn time average thrust, lbf.............................. 7,784
Maximum thrust, lbf 8,751

NOZZLE

Initial throat diameter, in. 2.963
Exit diameter, in. 12.50
Expansion ratio, initial....................................... 17.8:1

WEIGHTS, LBM

Total loaded 575.6
Propellant (including 0.4 lbm igniter propellant)
.... 524.0
Case assembly 23.5
Nozzle assembly 19.3
Total inert.. 51.6
Burnout 50.3
Propellant mass fraction 0.91

TEMPERATURE LIMITS

Operation .... 50º-90°F
Storage .... 40º-100°F

PROPELLANT DESIGNATION TP-H-3114

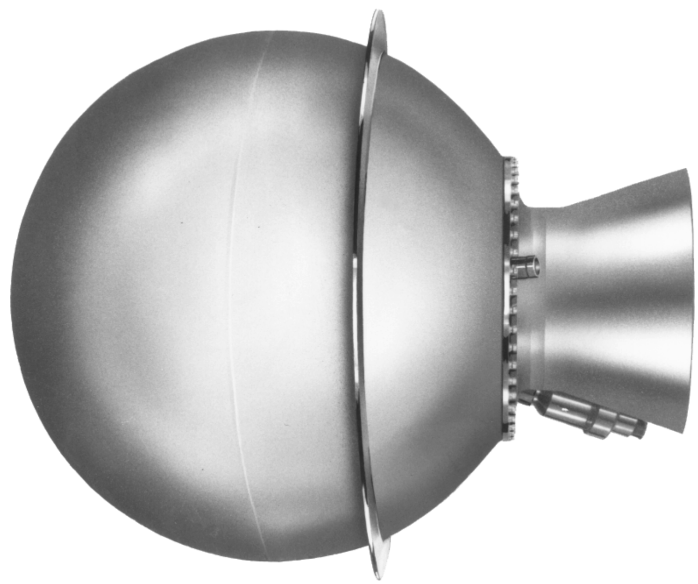
CASE MATERIAL................................ Titanium

PRODUCTION STATUS .... Flight-proven

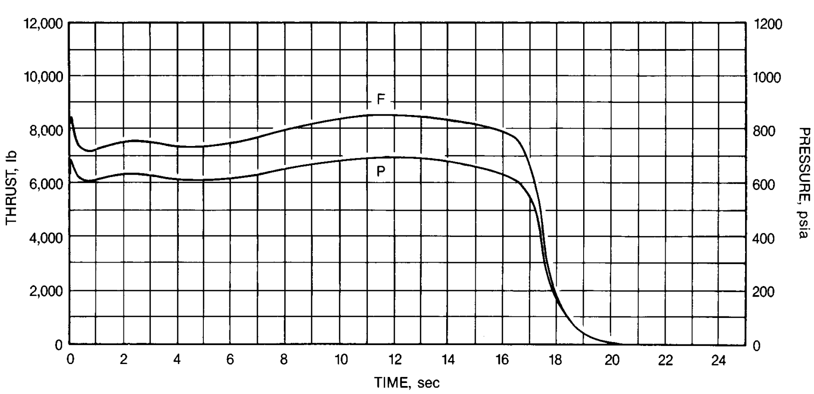
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 26C

TE-M-442-2



The STAR 26C employs the same titanium alloy case as the STAR 26B; however, the insulation is increased to accommodate high-spin-rate applications. The motor has been used as an upper stage for Sandia National Laboratories Strypi IV vehicle and for applications for the U.S. Army.



MOTOR DIMENSIONS

Motor diameter, in.	26.1
Motor length, in.	33.1

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	16.8/18.3
Ignition delay time, sec	0.06
Burn time average chamber pressure, psia	640
Maximum chamber pressure, psia	690
Total impulse, lbf-sec	139,800
Propellant specific impulse, lbf-sec/lbm	273.4
Effective specific impulse, lbf-sec/lbm	272.1
Burn time average thrust, lbf	7,870
Maximum thrust, lbf	8,600

NOZZLE

Initial throat diameter, in.	2.963
Exit diameter, in.	12.50
Expansion ratio, initial	17.8:1

WEIGHTS, LBM

Total loaded	579.0
Propellant (incluidng igniter propellant)	511.4
Case assembly	23.6
Nozzle assembly	19.8
Total inert	67.6
Burnout	65.1
Propellant mass fraction	0.88

TEMPERATURE LIMITS

Operation	50º-90°F
Storage	40º-100°F

SPIN CAPABILITY, RPM 250

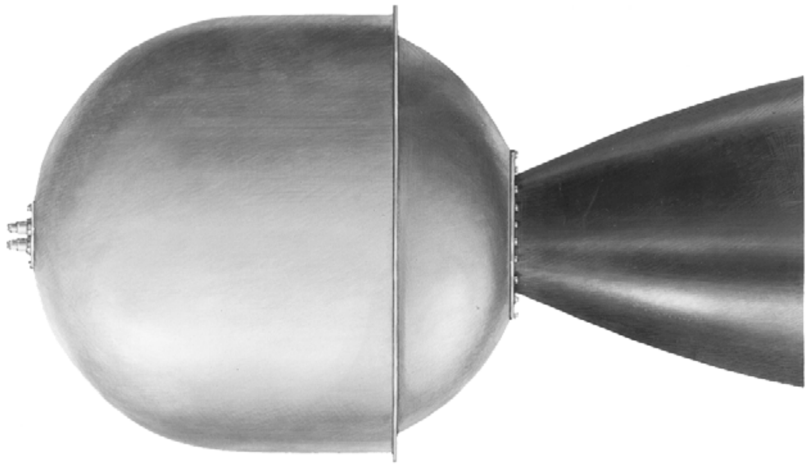
PROPELLANT DESIGNATION TP-H-3114

CASE MATERIAL .... Titanium

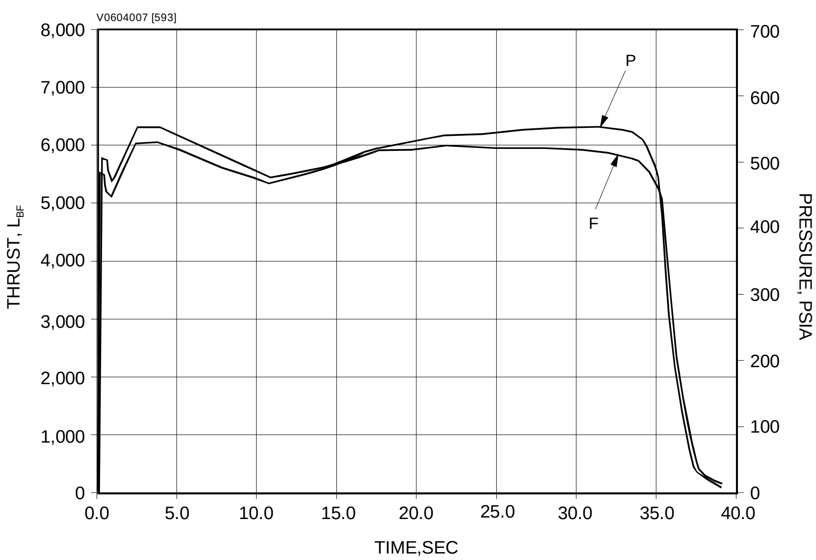
PRODUCTION STATUS .... Flight-proven

STAR 27

TE-M-616



The STAR 27 rocket motor was developed and qualified in 1975 for use as the apogee kick motor (AKM) for the Canadian Communications Research Centre's Communications Technology Satellite. With its ability to accommodate various propellant loadings (9% offload flown) and explosive transfer assemblies, it has served as the apogee kick motor for various applications. The high-performance motor utilizes a titanium case and carbon-phenolic nozzle. The motor first flew in January 1976 on Delta 119. It has flown for NAVSTAR on Atlas vehicles launched from WTR, for GOES, for the Japanese N-II vehicle from Tanagashima, and for the GMS series of weather satellites.



MOTOR DIMENSIONS

Motor diameter, in. 27.3
Motor length, in. 48.7

MOTOR PERFORMANCE (60°F VACUUM)*

Burn time/action time, sec 34.4/37.3
Ignition delay time, sec 0.076
Burn time average chamber pressure, psia 563
Maximum chamber pressure, psia 497
Total impulse, lbf-sec 213,790
Propellant specific impulse, lbf-sec/lbm 290.7
Effective specific impulse, lbf-sec/lbm 287.9
Burn time average thrust, lbf 5,720
Maximum thrust, lbf 6,340

NOZZLE

Initial throat diameter, in. 2.74
Exit diameter, in. 19.1
Expansion ratio, initial 48.8:1

WEIGHTS, LBM

Total loaded 796.2
Propellant (including 0.5 lbm igniter propellant) 735.6
Case assembly 23.6
Nozzle assembly 20.4
Total inert 60.6
Burnout 53.6
Propellant mass fraction 0.92

TEMPERATURE LIMITS

Operation .... 20 to 100°F
Storage .... 40 to 100°F

SPIN CAPABILITY, RPM 110

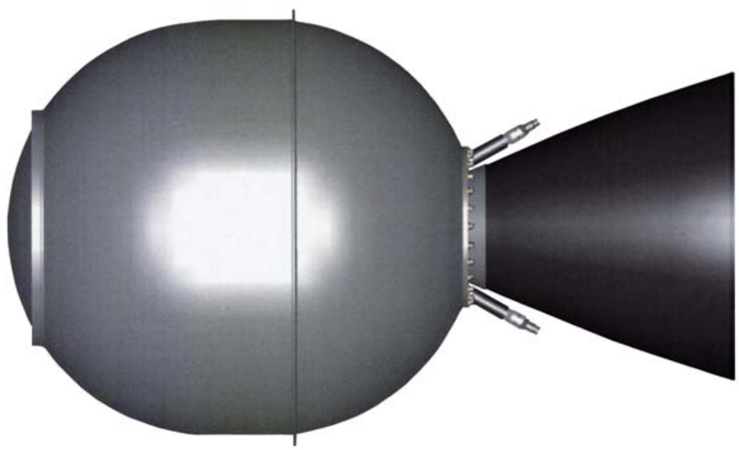
PROPELLANT DESIGNATION TP-H-3135

CASE MATERIAL .... Titanium

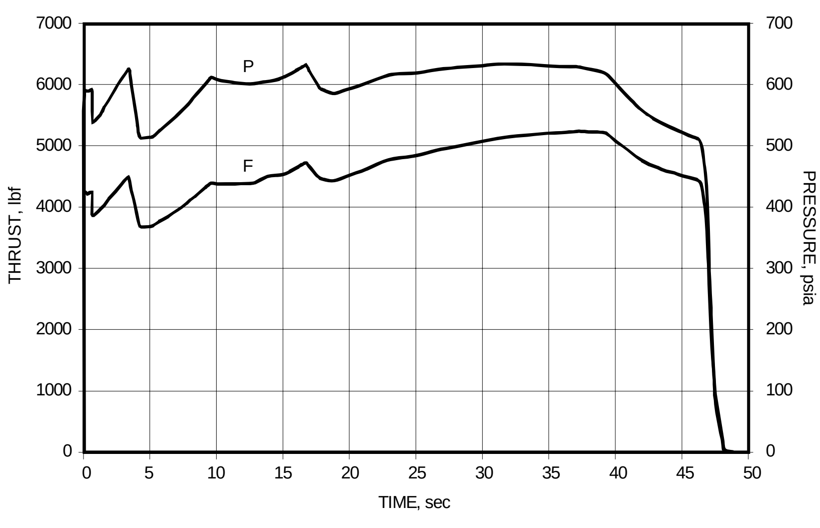
PRODUCTION STATUS .... Flight-proven

STAR 27H

TE-M-1157



The STAR 27H was developed as the apogee kick motor for NASA's Interstellar Boundary Explorer (IBEX) mission in 2006, and will complete qualification testing in July 2007. The STAR 27H is an updated version of the previously qualified STAR 27 motor and features a titanium case with forward and meridional attach flanges, and ATK's space-qualified HTPB propellant. The nozzle design, which is also used on the STAR 30C motor, incorporates a contoured nozzle with an integral toroidal igniter and carbon-phenolic exit cone and has flown on over 20 successful missions



MOTOR DIMENSIONS

Motor diameter, in. 27.3
Motor length, in. 48.0

MOTOR PERFORMANCE (70°F VACUUM)*

Burn time/action time, sec 46.3/47.3
Ignition delay time, sec 0.150
Burn time average chamber pressure, psia 596
Maximum chamber pressure, psia 633
Total impulse, lbf-sec 219,195
Propellant specific impulse, lbf-sec/lbm 294.3
Effective specific impulse, lbf-sec/lbm 291.4
Burn time average thrust, lbf 4,650
Maximum thrust, lbf 5,250

NOZZLE

Initial throat diameter, in. 2.20
Exit diameter, in. 19.89
Expansion ratio, initial 81.7:1

WEIGHTS, LBM

Total loaded 810.9
Propellant (including 0.5 lbm igniter propellant 744.8
Case assembly 21.8
Nozzle assembly 29.0
Total inert 66.1
Burnout 58.8
Propellant mass fraction 0.92

TEMPERATURE LIMITS

Operation .... 40 to 90°F
Storage .... 40 to 100°F

SPIN CAPABILITY, RPM 110

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Development

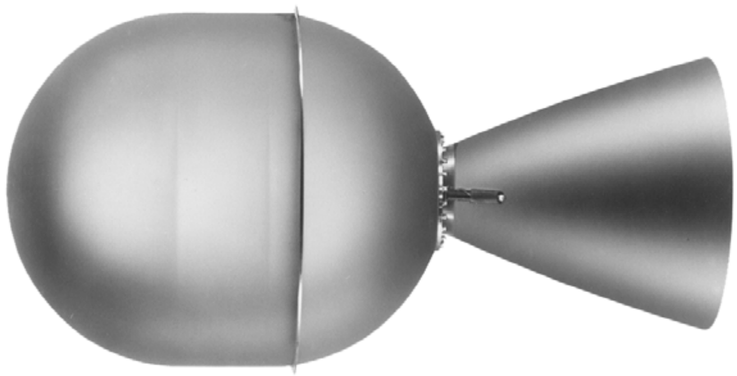
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 30 SERIES

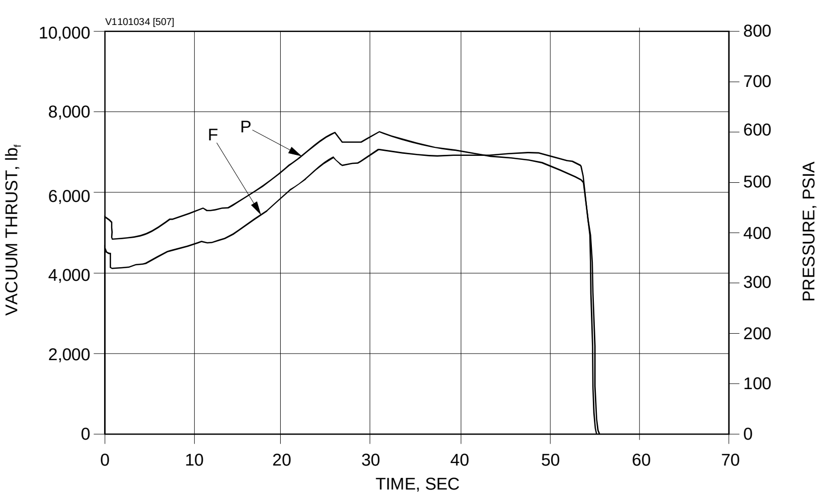
.

STAR 30BP

TE-M-700-20



The STAR 30BP rocket motor serves as the apogee kick motor (AKM) for several different satellite manufacturers such as RCA/GE/Lockheed Martin, Hughes/Boeing, and Orbital. The design incorporates an 89%-solids hydroxyl-terminated polybutadiene (HTPB) propellant in a 6Al-4V titanium case insulated with silica-filled ethylene propylene diene monomer (EPDM) rubber. This motor was the prototype for a head-end web grain design with an integral toroidal igniter incorporated into the submerged nozzle. The STAR 30BP was qualified in 1984 and has flown from Ariane, Space Shuttle, and Delta.



MOTOR DIMENSIONS

Motor diameter, in. 30.0
Motor length, in. 59.3

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 54/55
Ignition delay time, sec 0.150
Burn time average chamber pressure, psia.......... 514
Maximum chamber pressure, psia 595
Total impulse, lbf-sec.................................... 328,455
Propellant specific impulse, lbf-sec/lbm............. 294.9
Effective specific impulse, lbf-sec/lbm 292.3
Burn time average thrust, lbf.............................. 5,985
Maximum average thrust, lbf 6,945

NOZZLE

Initial throat diameter, in. 2.68
Exit diameter, in. 23.0
Expansion ratio, initial 73.7:1

WEIGHTS, LBM ....

