Monopropellant Propulsion
Aerojet Rocketdyne produces monopropellant rocket engines with thrust ranges from 0.02 lbf to 600 lbf.

> 17,000 flight monopropellant thrusters delivered
**Design Characteristics**

- Propellant: Hydrazine
- Catalyst: S-405
- Thrust/Steady State: 0.07 – 0.09 N (0.016 - 0.020 lbf)
- Feed Pressure: 14.8 – 18.6 bar (215 - 270 psia)
- Flow Rate: 154.2 – 181.4 g/hr (0.34 – 0.40 lbm/hr)
- Valve: Dual Seat
- Valve Power: 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power: 1.9 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr: 1.8 Watts Max @ 28 Vdc & 21°C
- Mass: 0.60 kg (1.32 lbm)
  - Engine: 0.33 kg (0.74 lbm)
  - Valve: 0.20 kg (0.44 lbm)
  - Heaters: 0.065 kg (0.14 lbm)

**Performance**

- Specific Impulse, steady state: 180 - 184 sec (lbf-sec/lbm)
- Specific Impulse, cumulative: 150 - 177 sec (lbf-sec/lbm)
- Total Impulse: 199,693 N-sec (44,893 lbf-sec)
- Total Starts/Pulses: 5,960
- Min Impulse Bit: 4.0 N-sec @ 14.8 bar & 60 sec ON
  (0.9 lbf-sec @ 215 psia & 60 sec ON)
- Steady State Firing: 0 - 900 sec Single Firing
  720 hrs Cumulative

**Status**

- Flight Proven
- Currently in Production

**Reference**

- JANNAF, 2011, paper 2225
MR-103G 1N (0.2 lbf) Rocket Engine Assembly

**Design Characteristics**
- Propellant: Hydrazine
- Catalyst: S-405
- Thrust/Steady State: 1.13 - 0.19 N (0.253 - 0.043 lbf)
- Feed Pressure: 28.3 - 4.8 bar (420 - 70 psia)
- Chamber Pressure: 23.8 - 4.5 bar (345 - 65 psia)
- Expansion Ratio: 100:1
- Flow Rate: 0.5 - 0.09 g/sec (0.0011 - 0.0002 lbm/sec)
- Valve: Dual Seat
- Valve Power: 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power: 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr: 6.32 Watts Max @ 28 Vdc & 21°C
- Mass: Engine: 0.33 kg (0.73 lbm), Valve: 0.13 kg (0.24 lbm), Heaters: 0.033 kg (0.14 lbm)

**Performance**
- Specific Impulse: 224 - 202 sec (lbf-sec/lbm)
- Total Impulse: 97,078 N-sec (21,825 lbf-sec)
- Total Pulses: 835,017
- Min Impulse Bit: 0.0133 N-sec @ 6.9 bar & 15 ms ON (0.003 lbf-sec @ 100 psia & 15 ms ON)
- Steady State Firing: 300 & 1,000 sec Single Firing
  23.8 — 40.6 hrs Cumulative

**Status**
- Flight Proven
- Currently in Production; Transitioning to MR-103J

**Reference**
- AIAA-2005-3952
### Design Characteristics

- **Propellant**: Hydrazine
- **Catalyst**: S-405
- **Thrust/Steady State**: 1.13 - 0.19 N (0.253 - 0.043 lbf)
- **Feed Pressure**: 28.3 - 4.8 bar (420 - 70 psia)
- **Chamber Pressure**: 23.8 - 4.5 bar (345 - 65 psia)
- **Expansion Ratio**: 100:1
- **Flow Rate**: 0.5 - 0.09 g/sec (0.0011 - 0.0002 lbm/sec)
- **Valve**: Dual Seat
- **Valve Power**: 8.25 Watts Max @ 28 Vdc & 21°C
- **Valve Heater Power**: 1.54 Watts Max @ 28 Vdc & 21°C
- **Cat. Bed Heater Pwr**: 6.32 Watts Max @ 28 Vdc & 21°C
- **Mass**: 0.37 kg (0.82 lbm)
  - **Engine**: 0.11 kg (0.24 lbm)
  - **Valve**: 0.20 kg (0.44 lbm)
  - **Heaters**: 0.065 kg (0.14 lbm)

### Performance

- **Specific Impulse**: 224 - 202 sec (lbf-sec/lbm)
- **Total Impulse**: 183,000 N-sec (41,000 lbf-sec)
- **Total Pulses**: 1,002,345
- **Min Impulse Bit**: 0.0133 N-sec @ 6.9 bar & 15 ms ON (0.003 lbf-sec @ 100 psia & 15 ms ON)
- **Steady State Firing**: 3,600 sec Single Firing 84hrs Cumulative

### Status

- **Qualified; First Flight in 2020**
- **Currently in Production**

### Reference

- **AIAA-2016-4980**
Design Characteristics

- Propellant: Hydrazine
- Catalyst: S-405
- Thrust/Steady State: 4.9 - 1.8 N (1.1 - 0.4 lbf)
- Feed Pressure: 24.1 - 6.7 bar (350 - 100 psia)
- Chamber Pressure: 10.0 - 3.7 bar (145 - 54 psia)
- Expansion Ratio: 74:1
- Flow Rate: 2.0 - 0.77 g/sec (0.0044 - 0.0017 lbm/sec)
- Valve: Dual Seat
- Valve Power: 8.25 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power: 1.54 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Power: 6.32 Watts Max @ 28 Vdc & 21°C
- Mass: 0.37 kg (0.82 lbm)
  - Engine: 0.11 kg (0.24 lbm)
  - Valve: 0.20 kg (0.44 lbm)
  - Heaters: 0.065 kg (0.14 lbm)

Performance

- Specific Impulse: 229 - 219 sec (lbf-sec/lbm)
- Total Impulse: 262,000 N-sec (59,000 lbf-sec)
- Total Pulses: 420,000
- Min Impulse Bit: 0.076 N-sec @ 15.5 bar & 20 ms ON
  - (0.017 lbf-sec @ 225 psia & 20 ms ON)
- Steady State Firing: 10,000 sec demonstrated - Single Firing

Status

- Flight Proven
- Currently in Production

Reference

- AIAA-2012-3817
Design Characteristics

- Propellant: Hydrazine
- Catalyst: S-405/LCH-202
- Thrust/Steady State: 34 - 10 N (7.7 - 2.3 lbf)*
- Feed Pressure: 27.6 - 5.9 bar (400 - 85 psia)
- Chamber Pressure: 13.4 – 3.8 bar (195 – 56 psia)
- Expansion Ratio: 60:1
- Flow Rate: 14.0 – 4.1 g/sec (0.031 - 0.009 lbm/sec)
- Valve: Dual Seat
- Valve Power: 25.1 Watts Max @ 28 Vdc & 21°C
- Valve Heater Power: 4.00 Watts Max @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr: 7.06 Watts Max @ 28 Vdc & 21°C
- Mass: 0.59 kg (1.14 lbm) Nom

* Note: thrust levels up to 9 lbf have been qualified and flown

Performance

- Specific Impulse: 235 - 228 sec (lbf-sec/lbm)
- Total Impulse: 561,388 N-sec (126,205 lbf-sec)
- Total Pulses: 120,511
- Min Impulse Bit: 0.015 N-sec @ 5.9 bar & 16 ms ON (0.034 lbf-sec @ 85 psia & 16 ms ON)
- Steady State Firing: 4,000 sec Single Firing

