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 I-IV family has a combined total of over 1,900 flights and a demonstrated reliability of 99.95%. Since then, newer derivatives including the CASTOR IVA, IVA-XL, and IVB have replaced the CASTOR IV motor.

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

Northrop Grumman currently manufactures a complete line of first- and second-stage and strap-on solid rocket motors. Over 50% of the U.S. space launches carry commercial satellites and CASTOR motors are designed to provide low-cost, high-reliability propulsion to support that access to space. Northrop Grumman has used the base technology from four generations of ballistic missile boosters and the technology and experience from expendable launch vehicle programs to continue to add to the CASTOR series.

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 have served as stage one of the Lockheed Martin Athena I and stages one and two on Athena II, and Northrop Grumman Taurus and Minotaur-C vehicles used it as an initial stage (Stage 0) booster.

The CASTOR 30/30B/30XL upper stages have each flown successfully on Northrop Grumman's Antares launch vehicle for International Space Station resupply missions.

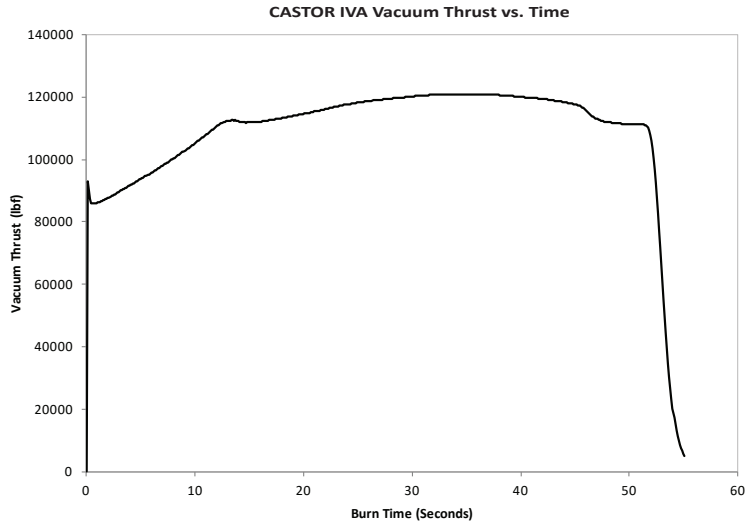
Inquiries regarding our CASTOR motor products should be directed to our business development representatives at psbdev@ngc.com.

CASTOR IVA

NORTHROP GRUMMAN

FIXED NOZZLE

The CASTOR IVA motor was developed in the early 1980s for NASA. By switching to HTPB propellant (from the earlier CASTOR IV), 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. In addition, a straight nozzle version powered Orbital Sciences' Prospector suborbital vehicle and two motors flew on the Conestoga in October 1995. CASTOR IVA motors have also flown on the Lockheed Martin Atlas IIAS, which was first flown in 1993. The four strap-on boosters on the Atlas IIAS increased payload capacity by 1,500 lb. Two boosters are ground-lit at ignition and two are air-ignition. Two configurations are available; -03, with an 11-degree canted nozzle, and -04, with a 7-degree canted nozzle.



MOTOR DIMENSIONS

Motor diameter, in. 40.1
Overall motor length (including nozzle), in. 363.4
Nozzle exit cone diameter, in. 33.6

MOTOR PERFORMANCE (73°F NOMINAL, VACUUM)

Burn time, sec 55.2
Maximum thrust, lbf 120,880
Specific impulse, lbf-sec/lbm 265.3
Total impulse, lbf-sec 5,967,840
Burn time average thrust, lbf 108,190

