



AEROSPACE INFORMATION REPORT

AIR1855™**REV. A**

Issued 1985-08
Revised 1995-08
Reaffirmed 2023-04

Superseding AIR1855

Actuation System Data Summary for Missiles and Launch Vehicles

RATIONALE

AIR1855A has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE:

This SAE Aerospace Information Report (AIR) includes all missile and launch vehicle actuation systems, including electrohydraulic, electropneumatic, and electromechanical types. The data for many systems are not complete. As more information becomes available, periodic updates will be issued to complete existing data sheets and to add new ones.

An index by type of vehicle and by type of actuation system is included. The actual data sheets in the body of the report are organized in alphabetical order.

1.1 Purpose:

A survey of existing designs (past and present) is a valuable aid during the concept formulation stage of a new design. This summary report on missile and launch vehicle actuation systems has been formulated to provide a data base that should be useful in the initial design stages of a new system.

2. REFERENCES:

There are no referenced publications specified herein.

3. VEHICLE INDEX:

3.1 Type of Vehicle:

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SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

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Documents

Document Sharing Hub

3.1.1 Missile:

- ACM (Advanced Cruise Missile)
- ALCM (Air Launched Cruise Missile)
- AMRAAM (Advanced Medium Range Air-Air Missile)
- ASALM (Advanced Strategic Air-Launched Missile)
- Condor
- Copperhead
- Dragon
- Falcon (Aim 4D, F and G)
- GBU-15 (Guided Bomb Unit)
- Harm
- Harpoon
- Hawk
- Hellfire
- HOBOS (GBU-8)
- Hornet
- Maverick
- Nike Hercules
- Patriot
- Pershing (P-1a)
- Phoenix
- SIAM
- SICBM (Small Intercontinental Ballistic Missile)
- Sidewinder
- Sparrow
- Standard Missile
- Stinger Alternate
- Talos
- Tomahawk (Rocket Motor, Rocket Motor Improved, and Cruise)
- TOW (Tube-Launched, Optically Tracked, Wire-Guided)

3.1.2 Booster/Space Vehicle:

- Atlas (Booster, Sustainer, Vernier)
- Centaur
- Delta (1st Stage)
- IUS (Inertial Upper Stage)
- Titan (1st Stage, 2nd Stage Main and Roll Engines)
- Titan IV (SRM Booster)

3.1.3 ICBM/ABM:

- Minuteman I, II, III (Stages 1, 2, 3)
- Peacekeeper (Stages 1 and 3)
- Spartan
- Sprint (Stages 1 and 2)

3.2 Type of Actuation System:

3.2.1 Hydraulic:

- ASALM
- Atlas (Booster, Sustainer, Vernier)
- Centaur
- Delta (1st Stage)
- Falcon (Aim 4D, F, and G)
- Hawk
- Minuteman I, II, III (Stages 1, 2, and 3)
- Nike Hercules
- Patriot
- Peacekeeper (Stages 1 and 3)
- Pershing (P-1a)
- Phoenix
- SICBM
- Sparrow
- Spartan
- Sprint (Stages 1 and 2)
- Talos
- Titan II, III, and IV (1st Stage, 2nd Stage Main and Roll Engines)
- Titan IV Solid Rocket Motor Upgrade (SRMU)
- Tomahawk (Rocket Motor and Rocket Motor Improved)

3.2.2 Electropneumatic:

- Copperhead
- Dragon
- GBU-15
- Hellfire
- HOBOS (GBU-8)
- Hornet
- Maverick
- SIAM
- Sidewinder
- Stinger Alternate
- TOW

3.2.3 Electromechanical:

- Advanced Cruise Missile
- Air Launched Cruise Missile
- AMRAAM (Advanced Development)
- ASALM
- Condor
- Harm
- Harpoon/Slam
- IUS
- Standard Missile
- Titan IV Type I Space Launch Booster
- Tomahawk (Cruise)

4. GENERAL NOTES OR DISCLAIMER:

In most cases, the data sheets list the original vehicle and actuation system manufacturers. No attempt has been made to keep current all of the listed companies and trace mergers, consolidations, divestitures, etc. such as the following examples:

- a. Lockheed Martin is now the vehicle manufacturer for the Atlas and Centaur which prior to the merger was Martin Marietta and previously General Dynamics Convair or GDSS.
- b. Hughes is the vehicle manufacturer for the Tomahawk previously done by General Dynamics Convair (McDonnell Douglas is a second source).