Status

- Flight Proven
- Currently in Production

Reference

- AIAA-2005-3954
**Design Characteristics**

- **Propellant**: Hydrazine
- **Catalyst**: S-405/LCH-202
- **Thrust/Steady State**: 125 - 54 N (28 - 12 lbf)
- **Feed Pressure**: 35 - 7 bar (500 - 100 psia)
- **Chamber Pressure**: 4.7 – 1.8 bar (69 - 26 psia)
- **Expansion Ratio**: 21.5:1
- **Flow Rate**: 55.8 – 22.7 g/sec (0.125 - 0.05 lbm/sec)
- **Valve**: Single Seat
- **Valve Power**: 34.8 Watts Max @ 28 Vdc & 20°C
- **Valve Heater Power**: 4.0 Watts Max @ 28 Vdc & 21°C
- **Cat. Bed Heater Pwr**: 13.2 Watts Max @ 28 Vdc & 21°C
- **Mass**: 1.01 kg (2.23 lbm)
  - Engine: 0.67 kg (1.48 lbm)
  - Valve: 0.34 kg (0.75 lbm)
  - Heaters: 0.065 kg (0.14 lbm)

**Performance**

- **Specific Impulse**: 222 - 225 sec (lbf-sec/lbm)
- **Total Impulse**: 162,360 N·sec (36,500 lbf·sec)
- **Total Pulses**: 36,500
- **Min Impulse Bit**: 0.015 N·sec @ 5.9 bar & 16 ms ON
  - (0.034 lbf·sec @ 85 psia & 16 ms ON)
- **Steady State Firing**: 100 sec @ 125 N (28 lbf)
  - 100 sec @ 54 N (12 lbf)

**Status**

- Flight Proven
- Currently in Production

**Reference**

- AIAA-2012-3817
### Design Characteristics
- **Propellant**: Hydrazine
- **Catalyst**: S-405/LCH-202
- **Thrust/Steady State**: 360 - 85 N (81 - 19 lbf)
- **Feed Pressure**: 35 - 7 bar (500 - 100 psia)
- **Chamber Pressure**: 14 - 4 bar (197 - 45 psia)
- **Expansion Ratio**: 21.5:1
- **Flow Rate**: 154.7 - 36.3 g/sec (0.341 - 0.08 lbm/sec)
- **Valve**: Single Seat
- **Valve Power**: 34.8 Watts Max @ 28 Vdc & 20°C
- **Valve Heater Power**: 4.0 Watts Max @ 28 Vdc & 21°C
- **Cat. Bed Heater Pwr**: 13.2 Watts Max @ 28 Vdc & 21°C
- **Mass**: 1.01 kg (2.23 lbm)
- **Engine**: 0.67 kg (1.48 lbm)
- **Valve**: 0.34 kg (0.75 lbm)
- **Heaters**: 0.065 kg (0.14 lbm)

### Performance
- **Specific Impulse**: 225 - 236 sec (lbf-sec/lbm)
- **Total Impulse**: 337,620 N-sec (75,900 lbf-sec)
- **Total Pulses**: 30,300
- **Min Impulse Bit**: 0.015 N-sec @ 5.9 bar & 16 ms ON (0.034 lbf-sec @ 85 psia & 16 ms ON)
- **Steady State Firing**: 41 sec @ 360 N (81 lbf)
  - 30 sec @ 285 N (64 lbf)
  - 100 sec @ 236 N (53 lbf)

### Status
- **Flight Proven
- **Currently in Production**

### Reference
- **AIAA-2012-3817**
**Design Characteristics**

- **Propellant**: Hydrazine
- **Catalyst**: S-405/LCH-202
- **Thrust/Steady State**: 307 - 182 N (69 - 41 lbf)
- **Feed Pressure**: 52.4 – 20.6 bar (760 - 300 psia)
- **Chamber Pressure**: 8.4 – 2.6 bar (122 – 38 psia)
- **Expansion Ratio**: 21.5:1
- **Flow Rate**: 98 – 31 g/sec (0.216 - 0.07 lbm/sec)
- **Valve**: Single Seat
- **Valve Power**: 34.8 Watts Max @ 28 Vdc & 20°C
- **Valve Heater Power**: 4.0 Watts Max @ 28 Vdc & 21°C
- **Cat. Bed Heater Pwr**: 13.2 Watts Max @ 28 Vdc & 21°C
- **Mass**:
  - Engine: 1.16 kg (2.56 lbm)
  - Valve: 0.22 kg (0.50 lbm)
  - Mass: 1.38 kg (3.06 lbm)

**Performance**

- **Specific Impulse**: 229 - 223 sec (lbf-sec/lbm)
- **Total Impulse**: 102,691 N-sec (23,086 lbf-sec)
- **Total Pulses**: 4,412
- **Min Impulse Bit**: 0.015 N-sec @ 5.9 bar & 16 ms ON (0.034 lbf-sec @ 85 psia & 16 ms ON)
- **Steady State Firing**: 100 sec @ 111 N (25 lbf)

**Status**

- Flight Proven
- Currently in Production

**Reference**

- AIAA-2012-3817

*Note: ICD Available Upon Request*
Design Characteristics

- **Propellant**: Hydrazine
- **Catalyst**: S-405/LCH-202
- **Thrust/Steady State**: 220 - 67 N (49.5 - 15 lbf)
- **Feed Pressure**: 26 – 5.5 bar (377 - 80 psia)
- **Chamber Pressure**: 8.4 – 2.6 bar (122 – 38 psia)
- **Expansion Ratio**: 21.5:1
- **Flow Rate**: 98 – 31 g/sec (0.216 - 0.07 lbm/sec)
- **Valve Power**: 34.8 Watts Max @ 28 Vdc & 20°C
- **Valve Heater Power**: 4.0 Watts Max @ 28 Vdc & 21°C
- **Cat. Bed Heater Pwr**: 13.2 Watts Max @ 28 Vdc & 21°C
- **Mass**: 1.01 kg (2.23 lbm) Engine
- **Valve**: 0.67 kg (1.48 lbm)
- **Heaters**: 0.065 kg (0.14 lbm)

Performance

- **Specific Impulse**: 229 - 223 sec (lbf-sec/lbm)
- **Total Impulse**: 362,303 N-sec (81,449 lbf-sec)
- **Total Pulses**: 10,161
- **Min Impulse Bit**: 0.015 N-sec @ 5.9 bar & 16 ms ON (0.034 lbf-sec @ 85 psia & 16 ms ON)
- **Steady State Firing**: 100 sec @ 111 N (25 lbf)

Status

- **Flight Proven**
- **Currently in Production**

Reference

- AIAA-2012-3817
Design Characteristics

- Propellant: Hydrazine
- Catalyst: S405/LCH-202
- Thrust/Steady State: 554.2 – 201.0 N (124.6 – 45.2 lbf)*
- Feed Pressure: 28.9 – 6.9 bar (420 – 100 psia)
- Chamber Pressure: 10.7 – 3.9 bar (155 – 56 psia)
- Expansion Ratio: 54:1
- Flow Rate: 249.5 – 90.8 g/sec (0.55 – 0.20 lbm/sec)
- Valve: Dual Seat
- Valve Power: 52 Watts @ 28 Vdc & 21°C
- Cat. Bed Heater Pwr: 8.1 Watts/el @ 28 Vdc & 21°C
- Weight: 2.40 kg (5.3 lbm) Engine, 1.40 kg (3.1 lbm) Valve

Performance

- Specific Impulse: 237 – 223 sec (lbf-sec/lbm)
- Total Impulse: 854,000 N-sec (192,000 lbf-sec)
- Total Pulses: 6,520
- Minimum Impulse Bit: 8.23 N-sec @ 24 bar & 22 ms ON
  (1.85 lbf-sec @ 350 psia & 22ms ON)
- Steady State Firing: 2,011 sec – Single Firing, 2,654 sec – Cumulative

Status

- Flight Proven
- Currently in Production

*Note: Thrust levels up to 200 lbf have been demonstrated.