WEIGHTS, LBM

Total motor 25,737
Propellant 22,286
Burnout 3,239

PROPELLANT DESIGNATION

..... TP-H8299, HTPB POLYMER, 20% ALUMINUM

HAZARDS CLASSIFICATION 1.3

RACEWAY ..... YES

ORDNANCE ..... YES

TVA ..... NO

TEMPERATURE LIMITS

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

PRODUCTION STATUS

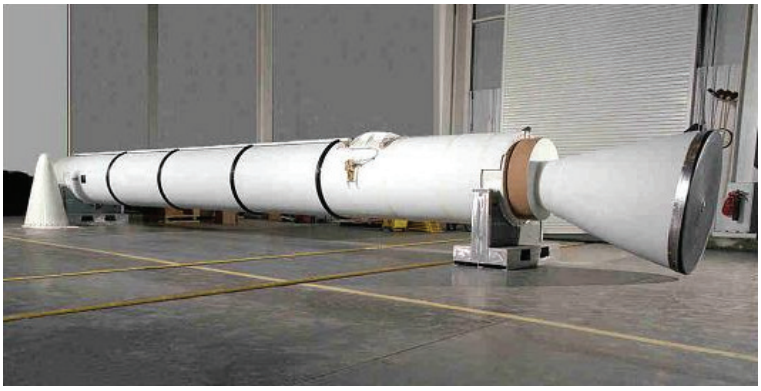
..... FLIGHT PROVEN, INACTIVE PRODUCTION

For more information, contact:
psbdev@ngc.com

northropgumman.com

CASTOR IVA-XL

NORTHROP GRUMMAN



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 used modified CASTOR IVA-XL motors with 6-degree canted nozzles as solid strap-on boosters. The H-IIA can use two or four solid strap-on boosters depending on mission requirements and vehicle configuration. The first CASTOR IVA-XL solid strap-on booster motors flew on the H-IIA vehicles in 2002.

MOTOR DIMENSIONS

Motor diameter, in. 40.1
Overall motor length (including nozzle), in. 457.0
Nozzle exit cone diameter, in. 50.5

MOTOR PERFORMANCE (73°F NOMINAL, VACUUM)

Burn time, sec 58.0
Maximum thrust, lbf 172,060
Specific impulse, lbf-sec/lbm 282.4
Total impulse, lbf-sec 8,140,170
Burn time average thrust, lbf 140,480

WEIGHTS, LBM

Total motor 33,031
Propellant 28,906
Burnout 3,653

PROPELLANT DESIGNATION

..... TP-H8299, HTPB POLYMER, 20% ALUMINUM

HAZARDS CLASSIFICATION 1.3

RACEWAY ..... YES

ORDNANCE ..... YES

TVA ..... NO

TEMPERATURE LIMITS

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

PRODUCTION STATUS

..... FLIGHT PROVEN, INACTIVE PRODUCTION

VECTORABLE NOZZLE IN-LINE BOOSTER

For more information, contact:
psbdev@ngc.com

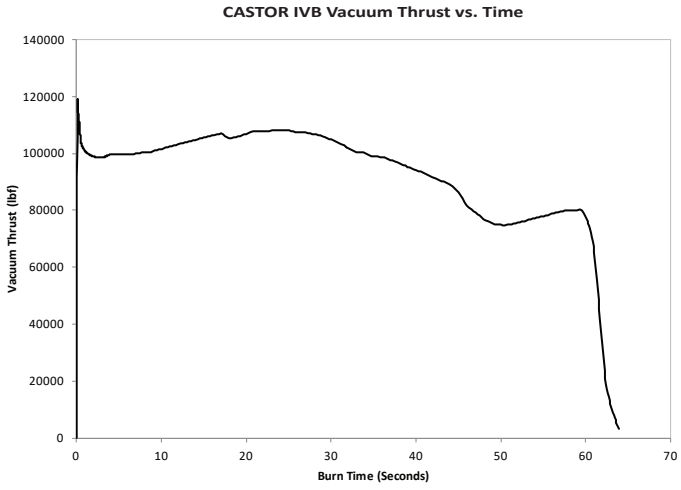
northropgumman.com

CASTOR IVB

NORTHROP GRUMMAN

VECTORABLE NOZZLE IN-LINE BOOSTER

The CASTOR IVB motor was the first in the series of CASTOR IV motors to incorporate thrust vector control 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 also served as first stage motors for three of the U.S. Army's Theater Critical Measurement Program launches in 1996 and 1997, for the U.S. Air Force's ait-2 (launched from Kodiak, Alaska in 1999), for Spain's Capricornio in 1997, as first and second stages for the Conestoga launch vehicle in 1995, and as numerous target vehicles for the Missile Defense Agency.