PREPARED BY THE MISSILE AND SPACE SYSTEMS PANEL OF
SAE SUBCOMMITTEE A-6A, FLUID POWER SYSTEMS OF
COMMITTEE A-6, AEROSPACE FLUID POWER, ACTUATION & CONTROL TECHNOLOGIES

1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Advanced Cruise Missile</u> - TYPE: <u>Air - Surface</u> - CONTROL: <u>Aerodynamic Fin</u> - COMPANY: <u>GDC/MDSSC</u> - PROGRAM: <u>Production</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Allied Signal</u> - TYPE PROGRAM: <u>Production</u> - TYPE DESIGN: <u>EM</u> - AXES: <u>1</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-65 to +215 °F; -54 to +102 °C</u> <u>LOAD</u> - TRAVEL: <u>1.75 in, 2.2 in</u> - TYPE: <u>FIN</u> - INERTIA: _____ - f_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>630 lb</u> - STALL LOAD: <u>700 lb</u> - DESIGN RATE: <u>3.5 in/s</u> - NO LOAD RATE: <u>6.5 in/s</u> <u>DUTY CYCLE</u> - DURATION: <u>7 h</u> - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: <u>20 Hz</u> - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: <u>0.002 in</u> - THRESHOLD: <u>0.05 deg</u> - HYSTERESIS: <u>0.005 in</u> - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u>: <u>1.75 in, 2.2 in</u> <u>WEIGHT</u>: <u>3.3 lb</u> <u>FEEDBACK</u> - TYPE: <u>Potentiometer</u> - METHOD: _____ <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>Pulse Width Modulated</u> - SIGNAL LEVEL: _____ <u>LOOP ELECTRONICS</u>: _____ 3. ELECTROMECHANICAL - MOTOR • DC: <u>.5 HP Samarium Cobalt, Brush</u> • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: <u>Ball Screw</u> • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Air Launched Cruise Missile</u> - TYPE: <u>Air - Surface</u> - CONTROL: <u>Aerodynamic Fin</u> - COMPANY: <u>Boeing</u> - PROGRAM: <u>Production 79-84</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Allied Signal</u> - TYPE PROGRAM: <u>Production</u> - TYPE DESIGN: <u>EM</u> - AXES: <u>2</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-65 to +200 °F: -54 to +93 °C</u> <u>LOAD</u> - TRAVEL: <u>36 deg</u> - TYPE: <u>FIN</u> - INERTIA: _____ - I_n : _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>400 lb</u> - STALL LOAD: <u>500 lb</u> - DESIGN RATE: _____ - NO LOAD RATE: <u>180 deg/s</u> <u>DUTY CYCLE</u> - DURATION: <u>3.5 h</u> - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: <u>18 Hz</u> - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: <u>0.002 in</u> - THRESHOLD: <u>0.05 deg</u> - HYSTERESIS: <u>0.005 in</u> - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u> : <u>1.78 in</u> <u>WEIGHT</u> : <u>2.97 lb/act, 7 lb/controller</u> <u>FEEDBACK</u> - TYPE: <u>Potentiometer</u> - METHOD: _____ <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>2 Channel PWM</u> - SIGNAL LEVEL: <u>+7, -11</u> <u>LOOP ELECTRONICS</u> : _____ 3. ELECTROMECHANICAL - MOTOR • DC: <u>Samarium Cobalt Brush .33 HP</u> • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: <u>Ball Screw</u> • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES
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1. GENERAL DESCRIPTION VEHICLE - NAME: <u>Applicable to Adv. Med. Range Air-Air Missile (AMRAAM)</u> - TYPE: _____ - CONTROL: <u>Propulsion Control Valve (1 actuator)</u> - COMPANY: _____ - PROGRAM: _____ ACTUATION SYSTEM - COMPANY: <u>United Technologies</u> - TYPE PROGRAM: <u>Development, 1978</u> - TYPE DESIGN: <u>Electromechanical</u> - AXES: _____ - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-65 to +250 °F; -54 to +121 °C</u> LOAD - TRAVEL: <u>45 deg</u> - TYPE: <u>Coulomb Friction, Aero</u> - INERTIA: _____ - f_n: _____ - OTHER: <u>Aero: 50 lb-in / Friction: 50 lb-in</u> 2. ACTUATION SYSTEM DESIGN RATED CONDITIONS - DESIGN LOAD: <u>150 lb-in</u> - STALL LOAD: <u>300 lb-in</u> - DESIGN RATE: <u>30 deg/s</u> - NO LOAD RATE: <u>400 deg/s</u> DUTY CYCLE - DURATION: <u>180 s</u> - DESCRIPTION: <u>Hold-Ramp Open-Hold-Ramp Closed-Hold</u> DYNAMIC PERFORMANCE - BANDWIDTH: <u>15 Hz Based on -3 dB</u> - STEP RESPONSE: <u>5 deg Step in 20 ms; 10% Overshoot</u> STATIC PERFORMANCE - RESOLUTION: <u>0.2 deg</u> - THRESHOLD: <u>0.05 deg</u> - HYSTERESIS: <u><0.05 deg</u> - CLOSED LOOP STIFFNESS: <u>>50 000 lb-in/deg</u> STROKE: 45 deg WEIGHT: 3 lb FEEDBACK - TYPE: <u>Position</u> - METHOD: <u>Film Potentiometer</u> ELECTRONIC CONTROLLER - TYPE: <u>PWM at 3 kHz</u> - SIGNAL LEVEL: <u>28V; 10A</u> LOOP ELECTRONICS: Analog 3. ELECTROMECHANICAL - MOTOR • DC: <u>Brush Motor Rated at 27V & 20A</u> • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: <u>Servomotor</u>	4. HYDRAULIC SYSTEM - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ SERVOVALVE - OPERATION: _____ - CONFIGURATION: _____ ACTUATOR - LINEAR: _____ - ROTARY: _____ POWER SUPPLY - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS SYSTEM - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ CONTROL VALVE - OPERATION: _____ - CONFIGURATION: _____ ACTUATOR - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Planetary or harmonic gearing drives high speed servomotor and hot gas butterfly valve
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>ASALM (Advanced Strategic Air Launched Missile)</u> - TYPE: <u>Air-to-surface</u> - CONTROL: <u>Aerodynamic fin (4 actuators)</u> - COMPANY: <u>Martin/Orlando</u> - PROGRAM: <u>Development, 1978-1980</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Martin/Orlando</u> - TYPE PROGRAM: <u>Development, 1978-1980</u> - TYPE DESIGN: <u>Electromechanical</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-60 to +600 °F; -51 to +316 °C</u> <u>LOAD</u> - TRAVEL: <u>±26.5 deg</u> - TYPE: <u>Aero and inertia</u> - INERTIA: <u>0.46 lb-in-s²</u> - f_n: _____ - OTHER: <u>Aero: 3700 lb-in / Coulomb friction: 90 lb-in</u> 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>1200 lb-in</u> - STALL LOAD: <u>3000 lb-in</u> - DESIGN RATE: <u>180 deg/s</u> - NO LOAD RATE: <u>250 deg/s</u> <u>DUTY CYCLE</u> - DURATION: <u>1000 s</u> - DESCRIPTION: <u>120 in-lb/deg, 5 Hz, ±0.40 deg</u> <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: <u>30 Hz based on $\theta = 90^\circ$</u> - STEP RESPONSE: <u>±5°, <20% overshoot</u> <u>STATIC PERFORMANCE</u> - RESOLUTION: <u>0.10 deg</u> - THRESHOLD: <u>0.02 deg</u> - HYSTERESIS: <u>0.38 deg</u> - CLOSED LOOP STIFFNESS: <u>9950 lb-in/deg</u> <u>STROKE</u>: <u>27 deg</u> <u>WEIGHT</u>: <u>±55 lb</u> <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Film potentiometer</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>AC</u> - SIGNAL LEVEL: <u>2.5 deg/volt ±10%</u> <u>LOOP ELECTRONICS</u>: <u>Digital and analog with D/A converter</u> 3. ELECTROMECHANICAL - MOTOR • DC: <u>Brushless with 8 VDC @ 3200 Hz and 0.02 amps</u> • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: <u>Ball screw with linear to rotary link</u> • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Samarium cobalt magnets resulted in competitive EM performance