Photo: optional right angle thruster shown with 24:1 expansion ratio nozzle
Design Characteristics

- Propellant: Hydrazine
- Catalyst: S405/LCH-202
- Feed Pressure: 28.2 – 20 bar (410 – 290 psia)
- Chamber Pressure: 12.4 – 8.5 bar (180–124 psia)
- Expansion Ratio: 7:1
- Flow Rate: 284.4 – 195.0 g/sec (0.627 – 0.43 lbm/sec)
- Minimum Electrical Pulse width: 40 msec
- Valve: Dual Seat
- Max Valve Heater Power: 6 Watts @ 37 Vdc
- Max Cat. Bed Heater Pwr: 26 Watts/el @ 34 Vdc
- Max Valve Pwr: 56 Watts/coil@ 28 Vdc
- Weight (-301): 6.44 kg (14.2 lbm)
- Valve: 1.00 kg (2.2 lbm)

Key Capabilities

- Thermally isolated valve
- Full mechanical attachment for integration and replacement simplicity
- Integrated flow inhibitor to block re-entry gasses
- Patent pending nozzle brace - Hot shock capable
- Designed for reusability

Performance

- Vac Specific Impulse (MR-104J): 223 – 215 sec (lbf-sec/lbm)
- Total Impulse(MR-014G)......912,000 N-sec (205,000 lbf-sec)
- Total Pulses(MR-104G)........................................6,600
- Steady State Firing (MR-104D).......2,011 sec – Single Firing
  .................................................................2,654 sec – Cumulative

Status

- Qualified; First Flight 2019
- Currently in Production

*Note thrust levels up to 200 lbf and down to 45 lbf have been demonstrated.
Design Characteristics

- Propellant: Hydrazine
- Catalyst: S-405
- Thrust/Steady State: 3603 - 31 N (810 - 7 lbf)
- Thrust step response: 80 msec for 90% step
- Feed Pressure: 47.2 bar (685 psia)
- Chamber Pressure: 19.44 – 0.14 bar (282 - 2 psia)
- Expansion Ratio: 27.2:1
- Flow Rate: 98 – 31 g/sec (3.64 - 0.0009 lbm/sec)
- Valve: Cavitating Throttle
- Valve Power: 8 Watts Max @ 28 Vdc & 20°C
- Valve Heater Power: 9.45 Watts Max @ 30 Vdc & 21°C
- Cat. Bed Heater Pwr: 6.3 Watts Max @ 30 Vdc & 21°C
- Mass: 168 kg (18.76 lbm)
  - Engine: 92 kg (15.26 lbm)
  - Valve: 1.59 kg (3.50 lbm)

Performance

- Specific Impulse: 225 - 200 sec (lbf-sec/lbm)

<table>
<thead>
<tr>
<th></th>
<th>Dev. #1</th>
<th>Dev. #2</th>
<th>Dev. #3R</th>
<th>Qual.</th>
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<tbody>
<tr>
<td>Starts</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>10</td>
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<tr>
<td>Totals</td>
<td>292.1 kg</td>
<td>183.7 kg</td>
<td>451.3 kg</td>
<td>308.4 kg</td>
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<td>Throughput</td>
<td>(644 lbm)</td>
<td>(405 lbm)</td>
<td>(995 lbm)</td>
<td>(680 lbm)</td>
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<td>Total Firing Time</td>
<td>334 sec</td>
<td>418 sec</td>
<td>806 sec</td>
<td>560 sec</td>
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<td>Longest Single Firing</td>
<td>76 sec</td>
<td>117 sec</td>
<td>137 sec</td>
<td>214 sec</td>
</tr>
</tbody>
</table>

Status

- Flight Proven
- Currently in Production

Reference

- 2007-AIAA-5481
MRM-106F 40N (9.0-lbf) Rocket Engine Module

### Design Characteristics
- Propellant: Monopropellant Hydrazine
- Catalyst: LCH-207/202
- Thrust/Steady State (per rocket): 40N (9.0 lbf)
- Chamber Pressure: 16 bar (237 psia)
- Expansion Ratio: 61:1
- Flow Rate: 17.7 g/sec (0.039 lbm/sec)
- Valve: Single Seat, Non-sliding Fit
- Valve Power: 20.1 Watts Nominal @ 28 Vdc & 21°C
- Mass: <2.23 kg (4.9 lbm) per REM
- No Catalyst Bed Heaters or Valve Heaters
- 22 Pin Electrical Connector

### Performance
- Specific Impulse: 231 sec (lbf-sec/lbm)
- Total Impulse: 136,000 N-sec (30,618 lbf-sec)
- Total Pulses: 1,570
- Minimum Impulse Bit: 2.62 N-sec @ 31 bar & 20 ms ON
  (0.59 lbf-sec @ 450 psia & 60 ms ON)
- Steady State Firing: 1,000 sec Single Firing
  2,991 sec – Cumulative

### Status
- Flight Proven
- Currently in Production
Performance
- Specific Impulse
  - 228 – 217 sec (lbf·sec/lbm)
- Total Impulse
  - 332,000N·sec (74715 lbf·sec)
- Total pulses
  - 7,005
- Minimum impulse Bit
  - 1.20 N·sec @9.3 bar & 20ms ON
  - (0.27 lbf·sec @135 psia & 20 ms ON)
- Steady State Firing
  - 2,137 sec – Single Firing
  - 2,684 sec - Cumulative

Status
- Flight Proven
- Currently in Production
Bipropellant Propulsion
Bipropellant rocket engines range from 5 lbf to 6000 lbf

HiPAT™ Dual Mode 100 lbf
HiPAT™ 100 lbf
R-4D 110 lbf
R-42 200 lbf
R-40B 900 lbf
R-6F 5 lbf
R-1E 25 lbf Shuttle Vernier
AJ10-220 14 lbf
AJ10-190 6,000 lbf

AR has delivered >2,500 bipropellant engines
Design Characteristics

- Propellant: MMH/NTO (MON-3)
- Nominal Thrust (steady state): 62.3 N (14.0 lbf)
- Thrust Range (steady state)*: 59.2–65.4 N (13.3-14.7 lbf)
- Chamber Pressure*: 6.89 bar (100 psia)
- Inlet Pressure*: 15.2 bar (220 psia)
- Inlet Pressure Range: 25.5 – 9.99 bar (370 – 145 psia)
- Valve, Power: Moog, 38 W @ 28 VDC
- Expansion Ratio: 75:1
- Nominal Flow Rate: 22.3 g/s (0.049 lbm/s)
- Nominal Mixture Ratio (O/F): 1.65
- Mixture Ratio Range (O/F): 1.50 -1.80
- Mass: 1.95 kg (4.3 lbm)

Performance

- Specific Impulse @ 220 psia, 70°F and MR=1.65: 285 s (Steady firing) / 268 s (Pulse Mode)
- Total Impulse Qualified: 685,000 N-s (154,000 lbf-s)
- Minimum Impulse Bit: 0.898 N-s (0.202 lbf-s)
- Demonstrated Steady State Firing Duration: 300 s
- Total Number of Pulses Qualified: 65,000+