Total loaded*... 1,196.7
Propellant (including 0.6 lbm
igniter propellant) 1,113.6
Case assembly 30.5
Nozzle/igniter assembly
(excluding igniter propellant)............................... 33.8
Total inert* 83.1
Burnout* 72.4
Propellant mass fraction*.................................... 0.93
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation .... 40º-90°F
Storage .... 40º-100°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL..................................... Titanium

PRODUCTION STATUS.................. Flight-proven

Note: Design has been ground tested with a 20% offload

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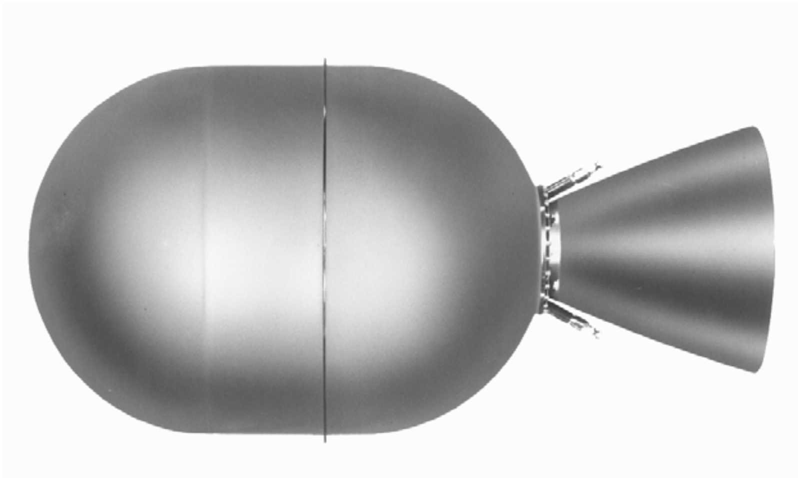
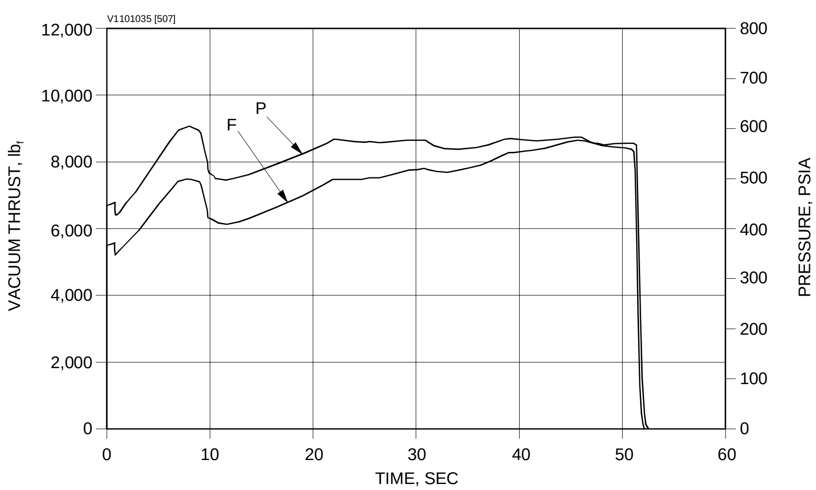
STAR 30C

TE-M-700-18



The STAR 30C was qualified in 1985 as an apogee kick motor for the RCA/GE/Lockheed Martin Series 3000 satellites. It currently serves on the Hughes/Boeing Satellite Systems HS-376 spacecraft. The case design incorporates an elongated cylindrical section, making the case 5 in. longer than the STAR 30BP case. Like the STAR 30BP, the STAR 30C uses an 89%-solids HTPB propellant in a 6Al-4V titanium case insulated with silica-filled EPDM rubber. It has a contoured nozzle with an integral toroidal igniter and a carbon-phenolic exit cone. However, the nozzle is truncated 5 in. to maintain nearly the same overall length as the STAR 30BP. The STAR 30C has flown since 1985 from the Space Shuttle, Ariane, Long March, and Delta.



MOTOR DIMENSIONS

Motor diameter, in. 30.0
Motor length, in. 58.8

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 51/52
Ignition delay time, sec 0.15
Burn time average chamber pressure, psia.......... 552
Maximum chamber pressure, psia 604
Total impulse, lbf-sec.................................... 376,095
Propellant specific impulse, lbf-sec/lbm............. 288.8
Effective specific impulse, lbf-sec/lbm 286.4
Burn time average thrust, lbf.............................. 7,300
Maximum thrust, lbf 8,450

NOZZLE

Initial throat diameter, in. 2.89
Exit diameter, in. 19.7
Expansion ratio, initial...................................... 46.4:1

WEIGHTS, LBM

Total loaded*... 1,389.3
Propellant (including igniter propellant)
.... 1,302.5
Case assembly 35.7
Nozzle/igniter assembly
(excluding igniter propellant)......................................
Total inert* 84.8
Burnout* 74.2
Propellant mass fraction*.................................... 0.94
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation .... 40º-90°F
Storage .... 40º-100°F

SPIN EXPERIENCE, RPM........................... 100

PROPELLANT DESIGNATION TP-H-3340

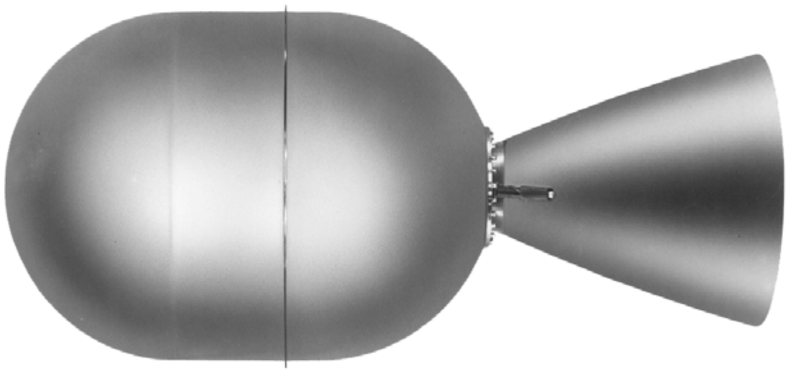
CASE MATERIAL .... Titanium

PRODUCTION STATUS............... Flight-proven

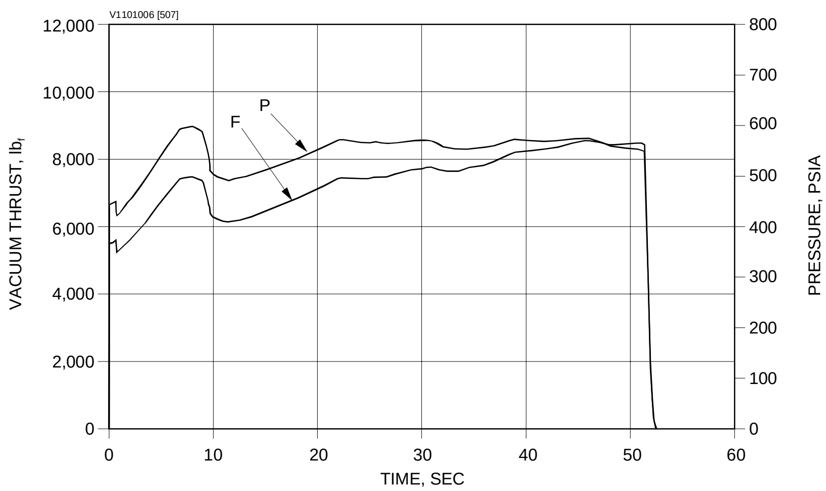
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 3OC/BP

TE-M-700-25



The STAR 30C/BP rocket motor combines the flight-qualified STAR 30C motor case with the same flight-qualified nozzle assembly as the STAR 30BP and STAR 30E motors. No ground qualification test was performed before the first flight. This combination increases the overall motor length and improves the delivered I_{sp}. The STAR 30C/BP has flown on the Hughes/BSS HS-376 and Orbital Sciences Start-1 Bus satellites. The design incorporates an 89%-solids HTPB propellant in a 6Al-4V titanium case insulated with silica-filled EPDM rubber. It has a contoured nozzle with an integral toroidal igniter and a carbon-phenolic exit cone.



MOTOR DIMENSIONS

Motor diameter, in. 30.0
Motor length, in. 64.3

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 51/52
Ignition delay time, sec 0.08
Burn time average chamber pressure, psia 552
Maximum chamber pressure, psia 604
Total impulse, lbf-sec 383,270
Propellant specific impulse, lbf-sec/lbm 294.2
Effective specific impulse, lbf-sec/lbm 291.8
Burn time average thrust, lbf 7,400
Maximum thrust, lbf 8,550

NOZZLE

Initial throat diameter, in. 2.89
Exit diameter, in. 23.0
Expansion ratio, initial/average 63.2:1

WEIGHTS, LBM ....

Total loaded* 1,393.6
Propellant (including 0.6 lbm igniter propellant) 1,302.5
Case assembly 35.7
Nozzle/igniter assembly (including igniter propellant) 34.5
Total inert* 90.6
Burnout* 79.6
Propellant mass fraction* 0.93
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation .... 40º-90°F
Storage .... 40º-100°F

SPIN EXPERIENCE, RPM 100

PROPELLANT DESIGNATION TP-H-3340

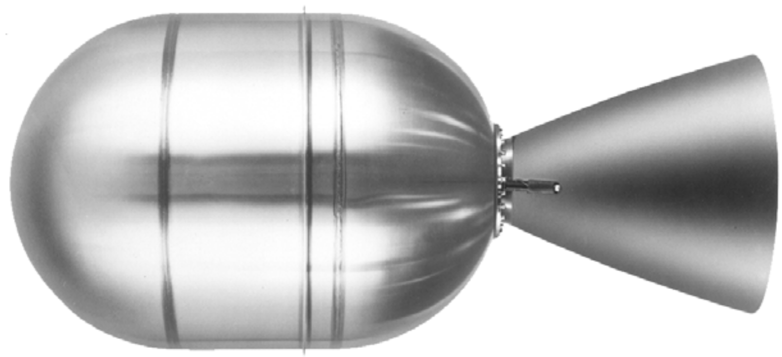
CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

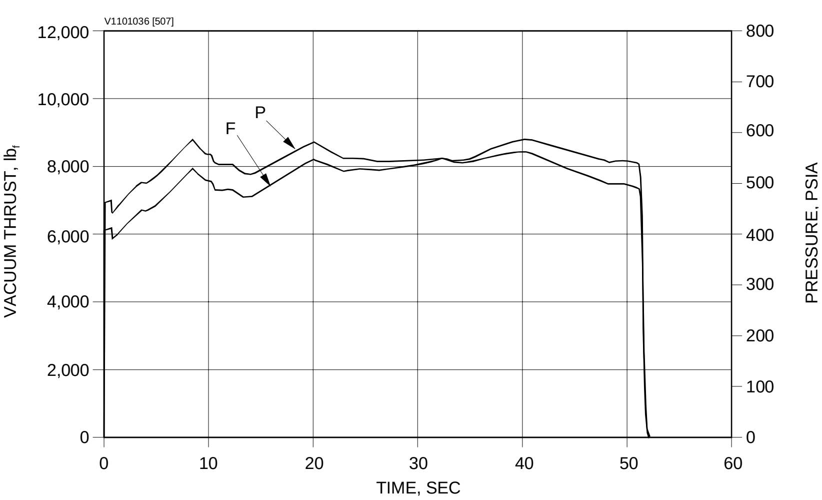
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 30E

TE-M-700-19



The STAR 30E serves as an apogee kick motor (AKM). Qualified in December 1985, the design incorporates a case cylinder 7 in. longer than the STAR 30BP and a nozzle assembly with the same length exit cone as the STAR 30BP. It utilizes an 89%-solids HTPB propellant in a 6Al-4V titanium case insulated with silica-filled EPDM rubber. It has a contoured nozzle with an integral toroidal igniter and a carbon-phenolic exit cone. The STAR 30E first flew as an AKM for Skynet in a December 1988 launch from Ariane.



MOTOR DIMENSIONS

Motor diameter, in. 30.0
Motor length, in. 66.3

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 51.1/51.8
Ignition delay time, sec 0.20
Burn time average chamber pressure, psia 537
Maximum chamber pressure, psia 590
Total impulse, lbf-sec 407,550
Propellant specific impulse, lbf-sec/lbm 292.8
Effective specific impulse, lbf-sec/lbm 290.4
Burn time average thrust, lbf 7,900
Maximum thrust, lbf 8,850

NOZZLE

Initial throat diameter, in. 3.0
Exit diameter, in. 23.0
Expansion ratio, initial 58.6:1

WEIGHTS, LBM

Total loaded* 1,485.7
Propellant (including 0.6 lbm igniter propellant) 1,392.0
Case assembly 37.9
Nozzle/igniter assembly (excluding igniter propellant) 33.6
Total inert* 93.7
Burnout* 82.5
Propellant mass fraction* 0.93
*Excluding remote S&A/TA

TEMPERATURE LIMITS

Operation .... 40º-90°F
Storage .... 40º-100°F

SPIN EXPERIENCE, RPM 100

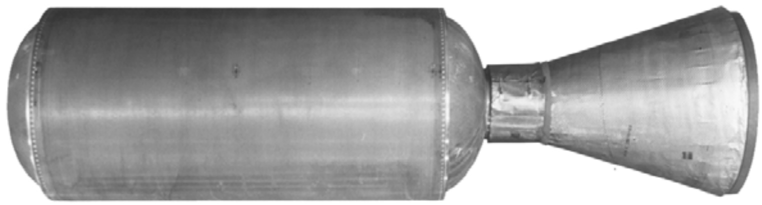
PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Titanium

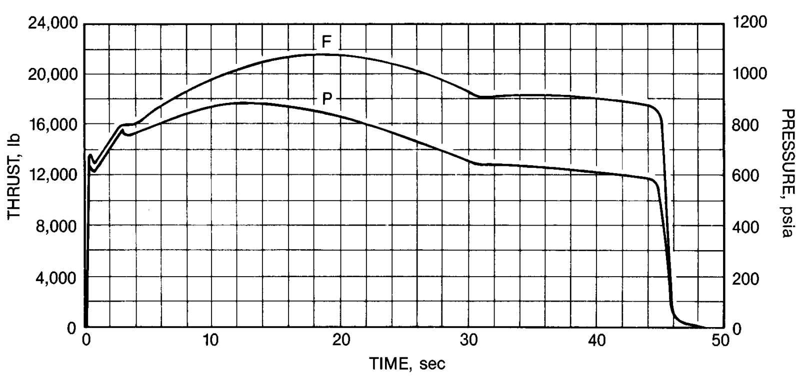
PRODUCTION STATUS .... Flight-proven

STAR 31 AND 37 SERIES

STAR 31 TE-M-762



The STAR 31 Antares III is a third-stage rocket motor developed and qualified (1978-1979) for Vought Corporation's Scout launch vehicle. The design incorporates an 89%-solids HTPB propellant in a Kevlar® filament-wound case insulated with silica-filled EPDM rubber. The STAR 31 first flew from the WTR in October 1979 to launch the MAGSAT satellite.



MOTOR DIMENSIONS

Motor diameter, in. 30.1
Motor length, in. 113

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 45/46
Ignition delay time, sec 0.14
Burn time average chamber pressure, psia.......... 712
Maximum chamber pressure, psia 865
Total impulse, lbf-sec.................................... 840,000
Propellant specific impulse, lbf-sec/lbm............. 296.3
Effective specific impulse, lbf-sec/lbm 293.5
Burn time average thrust, lbf............................ 18,500
Maximum thrust, lbf 21,500

NOZZLE

Initial throat diameter, in. 3.74
Exit diameter, in. 28.67
Expansion ratio, initial... 58:1

WEIGHTS, LBM

Total loaded 3,072
Propellant (including igniter propellant) 2,835
Case assembly 92
Nozzle assembly 65.5
Total inert... 237
Burnout 210
Propellant mass fraction 0.92/0.93
(with/without external insulation)

TEMPERATURE LIMITS

Operation .... 40°-90°F
Storage .... 20°-100°F

PROPELLANT DESIGNATION TP-H-3340

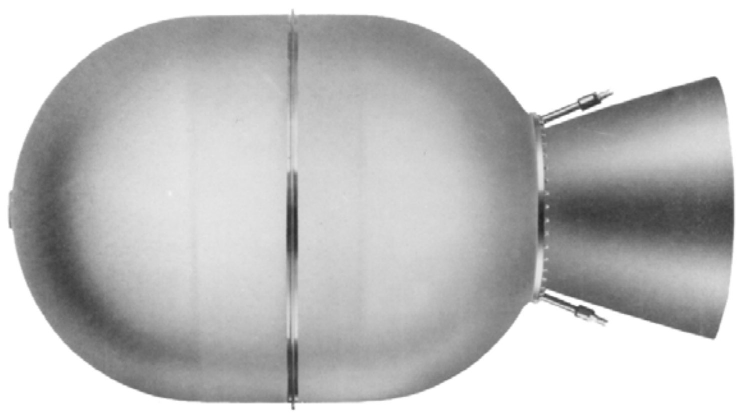
CASE MATERIAL............. Kevlar-epoxy composite

PRODUCTION STATUS...............Flight-proven

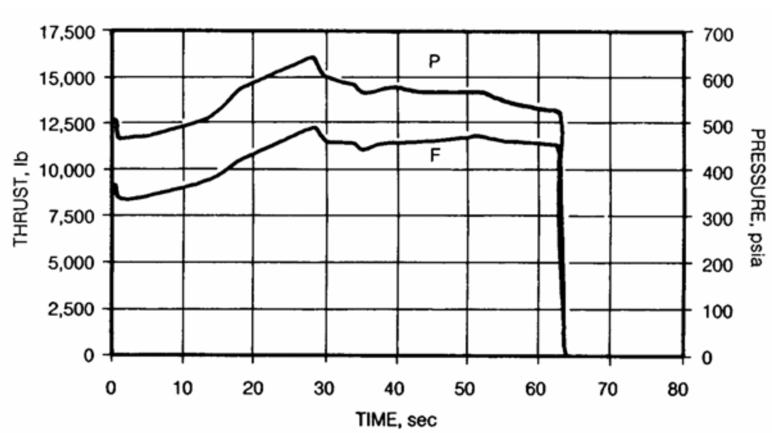
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 37FM

TE-M-783



The STAR 37FM rocket motor was developed and qualified (1984) for use as an apogee kick motor on TRW FLTSATCOM, NASA ACTS, GE/LM, and GPS Block IIR satellites and serves as the third stage on Boeing's Delta II Med-Lite launch vehicle. The motor design features a titanium case, a 3-D carbon-carbon throat, and a carbon-phenolic exit cone. The first flight of the STAR 37FM occurred in 1986.