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1. GENERAL DESCRIPTION VEHICLE - NAME: <u>ASALM (Advanced Strategic Air Launched Missile)</u> - TYPE: <u>Air-to-surface</u> - CONTROL: <u>Aerodynamic fin (4 actuators)</u> - COMPANY: <u>Martin/Orlando</u> - PROGRAM: <u>Development, 1978-1980</u> ACTUATION SYSTEM - COMPANY: <u>Martin/Orlando</u> - TYPE PROGRAM: <u>Development, 1978-1980</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-12 to +600 °F; -24 to +316 °C</u> LOAD - TRAVEL: <u>±22 deg</u> - TYPE: <u>Inertia and aero</u> - INERTIA: <u>0.46 lb-in-s²</u> - I_n : _____ - OTHER: <u>Aero: 3700 lb-in / Coulomb fric: <400 lb-in</u> 2. ACTUATION SYSTEM DESIGN RATED CONDITIONS - DESIGN LOAD: <u>1200 lb-in</u> - STALL LOAD: <u>3000 lb-in</u> - DESIGN RATE: <u>180 deg/s</u> - NO LOAD RATE: <u>25 deg/s</u> DUTY CYCLE - DURATION: <u>1000 s</u> - DESCRIPTION: <u>Max activity of 600 deg in 1.0 s (sum of 4 fins)</u> DYNAMIC PERFORMANCE - BANDWIDTH: <u>30 Hz based on $\phi = 90^\circ$</u> - STEP RESPONSE: <u>±5°, <20% overshoot</u> STATIC PERFORMANCE - RESOLUTION: <u>0.05 deg</u> - THRESHOLD: <u>0.05 deg</u> - HYSTERESIS: <u>1.00 deg</u> - CLOSED LOOP STIFFNESS: <u>97 Hz at 100 °F fluid temp.</u> - STROKE: <u>±24 deg</u> - WEIGHT: <u>100 lb</u> FEEDBACK - TYPE: <u>Position</u> - METHOD: <u>RVDT</u> ELECTRONIC CONTROLLER - TYPE: <u>DC</u> - SIGNAL LEVEL: <u><13.5 ma</u> - LOOP ELECTRONICS: <u>Digital and analog with D/A converter</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC SYSTEM - TYPE: <u>Recirculating</u> - PRESSURE: <u>3500 psi</u> - FLOW: <u>2 gpm</u> - FLUID: <u>Chevron M2-V</u> - SEALS: <u>Fluorocarbon</u> - FILTER: <u>40 μm</u> SERVOVALVE - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage single nozzle flapper</u> ACTUATOR - LINEAR: _____ - ROTARY: <u>Rack and pinion with 0.67 in² effective area</u> POWER SUPPLY - PUMP • TYPE: <u>Fixed piston</u> • POWER SOURCE: <u>Gas turbine</u> - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: <u>Stored gas accumulator</u> - GAS GEN/ACCUM: <u>Gas generator bleed air</u> 5. PNEUMATIC/WARM GAS SYSTEM - STORED GAS • TYPE GAS: <u>N₂</u> • SUPPLY PRESS: <u>3500 psi</u> • PROOF PRESS: <u>5300 psi</u> • BURST PRESS: <u>15 000 psi</u> • VESSEL TYPE: <u>Cylinder</u> • VESSEL VOL: _____ • SEALS: <u>Fluorocarbon</u> - GAS GENERATOR • PROPELLANT: <u>Ammonia Nitrate</u> • FLOW RATE: <u>0.2 lb/s</u> • REG. VALVE: <u>No</u> • TEMP @ ACT: <u>1500 °F at turbine</u> • PRESS @ ACT: _____ CONTROL VALVE - OPERATION: _____ - CONFIGURATION: _____ ACTUATOR - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Selection based primarily upon high temperature performance and stiffness