Status

- Flight Proven
- Currently in Production

Dimensional Envelope

- 19.0 cm (7.5 in) long, 7.30 cm (2.9 in) diameter

References

- 1993-AIAA-2218

* Standard Inlet Conditions
R-1E 110N (25 lbf) Bipropellant Rocket Engine

Design Characteristics
- Propellant: MMH/NTO(MON-3)
- Thrust/Steady State: 111 N (25 lbf)
- Inlet Pressure Range: 27.6-6.9 bar (400-100 psia)
- Chamber Pressure*: 7.3 bar (106 psia)
- Expansion Ratio: 100:1
- Flowrate*: 40.4 g/sec (0.089 lbm/sec)
- Valve: Aerojet Solenoid, Single Coil, Single Seat
- Valve Power: 36 Watts @ 28 Vdc
- Mass: 2 kg (4.4 lbm)

Performance
- Specific Impulse*: 280 sec (lbf-sec/lbm)
- Total Impulse: 11,120,000 N-sec (2,500,000 lbf-sec)
- Total Pulses: 330,000
- Minimum Impulse Bit: 0.89 N-sec (0.2 lbf-sec)
- Steady State Firing (sec): No Limitations

Status
- Flight Proven
- Currently in Production

Reference
- AIAA - 1990 - 1837

* At rated thrust
Design Characteristics

- Propellant: MMH/NTO (MON-3)
- Nominal Thrust (steady state): 490 N (110 lbf)
- Thrust Range (steady state): 378 – 511 N (85-115 lbf)
- Chamber Pressure*: 7.45 bar (108 psia)
- Inlet Pressure*: >14 bar (>205 psia)
- Inlet Pressure Range: 4.1 – 29.3 bar (60 – 425 psia)
- Valve: Aerojet Rocketdyne, Single Coil, Single Seat
- Expansion Ratio: 164:1, 300:1
- Nominal Mixture Ratio (O/F): 1.65
- Mixture Ratio Range (O/F): 1.17 – 2.13
- Mass: 164:1 = 3.76 kg (8.3 lbm), 300:1 = 4.31 kg (9.5 lbm)

Performance

- Specific Impulse @ 70°F and MR = 1.65: 164:1 = 311 sec (lbf·sec/lbm)
- Total Impulse Demonstrated: 20,016,000 N·sec (4,500,000 lbf·sec)
- Minimum Impulse Bit: 15.6 N·sec (3.5 lbf·sec)
- Demonstrated Steady State Firing Duration: 12,000 s
- Total Number of Pulses Qualified: 31,950 starts†
- C-103/Ti 300:1 = 85 thermal cycles†
- C-103 164:1 = 245 thermal cycles†

Status

- Flight Proven
- Currently in Production

References


† Performed on different engines.
* At nominal thrust
R-4D-15 HiPAT™ 445 N (100 lbf) High Performance Rocket Engine

**Design Characteristics**
- Propellant: MMH/NTO (MON-3)
- Nominal Thrust (steady state): 445 N (100 lbf)
- Thrust Range (steady state): 378 – 511 N (85-115 lbf)
- Chamber Pressure*: 9.44 bar (137 psia)
- Inlet Pressure*: >14 bar (>205 psia)
- Inlet Pressure Range: 27.6 - 6.9 bar (400 – 100 psia)
- Valve: Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio: 300:1 or 375:1
- Nominal Mixture Ratio (O/F): 1.65
- Mixture Ratio Range (O/F): 1.50 - 1.80
- Mass: 5.2 kg (11.5 lbm) / 5.44 kg (12.0 lbm)

*At nominal Thrust

**Performance**
- 375:1 Specific Impulse @ 70°F and MR = 1.65: 320.6 s (typical for 60 s run)
- Total Impulse Qualified: 13,019,945 N-s (2,927,000 lbf-s)
- Minimum Impulse Bit: 35.6 N-s (8 lbf-s)
- Demonstrated Steady State Firing Duration: 7,200 sec
- Total Number of Pulses Qualified: 391 starts

**Status**
- Flight Proven
- Currently in Production

**References**
R-4D-15 HiPAT™ 445 N (100 lbf) Dual Mode High Performance Rocket Engine

Design Characteristics
- Propellant: Hydrazine/NTO (MON-3)
- Nominal Thrust (steady state): 445 N (100 lbf)
- Thrust Range (steady state): 329 – 556 N (70-125 lbf)
- Chamber Pressure*: 9.4 bar (137 psia)
- Inlet Pressure*: >16.2 bar (235 psia)
- Inlet Pressure Range: 21.4 – 15.2 bar (310 – 220 psia)
- Valve: Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio: 300:1 or 375:1
- Nominal Mixture Ratio (O/F): 1.0
- Mixture Ratio Range (O/F): 0.70 – 1.33
- Mass: 300:1 = 5.2 kg (11.5 lbm), 375:1 = 5.44 kg (12.0 lbm)

Performance
- Specific Impulse @ 70°F and MR = 1.0: 300:1 = 326 sec, 375:1 = 329 sec
- Total Impulse Qualified: > 9.55 X10^6 N·sec (2.15 X 10^6 lbf·sec)
- Minimum Impulse Bit: 35.6 N·s (8 lbf·s)
- Demonstrated Steady State Firing Duration: 1,800 sec
- Total Number of Pulses Qualified: 672 starts
- 345 thermal cycles

Status
- Qualified
- Currently in Production

References
- AIAA-2003-4775

* At nominal Thrust
Design Characteristics

- Propellant: MMH/NTO(MON-3)
- Thrust/Steady State: 890 N (200 lbf)
- Inlet Pressure Range: 29.3-6.9 bar (425-100 psia)
- Chamber Pressure*: 7.1 bar (103 psia)
- Expansion Ratio: 160:1
- Flowrate*: 300 g/sec (0.66 lbm/sec)
- Valve: Aerojet Rocketdyne Single or Dual Seat
- Valve Power: Various (46 Watts @ 28 Vdc Typical for Single Seat)
- Mass: 4.53 kg (10.0 lbm)

Performance

- Specific Impulse*: 305 sec (lbf-sec/lbm)
- Total Impulse: 24,271,000 N-sec (5,456,700 lbf-sec)
- Total Starts: 150
- Minimum Impulse Bit: 44.48 N-sec (10.0 lbf-sec)
- Steady State Firing Cumulative: 27,000 sec
- Steady State Firing (Single Firing): 3,940 sec

Status

- Flight Proven
- Currently in Production

Reference

- AIAA - 1990 - 2055

*At nominal conditions
R-6F 22N (5lbf) Bipropellant Rocket Engine

**Design Characteristics**
- Propellant: MMH/NTO (MON-3)
- Thrust/Steady State: 22 N (5 lbf)
- Operating Thrust Range: 13.3 to 27.8 N (3.0 to 6.25 lbf)
- Mixture Ratio/Steady State: 1.61
- Operating Mixture Ratio Range: 1.0 to 2.0
- Expansion Ratio: 150:1
- Nominal Flow Rate: 7.44 g/sec (0.00164 lbm/sec)
- Inlet Pressure: 6.9 to 20.79 bar (100 to 300 psia)
- Valve: Bipropellant duel seat solenoid with upstream latching feature
- Valve Power: 11 watts @ 28 Vdc
- Mass: 0.965 kg (2.1 lbm)

**Performance**
- Specific Impulse: 305 lbf-sec/lbm
- Total Impulse: >89,700 N-sec (20,175 lbf-sec)
- Total pulses: >19,881
- Minimum Impulse Bit: 0.53 N-sec (0.12 lbf-sec)
- Steady State Firing: 0.010 sec to Unlimited