MOTOR DIMENSIONS

Motor diameter, in.	36.8
Motor length, in.	66.5

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	62.7/64.1
Ignition delay time, sec	0.13
Burn time average chamber pressure, psia	540
Maximum chamber pressure, psia	642
Total impulse, lbf-sec	685,970
Propellant specific impulse, lbf-sec/lbm	291.9
Effective specific impulse, lbf-sec/lbm	289.8
Burn time average thrust, lbf	10,625
Maximum thrust, lbf	12,320

NOZZLE

Initial throat diameter, in.	3.52
Exit diameter, in.	24.45
Expansion ratio, initial	48.2:1

WEIGHTS, LBM

Total loaded*	2,530.8
Propellant (including igniter propellant)	2,350.1
Case assembly	71.1
Nozzle assembly/igniter assembly (excluding igniter propellant)	75.0
Total inert	180.1
Burnout*	162.5
Propellant mass fraction	0.93

*Excluding ETA lines and S&A

TEMPERATURE LIMITS

Operation	20°-110°F
Storage	40°-110°F

SPIN EXPERIENCE, RPM 60

PROPELLANT DESIGNATION TP-H-3340

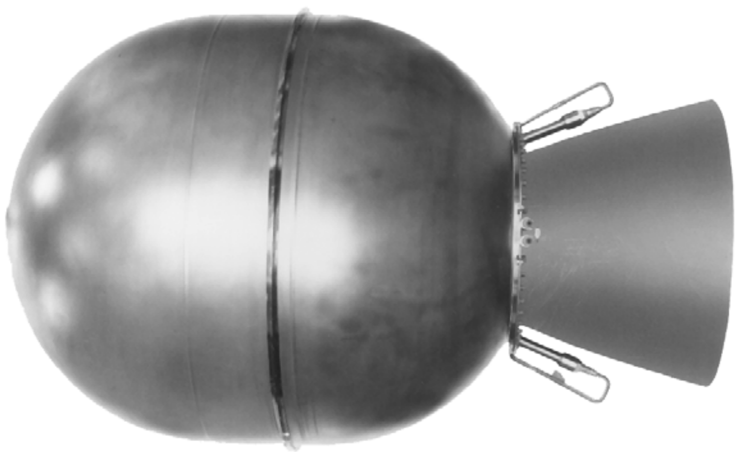
CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

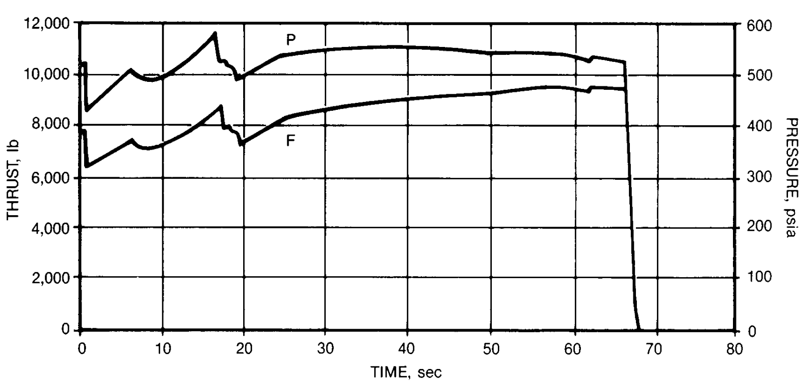
Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 37XFP

TE-M-714-16/-17



The STAR 37XFP was qualified (1984) as an insertion motor for the Rockwell/Boeing Global Positioning System Block II as well as LEO orbit insertion for RCA/GE/LM TIROS and DMSP and as an apogee motor for RCA/GE/LM series-4000 satellites. It features a titanium case, 3-D carbon-carbon throat, carbon-phenolic exit cone, and a head-end web grain design. This motor first flew from the Space Shuttle as an AKM for SATCOM in 1985 and has also been launched from Ariane and Delta launch vehicles.



MOTOR DIMENSIONS

Motor diameter, in. 36.7
Motor length, in. 59.2

MOTOR PERFORMANCE (55°F VACUUM)

Burn time/action time, sec 66/67
Ignition delay time, sec 0.12
Burn time average chamber pressure, psia 527
Maximum chamber pressure, psia 576
Total impulse, lbf-sec 570,040
Propellant specific impulse, lbf-sec/lbm 292.6
Effective specific impulse, lbf-sec/lbm 290.0
Burn time average thrust, lbf 8,550
Maximum thrust, lbf 9,550

NOZZLE

Initial throat diameter, in. 3.18
Exit diameter, in. 23.51
Expansion ratio, initial 54.8:1

WEIGHTS, LBM ....

Total loaded 2.55
Propellant 1.06
Case assembly 0.40
Nozzle assembly 0.58
Total inert 1.49
Burnout 1.49
Propellant mass fraction 0.42

TEMPERATURE LIMITS

Operation .... -40°-104°F
Storage .... -65°-140°F

PROPELLANT DESIGNATION TP-H-3498

CASE MATERIAL .... Titanium

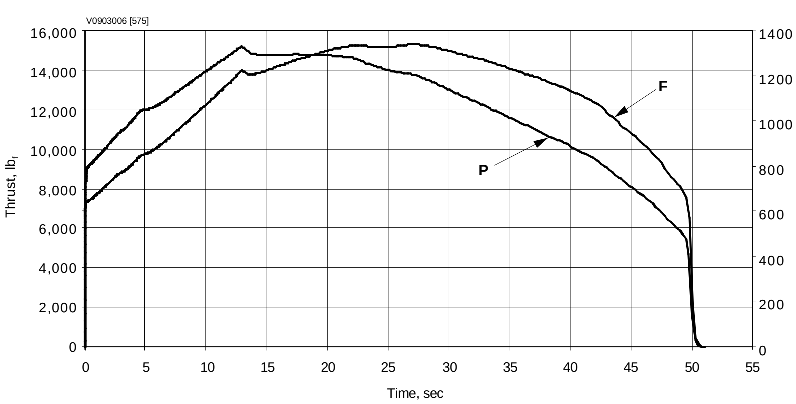
PRODUCTION STATUS .... Flight-proven

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 37GV

TE-M-1007-1

The STAR 37GV composite case rocket motor was designed to provide increased specific impulse and reduced inert mass to achieve a high mass fraction. It incorporates an electro-mechanical flexseal thrust vector control (TVC) system that provides ±4 deg vectorability using electromechanical actuators. Mid-cylinder, head end, aft end, or custom skirts can be implemented easily to meet specific interface requirements. The STAR 37GV was demonstrated in a successful December 1998 static firing.



MOTOR DIMENSIONS

Motor diameter, in.	35.2
Motor length, in.	66.2

MOTOR PERFORMANCE (70°F, VACUUM)**

Burn time/action time, sec	49.0/50.2
Ignition delay time, sec	0.16
Burn time average chamber pressure, psia	1,050
Maximum chamber pressure, psia	1,350
Total impulse, lbf-sec	634,760
Propellant specific impulse, lbf-sec/lbm	295.5
Effective specific impulse, lbf-sec/lbm	293.5
Burn time average thrust, lbf	12,800
Maximum thrust, lbf	15,250

NOZZLE

Initial throat diameter, in.	2.5
Exit diameter, in.	23.4
Expansion ratio, initial	88.2:1
Type	Vectorable, ±4 deg

WEIGHTS, LBM*

Total loaded	2,391
Propellant	2,148
Case assembly	153.5
Nozzle assembly	75.6
Total inert	243.0
Burnout	228.6
Propellant mass fraction	0.90

TEMPERATURE LIMITS

Operation	40°- 90°F
Storage	40°-100°F

PROPELLANT DESIGNATION........... TP-H-3340

CASE MATERIAL..........Graphite-epoxy composite

PRODUCTION STATUS................. Development

* Weights do not include TVA system hardware (actuators, brackets, controller, etc.) and reflect test motor configuration

** Motor performance reflects test motor configuration. By optimizing the case design and increasing the operating pressure, we estimate that the flightweight motor will result in a 15% performance increase

STAR 48 SERIES

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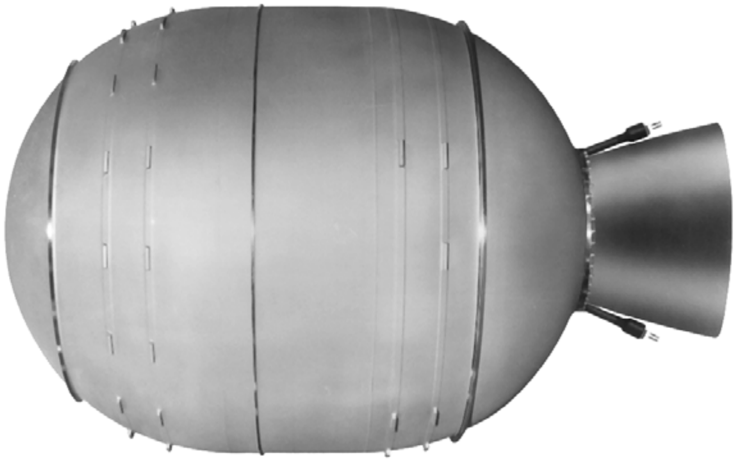
STAR 48A

TE-M-799-1

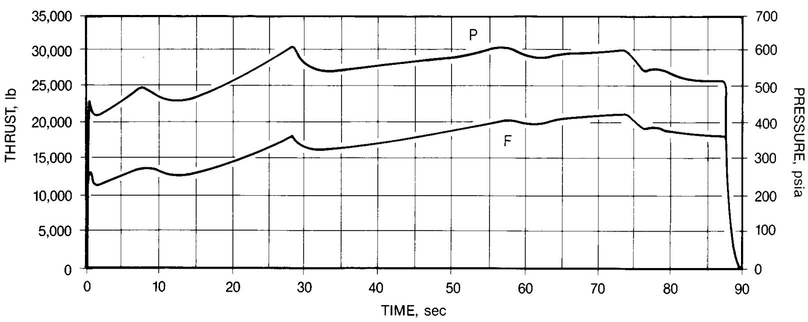


SHORT NOZZLE

The STAR 48A motor was designed and tested in 1984 as an increased payload capability version of the basic STAR 48 by incorporating an 8-in. stretch of the motor case. The short nozzle version is designed to fit within the same 80-in. envelope as the long nozzle versions of the STAR 48 and 48B.

The design uses a high-energy propellant and high-strength titanium case. The submerged nozzle uses a carbon-phenolic exit cone and a 3-D carbon-carbon throat.

The case features forward and aft mounting flanges and multiple tabs for attaching external hardware that can be relocated or modified for varying applications without requalification.



MOTOR DIMENSIONS

Motor diameter, in. 49.0
Motor length, in. 80.0

MOTOR PERFORMANCE (75°F VACUUM)**

Burn time/action time, sec 87.2/88.2
Ignition delay time, sec 0.100
Burn time average chamber pressure, psia..........543
Maximum chamber pressure, psia 607
Total impulse, lbf-sec.................................1,528,400
Propellant specific impulse, lbf-sec/lbm.............285.3
Effective specific impulse, lbf-sec/lbm 283.4
Burn time average thrust, lbf............................17,350
Maximum thrust, lbf 21,150

NOZZLE

Initial throat diameter, in. 4.49
Exit diameter, in. 25.06
Expansion ratio, initial.......................................31.2:1

WEIGHTS, LBM

Total loaded*..5,673.7
Propellant (including igniter propellant) 5,357.2
Case assembly 153.6
Nozzle assembly (excluding igniter propellant) ...84.4
Total inert..316.5
Burnout*..280.0
Propellant mass fraction*.....................................0.94
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation ....30°-100°F
Storage ....30°-100°F

SPIN EXPERIENCE, RPM 80

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL.....................................Titanium

**Calculated thrust and impulse based on static test data.

STAR 48A

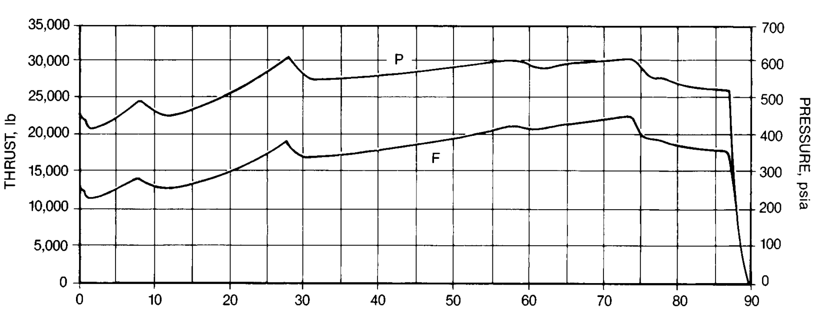
TE-M-799

LONG NOZZLE

The STAR 48A motor is designed as an increased payload capability version of the basic STAR 48 by incorporating an 8-in. stretch of the motor case. The long nozzle version maximizes performance by also incorporating an 8-in. longer exit cone, resulting in a longer overall envelope.

The design uses a high-energy propellant and high-strength titanium case. The submerged nozzle uses a carbon-phenolic exit cone and a 3-D carbon-carbon throat.

The case features forward and aft mounting flanges and multiple tabs for attaching external hardware that can be relocated or modified for varying applications without requalification.



MOTOR DIMENSIONS

Motor diameter, in. 49.0
Motor length, in. 88.0

MOTOR PERFORMANCE (75°F VACUUM)

Burn time/action time, sec 87.2/88.2
Ignition delay time, sec 0.100
Burn time average chamber pressure, psia....543
Maximum chamber pressure, psia 607
Total impulse, lbf-sec....1,563,760
Propellant specific impulse, lbf-sec/lbm....291.9
Effective specific impulse, lbf-sec/lbm....289.9
Burn time average thrust, lbf....17,750
Maximum thrust, lbf 21,650

NOZZLE

Initial throat diameter, in. 4.49
Exit diameter, in. 29.5
Expansion ratio, initial....43.1:1

WEIGHTS, LBM

Total loaded*....5,691.1
Propellant (including igniter propellant) 5,357.2
Case assembly 153.6
Nozzle assembly (excluding igniter propellant) .101.8
Total inert....333.9
Burnout*....294.3
Propellant mass fraction*....0.94
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation....30°-100°F
Storage ....30°-100°F

SPIN EXPERIENCE, RPM 80

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL....Titanium

PRODUCTION STATUS.... Development

STAR 48B

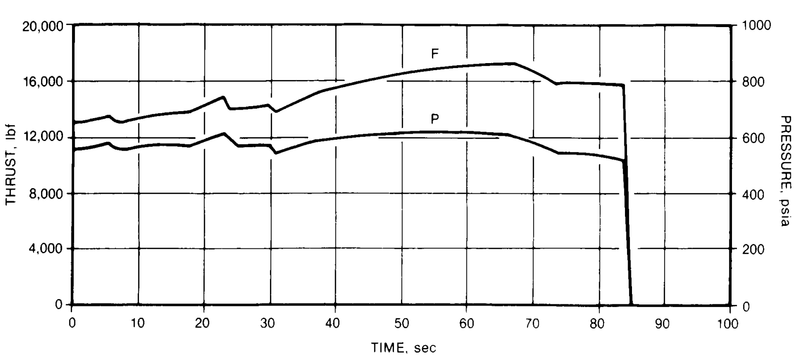
TE-M-711-17

SHORT NOZZLE

The short nozzle STAR 48B was qualified in 1984 as a replacement for the short nozzle STAR 48 used on the Space Shuttle Payload Assist Module (PAM). The short nozzle configuration first flew from the Space Shuttle in June 1985 for ARABSAT.

The design uses a high-energy propellant and high-strength titanium case. The submerged nozzle uses a carbon-phenolic exit cone and a 3-D carbon-carbon throat.

The case features forward and aft mounting flanges and multiple tabs for attaching external hardware that can be relocated or modified for varying applications without requalification.



MOTOR DIMENSIONS

Motor diameter, in. 49.0
Motor length, in. 72.0

MOTOR PERFORMANCE (75°F VACUUM)

Burn time/action time, sec 84.1/85.2
Ignition delay time, sec 0.100
Burn time average chamber pressure, psia 579
Maximum chamber pressure, psia 618
Total impulse, lbf-sec 1,275,740
Propellant specific impulse, lbf-sec/lbm 287.9
Effective specific impulse, lbf-sec/lbm 286.0
Burn time average thrust, lbf 15,100
Maximum thrust, lbf 17,110

NOZZLE

Initial throat diameter, in. 3.98
Exit diameter, in. 25.06
Expansion ratio, initial 39.6:1

WEIGHTS, LBM

Total loaded* 4,705.4
Propellant (including igniter propellant) 4,431.2
Case assembly 128.5
Nozzle assembly (excluding igniter propellant) 81.2
Total inert* 274.2
Burnout* 245.4
Propellant mass fraction* 0.94
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation .... 30°-100°F
Storage .... 30°100°F

SPIN EXPERIENCE, RPM 80

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Flight-proven

STAR 48B

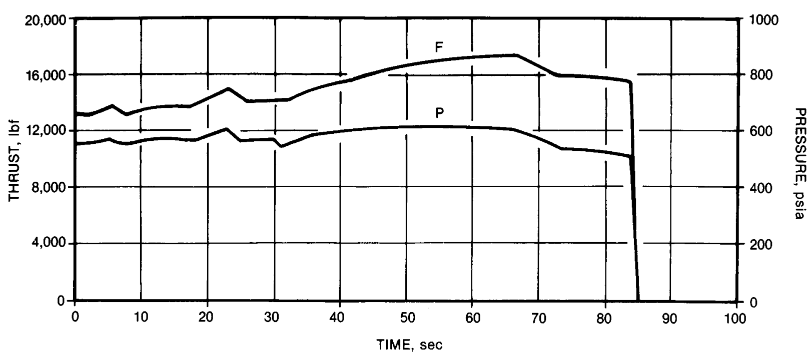
TE-M-711-18

LONG NOZZLE

The long nozzle STAR 48B was qualified in 1984 as a replacement for the long nozzle STAR 48 for the Delta II launch vehicle third stage Payload Assist Module (PAM)-Delta. The long nozzle version first flew in June 1985 from the Space Shuttle to place the Morelos satellite in orbit.

The design uses a high-energy propellant and high-strength titanium case. The submerged nozzle uses a carbon-phenolic exit cone and a 3-D carbon-carbon throat.

The case features forward and aft mounting flanges and multiple tabs for attaching external hardware that can be relocated or modified for varying applications without requalification.