MOTOR DIMENSIONS

Motor diameter, in. 40.1
Overall motor length (including nozzle), in. 353.7
Nozzle exit cone diameter, in. 37.0

MOTOR PERFORMANCE (73°F NOMINAL, VACUUM)

Burn time, sec. 63.6
Maximum thrust, lbf. 119,150
Specific impulse, lbf-sec/lbm 267.3
Total impulse, lbf-sec 5,880,600
Burn time average thrust, lbf 92,490

WEIGHTS, LBM

Total motor 25,441
Propellant 21,990
Burnout 3,254

PROPELLANT DESIGNATION

..... TP-H8299, HTPB POLYMER, 20% ALUMINUM

HAZARDS CLASSIFICATION..... ..... 1.3

RACEWAY ..... YES

ORDNANCE ..... YES

TVA ..... YES

TEMPERATURE LIMITS

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

PRODUCTION STATUS .....

.....FLIGHT PROVEN, PRODUCTION

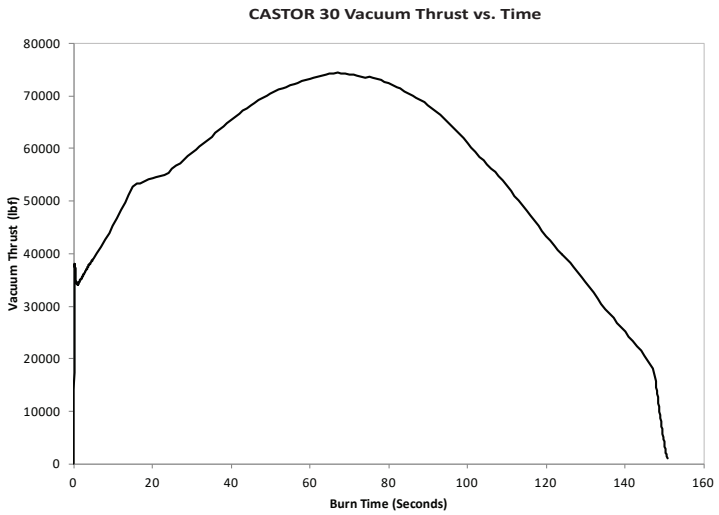
For more information, contact:
psbdev@ngc.com

northropgumman.com

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 commercially developed motor is 144 inches 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
Overall motor length (including nozzle), in. 144.2
Nozzle exit cone diameter, in. 49.7

MOTOR PERFORMANCE (70°F NOMINAL, VACUUM)

Burn time, sec. 149.8
Maximum thrust, lbf 74,359
Specific impulse, lbf-sec/lbm. 293.1
Total impulse, lbf-sec 8,239,110
Burn time average thrust, lbf 53,700