**Status**
- Ready for flight qualification
- Not in Production
**Design Characteristics**

- **Propellant**: Hydrazine/NTO (MON-3)
- **Thrust/Steady State**: 890 N (200 lbf)
- **Inlet Pressure Range**: 31.0-5.5 bar (450-80 psia)
- **Chamber Pressure**: 9.6 bar (140 psia)
- **Expansion Ratio**: 200:1
- **Oxidizer / Fuel Ratio**: 0.8 – 1.30 (1.0 nominal)
- **Flowrate**: 277 g/sec (0.61 lbm/sec)
- **Valve**: Aerojet Rocketdyne Single or Dual Seat
- **Valve Power**: Various (45 Watts @ 28 Vdc Typical for Single Seat)
- **Mass**: with single seat valves 7.3 kg (16.0 lbm)

**Performance**

- **Specific Impulse**: 327 sec (lbf-sec/lbm)
- **Total Impulse**: >20,000,000 N-sec (4,500,000 lbf-sec)
- **Total Starts**: >60
- **Minimum Impulse Bit**: 44.48 N-sec (10.0 lbf-sec)
- **Steady State Firing Cumulative**: 6,400 sec
- **Steady State Firing (Single Firing)**: 1,000 sec

**Status**

- Ready for flight qualification
- Not in Production

*At nominal conditions*
AMBR 556 N (125 lbf) Dual Mode High Performance Rocket Engine

Design Characteristics
- Propellant: Hydrazine/NTO(MON-3)
- Nominal Thrust (steady state): 489 – 556 N (110 – 125 lbf)
- Thrust Range (steady state): 325 – 645 N (73 – 145 lbf)
- Chamber Pressure*: 10.3 – 11.7 bar (150 – 170 psia)
- Inlet Pressure*: >14 bar (>205 psia)
- Valve: Aerojet Rocketdyne, Dual Coil, Single Seat
- Expansion Ratio: 400:1
- Nominal Mixture Ratio (O/F): 1.0 – 1.3
- Mixture Ratio Range (O/F): 0.62 – 1.96
- Mass: 4.9 kg (10.8 lbm)

* At nominal Thrust

Performance
- Specific Impulse @ 70°F and MR = 1.0: 329 sec (lbf·sec/lbm)
- Total Impulse: 5,792,919 N·sec (1,302,300 lbf·sec)
- Demonstrated Steady State Firing Duration: 2,700 sec
- Total Number of Starts Demonstrated: 88 total starts

Status
- Ready for final flight design/analysis, and qualification
- Not in Production

References
Design Characteristics

- Propellant: MMH/NTO(MON-3)
- Thrust/Steady State*: 3,870 N (870 lbf)
- Inlet Pressure Range: 27.6 – 10.3 bar (400 - 150 psia)
- Chamber Pressure*: 9.9 bar (150 psia)
- Expansion Ratio: 22:1
- Flowrate*: 1,400 g/sec (3.07 lbm/sec)
- Valve: Aerojet Rocketdyne Single Seat
- Valve Power: 70 Watts @ 28 Vdc
- Mass**: 10.5 kg (23.0 lbm)

*At rated thrust
**Varies by configuration

Performance

- Specific Impulse*: 281 sec (lbf-sec/lbm)
- Total Impulse: 92,073,600 N-sec (20,700,000 lbf-sec)
- Total Pulses: 50,000
- Minimum Impulse Bit: 111 N-sec (25.0 lbf-sec)
- Steady State Firing Cumulative: 23,000 sec

Status

- Flight Proven
- Not in Production; Requires component obsolescence update

Reference

- AIAA-1985-1222
- AIAA-1980-1131
- AIAA-1980-1130
R-40B 4,000N (900 lbf) Bipropellant Rocket Engine

Design Characteristics

- Propellant: MMH/NTO(MON-3)
- Thrust/Steady State*: 4,000 N (900 lbf)
- Inlet Pressure Range: 27.6 – 10.3 bar (400 - 150 psia)
- Chamber Pressure*: 10.34 bar (150 psia)
- Expansion Ratio: 60:1
- Flowrate*: 1,400 g/sec (3.07 lbm/sec)
- Valve: Aerojet Rocketdyne Single Seat
- Valve Power: 70 Watts @ 28 Vdc
- Mass: 10.5 kg (23.0 lbm)

*At rated thrust

Performance

- Specific Impulse*: 293 sec (lbf-sec/lbm)
- Total Impulse: 92,073,600 N-sec (20,700,000 lbf-sec)
- Total Pulses: 50,000
- Minimum Impulse Bit: 111 N-sec (25.0 lbf-sec)
- Steady State Firing Cumulative: 23,000 sec

Status

- Flight Proven
- Not in Production; Requires component obsolescence update

Reference

- IAF-1987-0283
**Design Characteristics**

- Propellant: MMH/NTO (MON-3)
- Thrust/Steady State*: N (6,000 lbf)
- Inlet Pressure Range: 16.6 bar (240 psia)
- Chamber Pressure*: bar (125 psia)
- Expansion Ratio: 55:1
- Flowrate: 8.61 kg/sec (19.0 lbm/sec)
- Valve: Aerojet Rocketdyne Pneumatic Procured Solenoid Pilot
- Valve Power (all coils energized): 125 Watts @ 28 Vdc
- Mass: 118 kg (260 lbm)
- Engine Length: 77 in. / Engine Dia: 46 in.

*At rated thrust

**Performance**

- Specific Impulse*: 316 sec (lbf-sec/lbm)
- Gimbal: ± 7 °
- Total Impulse: 1,440 MN-sec (324,000,000 lbf-sec)
- Total Starts: 1,000
- Steady State Firing Cumulative: 54,000 sec

**Status**

- Flight Proven
- Not in Production

**Reference**

- AIAA 2014-3882
Chemical Propulsion Systems
AR has delivered 250 flight propulsion systems
THEMIS

- THEMIS: Time History of Events and Macroscale Interactions During Substorms
- NASA MIDEX Mission, Launched February 17, 2007
- Number of Systems: 5
- Propellant Load: 109 lbm (49.5 kg) Hydrazine
- 400-50 psia (27.6-3.5 bar) Blowdown Operation with Single Repressurization Event from 1700 psia (117 Bar) Pressurant Subsystem
- 4 MR-111C 1-lbf (4.5 N) Thrusters
- Used for Delta-V and Orbit Maintenance
- Aerojet Designed and Integrated System on Customer-Supplied Structure
- Reference: AIAA-2006-5217
STEREO: Solar-TERrestrial RELations Observatory
NASA Earth-Sun Science Mission
Launched: October 26, 2006
Systems Delivered to JHU/APL: 2
Propellant Load: 135 lbm (61 kg) Hydrazine Each

320-110 psia (22.1-7.6 bar) Blowdown Operation
12 MR-111C 1.0-lbf (4 N) Thrusters
Designed for Attitude Control and Course Correction
Aerojet Rocketdyne Designed and Integrated System on Customer-Supplied Structure
Mission to Pluto
- Launched: January 19, 2006
- Systems Delivered to JHU/APL: 1
- Propellant Load: 143 lbm (65 kg) Hydrazine
- 420-75 psia (28.9-5.2 bar) Blowdown Operation
- 12 MR-103H 0.2-lbf (1N) Thrusters
- 4 MR-111C 1-lbf (5N) Thrusters
- Designed for Attitude Control and Course Correction
- Aerojet Designed and Integrated System on Customer-Supplied Structure
- Reference: IAC-2004-S.1.09
• Systems Flown: 3
• Propellant Load: 464 lbm (210 kg) Hydrazine Total in 2 Tanks
• 400-100 psia (27.5-6.9 bar) Blowdown Operation
• 12 MR-103G 0.2-lbf (1 N) Thrusters
• 4 MR-501B Electrothermal Hydrazine Thrusters (EHTs)
• Used for Orbit Raising and Attitude Control (GEO Spacecraft)
• Aerojet Integrated System on Customer-Supplied Structure
Performance Parameters
• Propellant Mass…118 – 145kg (260 – 320 lbm)
• Total Impulse…249,000 N-S (56,000 lbf·sec)
• Pressurant Mass… 1.8 kg (4lbm)
• Pressure BOL/EOL…27.5/6.5 – 11.4 bar (400/95 – 165 psia)
• Blowdown Ratio…4:1