MOTOR DIMENSIONS

Motor diameter, in. 49.0
Motor length, in. 80.0

MOTOR PERFORMANCE (75°F VACUUM)

Burn time/action time, sec 84.1/85.2
Ignition delay time, sec 0.100
Burn time average chamber pressure, psia 579
Maximum chamber pressure, psia 618
Total impulse, lbf-sec 1,303,700
Propellant specific impulse, lbf-sec/lbm 294.2
Effective specific impulse, lbf-sec/lbm 292.1
Burn time average thrust, lbf 15,430
Maximum thrust, lbf 17,490

NOZZLE

Initial throat diameter, in. 3.98
Exit diameter, in. 29.5
Expansion ratio, initial 54.8:1

WEIGHTS, LBM

Total loaded 4,720.8
Propellant (including igniter propellant) 4,431.2
Case assembly 128.5
Nozzle assembly (excluding igniter propellant) 96.6
Total inert* 289.6
Burnout* 257.8
Propellant mass fraction* 0.94
*Excluding remote S&A/ETA

TEMPERATURE LIMITS

Operation .... 30°-100°F
Storage .... 30°-100°F

SPIN EXPERIENCE, RPM 80

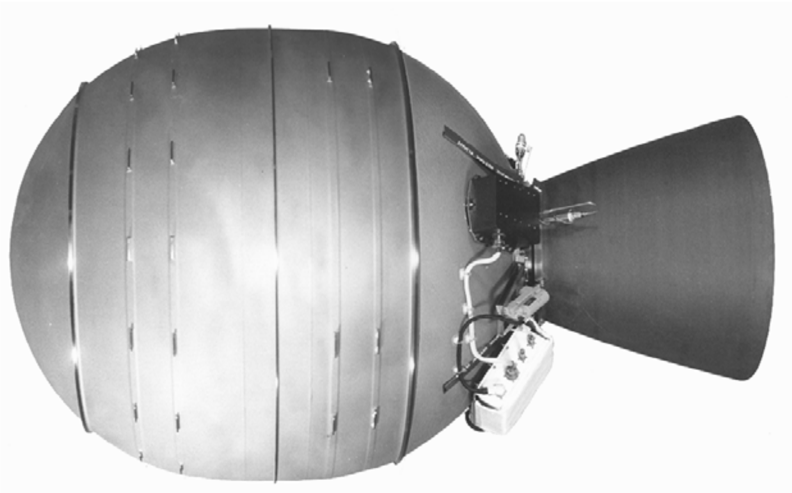
PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Titanium

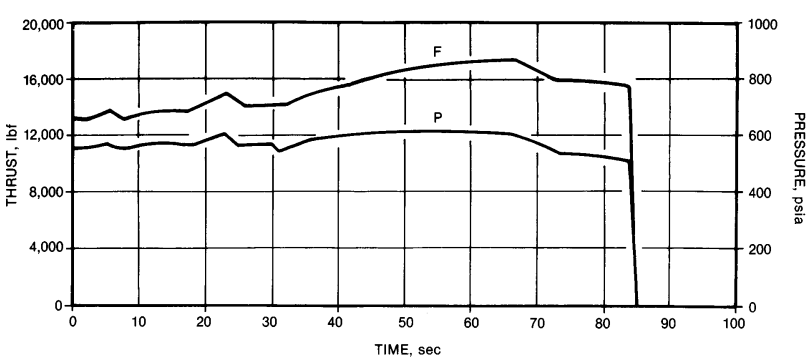
PRODUCTION STATUS .... Flight-proven

STAR 48V

TE-M-940-1



The STAR 48V has been qualified (1993) as an upper stage for EER System's Conestoga Vehicle. The STAR 48V is derived from the highly successful STAR 48B (TE-M-711 series) rocket motor. The STAR 48V provides the same range of total impulse as the STAR 48B with the long exit cone and includes an electromechanically actuated flexseal nozzle thrust vector control system for use on a nonspinning spacecraft. Case attachment features can be modified or relocated for varying applications without requalification.



MOTOR DIMENSIONS

Motor diameter, in. 49.0
Motor length, in. 81.7

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 84.1/85.2
Ignition delay time, sec 0.100
Burn time average chamber pressure, psia 579
Maximum chamber pressure, psia 618
Total impulse, lbf-sec 1,303,700
Propellant specific impulse, lbf-sec/lbm 294.2
Effective specific impulse, lbf-sec/lbm 292.1
Burn time average thrust, lbf 15,430
Maximum thrust, lbf 17,490

NOZZLE

Initial throat diameter, in. 3.98
Exit diameter, in. 29.43
Expansion ratio, initial 54.8:1
Type .... Vectorable, ±4 deg

WEIGHTS, LBM

Total loaded 4,772.0
Propellant 4,431.2
Case assembly 128.5
Nozzle assembly 116
Total inert 339.8
Burnout 305.5
Propellant mass fraction 0.93

TEMPERATURE LIMITS

Operation .... 30°-100°F
Storage .... 30°-100°F

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Titanium

PRODUCTION STATUS .... Qualified

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 63 SERIES

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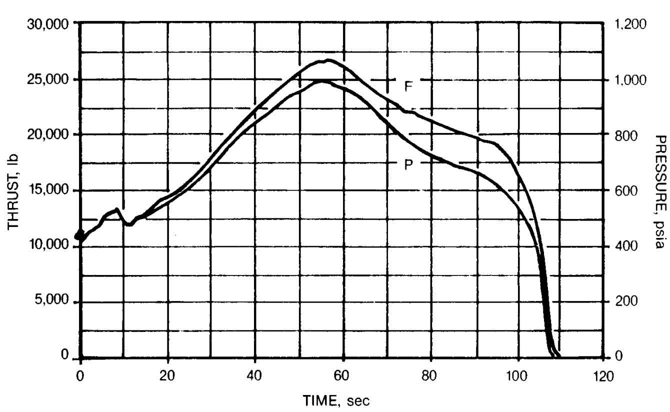
STAR 63D

TE-M-936

The STAR 63, as part of the PAM DII upper stage, has been flown from the Space Shuttle. The motor utilizes a head-end web and a carbon-phenolic nozzle. The case material is a Kevlar-epoxy composite, through future motors would be made using a graphite-epoxy composite. Testing of STAR 63 series motors began in 1978 with completion of the PAM DII motor qualification in 1985. The first STAR 63D flight was from the Shuttle in November 1985 to place a defense communication satellite in orbit.

The motor derives its heritage from the Advanced Space Propellant Demonstration (ASPD) and the Improved-Performance Space Motor II (IPSM) programs. On the ASPD program, a delivered I_{sp} of over 314 lb_f-sec/lb_m was demonstrated at AEDC. On the IPSM II program, a dual-extending exit cone with gas-deployed skirt was demonstrated at AEDC.

In 1994, an 8-year-old STAR 63D motor was tested with a flexseal nozzle. Designated the STAR 63DV, the motor successfully demonstrated performance of the 5-deg TVC nozzle and electromechanical actuation system.



MOTOR DIMENSIONS

Motor diameter, in.	63.0
Motor length, in.	70.0

MOTOR PERFORMANCE (77°F VACUUM)

Action time, sec	108
Ignition delay time, sec	0.300
Action time average chamber pressure, psia	607
Maximum chamber pressure, psia	957
Total impulse, lbf-sec	2,042,450
Propellant specific impulse, lbf-sec/lbm	285.0
Effective specific impulse, lbf-sec/lbm	283.0
Action time average thrust, lbf	19,050
Maximum thrust, lbf	26,710

NOZZLE

Initial throat diameter, in.	4.174
Exit diameter, in.	21.82
Expansion ratio, initial	27.3:1

WEIGHTS, LBM

Total loaded	7,716.0
Propellant (including igniter propellant)	7,166.5
Case assembly	233.5
Nozzle assembly	134.0
Total inert	550.0
Burnout	508.0
Propellant mass fraction	0.93

TEMPERATURE LIMITS

Operation	30°-100°F
Storage	30°-100°F

SPIN EXPERIENCE, RPM 85

PROPELLANT DESIGNATION TP-H-1202

CASE MATERIAL...........Kevlar-Epoxy Composite*

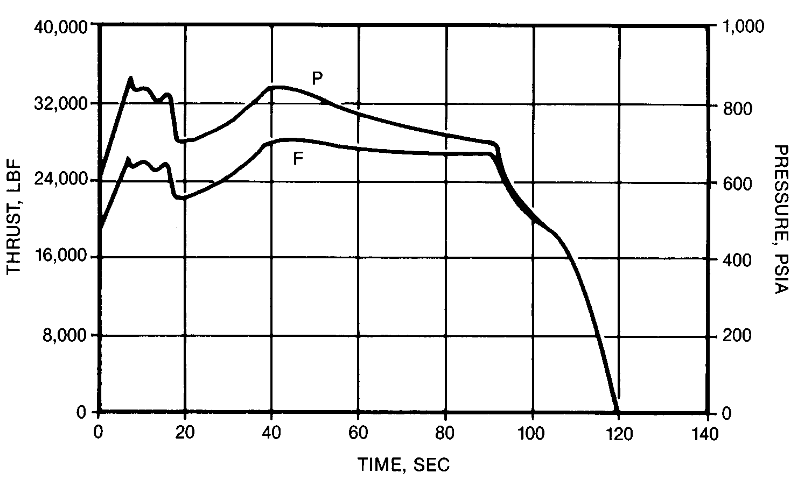
PRODUCTION STATUS..................Flight-proven

*To be replaced with a graphite composite

STAR 63F

TE-M-963-2

The STAR 63F successfully completed qualification in 1990. It has been utilized as a stage for the Long March launch vehicle. The motor is an extended-case version of the STAR 63D to increase the propellant weight. With the addition of a larger nozzle, the STAR 63F delivers nearly a 300 lb_f-sec/lb_m specific impulse. Like the STAR 63D, the motor case material was qualified with Kevlar-epoxy composite and requires a change to graphite-epoxy composite.



MOTOR DIMENSIONS

Motor diameter, in. 63.1
Motor length, in. 106.7

MOTOR PERFORMANCE (70°F VACUUM)

Action time, sec 120
Ignition delay time, sec 0.335
Action time average chamber pressure, psia 680
Maximum chamber pressure, psia 874
Total impulse, lbf-sec....2,816,700
Propellant specific impulse, lbf-sec/lbm....299.6
Effective specific impulse, lbf-sec/lbm....297.1
Action time average thrust, lbf....23,520
Maximum thrust, lbf 28,160

NOZZLE

Initial throat diameter, in. 4.45
Exit diameter, in. 39.4
Expansion ratio, initial....78.4:1

WEIGHTS, LBM

Total loaded....10,122.9
Propellant (including igniter propellant) 9,401.6
Case assembly 283.3
Nozzle assembly 211.4
Total inert....721.3
Burnout 643.3
Propellant mass fraction 0.93

TEMPERATURE LIMITS

Operation....35°-95°F
Storage ....35°-95°F

SPIN EXPERIENCE, RPM 85

PROPELLANT DESIGNATION TP-H-1202

CASE MATERIAL....Kevlar-epoxy composite*

PRODUCTION STATUS....Flight-proven

*To be replaced with a graphite composite

STAR 75 SERIES

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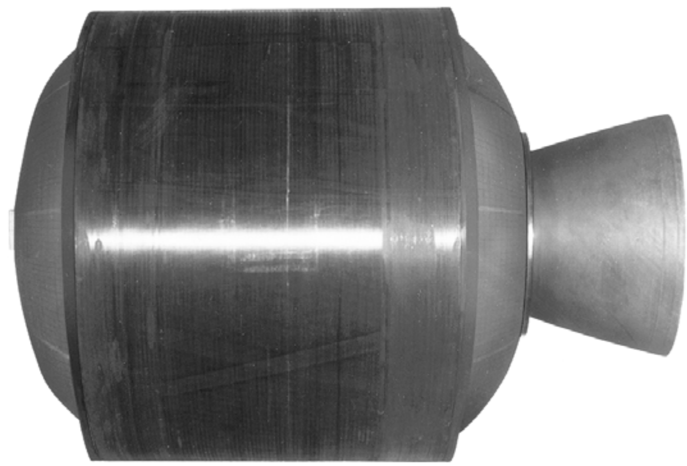
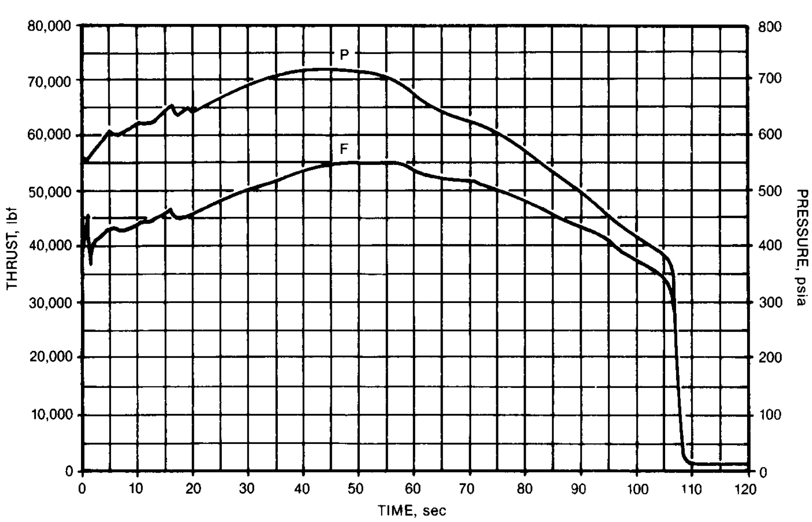
STAR 75

TE-M-775-1



The STAR 75 demonstration motor was made and tested in December 1985 as a first step in the development and qualification of perigee kick motors in the 9,000- to 17,500-lb_m propellant range. The STAR 75 includes many design features and materials proven on previous ATK space motors: a slotted, center-perforate propellant grain housed in a graphite-epoxy, filament-wound case, and a submerged nozzle with a carbon-phenolic exit cone.



MOTOR DIMENSIONS

Motor diameter, in. 75.0
Motor length, in. 102.0**

MOTOR PERFORMANCE (75°F)

Burn time/action time, sec 105/107
Ignition delay time, sec 0.42
Burn time average chamber pressure, psia....616
Maximum chamber pressure, psia 719
Total impulse, lbf-sec.... 4,797,090*
Propellant specific impulse, lbf-sec/lbm.... 290.0*
Effective specific impulse, lbf-sec/lbm 288.0*
Burn time average thrust, lbf.... 45,000*
Maximum thrust, lbf 55,000*

NOZZLE

Initial throat diameter, in. 6.8
Exit diameter, in. 28.5**
Expansion ratio, sea level, initial 17.7:1**

WEIGHTS, LBM

Total loaded 17,783
Propellant (including 4.71 lbm igniter propellant) 16,542
Case assembly 864
Nozzle assembly 260
Total inert....1,241
Burnout 1,126.4
Propellant mass fraction 0.93

TEMPERATURE LIMITS

Operation ....30°-100°F
Storage ....30°-100°F

PROPELLANT DESIGNATION.... TP-H-3340

CASE MATERIAL....Graphite-epoxy composite

PRODUCTION STATUS....Demonstrated

* Predictions under vacuum with flight exit cone
**Demonstration motor

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

STAR 92 SERIES

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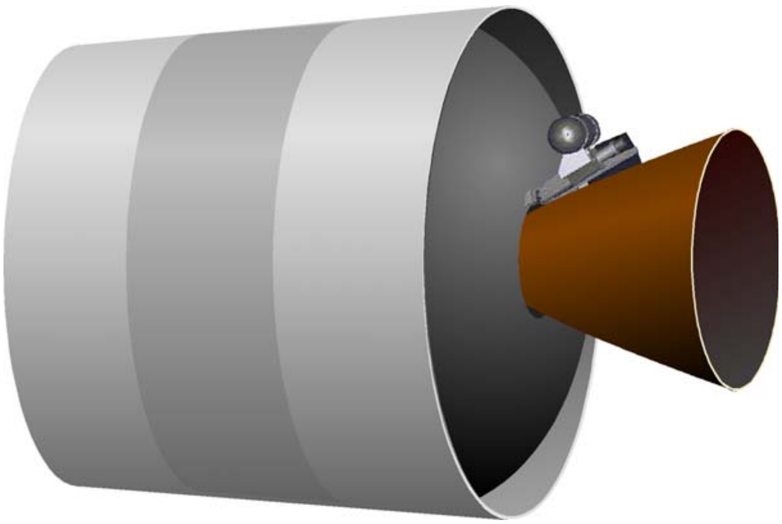
STAR 92



The STAR 92 is a derivative of our successful STAR and CASTOR series of motors. It incorporates the motor heritage of both systems and can be used in either a third-stage or an upper-stage application. This design progressed to the point at which a preliminary design review was held.