WEIGHTS, LBM

Total motor 30,590
Propellant 28,098
Burnout 2,268

PROPELLANT DESIGNATION

..... TP-H1265, HTPB POLYMER, 20% ALUMINUM

HAZARDS CLASSIFICATION… 1.3

RACEWAY ..... OPTIONAL

ORDNANCE ..... OPTIONAL

TVA ..... YES

TEMPERATURE LIMITS

Operation ..... +30°-100°F
Storage…. ..... +30°-105°F

PRODUCTION STATUS ..... FLIGHT-PROVEN

For more information, contact:
psbdev@ngc.com

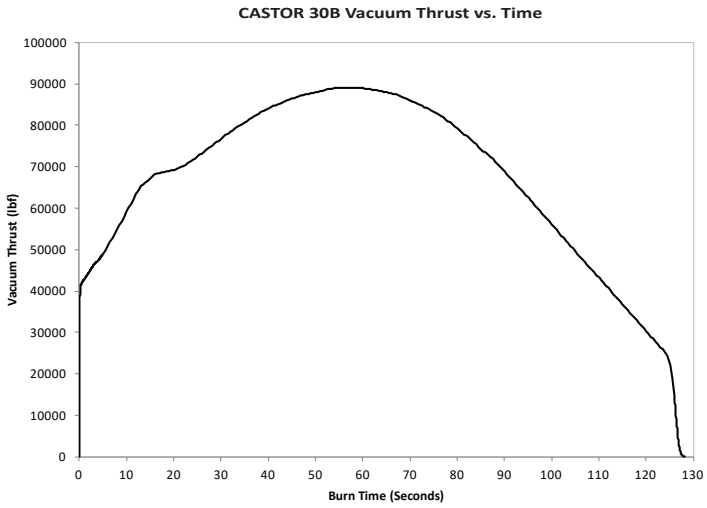
northropgumman.com

CASTOR 30B

NORTHROP GRUMMAN

VECTORABLE NOZZLE IN-LINE UPPER STAGE BOOSTER

The CASTOR 30B is a low-cost, robust, state-of-the-art upper stage motor. This production motor incorporates a few modifications from the CASTOR 30, primarily a change in propellant and a longer nozzle. It is 169.9 inches long and nominally designed as an upper stage that can function as a second or third stage depending on the vehicle configuration.



MOTOR DIMENSIONS

Motor diameter, in. 92
Overall motor length (including nozzle), in. 169.9
Nozzle exit cone diameter, in. 62.4

MOTOR PERFORMANCE (70°F NOMINAL, VACUUM)

Burn time, sec 126.7
Maximum thrust, lbf 89,090
Specific impulse, lbf-sec/lbm 300.6
Total impulse, lbf-sec 8,539,320
Burn time average thrust, lbf 67,370