Reference
• AIAA-1999-3469
Performance Parameters
• Propellant Mass...22.3 kg (49 lbm)
• Total Impulse (per REA)...46,000 N·sec (10,428 lbf·sec) @ 21°C
• Pressure BOL/EOL...18.8/5.2 bar (273/76 psia) @ 21°C
• Blowdown Ratio...36:1

Status
• Flight Proven

Reference
• AIAA-2001-3637

Component Description
• See chart at top right

<table>
<thead>
<tr>
<th>Item</th>
<th>QTY</th>
<th>Manufacture</th>
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<tbody>
<tr>
<td>Tank</td>
<td>1</td>
<td>PSI</td>
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<tr>
<td>1N (0.2 lbf) REA (MR103G)</td>
<td>4</td>
<td>Aerojet Rocketdyne</td>
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<tr>
<td>Fill/Drain Valve Fuel</td>
<td>1</td>
<td>Moog</td>
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<tr>
<td>Fill/Drain Valve GN2</td>
<td>1</td>
<td>Moog</td>
</tr>
<tr>
<td>Latch Valve</td>
<td>1</td>
<td>Moog</td>
</tr>
<tr>
<td>Pressure Transducer</td>
<td>1</td>
<td>Paine</td>
</tr>
<tr>
<td>Filter</td>
<td>-</td>
<td>Wintec, LLC</td>
</tr>
</tbody>
</table>
Performance Parameters
- Propellant Mass: 22 kg (49 lbm)
- Total Impulse: 42,000 N·sec (9500 lbf·sec)
- Pressure Mass: 0.22 kg (0.49 lbm)
- Pressure BOL/EOL: 22.7 / 6.2 bar (329/90 psia)
- Blowdown Ratio: 3.7:1
- System Mass BOL/EOL: 39.5 / 17.2 kg (87/38 lbm)

Status
- Flight Proven

Component Description
- See chart at right

<table>
<thead>
<tr>
<th>Item</th>
<th>QTY</th>
<th>Manufacture</th>
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<tr>
<td>Tank</td>
<td>2</td>
<td>PSI</td>
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<tr>
<td>1N (0.2 lbf) REA (MR-103C)</td>
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<td>Aerojet Rocketdyne</td>
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<tr>
<td>4N (1.0 lbf) REA (MR-111C)</td>
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<td>Fill/Drain Valve GN2</td>
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<td>VACCO</td>
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<tr>
<td>Latch Valve</td>
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<tr>
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<td>1</td>
<td>Paine</td>
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<tr>
<td>Filter</td>
<td>1</td>
<td>VACCO</td>
</tr>
</tbody>
</table>
• Systems Flown: 1
• Propellant Load: 165 lbm (90 kg) Hydrazine
• 350-125 psia (24.1-8.6 bar) Blowdown Operation
• 14 MR-103G 0.2-lbf (1 N) Thrusters
  2 MR-106E 5-lbf (22 N) Thrusters
• Used for Attitude Control (Interplanetary Spacecraft)
• Aerojet Integrated System on Customer-Supplied Structure
• Systems Flown: 1
• Propellant Load: 200 lbm (91 kg) Hydrazine
• 400-75 psia (27.5-5.2 bar) Blowdown Operation
• 4 MR-111C 1-lbf (4 N) Thrusters
• Used for Orbit Raising (LEO Spacecraft)
• Aerojet Integrated System and Secondary Structure on Customer-Supplied Primary Structure

(Coriolis HPS Schematic)
Green & CubeSat Propulsion
Green Propulsion and CubeSat Propulsion

GPIM

GR-1

GR-1A

MPS-130-1U

GR-M1

MPS-135-6U
Modular Propulsion Systems

CubeSat Modular Propulsion Systems

- High reliability, high delta-V propulsion for CubeSats and SmallSats
- Orbit maintenance, station keeping, and reaction control
- High density non-toxic green propellant and traditional hydrazine

System Specifications

<table>
<thead>
<tr>
<th>Thrust Range</th>
<th>1U</th>
<th>2U</th>
<th>4U</th>
<th>6U</th>
<th>8U</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.25 – 1.0 N (per thruster)</td>
<td>MPS-130-1U</td>
<td>MPS-130-2U</td>
<td>MPS-135-4U</td>
<td>MPS-135-6U</td>
<td>MPS-135-8U</td>
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<tr>
<td>System Impulse* (N·s)</td>
<td>&gt;1,130</td>
<td>&gt;2,720</td>
<td>&gt;7,290</td>
<td>&gt;13,740</td>
<td>&gt;19,390</td>
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<tr>
<td>System Dry Mass (kg)</td>
<td>1.1</td>
<td>1.4</td>
<td>3.5</td>
<td>4.3</td>
<td>5.1</td>
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<tr>
<td>System Wet Mass (kg)</td>
<td>1.7</td>
<td>2.8</td>
<td>7.2</td>
<td>11.2</td>
<td>14.7</td>
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</table>

Hydrazine

<table>
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<th>1U</th>
<th>2U</th>
<th>4U</th>
<th>6U</th>
<th>8U</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.25 – 1.0 N (per thruster)</td>
<td>MPS-120-1U</td>
<td>MPS-120-2U</td>
<td>MPS-125-4U</td>
<td>MPS-125-6U</td>
<td>MPS-125-8U</td>
</tr>
<tr>
<td>System Impulse* (N·s)</td>
<td>&gt;810</td>
<td>&gt;1,950</td>
<td>&gt;5,240</td>
<td>&gt;9,800</td>
<td>&gt;13,930</td>
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<tr>
<td>System Dry Mass (kg)</td>
<td>1.2</td>
<td>1.5</td>
<td>3.6</td>
<td>4.4</td>
<td>5.1</td>
</tr>
<tr>
<td>System Wet Mass (kg)</td>
<td>1.6</td>
<td>2.5</td>
<td>6.2</td>
<td>9.3</td>
<td>12.1</td>
</tr>
</tbody>
</table>

*System impulse based on steady state firing operation. Actual total impulse will vary based on operational duty cycles.