MOTOR DIMENSIONS

Motor diameter, in.	93.0
Motor length, in.	143.0

MOTOR PERFORMANCE (75°F VACUUM)

Burn time, sec	175.6
Average chamber pressure, psia	791
Total impulse, lbf-sec	10,120,100
Propellant specific impulse, lbf-sec/lbm	290.1
Effective specific impulse, lbf-sec/lbm	287.7
Burn time average thrust, lbf	57,570

NOZZLE

Exit diameter, in.	42.4
Expansion ratio, average	39.0:1

WEIGHTS, LBM

Total loaded	37,119
Propellant	34,879
Case	1,418
Nozzle	634
Other	188
Total inert	2,240
Burnout	1,939
Mass fraction	0.94

TEMPERATURE LIMITS

Operation	30 to 95°F
Storage	30 to 95°F

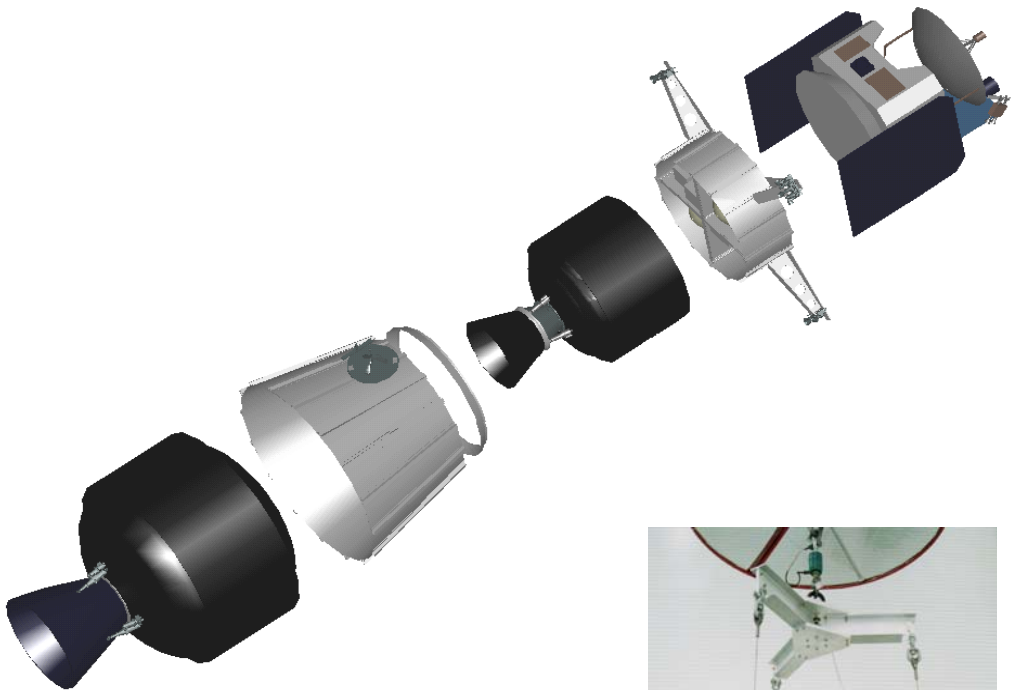
PROPELLANT DESIGNATION........... TP-H-8299

CASE MATERIAL..........Graphite-epoxy composite

PRODUCTION STATUS

..................................Design concept (through PDR)

STAR STAGES



STAR Stage 3700S
for NASA's Lunar Prospector

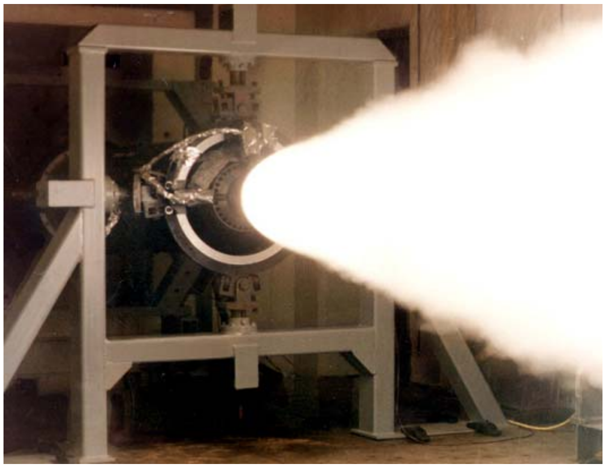
ATK has established a STAR stage family of modular, robust, high-performance space propulsion upper stages that are based on the ATK STAR motor series. The broad range of available ATK STAR motor sizes and performance combined with a programmable flight computer and mission-specific interstage structures allows exceptional flexibility configuring STAR Stages to meet mission requirements. Both spin-stabilized and three-axis stabilized configurations can be provided. In addition, the STAR Stage architecture is suitable for either expendable launch vehicle (ELV) or Space Shuttle applications. ATK's STAR Stage 3700S successfully placed NASA's Lunar Prospector Spacecraft into a Trans-Lunar trajectory from low earth orbit (LEO) on January 7, 1998. The STAR Stage 3700S is a spin-stabilized, single-motor stage based on the ATK STAR 37FM motor, which provided primary propulsion. In addition to the STAR 37FM motor, this stage incorporated a command timer; initiation, destruct, and separation ordnance; a lightweight hourglass composite interstage structure; spin motors; a collision avoidance system; and associated wiring harnesses.

ATK STAR Stages utilize a standard set of avionics and accessories incorporating proven technologies from experienced suppliers. These building blocks enable ATK to easily configure an avionics suite for each mission. The baseline STAR Stage avionics suite for three-axis stabilized missions is designated the Common Avionics Module (CAM). The CAM is designed to be compatible with different motors and scalable for reaction control system (RCS) capacity. Spin-stabilized missions use a subset of CAM hardware with a simplified structure to minimize inert mass. The CAM supports the following applications:

- Spin- or three-axis stabilization, including attitude determination and control
- Fixed or electromechanical thrust vector control (TVC) nozzles
- On-board power or spacecraft-supplied power
- Collision avoidance
- Spin-up, spin-down (as required for spin stabilization)
- Autonomous flight path dispersion correction after main propulsion burn via RCS
- Destruct (commanded and/or autonomous)
- Telemetry
- Mission event sequencing
- Onboard navigation and guidance
- Ordnance initiation
- Control of separation events
- Nutation control (as required for spin stabilization)
- Command/telemetry/power pass-through from launch vehicle to spacecraft

By using a modular CAM approach with proven STAR motors, ATK can deliver a STAR Stage propulsion solution to meet specific mission requirements, vehicle dynamics, and physical envelope at minimum risk without requalification of the entire stage system. As a result, ATK STAR Stages can satisfy a wide range of performance requirements with existing motor designs and minimal nonrecurring effort.

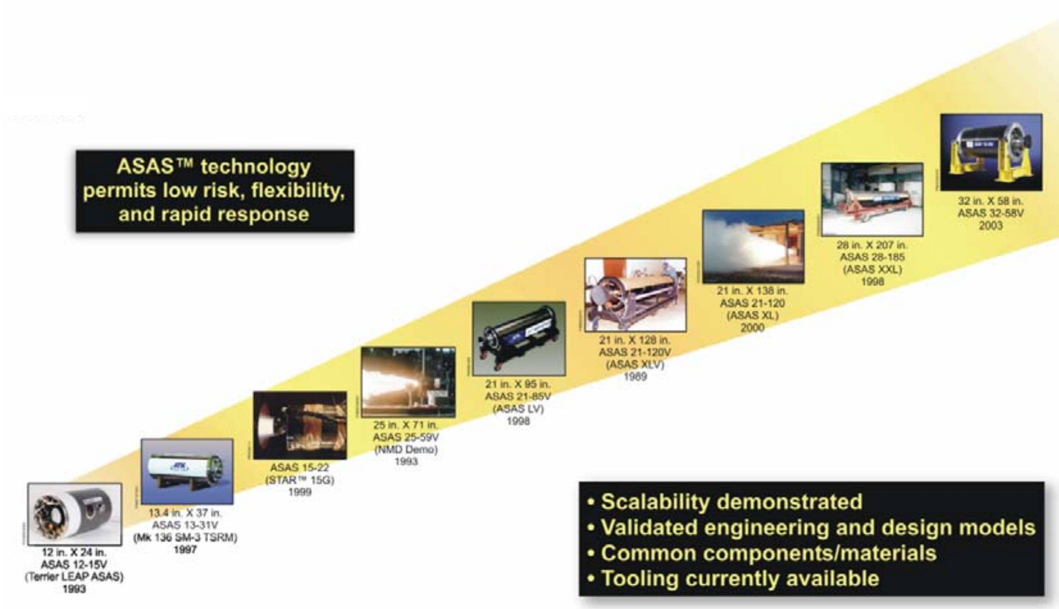
ADVANCED SOLID AXIAL STAGE (ASAS™) MOTORS


ASAS 21-in. Motor Firing (1998)

ATK's ASAS family of high-performance solid propellant motors is adaptable to a wide variety of applications. These designs incorporate proven design concepts, materials technology, and manufacturing techniques that provide enhanced operational performance. The technologies reflected in these motor designs were identified and developed in more than 425 tests performed as part of technology programs conducted between 1985 and 2003 for the USAF and the Missile Defense Agency (MDA).

The ASAS family of motors employs, as appropriate, design features including the following:

- High-strength, high-stiffness graphite-epoxy composite cases permitting increased operating pressure to increase expansion ratio and enhance motor performance, particularly for demanding interceptor applications
- Carbon-carbon throat materials that minimize throat erosion and related performance losses



- Erosion-resistant Kevlar-filled elastomeric insulation to provide thermal protection at minimum weight
- High-performance conventional and advanced composite solid propellant formulations providing required energy, temperature capability, and insensitive munitions (IM) characteristics for each of the motor designs
- Electromechanically actuated, flexseal or trapped ball thrust vector control (TVC) nozzle technology
- Mission-specific component technology, including carbon-carbon exit cones, consumable igniters, SCB-based ignition systems, integrated hybrid warm/cold-gas attitude control systems, and isolation of multiple pulses with a barrier (rather than bulkhead) insulation system

ASAS component and materials technology is mature, design scalability has been demonstrated, related engineering design models have been validated, and common components and materials are used in all of these booster configurations. These component technologies have been successfully demonstrated in sea level and simulated altitude tests and in successful flight tests.

By applying these proven technologies to new motor designs, ATK can offer:

1. Reductions in design, analysis, and development cost and schedule with streamlined component- and motor-level test programs
2. Off-the-shelf component and materials technologies with proven scalability across a range of booster configurations. This will reduce development risk and ensure that performance will meet design specifications
3. Established tooling, manufacturing, and inspection techniques that provide reproducible, high-quality products

The development philosophy for these motors has been to test a somewhat heavyweight prototype or development unit to confirm design margins without risking failure. This first firing is generally conducted at sea level. Scalability of ASAS design concepts and material technology has been demonstrated in motors ranging from 4 to 32 inches in diameter and will soon be demonstrated in a motor at 40-in. diameter.

Graphite-Epoxy Composite Case Winding (21-in. booster)

Flexseal TVC Nozzle Assembly

Motor Static Firing at Simulated Altitude (ASAS AKS-2 Qualification Motor)

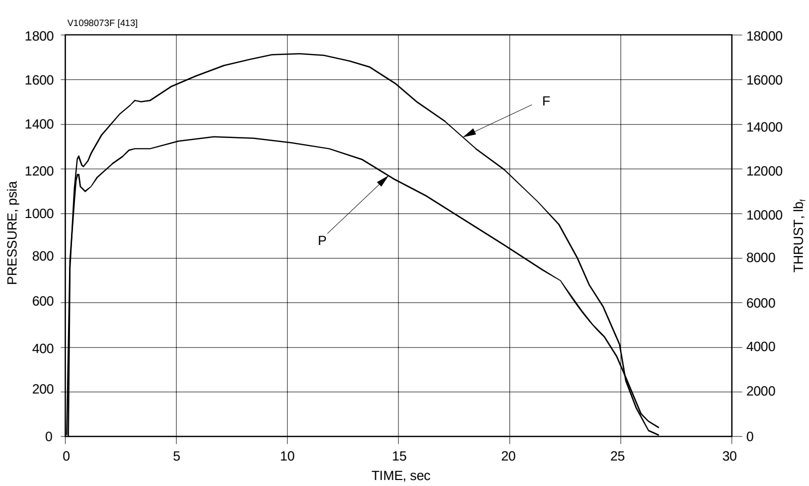
SM-3 FTR-1A Missile Launch with ATK TSRM (January 25, 2001)

ASAS 21-85V

TE-M-1031-1

The ASAS 21-85V is a solid rocket motor with a graphite composite case that was developed for sounding rockets and high-performance guided booster applications. The initial 21-in. motor static test was conducted to demonstrate application and scaling of ASAS technology to vertical launch system-compatible large booster designs in April 1998. The design incorporated a 4.5-deg thrust vector control nozzle and a low-temperature capable propellant.

Early test efforts led to a June 1999 test for AFRL that incorporated a fixed nozzle (blast tube) arrangement and that evaluated use of low-cost materials and design concepts. The ASAS II version of the motor also incorporated a new propellant (TP-H-3516A) with 20% aluminum, 88.5% total solids, and 1% plasticizer.



MOTOR DIMENSIONS

Motor diameter, in. 20.4
Motor length, in. 95.5

MOTOR PERFORMANCE (75°F SEA LEVEL)

Burn time/action time, sec 24.4/25.7
Ignition delay time, sec 0.012
Burn time average chamber pressure, psia 1,100
Maximum chamber pressure, psia 1,350
Total impulse, lbf-sec 347,400
Propellant specific impulse, lbf-sec/lbm 240.6
Burn time average thrust, lbf 14,000
Maximum thrust, lbf 17,250

NOZZLE

Initial throat diameter, in. 3.1
Exit diameter, in. 11.6
Expansion ratio, initial 13.9:1
TVC, deg .... ±4.5

WEIGHTS, LBM

Total loaded 1,656
Propellant 1,444
Case assembly 129
Nozzle assembly 33
Total inert 212
Propellant mass fraction 0.87

TEMPERATURE LIMITS

Operation .... -10°-130°F
Storage .... -20°-130°F

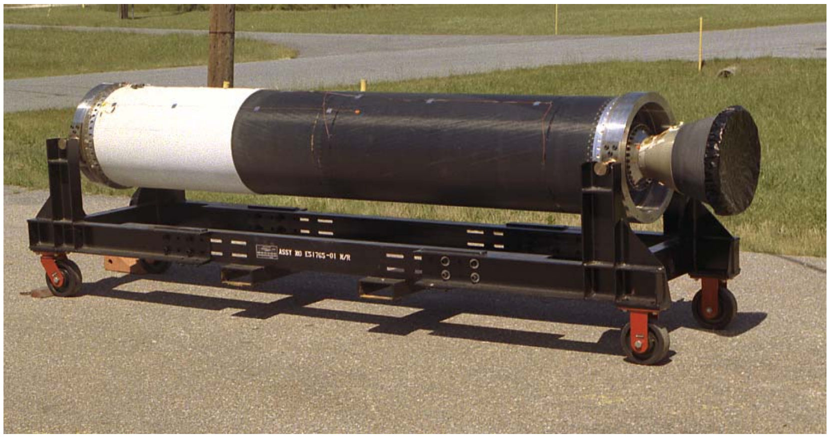
PROPELLANT DESIGNATION TP-H-3514A

CASE MATERIAL .... Graphite-epoxy composite

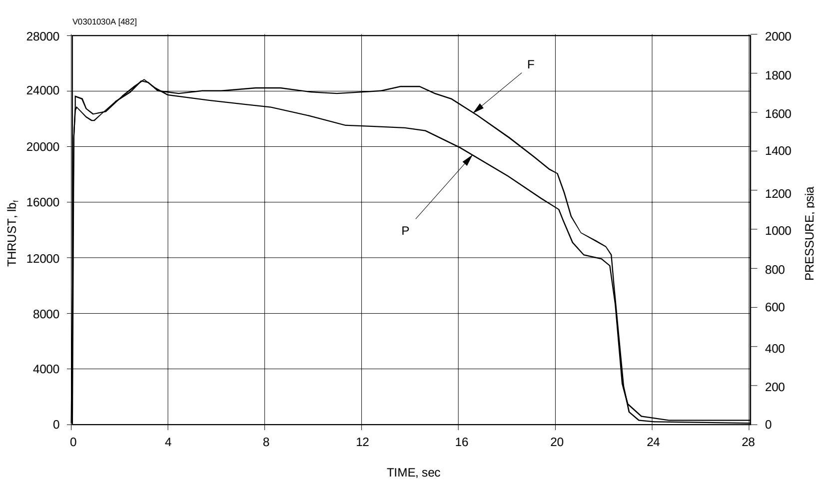
PRODUCTION STATUS .... Development

ASAS 21-120

TE-M-1059-1



The ASAS 21-120 is a solid rocket motor with a graphite composite case that was developed in 2000 for VLS, target, and sounding rocket applications. This is a fixed nozzle version of the ASAS 21-120V motor.



MOTOR DIMENSIONS

Motor diameter, in. 20.5
Motor length, in. 138.0

MOTOR PERFORMANCE (75°F SEA LEVEL)

Burn time/action time, sec 22.1/22.8
Ignition delay time, sec 0.012
Burn time average chamber pressure, psia....... 1,480
Maximum chamber pressure, psia 1,760
Total impulse, lbf-sec.................................. 497,600
Propellant specific impulse, lbf-sec/lbm............. 244.4
Burn time average thrust, lbf........................... 22,300
Maximum thrust, lbf 24,700

NOZZLE

Initial throat diameter, in. 3.36
Exit diameter, in. 16.80
Expansion ratio, initial 25:1

WEIGHTS, LBM

Total loaded 2,323
Propellant.. 2,036
Case assembly*.. 254
Nozzle assembly.. 32
Total inert.. 286
Propellant mass fraction 0.88
*Includes igniter without 1.08 lbm propellant

TEMPERATURE LIMITS

Operation .... 40°-100°F
Storage .... 0°-100°F

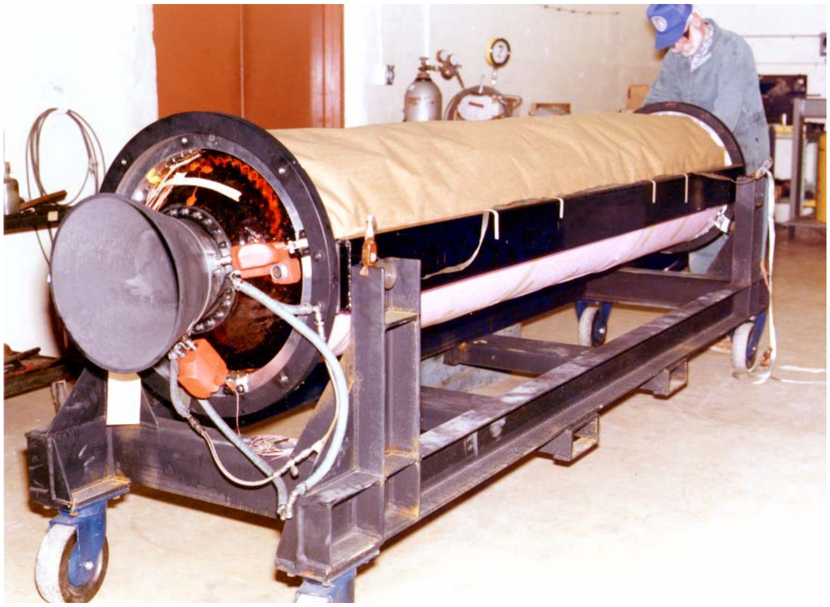
PROPELLANT DESIGNATION TP-H-3516A

CASE MATERIAL..........Graphite-epoxy composite

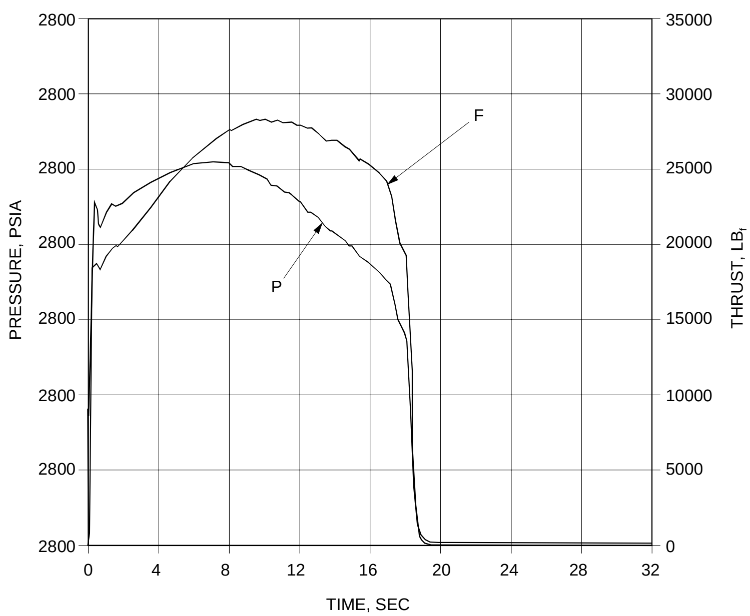
PRODUCTION STATUS................. Development

ASAS 21-120V

TE-M-909-1



The ASAS 21-120V solid rocket motor was designed, fabricated, and tested in just 4½ months after program start. It features a 5-deg flexseal TVC nozzle with a carbon phenolic exit cone. This successful test led to receipt of the Strategic Defense Initiative Office Director's Award in recognition of outstanding achievement. The ASAS 21-120V configuration is applicable to vertical launch system (VLS), target, sounding rocket, and high-performance guided booster applications.