WEIGHTS, LBM

Total motor 30,800
Propellant 28,405
Burnout 2,203

PROPELLANT DESIGNATION

..... TP-H8299, HTPB POLYMER, 20% ALUMINUM

HAZARDS CLASSIFICATION 1.3

RACEWAY ..... OPTIONAL

ORDNANCE ..... OPTIONAL

TVA ..... YES

TEMPERATURE LIMITS

Operation ..... +30°-100°F
Storage ..... +30°-105°F

PRODUCTION STATUS ..... FLIGHT-PROVEN

For more information, contact:
psbdev@ngc.com

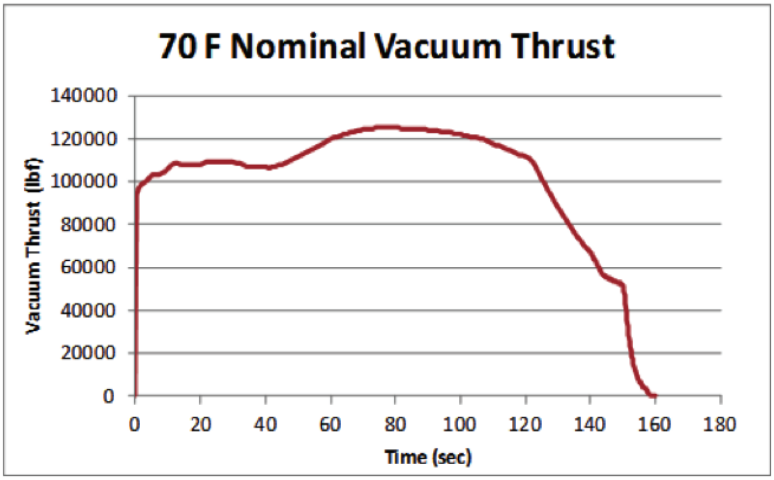
northropgumman.com

CASTOR 30XL

NORTHROP GRUMMAN

VECTORABLE NOZZLE IN-LINE UPPER STAGE BOOSTER

The CASTOR 30XL is a low-cost, robust, state-of-the-art upper stage motor. CASTOR 30XL is more than a stretched version of the CASTOR 30. The motor also capitalizes on existing common designs and materials, plus lessons learned while developing the Large Class Stage I and III. The motor is 235.8 inches long and nominally designed as an upper stage that can function as a second or third stage depending on the vehicle configuration. The nozzle is 8 feet long with a submerged design with a high-performance expansion ratio (55.9:1) and a dual density exit cone well suited for high altitude operation. It features an electro-mechanical thrust vector actuation system with actuators, thermal battery, and electronic controller. First flight on Antares was October 2016.



MOTOR DIMENSIONS

Motor diameter, in. 92
Overall motor length (including nozzle), in. 235.8
Nozzle exit cone diameter, in. 78.7

MOTOR PERFORMANCE (70°F VACUUM, VACUUM)

Burn time, sec 155.0
Maximum thrust, lbf 119,900
Effective specific impulse, lbf-sec/lbm… 294.4
Total impulse, lbf-sec 16,174,800
Burn time average thrust, lbf 104,350

WEIGHTS, LBM

Total motor 58,217
Propellant 54,949
Burnout (est.) 3,069

PROPELLANT DESIGNATION

..... QDL-1, HTPB POLYMER, 19% ALUMINUM

HAZARDS CLASSIFICATION…. 1.3

RACEWAY ..... NO

ORDNANCE ..... NO

TVA ..... YES

TEMPERATURE LIMITS

Operation ..... +55°-85°F
Storage… ..... +30°-100°F

PRODUCTION STATUS ..... FLIGHT-PROVEN, ... IN PRODUCTION

For more information, contact:
psbdev@ngc.com

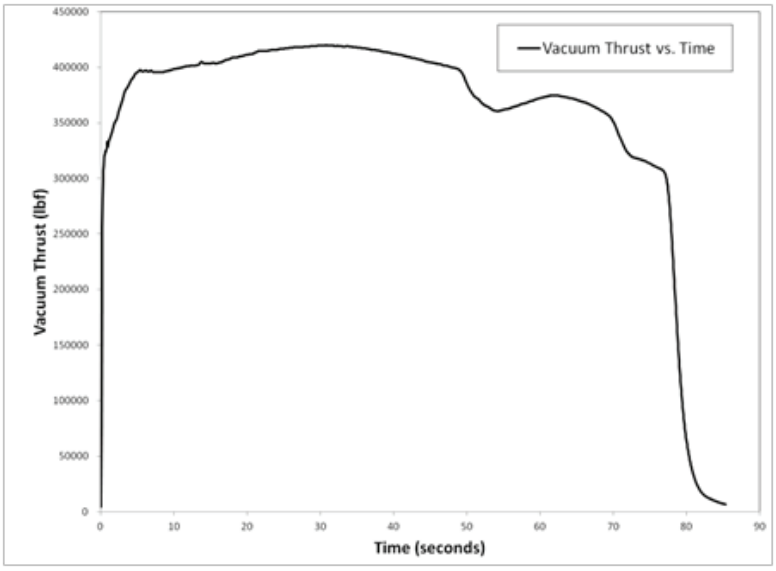
northropgumman.com

CASTOR 120

NORTHROP GRUMMAN

VECTORABLE NOZZLE

The CASTOR 120 was designed, using proven technology, to meet the need for a medium-sized, reliable solid rocket booster. While primarily anticipated for in-line use, the CASTOR 120 motor can also be configured as a strap-on booster with a moveable nozzle and a cold-gas blowdown system thrust vector control. The thrust vector control system can be removed and the nozzle fixed. The propellant grain can also be tailored to reduce thrust during max-Q pressure for high initial thrust or for a regressive thrust to reduce acceleration. To date, the CASTOR 120 has been used in both first stage and second stage applications.