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Atlas Booster (2 engines)</u> - TYPE: <u>Space Launch Vehicle</u> - CONTROL: <u>Gimbaled nozzles (4 actuators)</u> - COMPANY: <u>Convair</u> - PROGRAM: <u>Production 1957-</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Convair & Hydraulic Research</u> - TYPE PROGRAM: <u>Production, 1957-</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: _____ - REDUNDANCY: <u>None</u> - TEMP. RANGE: _____ <u>LOAD</u> - TRAVEL: <u>±5 deg</u> - TYPE: _____ - INERTIA: _____ - f_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>75,470 lb-in</u> - STALL LOAD: <u>226,410 lb-in</u> - DESIGN RATE: <u>24.0 deg/s</u> - NO LOAD RATE: <u>27.5 deg/s</u> <u>DUTY CYCLE</u> - DURATION: _____ - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: <u>0.1 ma</u> - HYSTERESIS: <u>0.2 ma</u> - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u>: <u>±1.85 in</u> <u>WEIGHT</u>: _____ <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Variable reluctance</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>4.0 ma</u> <u>LOOP ELECTRONICS</u>: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: <u>Recirculating</u> - PRESSURE: <u>3000 psi</u> - FLOW: <u>22.5 gpm</u> - FLUID: <u>MIL-H-5606</u> - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage dual nozzle flapper</u> <u>ACTUATOR</u> - LINEAR: <u>3.5 in² balanced area</u> - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: <u>Variable volume</u> • POWER SOURCE: <u>Turbine driven gearbox</u> - ENERGY SOURCE • BATTERY: _____ • OTHER: <u>Engine fuel</u> - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Fuel/hydraulic interface valve to provide fuel to back up limited hydraulic fluid supply in the event of system leakage
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Atlas Sustainer (1 engine)</u> - TYPE: <u>Space Launch Vehicle</u> - CONTROL: <u>Gimbaled nozzle (2 actuators)</u> - COMPANY: <u>Convair</u> - PROGRAM: <u>Production 1957-</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Convair</u> - TYPE PROGRAM: <u>Production 1957-</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw</u> - COMPENSATION: _____ - REDUNDANCY: <u>No</u> - TEMP. RANGE: _____ <u>LOAD</u> - TRAVEL: <u>±3 deg</u> - TYPE: _____ - INERTIA: _____ - I_n : _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>49 300 lb-in</u> - STALL LOAD: <u>177 120 lb-in</u> - DESIGN RATE: <u>7.9 deg/s</u> - NO LOAD RATE: <u>14.2 deg/s</u> <u>DUTY CYCLE</u> - DURATION: _____ - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: <u>0.1 ma</u> - HYSTERESIS: <u>0.2 ma</u> - CLOSED LOOP STIFFNESS: _____ - STROKE: <u>±0.51 in</u> <u>WEIGHT</u> : _____ <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Variable reluctance</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>4.0 ma</u> - LOOP ELECTRONICS: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: <u>Recirculating</u> - PRESSURE: <u>3000 psi</u> - FLOW: <u>MIL-H-5606</u> - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage dual nozzle flapper</u> <u>ACTUATOR</u> - LINEAR: <u>5.9 in² balanced area</u> - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: <u>Variable volume</u> • POWER SOURCE: <u>Turbine driven gearbox</u> - ENERGY SOURCE • BATTERY: _____ • OTHER: <u>Engine fuel</u> - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Fuel/hydraulic interface valve to provide fuel to back up limited hydraulic fluid supply in the event of system leakage