MOTOR DIMENSIONS

Motor diameter, in.	20.5
Motor length, in.	130.0

MOTOR PERFORMANCE (70°F SEA LEVEL)*

Burn time/action time, sec	17.9/18.6
Ignition delay time, sec	0.005
Burn time average chamber pressure, psia	1,800
Maximum chamber pressure, psia	2,050
Total impulse, lbf-sec	454,700
Propellant specific impulse, lbf-sec/lbm	250.8
Burn time average thrust, lbf	24,900
Maximum thrust, lbf	28,600

NOZZLE

Initial throat diameter, in.	3.0
Exit diameter, in.	14.0
Expansion ratio, initial	20:1
TVC, deg	±5.0

WEIGHTS, LBM*

Total loaded	2,236
Propellant (less igniter propellant)	1,813
Case assembly	363
Nozzle assembly	32
Total inert (including TVA)	423
Propellant mass fraction	0.81

TEMPERATURE LIMITS

Operation	40°-100°F
Storage	0°-100°F

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL .... Graphite-epoxy composite

PRODUCTION STATUS .... Development

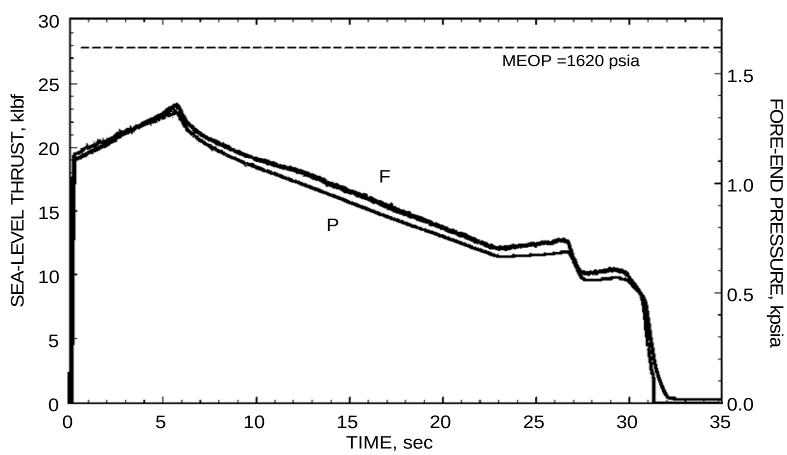
*Development motor values. Flight design mass fraction is 0.89 with total impulse improvement of approximately 15%

ORIOLE

The Oriole is a 22-in.-diameter, high-performance, low-cost rocket motor used as a first, second, or upper stage for sounding rockets, medium-fidelity target vehicles, and other transatmospheric booster and sled test applications. The motor was developed in the late 1990s as a next-generation, high-performance sounding rocket motor and was first successfully static tested in 2000. Five successful flight tests have been completed to date using the Oriole as a second-stage. The nozzle has been optimized for high-altitude applications, and the graphite-epoxy case and modern high-performance propellant combine to provide a high-mass-fraction and cost-effective design. Full-rate production (2008).

Future Oriole variants are in concept development. These include a version — for use as a booster in experimental scramjet or other similar applications — that has extra external insulation, allowing for extended flight times within the atmosphere. There is also a shorter burn time, first-stage booster specific version, which would be an ideal replacement for Talos/Taurus class motors and would yield greater performance. The first stage incorporates a low altitude optimized nozzle and has a burn time in the 12- to 15-sec range.

The Oriole motor also has the flexibility to accommodate a thrust vector control (TVC) system for high-fidelity target or orbital mission applications. In addition, a subscale version, called the Cardinal motor, is suitable for upper-stage applications with Oriole or other motors in the lower stage(s). The Cardinal motor would be about half the size and weight of the full-scale Oriole motor and take advantage of many similar proven components and processes to provide maturity and low-cost benefits.



MOTOR DIMENSIONS

Motor diameter, in. 22
Motor length, in. 154.68

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec 30.0/28.85
Ignition delay time, sec 0.025
Burn time average chamber pressure, psia....944
Maximum chamber pressure, psia 1,410
Total impulse, lbf-sec....624,290
Propellant specific impulse, lbf-sec/lbm....288.5
Burn time average thrust, lbf....20,790
Maximum thrust, lbf 29,570

NOZZLE

Initial throat diameter, in. 3.72
Exit diameter, in. 19.82
Expansion ratio, initial....28.4:1
TVC, deg ....N/A

WEIGHTS, LBM

Total loaded 2,588
Propellant (less igniter propellant) 2,152
Case assembly 214
Nozzle assembly....145
Total inert....436
Propellant mass fraction 0.83

TEMPERATURE LIMITS

Operation ....0°-120°F
Storage ....-10°-125°F

PROPELLANT DESIGNATION

....QDL/SAA-144 Aluminized HTPB

CASE MATERIAL....Graphite-epoxy composite

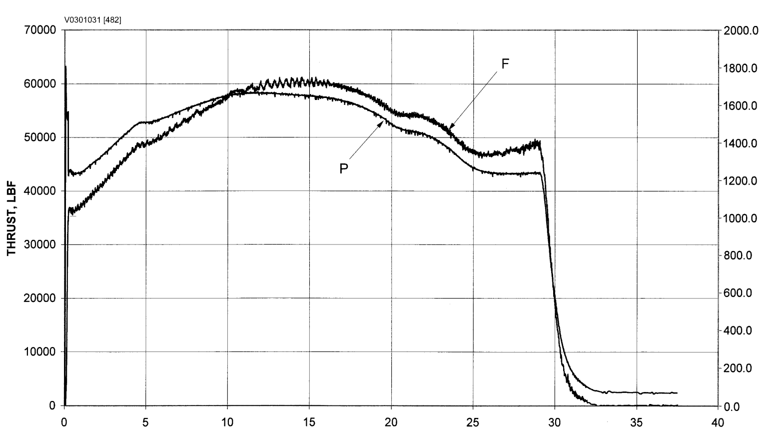
PRODUCTION STATUS....In production

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

ASAS 28-185/185V

TE-T-1032

The ASAS 28-185 motor is a graphite composite case, fixed nozzle, solid rocket motor applicable to guided first-stage, sounding rocket, and target applications. With a thrust vector control nozzle, the motor is designated ASAS 28-185V. The motor was tested on September 30, 1998, and confirmed scaling of ASAS technology from smaller motors to a 28.5-in. diameter motor configuration with extended burn time. Motor ignition was successfully achieved with a prototype electro-optical safe-and-arm (EOSA) device and a semiconductor bridge initiator. The motor incorporated a TVC nozzle simulator to evaluate thermal response for simulated flexseal components, but the test nozzle was not vectorable by design.



MOTOR DIMENSIONS

Motor diameter, in. 28.5
Motor length, in. 207

MOTOR PERFORMANCE (75°F SEA LEVEL)

Burn time/action time, sec 29.2/31.2
Ignition delay time, sec 0.010
Burn time average chamber pressure, psia....... 1,470
Maximum chamber pressure, psia 1,660
Total impulse, lbf-sec 1,559,050
Propellant specific impulse, lbf-sec/lbm............ 252.6
Burn time average thrust, lbf............................ 52,100
Maximum thrust, lbf 61,200

NOZZLE

Initial throat diameter, in. 5.0
Exit diameter, in. 21.3
Expansion ratio, initial 18.3:1
TVC, deg (design capability) .... ±5

WEIGHTS, LBM*

Total loaded 6,901
Propellant 6,172
Case assembly 608
Nozzle assembly 121
Total inert 729
Burnout 696
Propellant mass fraction 0.89
*weights without TVC

TEMPERATURE LIMITS

Operation .... 40°-90°F
Storage .... 20°-110°F

PROPELLANT DESIGNATION TP-H-3340

CASE MATERIAL ....Graphite-epoxy composite

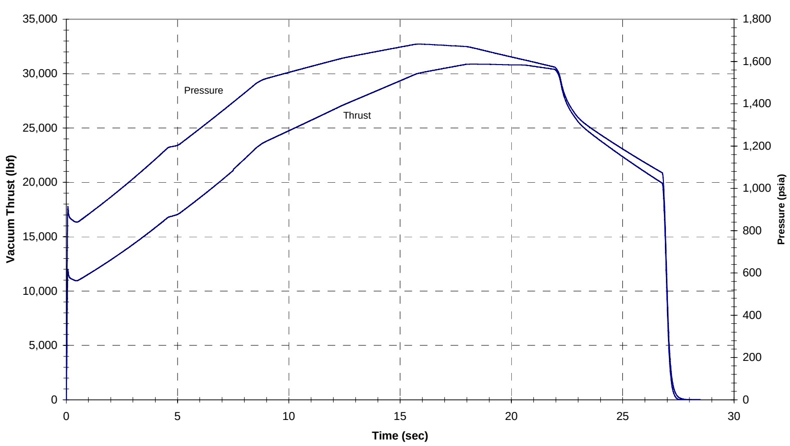
PRODUCTION STATUS................. Development

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

ASAS 32-58V (RAVEN)

TE-M-1106-1

Static tested on September 16, 2003, the ASAS 32-58V RApid VEctoring Nozzle (RAVEN) design demonstrated an enhanced slew rate with a trapped ball nozzle using electromechanical actuation. The nozzle was tested on a 32-in.-diameter composite case motor representative of a future missile defense interceptor second stage. The motor was ignited with an ATK Elkton electronic safe-and-arm (ESA) device and pyrotechnic igniter. Motor design, analysis, fabrication, and successful static test efforts were completed in a 5.5-month period.



MOTOR DIMENSIONS

Motor diameter, in.	32
Motor length, in.	74.8

MOTOR PERFORMANCE (70°F VACUUM)

Burn time/action time, sec	26.6/28.1
Ignition delay time, sec	0.057
Burn time average chamber pressure, psia	1,390
Maximum chamber pressure, psia	1,690
Total impulse, lbf-sec	640,580
Propellant specific impulse, lbf-sec/lbm	279.0
Effective specific impulse, lbf-sec/lbm	277.3
Burn time average thrust, lbf	23,900
Maximum thrust, lbf	30,880

NOZZLE

Initial throat diameter, in.	3.2
Exit diameter, in.	16.9
Expansion ratio, initial	28:1
Expansion cone half angle, exit, deg	22.5
Type	Contoured
TVC, deg	± 12

WEIGHTS, LBM

Total loaded	2,618
Propellant	2,296
Case assembly	209
Nozzle assembly (including actuators)	104
Igniter assembly (including ESA)	9
Total inert	322
Burnout	308
Propellant mass fraction	0.88

TEMPERATURE LIMITS

Operation	45°-90°F
Storage	-20°-140°F

PROPELLANT DESIGNATION TP-H-3527A

CASE MATERIAL..........Graphite-epoxy composite

PRODUCTION STATUS................. Development

Approved for Public Release
OSR No. 08-S-0259
Export Authority ITAR 125.4(b)(13)

LAUNCH STRUCTURES

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ATLAS V STRUCTURES

CORE VEHICLE

5M DIAMETER STRUCTURES FABRICATED WITH AUTOMATED TECHNOLOGY

Featuring state-of-the art designs, materials, and processes, the Atlas V family of rockets offers higher performance and greater reliability than its predecessors.

The robustness of the Atlas V system is enhanced by the use of common system elements assembled into a family of vehicles that satisfy a wide range of mission requirements while providing substantial performance margins.

ATK's Role

- Three part configurations
    1. Heat shield
    2. Centaur interstage adapter (CISA)
    3. Boattail
- Up to 5.4m in diameter (17.5 ft)
- Fabricated using automated fiber placement and advanced hand layup techniques
- Manufactured at both the Southern Composites Center and Utah Composites Center facilities

Customer: Lockheed Martin

Prime Contractor: Lockheed Martin

ATK Composites has pioneered the use of automated fiber placement for launch vehicle structures.

PRODUCTS

Heat Shield

Interstage

Boattail

.

DELTA IV STRUCTURES

COMMON BOOSTER CORE AND PAYLOAD ACCOMMODATIONS

5M DIAMETER CORE VEHICLE STRUCTURES

Delta IV is the newest family of rockets developed by The Boeing Company in partnership with the United States Air Force's Evolved Expendable Launch Vehicle program. The Delta IV is designed to reduce launch costs and provide assured access to space for U.S. government, commercial, and civilian launch customers.

The Delta IV family consists of five launch vehicles based on a common booster core first stage. The second stage is derived from the Delta III, with expanded fuel and oxidizer tanks. GEM-60 strap-ons can be added to provide additional launch capability.

ATK's Role

- Family of 10 configurations
    4. Centerbodies
    5. Interstages
    6. Thermal shields
    7. Aeroskirts
    8. Nose cones
    9. Payload fairings
    10. Payload adapters
    11. LO_2 forward skirts
- Up to 5m in diameter (16 ft)
- Up to 19m in length (63 ft)
- Manufactured using advanced hand layup techniques

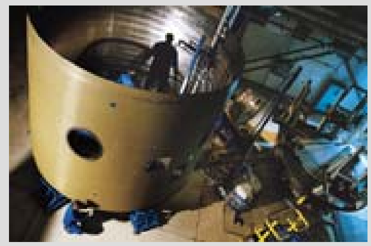
Customer: Boeing

Prime Contractor: Boeing

ATK provides over 35 different part configurations for the Delta IV family of launch vehicles.

PRODUCTS

Nose Cone



Centerbody

Thermal Shield

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GEM

FAMILY OF COMPOSITE CASES

LIGHTWEIGHT CASES SUPPORT MISSION AND COST OBJECTIVES

The Delta family of launch vehicles is configured with affordable, high-performance graphite epoxy motor (GEM) cases to provide additional lift capability during first stage ignition.

Designed to take advantage of proven, off-the-shelf technologies, the GEM system provides increased performance and heavier lift capability than the boosters of its predecessors. GEMs have demonstrated—through qualification and flight—they are the most reliable, lowest cost boosters available.

State-of-the-art automation, robotics, and process controls are used to produce GEMs. Cases are filament wound at ATK's Utah Composites Center by computer-controlled winding machines using high-strength graphite fiber and durable epoxy resin.

ATK's Role

- Composite filament-wound cases
    12. Up to 60 in. in diameter
    13. Up to 42.5 ft in length
    14. Over 950 cases delivered
    15. Production is in 16th year
- Composite filament-wound igniter casings
- Composite aeroskirts and nose cones

Customer: ATK

Prime Contractor: Boeing

This Delta II launch vehicle was configured with GEM-46 boosters to provide additional lift capability for the Opportunity Rover on its mission to Mars.

PRODUCTS

ATK Composites uses proven hand layup techniques to produce GEM-60 nose cones

GEM cases are produced using advanced filament winding techniques developed and refined by ATK Composites over 40 years

ORION

FAMILY OF COMPOSITE ROCKET MOTOR CASES

OFF-THE-SHELF COMPOSITE CASES FOR COMMERCIAL LAUNCH, MISSILE DEFENSE AND SCRAM JET APPLICATIONS

The Orion family of composite structures is a versatile line of structures supporting a range of mission platforms. Proven manufacturing techniques, an outstanding performance record, and affordability make Orion the rocket motor of choice.

ATK's Role

- Pegasus—First, second, and third stage rocket cases, interstage and payload fairing.
- Taurus—First, second, and third stage rocket cases
- Minotaur—Third and fourth stage rocket cases
- X-43C—First stage rocket case
- Ground-based Midcourse Defense (GMD)—First stage rocket case
- Proven filament winding and hand layup techniques
- Demonstrated reliability and repeatability

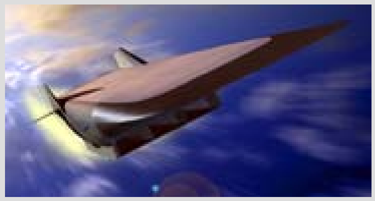
Customer: ATK

Prime Contractors: Orbital Sciences Corporation, ATK GASL

PRODUCTS

Pegasus

Taurus



X-43C

Ground-based Midcourse Defense (GMD)

PEGASUS®

PAYLOAD FAIRING

LIGHTWEIGHT, AFFORDABLE COMPOSITES

Initiated as a joint Air Force and industry venture in 1987, the Pegasus launches small, mainly experimental Air Force payloads into low Earth orbit (LEO).