Performance Data

- Piston Tank Systems
- Pump Tank Systems

11411 139th Place NE • Redmond, WA 98052
(425) 885-5000  FAX (425) 882-5747
Innovative Propulsion Solutions for CubeSats and SmallSats

- High reliability, high delta-V propulsion for CubeSats and SmallSats
- Orbit maintenance, station keeping, and reaction control
- High density non-toxic green propellant and traditional hydrazine

**Propulsion System Designations:**

**MPS - 135 - 6U**

- **Size of Propulsion System**
  - 1U = ~10 x 10 x 10 cm volume
  - 2U = ~10 x 10 x 20 cm volume
  - 4U = ~22 x 20 x 10 cm volume
  - 6U = ~22 x 20 x 16 cm volume
  - 8U = ~22 x 20 x 22 cm volume
  (U Designations for CubeSat systems only)

- **Model Number Designator**
  - 0 = Piston fed with condensable pressurant
  - 5 = Pump fed with PMD tanks

- **Propellant Type**
  - 1 = Cold gas
  - 2 = Hydrazine (most requested)
  - 3 = ‘Green’ AF-M315E (most requested)
  - 4 = Electric Propulsion

- **System Size Class**
  - 1 = CubeSat systems (most requested)
  - 2 = SmallSat systems
  - 3 = ESPA Ring systems

- **System Class**
  - MPS = Modular Propulsion System

**Figure** | **Models**
---|---
MPS-130-1U | MPS-120-1U
MPS-130-2U | MPS-120-2U
MPS-135-4U | MPS-125-4U
MPS-135-6U | MPS-125-6U
MPS-135-8U | MPS-125-8U
Electric Propulsion
AR has delivered over 550 electric propulsion devices

- Electrothermal Hydrazine Thruster and PPU / Arcjet and Feed System
- Hydrazine Arcjets and Power Processing Unit / Arcjet and Feed System
- High Power Ammonia Arcjet and Feed System
- Pulsed Plasma Thruster
- Hall Thruster
- Xenon Ion Engine
**Design Characteristics**

Propellant.............................................. Hydrazine
Catalyst................................................. S405
Thrust/Steady State................... 0.80 – 0.36N (0.18 – 0.08 lbf)
Feed Pressure.......................... 26.5-6.2 bar (285 – 90 psia)
Flow Rate......................... 0.28-0.12 g/sec (0.00026 lbm/sec)
Valve...................................................... Dual Seat Valve
Valve Power......................... 8.25 Watts Max @ 28 Vdc & 21°C
Valve Heater Power........... 1.54 Watts Max @ 28 Vdc & 21°C
Cat. Bed Heater Pwr............ 3.93 Watts Max @ 28 Vdc & 21°C
Augmentation Heater Pwr.......... 885 – 610 Watts
Augmentation Htr Voltage.............. 29.5 – Vdc
Letdown Mass................................. 0.87 kg (1.92 lbm)

**Performance**

Mission Specific Impulse *
Steady-State Blowdown............. 303 – 294 sec (lbf-sec/lbm)
Total Impulse...................... 524,864 N-sec (118,000 lbf-sec)
Total Pulses...................... MR-502A not designed for pulsing
Steady State Firing... 2 hrs Single Firing / 370 hrs Cumulative

**Status**

Flight Proven
In Production

**Reference**

A1AA-1987-0996
**Design Characteristics**

- **Mass** ............................................ 2 kg
- **Envelope** ............... 27.94 x 9.42 x 14.61 cm
- **Input Voltage** ......................... 15-29.9 vdc
- **Inrush Current** .............. 32 Amp Max
- **Efficiency** ................................. >97%

**Interface**

- **Enable/Disable Command** .... Latch Relay Drive
- **On/Off Command** .............. 0V – Off, 14V – On

**Demonstrated Performance**

- Limits inrush current to the 30 Amps during augmentation heater warm-up
- Two identical independent channels that can be operated either redundantly or simultaneously
- When used simultaneously, the IMPEHT pair should be started one after the other

**Status**

- Flight Proven
- Not currently in production
Design Characteristics
- Propellant: High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal): 18.6 – 13.8 bar (270 – 200 psia)
- Mass:
  - Arcjet thruster + 2000 mm (70") cable: 1.4 kg (3.0 lbm)
  - PCU: 6.2 kg (13.7 lbm)
- Envelope:
  - Arcjet: 240 x 125 x 90 mm³ (9.3 x 4.9 x 3.6 inch³)
  - PCU: 310 x 220 x 95 mm³ (12.2 x 8.7 x 3.7 inch³)
- Valve: Dual seat, electrically actuated
- Valve power (standard): 8.2 W @ 28 VDC
- PCU input power per arcjet: 1780 W
- PCU input voltage: 65 – 96 VDC
- PCU efficiency, avg.: >91%
- Power cable PCU – arcjet: < 2000 mm (79 inch)
- Currently available: 1575 mm (62 inch)

Demonstrated Performance
- At 1670 W input to the arcjet (1780 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down
- Total impulse: 866,500 Ns (194,500 lbf s)
- Thrust: 254 – 213 mN (57 – 47 mlbf)
- Specific impulse: > 502 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off: > 1050 cycles
  - Number of starts: >1170
  - Longest demonstrated burn: 65 h

Status
- Flight proven, no longer in production

References
- AIAA-1998-3631
- IEPC-1997-081
- Power Conditioning Unit (PN 1000)
- Cable Assembly (PN 31168)
- Arcjet Thruster (PN 32240)
**Design Characteristics**
- Propellant: High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal): 18.6 – 13.8 bar (270 – 200 psia)
- Mass:
  - Arcjet thruster + 3175 mm (125") cable: 1.6 kg (3.5 lbm)
- Envelope
  - Arcjet: 240 x 123 x 87 mm$^3$ (9.3 x 4.9 x 3.4 inch$^3$)
- Valve: Dual seat, electrically actuated
- Valve power (standard): 8.2 W @ 28 VDC
- Power cable PCU – arcjet: < 5590 mm (220 inch)

**Status**
- Flight proven
- Recent production

**Demonstrated Performance**
At 2000 W input to the arcjet (2200 W input to the PCU), and 18.6 to 13.8 bar (270 to 200 psia) feed pressure blow down
- Total impulse: 1,450,000 Ns (326,000 lbf s)
- Thrust: 258 – 222 mN (58 – 50 mlbf)
- Specific impulse: 585 - 615 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off: > 1730 cycles
  - Number of starts: > 1960
  - Demonstrated on-time duty cycles: 4 min to 20 h

**References**
MR-512 Low Power Bus Arcjet System

**Design Characteristics**
- Propellant: High Purity Grade Hydrazine per MIL-PRF 26536G
- Feed Pressure (nominal): 17.6 – 13.8 bar (250 – 200 psia)
- Mass:
  - Arcjet thruster + 2000 mm (70") cable: 1.4 kg (3.0 lbm)
  - PCU: 6.2 kg (13.7 lbm)
- Envelope:
  - Arcjet: 240 x 125 x 90 mm$^3$ (9.3 x 4.9 x 3.6 inch$^3$)
  - PCU: 310 x 220 x 95 mm$^3$ (12.2 x 8.7 x 3.7 inch$^3$)
- Valve: Dual seat, electrically actuated
- Valve power (standard): 8.2 W @ 28 VDC
- PCU input power per arcjet: 1780 W
- PCU input voltage: 33 – 51.5 VDC
- PCU efficiency, avg.: >91%
- Power cable PCU – arcjet: < 2000 mm (79 inch)
- Currently available: 1575 mm (62 inch)

**Demonstrated Performance**
At 1670 W input to the arcjet (1780 W input to the PCU), and 270 to 200 psia feed pressure blow down
- Total impulse: 866,500 Ns (194,500 lbf s)
- Thrust: 254 – 213 mN (57 – 47 mlbf)
- Specific impulse: > 502 s
- Firing time during lifetime demonstration test:
  - Duty cycle 1 h on, > 30 min off: > 1050 cycles
  - Number of starts: > 1170
  - Longest demonstrated burn: 65 h