MOTOR DIMENSIONS

Motor diameter, in. 92.0
Overall motor length (including nozzle), in. 355
Nozzle exit cone diameter, in. 59.7

MOTOR PERFORMANCE (70°F VACUUM, VACUUM)

Burn time, sec 79.4
Maximum thrust, lbf 440,000
Specific impulse, lbf-sec/lbm 280
Total impulse, lbf-sec 30,000,000
Burn time average thrust, lbf 379,000

WEIGHTS, lbm

Total motor 116,993
Propellant 107,914
Burnout 9,097

PROPELLANT DESIGNATION

..... TP-H1246, HTPB POLYMER, 19% ALUMINUM

HAZARDS CLASSIFICATION 1.3

RACEWAY ..... YES

ORDNANCE ..... YES

TVA ..... YES

TEMPERATURE LIMITS

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

PRODUCTION STATUS

..... FLIGHT PROVEN, INACTIVE PRODUCTION

For more information, contact:
psbdev@ngc.com

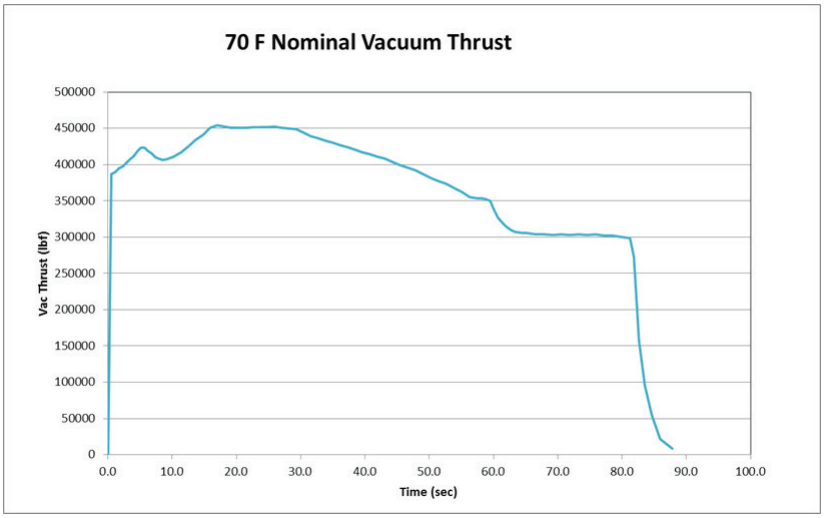
northropgumman.com

CASTOR 120XL

NORTHROP GRUMMAN

VECTORABLE NOZZLE BOOSTER

The CASTOR 120XL is a new low-cost, robust, state-of-the-art booster stage. CASTOR 120XL is more than just a stretched version of the CASTOR 120. The motor also capitalizes on existing common designs and materials, as well as lessons learned while developing the Large Class Stage I and III for the U.S. Air Force. The motor is 378.3 inches long and nominally designed as a medium-sized in-line booster. It features an electro-mechanical thrust vector actuation system with actuators, thermal battery and electronic controller.



MOTOR DIMENSIONS

Motor diameter, in. 92.1
Overall motor length (including nozzle), in. 378.3
Nozzle exit cone diameter, in. 59.8

MOTOR PERFORMANCE (70°F VACUUM, VACUUM)

Burn time, sec 83.5
Maximum thrust, lbf 458,500
Effective specific impulse, lbf-sec/lbm.... ..... 279.1
Total impulse, lbf-sec 31,892,000
Burn time average thrust, lbf 381,701

WEIGHTS, LBM

Total motor 123,383
Propellant 114,194
Burnout (est) 8,850

PROPELLANT DESIGNATION

..... TP-H1246, HTPB POLYMER, 19% ALUMINUM

HAZARDS CLASSIFICATION..... ..... 1.3

RACEWAY ..... Yes

ORDNANCE ..... Yes

TVA ..... Yes

TEMPERATURE LIMITS

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

PRODUCTION STATUS

..... QUALIFIED, INACTIVE PRODUCTION

For more information, contact:
psbdev@ngc.com

northropgumman.com