With over 35 successful missions and delivering more than 70 satellites to date, the Pegasus rocket has earned a reputation as the world's standard for affordable and reliable small launch vehicles.

The composite payload fairing produced by ATK separates approximately 110 seconds into flight, following second stage ignition.

ATK's Role

- Graphite/epoxy skins
- Aluminum honeycomb core
- 4.2-ft diameter; 14.2-ft length
- Hand layup construction
- Production is in 16th year

Customer: Orbital Sciences Corporation

Prime Contractor: Orbital Sciences Corporation

The Pegasus rocket is the first all-composite rocket to enter service.

PRODUCTS

A proven hand layup process developed by ATK Composites is used to fabricate the fairing components

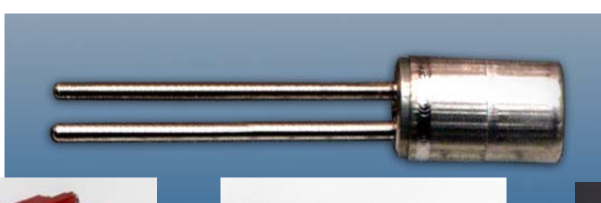
ORDNANCE PRODUCTS

ATK Elkton has produced a wide variety of ordnance products since the 1960s including:

- Conventional electromechanical safe-and-arm (S&A) devices for STAR series space motor initiation and launch vehicle/stage destruct functions
- Conical shaped charge (CSC) assemblies for booster destruct applications on STAR, CASTOR, Titan, Atlas, and Delta
- Semiconductor bridge (SCB)-based initiators for precise control of ordnance events for military applications such as the Universal Water Activated Release System (UWARS) for the U.S. Air Force
- Advanced electronics-based ordnance systems providing reductions in weight, enhanced event control, and system health monitoring

Several of these products are illustrated below and provide an overall heritage of proven reliability while providing flexibility to meet evolving customer needs.

SCB Initiator



Model 2134B Electromechanical S&A Device

Model 2011 CSC

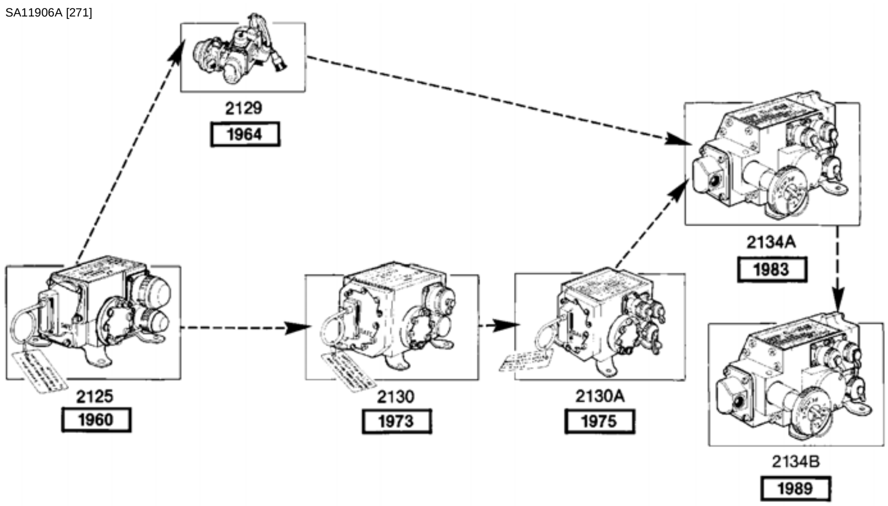
Electronic Safe-and-Arm (ESA) Device

ATK ordnance production facilities at Elkton include equipment for S&A assembly, initiator manufacturing, igniter manufacture, pyrotechnic and explosives loading, and laser welding. In addition to ordnance manufacture, ATK has facilities at Elkton to perform nondestructive testing, including X ray, random vibration, shock and thermal environments, functional testing, and associated live material and product storage.

Laser Welding Equipment

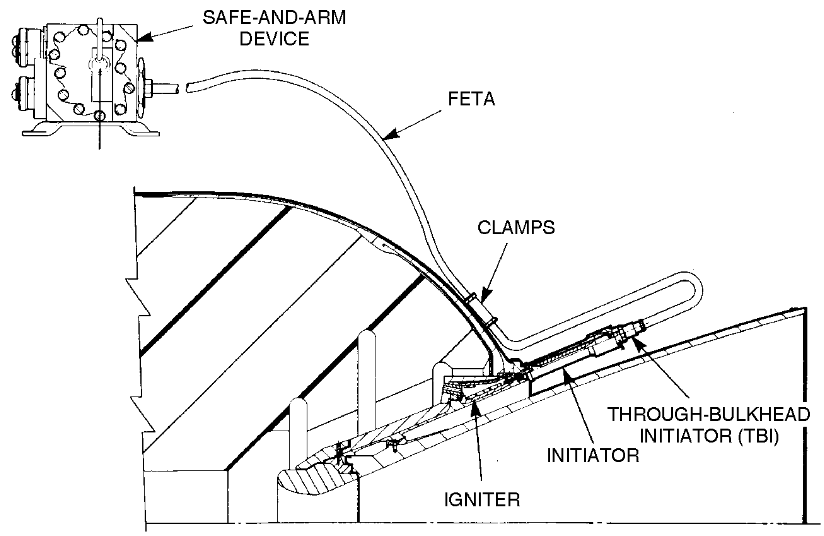
SCB Initiator Semi automated Manufacturing Line

Electromechanical S&As. The development and production heritage for electromechanical S&A devices represents more than 40 years of product maturity as illustrated below. These devices provide positive control of ordnance events in nonfragmenting and nonoutgassing designs that provide external status indication and a safety pin to inhibit operation when desired. The current production Model 2134B is routinely used to initiate STAR series space motors (next page) and for destruct on Atlas IIAS and Titan IVB. The Model 2134B has supported more than 300 flights since 1989 with a 100% operational success rate. It is EWR 127-1 compliant and has flown successfully from ETR, WTR, and Kourou and on vehicles such as Titan, Delta, Ariane, and Space Shuttle.



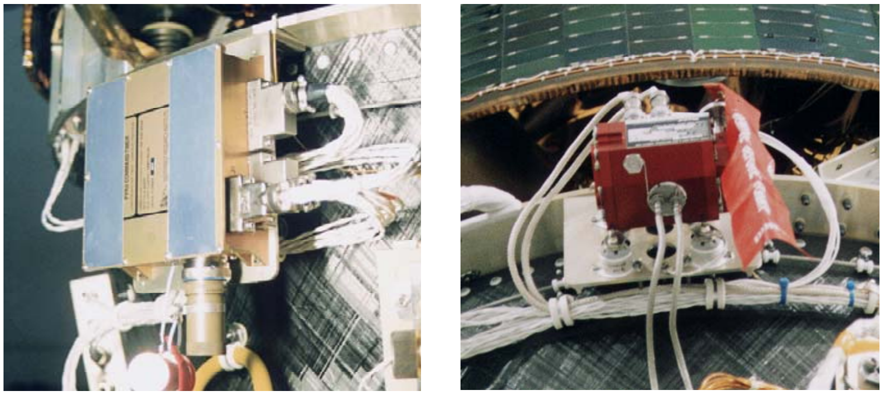
S&A Development Heritage Supports Product Reliability in Operation

ATK also supports S&A and ordnance system development having updated the documentation package and manufacturing instructions for the Space Shuttle S&A



Typical STAR Series Space Motor Ordnance Train to Provide On-Command Ignition

device. ATK also developed and qualified the Army TACMS arm/fire device for motor ignition and the S&A device for Army TACMS warhead initiation and has rebuilt/refurbished existing Minuteman III arm/disarm (A/D) switches for the USAF. For the Minuteman III A/D switch, six-sigma principals were employed to design and implement a manufacturing plan that features manufacturing cells and dedicated production stations. Trained technicians individually evaluate, rebuild, and then retest each A/D switch. In addition, ATK has integrated complete ordnance systems, which include Elkton-fabricated wiring harnesses for missile defense boosters such as the Terrier LEAP Advanced Solid Axial Stage (ASAS) and the SM-3 Mk 136 Third Stage Rocket Motor (TSRM). In the area of upper stages, ATK was the design activity for the Lunar Prospector Trans-Lunar Injection (TLI) stage. This upper stage used customer-supplied command timer/sequence to control all ordnance functions including initiation of spin motors, separation systems, primary axial propulsion, separation systems, and



Lunar Prospector Command Timer and S&A Integration Conducted by ATK

destruct functions (see below).

Conical Shaped Charge (CSC) Assemblies. CSCs produced at ATK provide a concentrated destructive jet of energy for flight termination applications on a variety of propulsion systems, including boosters used on Titan and Atlas as well as CASTOR and STAR series motors. ATK conducts in-house testing for CSC lot acceptance and has integrated destruct ordnance for stages including Lunar Prospector for Lockheed Martin

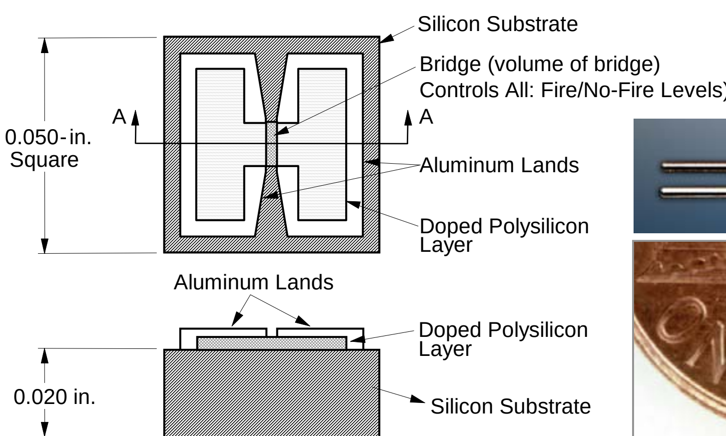
CSC Installed on Lunar Prospector TLI Stage

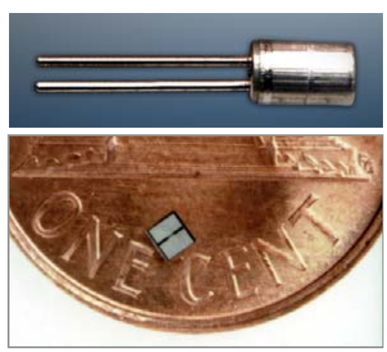
STAR 48 Destruct Test Using Model 2011 CSC

and NASA. CSCs produced at ATK are reviewed and approved by the Eastern and Western Ranges for each application and meet the requirements of EWR 127-1. Photos below shows two past uses of the CSC.

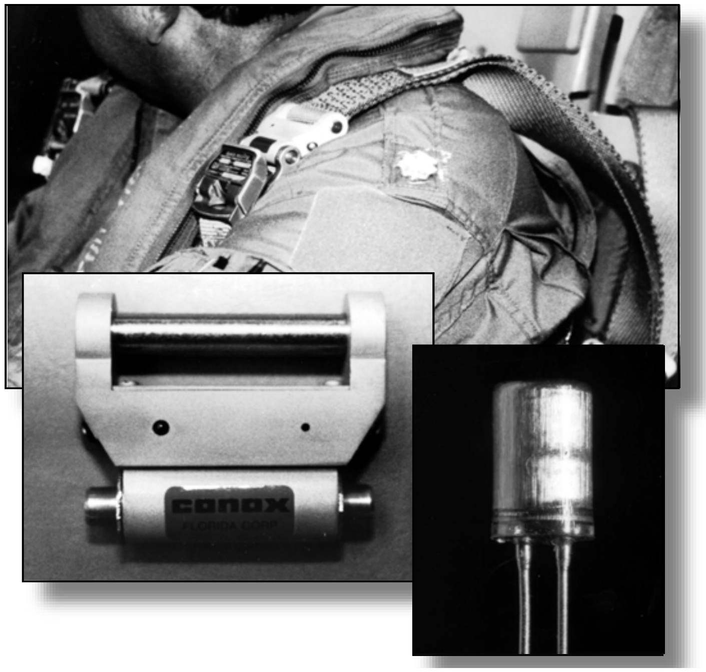
SCB Initiators. Since 1989, ATK has produced more than 60,000 SCB initiators for application in automotive airbags, in the mining industry, for parachute release, tank rounds, and for motor and ordnance event initiation. The majority of this production has supported the UWARS program following qualification of the device in 1994 (figure on following page). The flexibility and robustness of the basic SCB initiator configuration enables ATK to tailor pin designs, output charges, and design features for specific applications.

The SCB initiator provides advantages over other initiator technologies by providing low, consistent initiation energy with fast and highly repeatable function times. These devices enhance safety by readily passing no-fire requirements (>1 amp/1 watt/5 minutes), are ESD-tolerant, can be tailored to meet MIL-STD-1385B HERO requirements, and are qualified to MIL-STD-1512 requirements. This device produces a 8,500°F plasma at the bridge allowing initiation of insensitive materials. In addition, SCBs are inherently mass





SCB Chip and Initiator



Universal Water Activated Release System (UWARS)

producible at the chip and assembly level.

SCB initiators also provide excellent capability for health status monitoring and have proven compatible with high-acceleration environments in gun-launched applications (tank rounds), having survived forces in excess of 30,000 g. On-going SCB development and production efforts being conducted at ATK will further reduce unit costs and provide compatible electronic initiation systems that can reduce overall ordnance system weight.

Advanced Electronics-Based Ordnance. Traditional launch vehicle and spacecraft ordnance systems use dedicated, direct-wire systems. These systems employ bridgewire-type squibs, shielded twisted pair cable harnesses dedicated to each squib, and an electronic ordnance controller. Because the safety functions are performed in the ordnance controller (remote from the point of initiation), the firing energy must be transmitted along the entire length of the cable harness. The cabling must therefore be shielded from external electromagnetic interference. Safety-critical initiation events are typically supported by separate dedicated systems. This approach results in high system weight, larger cable bundles, very limited health monitoring capabilities, and higher system power requirements.

As a result, ATK has developed ordnance products that can replace the conventional S&A, explosive transfer assemblies (ETAs), and through-bulkhead initiators (TBIs) used for this type of application. These advanced ordnance systems combine modern electronics with SCB initiators to reduce weight and enhance reliability and safety for next-generation ordnance applications versus conventional electromechanical systems. These products are discussed below.

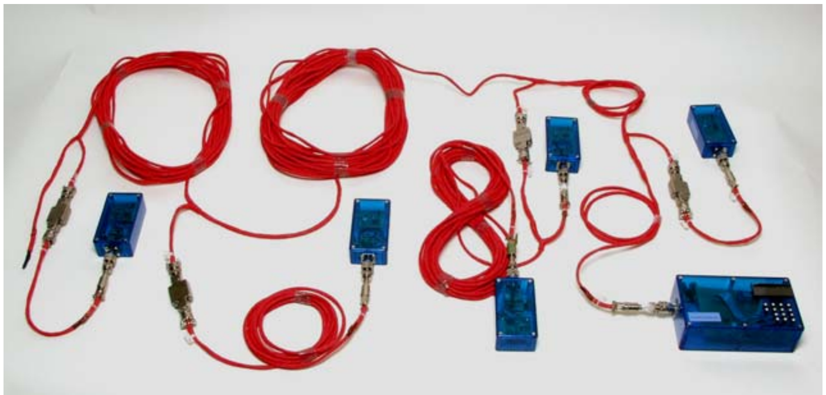
ESA. Among these products are the ESA, a device that contains a single SCB initiator that produces an output approximately the same as a NASA Standard Initiator (NSI). The

ATK ESA Device

ESA is designed to thread directly into a motor igniter. It has a bulkhead to contain motor pressure and a single electrical connector interface. The small envelope and weight of this S&A permits direct installation into the igniter and eliminates the need for ETAs and TBIs. The electronic safety features of the ESA will be supplemented with a blocking rotor mechanism driven by a small dc micromotor. The design will mechanically and electrically isolate the electrical initiator from the rest of the ignition train.

ATK performed initial environmental and operational testing of prototype ESA units under the ASAS II contract (1999-2000). A prototype of the ESA was also used to initiate ATK's 120,000-lb_m integrated high-payoff rocket propulsion technology (IHPRPT) rocket motor in November 2000 and ATK's rapid vectoring nozzle (RAVEN) motor in 2003.

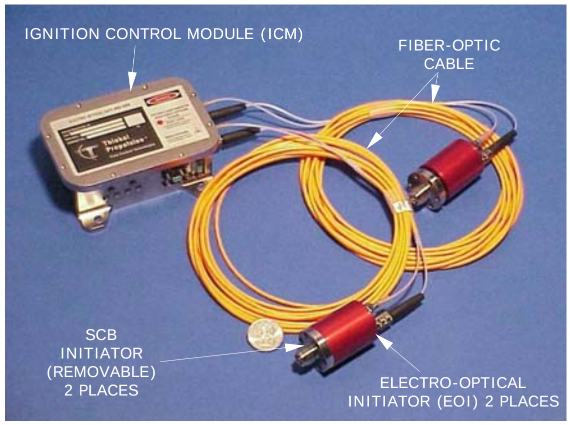
Addressable Bus Ordnance System. Under a 2001-2002 Advanced Ordnance Development program, ATK designed, fabricated, and demonstrated a breadboard addressable bus ordnance system based on ESA designs. The program also demonstrated implementation of communication protocols allowing individual device control and the ability to merge ordnance and telemetry system features on a single bus.