**Status**
- Flight proven, no longer in production

**References**
- AIAA-1998-3631
- IEPC-1997-081
**Design Characteristics**

- Propellant: Teflon® (Solid Bar)
- Max Thrust Level: 1.24 mN @ 100 Watts
- Power Level: Up to 100 Watts @ 28 vdc Unregulated
- Compact Solid State Propulsion System
- Ultra Low Minimum Impulse Bit for Precision Control
- Enables All-thruster ACS (No Momentum Wheels)
- Mass (w/o propellant): 4.74 kg
- Includes Integral Power Processing Electronics
- Power Efficiency: >80%

**Performance**

- Specific Impulse: Up to 1350 sec
- Thrust to Power Ratio: 12.4 μN/Watt
- Demonstrated Capability: 3,000 N-sec/thruster
- Predicted Capability (backed by selective testing): 15,600 N-sec/system (thruster pair)

**Status**

- Flight Proven; no longer in production

**Reference**

- AIAA-2003-5016
- AIAA-2002-3973
- AIAA-2001-3637
- AIAA-1999-3376
**XR-5 Hall Thruster**

### Design Characteristics
- Propellant: Xenon
- Mass (Thruster & Cathode): <12.3 kg
- Envelope (Thruster & Cathode): 14 x 25 x 28 cm
- Input Power: 1000 to 4500 Watt
- Input Voltage: 200 or 400 Volt

### Status
- Qualification Complete; 24 Thrusters Flown
- First flight system launched in 2010
- Six spacecraft currently flying (4 thrusters per S/C)

### Performance
<table>
<thead>
<tr>
<th>Power (kW)</th>
<th>Thrust (300 Volts)</th>
<th>Thrust (400 Volts)</th>
<th>Specific Impulse (300 V)</th>
<th>Specific Impulse (400 V)</th>
<th>Life Capability</th>
<th>Total Impulse</th>
<th>On/Off Cycles</th>
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</thead>
<tbody>
<tr>
<td>2.0</td>
<td>132 mN</td>
<td>117 mN</td>
<td>1676 sec</td>
<td>1858 sec</td>
<td>Mission Dependent</td>
<td>Mission Dependent</td>
<td>Mission Dependent</td>
</tr>
<tr>
<td>3.0</td>
<td>195 mN</td>
<td>170 mN</td>
<td>1700 sec</td>
<td>1920 sec</td>
<td></td>
<td></td>
<td>7,316 Cycles</td>
</tr>
<tr>
<td>4.5</td>
<td>290 mN</td>
<td>254 mN</td>
<td>1790 sec</td>
<td>2020 sec</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Status
- Flight Proven, In Production

### Reference
- AIAA-2010-6698
**Design Characteristics**

- Propellant: Xenon
- Thruster Mass: <13.3 kg
- Thruster Envelope Dimensions: 58 dia. x 44 cm
  Active optics area: 36 cm dia.
- Thruster Input Power: 600 to 6900 Watt
- Propellant Management System Mass
  - High Pressure Assembly: <2.2 kg
  - Low Pressure Assembly: <4.1 kg
- PMS Volume: <11,775 c.c.
- PMS does not require plenum tanks
- DCIU interface with Power Processing: RS-485

**Performance**

- Thrust: 235 mN
- Specific Impulse: >4100 sec
- Efficiency @ full power: >70%
- Propellant Throughput: >270 kg
- On/Off Cycles: >3650 cycles
- End of Life Xenon Residuals: <1% BOL

**Status**

- Qualified and in Production; First Flight DART mission

**Reference**

- AIAA-2005-3885
- AIAA-2004-4111
Electric Propulsion Power Electronics
Design Characteristics
- 3 independent power converters, 2 of which can be operated simultaneously
- Output can be switched between four different arcjets
- Redundant control circuitry and auxiliary power supplies
- Serial telemetry format; for other formats, contact Aerojet Rocketdyne
- Includes “Bubble Protection Mode” to mitigate gas induced shutdowns
- Calculated reliability for 15 years of GEO COMSAT use >0.99994
- Telemetry signals provided by the PCU:
  - Arc voltage and current
  - PCU status flags
- Mass…………………………………………15.8 kg (34.8 lbm)
- Envelope……635 x 360 x 110 mm³ (24.9 x 14.2 x 4.3 inch³)

(Design Characteristics Continued)
- Efficiency (avg.)…………………………………………………> 91%
- Heat rejection (two arcjets at 2040 W), to be dissipated by the spacecraft thermal management system.........<410 W @ 23°C
- Selectable output power levels for each converter 1530 W, 1700 W, 1870 W, 2040 W
- Input power when operating two converters at 2040 W….4430 W

Status
- Flight Proven; Recent Production

References

- Power Conditioning Unit (PN 1037)
MR-510 Arcjet System Power Conditioning Unit (PCU), 100 VDC Input

Design Characteristics
- 3 independent power converters, 2 of which can be operated simultaneously
- Output can be switched between four different arcjets
- Redundant control circuitry and auxiliary power supplies
- Serial telemetry format; for other formats, contact Aerojet Rocketdyne
- Includes “Bubble Protection Mode” to mitigate gas induced shutdowns
- Calculated reliability for 15 years of GEO COMSAT use > 0.99994
- Telemetry signals provided by the PCU:
  - Arc voltage and current
  - PCU status flags
- Mass: 19.1 kg (42.1 lbm)
- Envelope: 630 x 375 x 130 mm³ (24.8 x 14.8 x 5.1 inch³)

Design Characteristics Continued
- Efficiency: > 87%
- Heat rejection (two arcjets operating at 2040 W) to be dissipated by the spacecraft thermal management system: < 470 W
- Selectable output power levels for each converter:
  - 1530 W, 1700 W, 1870 W, 2040 W
- Input power when operating two converters at 2040 W: 4550 W

Status
- Flight Proven; Recent Production

References

- Power Conditioning Unit (PN 41540)
Design Characteristics

- Allows expansion of the MR-510 arcjet system from 1 PCU and 4 arcjets to 1 PCU and 6 (1 relay box) or 8 (2 relay boxes) arcjets
- Connects two PCU arcjet outputs to two each arcjets
- Calculated reliability for 15 years of GEO COMSAT use >0.99994
- Telemetry signals provided by the PCU:
  - Verification of relay position
  - Temperatures internal to the relay box
- Mass ......................................................... 2.2 kg (4.8 lbm)
- Envelope ........... 333 x 168 x 137 mm³ (13.1 x 6.6 x 5.4 inch³)
- Total cable length PCU to relay box to arcjet:
  ......................................................... not to exceed 5590 mm (220 inch)
- Currently, two PCU to relay box power cable lengths are available.......................... 1070 & 1625 mm (42 & 65 inch)

Status

- Flight Proven; Recent Production

References


- Relay Box (PN 41430)
**Design Characteristics**

- Mass: 12.5 kg
- Envelope: 43 x 40 x 11 cm
- Input Voltage: 70 +/- 2 VDC
- Efficiency (Avg): >92%
- MIL-STD-1553 Command & Telemetry Interface:
  - 30 Telemetry Channels
  - Commandable Power Settings:
  - Discharge Power: 2.0 - 4.5 kW
  - Discharge Voltage: 150 - 400 V

**Demonstrated Performance**

- Closed Loop Control of Xenon Flow Controller and Discharge Current
- Holding Valve Drivers
- S-Level, Radiation Hardened Components
- Optimized for Manufacturability
- Only Four Circuit Cards

**Status**

- Flight Proven; Recent Production

**Reference**

- AIAA-2005-3682
Aerojet Rocketdyne In-Space Propulsion
Redmond, Washington

CONTACT:  David Baughman  |  (425) 869-4588
david.baughman@rocket.com