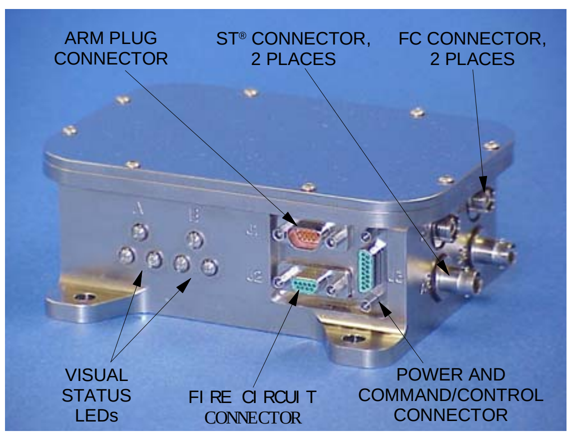
Addressable Bus Ordnance System Breadboard Prototype

ATK's addressable bus solution mitigates or eliminates many of the negative attributes associated with traditional ordnance systems. By substituting SCB-based squibs as an enabling technology, a digital bus network will support multiple, individually addressed devices (or nodes) that incorporate safety at the point of initiation and provide new, extensive ordnance and system health monitoring and telemetry gathering capabilities. The ATK-developed ESA device forms the basis of the initiator nodes in the proposed system. Because firing energy is stored and switched at the individual system nodes, only low-voltage power and digital commands are transmitted over the system cables. Significant protection from external EMI is therefore achieved without heavy shielding. Individual cables are no longer necessary, because all of the ordnance events are controlled from a common bus that utilizes a digital communication protocol. As a result, reductions in cabling mass and improvements in installation and checkout can be realized.

Electro-Optical S&A (EOSA). ATK has also demonstrated EOSA technology. This approach combines laser light energy and photovoltaic technology to control and power electroexplosive devices (EEDs). An advantage of this approach is that it uses fiber optics and thereby isolates the EED from typical electrical wires used to transfer energy and commands. ATK worked with Sandia to perform development and demonstration



EOSA



ESOA ICM

efforts for all the critical components including the ignition control module (ICM) (Figure 24), fiber-optic cabling, and electro-optical initiators (EOIs).

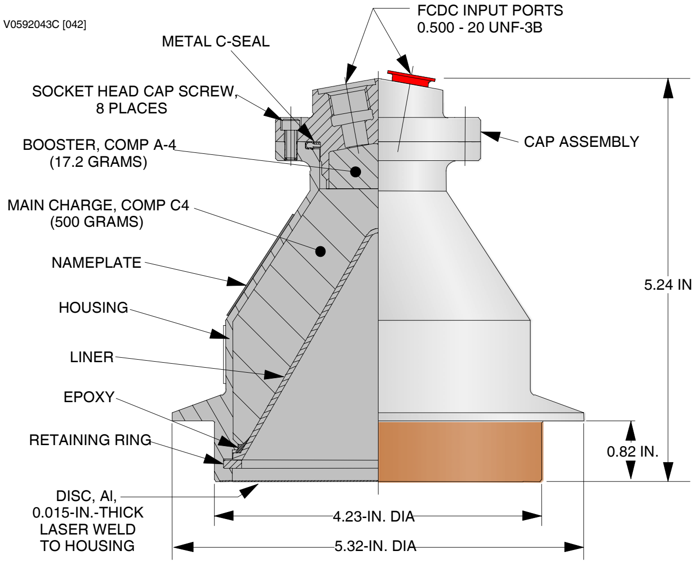
MODEL 2011 TE-O-958-1

DESTRUCT CONICAL SHAPED CHARGE (CSC)

ATK's Model 2011 CSC is an upgraded version of the highly successful Model 2001 design developed in the 1960s for use on the Delta launch vehicle. The Model 2011 has the same envelope, mounting interfaces, and explosive weight as its predecessor, the Model 2001.

The Model 2011 incorporates a 500-gram composition C4 main charge, which provides excellent safety, performance, and long-term storage characteristics for a variety of flight termination applications. The Model 2011 is designed to provide several improvements over prior CSC designs. These include: 1) enhanced safety through use of flexible confined detonating cord input, 2) hermetic sealing of each unit, and 3) incorporation of a liner manufactured to provide optimal target penetration and control of the jet angle.

ATK has manufactured more than 1,000 CSCs for flight termination. The Model 2011 was qualified for use on the Atlas IIAS launch vehicle and was first flown in December 1993. ATK's CSCs have flown in many other applications including the Delta, Japanese N, Titan/Centaur, and Atlas/Centaur launch vehicles. They have been reviewed and approved by Eastern and Western Range Safety for each application and meet the requirements of EWR 127-1.



U.N. Classification Code	1.1D
Base Charge	Composition C-4: 500 grams
Booster Charge	Composition A-4: 17 grams
Cap Material	Aluminum alloy
Housing Material	Aluminum alloy
Liner Material	Copper
Initiation Input	Flexible confined detonating cord with Type III end tip (144 mg HNS) (detachable)
Attachment Interface	Mounting flange using a Marman clamp
External Finish	Clear anodic coating
Penetration at 6-in. Stand-off	12-in. mild steel
Temperature Environmental Extremes	-65° to +160°F*
Qualification Vibration	47.7 grms for 3 min/axis
Qualification Shock	6,000 g at 700 to 3000 Hz, Q=10
Weight, Gross	2.8 lb
Applications	Solid motor destruct, liquid tank destruct, payload destruct

*High-temperature exposure up to 30 days

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Export Authority ITAR 125.4(b)(13)

MODEL 2134B

TE-O-734

SAFE-AND-ARM (S&A) DEVICE

The Model 2134B was originally qualified for the McDonnell Douglas Delta II launch vehicle. Model 2134B has successfully flown on a number of launch vehicles, including Delta, STS, Ariane, Titan, Japanese N, and Long March. They have initiated upper-stage sequencing and booster destruct systems and ignited upper-stage motors. Model 2134B improves upon the safe and reliable design of its predecessors by: 1) upgrading detonators to meet the requirements of MIL-STD-1576 and NHB1700.7A and 2) the optional modification of the safety pin to comply with the safety requirements of MIL-STD-1576 and EWR 127-1.

The Model 2134B is a nonfragmenting, nonoutgassing, electromechanical S&A initiation device that is remotely mounted and remotely actuated. Because of the nonfragmenting and nonoutgassing feature, the device can be located on spacecraft without damage to nearby equipment. The motive power for the unit is furnished by a 28-volt reversible dc motor with an integral planetary gear speed reduction unit. The rotational power of the dc motor is transmitted to the output shaft through spur gears and a friction clutch.

The explosive rotor assembly, visual indicator, and rotary switches are located on the output shaft. These switches control the electrical circuitry, including motor control, remote indication, and firing signals. In the safe position, the explosive rotor assembly is out of phase with the explosive train. When the safety pin is removed and arming current is applied, the output shaft rotates 90 deg to align the rotor with the explosive train. If arming current is applied with the safety pin installed, the motor operates through the slip clutch to preclude any damage to the unit. The safety pin physically prevents the rotor from rotating while being mechanically locked into place. The output area of the unit contains an adapter that provides interface of the explosive train with a receptor such as explosive transfer assemblies (ETA). The ETAs transfer the detonation output from the S&A device for purposes such as rocket motor ignition. The unit's redundant firing circuits and explosive trains assure a highly reliable initiation.

The Model 2134B has a separate firing connector for each firing circuit. A separate connector is also provided for the arm/disarm and monitor circuits.

CHARACTERISTICS·

Unit weight: .... 3.4 lb (typical)
Motor operating voltage: .... 24-32 Vdc
Inrush: ....1.0-3.0 amps for 50 ms max
Running: .... 100-250 mA at 28 ±4 Vdc
Stalled rotor current: .... 360 mA max
Actuation time: .... 0.15 to 0.3 sec at 28 ±4 Vdc
Operating temperature:........................–35° to 160°F
Firing circuit pin-to-pin resistance:
................................0.87 to1.07 ohms (Version 1) or
....0.90-1.10 (Version 2)
Detonator “No-Fire” current/power:
.... 1 amp/1 watt for 5 minutes
Detonator “All-Fire” current: ....3.5 amps·
Detonator (recommended).............5.0 to 22.0 amps·
Firing time at 5.0 amps: .... 3 ms (typical)

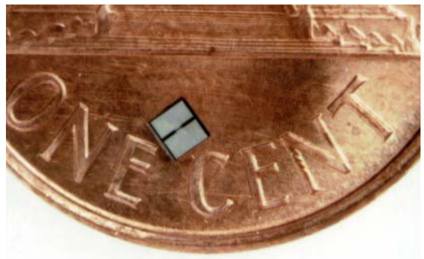
Optional Isolator Mounts For High Shock/Vibration Environments

PERFORMANCE FEATURES

- Non-fragmenting and non-outgassing
- Safe if inadvertently fired in the safe position
- Remote electrical arming and safing
- The unit can be manually disarmed but cannot be manually armed
- Mechanical and electrical systems are inseparable whether the device is operated electrically or manually
- The firing circuit and explosive train are redundant
- Firing circuits and control/monitor circuits are located in separate connectors
- Remote monitoring of safe or armed status is integral within the circuitry
- A visual indicator window shows safe or armed status
- A safety pin prevents accidental arming of the unit during transportation, handling, and checkout
- The safety pin is non-removable when arming power is applied
- In the safe position, the detonator lead wires are shunted and the shunt is grounded through 15,000-ohm resistors
- Firing circuits have 25-ohm resistors to provide for ordnance system checkout in safe position

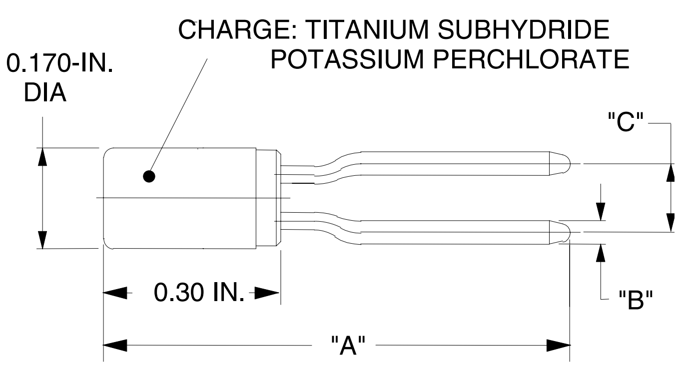
SCB INITIATOR

TEM-I-902



ATK Elkton's unique squib design employs a patented Semiconductor Bridge (SCB) to provide advantages over traditional hot-wire devices. Operation of the SCB chip produces a plasma output that enhances safety by allowing the initiation of insensitive materials (rather than primary explosives) in the squib. It achieves highly repeatable and fast function times (as low as 50 msec). The SCB initiator has been qualified to MIL-STD-1512 and serves as part of the human-rated U.S. Air Force Universal Water Activated Release System (UWARS). The SCB takes only 10% of the energy required by a conventional bridgewire for initiation (requiring 1 to 3 millijoules versus 30 to 35 millijoules for conventional bridgewire devices), but can meet 1-watt/1-amp for 5 minutes minimum no-fire requirements. The SCB interface configuration and all-fire and no-fire levels can be tailored for individual mission requirements. The device currently meets both DoD and DoE military requirements for electrostatic discharge.

The output of the squib and its mechanical interface can be tailored for specific applications. Our baseline initiator design serves as the core component for all our new devices, including digitally and optically addressable units. Design modifications can be made as necessary to accommodate new requirements or optimize high-volume production needs



PIN CONFIGURATION - BENT OR STRAIGHT
(A, B, C customer defined)

SAFETY/FEATURES/BENEFITS

- Contains no primary explosive material
- Pyrotechnic material test data compatible to MIL-STD-1316 approved material
- Qualified to MIL-STD-1512; human-rated
- Passed electrostatic discharge (ESD): 25 kV, 500 pF, through a 5000 ohm resistor, over 100 pulses
- Passes 1-watt/1-amp, 5-minute no-fire requirement
- Passed –420°F performance testing
- Passed simulated 10-year aging
- Passed >50,000 g performance testing
- Passed 28-day temperature shock, humidity, and altitude environments per MIL-I-23659
- Radiated RF sensitivity: MIL-STD-1385B (HERO), design-dependent
- Pressure shock: 15,000 psi
- Monitor current: 100ma, 1008 hours, -40° to 194°F, 42 cycles
- Low, consistent energy requirements (1–3 mJ)
- Highly repeatable, fast function time (as low as 50 µs);
- Highly reliable (0.9992 at 95% confidence)
- Requires 10% of the energy of a bridgewire initiator
- Ability to customize interface configuration and all-fire and no-fire levels
- Autoignition: 350°F for 6 hours; 257°F for 12 hours
- Digital and optical addressable units available
- Excellent heritage: over 40,000 units fabricated and over 5,000 successfully tested
- Handling shock: 6-foot drop, -65° and 215°F, 75 drops
- DoE-approved for use in actuators of weapon systems
- Thermal shock: 200 cycles, -40° to 194°F, 1 hour per cycle; 120 cycles, -65° to 215°F, 1-hour dwell

ESA

TEM-O-1068-1

The Electronic Safe-and-Arm (ESA) is a low-power, stand-alone S&A device for ordnance initiation. Designed as a drop-in replacement for traditional electromechanical devices, it provides fail-safe, no single-point failure, arm and fire interrupts, and physical blocking of pyrotechnic output in a smaller and lighter weight package. Based on ATK's semiconductor bridge (SCB) squib technology, the ESA provides advanced EMI immunity with safety at the point of initiation. By incorporating the SCB squib with a hermetic seal tested to >20,000 psi in the ESA, the traditional pyrotechnic transfer train components can be eliminated to allow for reduced hardware and lot acceptance test costs as well as reducing the burden of tracking items with limited shelf life. Added benefits of the ESA not available in electromechanical S&As are automatic built-in test (BIT) capability plus the availability of serial status telemetry including safe/arm status and bridge resistance verification.

UNIQUE DESIGN

Dimensions .... 1-in. diameter, 3.2-in. long
ESA assembly weight .... ~125 grams
Installed protrusion length................................ 2.2 in.
Material construction.................. 304L stainless steel

- Operates on typical 28 Vdc bus
- Threaded interface
- Harvard architecture microprocessor
- No primary explosives

FEATURES

- BIT capability
- Safe/arm monitor output (serial data)
- Initiator bridge verification
- LED visual status indicator
- Meets 1-amp/1-watt, 5-minute, NO FIRE requirement
- Hermetic and maintains reliable pressure seal (proofed to 20,000 psi)
- Low-energy SCB initiator

DEMONSTRATED

- Tested in STAR motor ignition systems
- Tested in 21-in. and 24-in. diameter tactical motor ignition systems (ASAS boosters)
- Tested in IHPRPT (Phase I) test motor
- Baseline for new design STAR motor ignition system

SAFETY

- Independent arm and fire inhibits
- Arm and fire sequence requirements
- Dual safing methods; quick safe feature and dual-bleed resistors for fail-safe discharge
- High- and low-side switch protection to isolate SCB from stray energy
- Range safety reviews successfully completed

Eastern/Western Range Review............ Spring 2000
Range Commanders Council Review..... Spring 2000
U.S. Army Safety Review Board................. Fall 1999

SYSTEM PERFORMANCE

Arm signal voltage output .... 22 – 36 Vdc
Peak power .... 7 W for 150 msec
Average power .... 1.4 W
Transient current................... <250 mA for 150 msec
Steady-state current .... ~ 50 mA
Arm time... <100 msec
Fire signal voltage input......................... 18 – 36 Vdc
Steady-state and transient current .... <10 mA
Fire output time .... <10 msec
Quick safe .... <1 msec
Bleed safe .... <7 sec
SCB firing time .... <50 µsec

- Operates over long distances (several hundred feet)
- Extensive diagnostic and system status monitoring
- Capable of autonomous timing of events

EOSA

TE-O-1054-1

ATK is developing an Electro-Optical Safe-and-Arm (EOSA) device that combines laser light energy and photovoltaic technology to safely and reliably initiate electroexplosive devices.

The EOSA consists of an ignition control module (ICM), dual fiber-optic transmission cables (FOTC), and electro-optical initiators (EOI). This system provides complete isolation of the electrical initiator from sources of energy that could cause inadvertent initiation. All power, command, and data signals are transmitted optically between the ICM and the EOI by laser diodes via fiber optic cables. The optical signals are then converted to electrical signals by photovoltaic converters for decoding and action.

This relieves the system from transmission loss effects over long cable lengths that are detrimental to direct laser ordnance initiation systems and from the shielding and noise penalties associated with electrical transmissions.

System input/output, self-diagnostic functions, arming plug, and visual safe/arm indicators are contained in the ICM. Safe-and-arm functions and the initiator squib are contained in the EOI and are activated by coded optical signals from the ICM. System arming causes the EOI to charge a capacitor locally storing the firing energy at the point of initiation. The FIRE command from the ICM causes the EOI to discharge the capacitor to the initiator squib causing it to fire. Either the SAFE command or the loss of signal from the ICM will cause the EOI to rapidly discharge the capacitor through bleed resistors rendering the system SAFE.

A built-in-test (BIT) capability provides a real-time system check and feedback of the safe/arm status to the user both visually and through vehicle telemetry. The design uses Sandia National Laboratory's patented electro-optical initiation technology and ATK's patented MIL-STD-1512 qualified semiconductor bridge (SCB) initiator.

SAFETY FEATURES

- Three independent and unique inhibits
- Dedicated connector for FIRE commands
- Dual safing methods:
  - SAFE command for rapid capacitor discharge
  - Dual bleed resistors for capacitor discharge for fail-to-safe loss of signal
- Visual LED status indicators for POWER, ARM, and SAFE
- Isolation from stray electrical and EMI energy at the point of initiation
- Coded optical commands for immunity to stray optical energy
- Arming plug removal to interrupt all electrical power to the control module
- Does not utilize direct initiation of ordnance by laser light

PHYSICAL CHARACTERISTICS

EOSA assembly weight .... 1.50 lb
ICM .... 1.63-in. high x 3.50-in. wide x 4.44-in. long
EOI.................................. 1.20-in. dia. X 2.34-in. long
Fiber size .... 100-micron silicon core fiber

SYSTEM PERFORMANCE

Operating voltage .... 28 Vdc
Peak power (per channel)..................... 5W for 1 sec
Average power (per channel) 3W
Arming/safing time .... 1 sec maximum
Firing time .... 100 msec

- Dual channels for complete redundancy
- Automatic built-in-test (BIT) with extensive diagnostic and system health monitoring
- Ability to operate over hundreds of feet of cable
- Autonomous timing and sequencing of events

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