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1. GENERAL DESCRIPTION VEHICLE - NAME: <u>Atlas Vernier (2 engines)</u> - TYPE: <u>Space Launch Vehicle</u> - CONTROL: <u>Gimbaled nozzles (4 actuators)</u> - COMPANY: <u>Convair</u> - PROGRAM: <u>Production 1957-</u> ACTUATION SYSTEM - COMPANY: <u>Convair</u> - TYPE PROGRAM: <u>Production 1957-</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: _____ - REDUNDANCY: <u>No</u> - TEMP. RANGE: _____ LOAD - TRAVEL: <u>Inboard: ±70 deg / Outboard: ±25 deg</u> - TYPE: _____ - INERTIA: _____ - f_n : _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN RATED CONDITIONS - DESIGN LOAD: <u>3430 lb-in</u> - STALL LOAD: <u>4120 lb-in</u> - DESIGN RATE: <u>393 deg/s</u> - NO LOAD RATE: <u>436 deg/s</u> DUTY CYCLE - DURATION: _____ - DESCRIPTION: _____ DYNAMIC PERFORMANCE - BANDWIDTH: _____ - STEP RESPONSE: _____ STATIC PERFORMANCE - RESOLUTION: _____ - THRESHOLD: <u>0.1 ma</u> - HYSTERESIS: <u>0.2 ma</u> - CLOSED LOOP STIFFNESS: _____ - STROKE: <u>Inboard: ±1.5 in; Outboard: ±0.5 in</u> WEIGHT: _____ FEEDBACK - TYPE: <u>Position</u> - METHOD: <u>Variable reluctance</u> ELECTRONIC CONTROLLER - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>4 ma</u> LOOP ELECTRONICS: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC SYSTEM - TYPE: <u>Blow down</u> - PRESSURE: <u>3000 to 1000 psi</u> - FLOW: <u>4.85 gpm</u> - FLUID: <u>MIL-H-5606</u> - SEALS: _____ - FILTER: _____ SERVOVALVE - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage dual nozzle flapper</u> ACTUATOR - LINEAR: <u>0.5 in² balanced</u> - ROTARY: _____ POWER SUPPLY - PUMP • TYPE: <u>Variable volume (sustainer engine operation)</u> • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: <u>Accumulator (after engine shuts down)</u> - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS SYSTEM - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ CONTROL VALVE - OPERATION: _____ - CONFIGURATION: _____ ACTUATOR - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Fuel/hydraulic interface valve provides fuel to back up limited hydraulic fluid supply in the event of system leakage during engine powered flight
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Centaur</u> - TYPE: <u>Space Launch Vehicle</u> - CONTROL: <u>Gimbaled nozzle (2 nozzles, 2 act/nozzle)</u> - COMPANY: <u>Convair</u> - PROGRAM: <u>Production, 1958-</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Convair</u> - TYPE PROGRAM: <u>Production, 1958-</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-30 to +275 °F; -34 to +135 °C</u> <u>LOAD</u> - TRAVEL: <u>±3 deg</u> - TYPE: _____ - INERTIA: _____ - I_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>5144 lb-in</u> - STALL LOAD: <u>15 447 lb-in</u> - DESIGN RATE: <u>8.1 deg/s</u> - NO LOAD RATE: <u>14.1 deg/s</u> <u>DUTY CYCLE</u> - DURATION: <u>10 min</u> - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: <u>0.10 ma</u> - HYSTERESIS: <u>0.20 ma</u> - CLOSED LOOP STIFFNESS: _____ <u>STROKE: ±0.75 in</u> <u>WEIGHT:</u> _____ <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Variable reluctance</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>4 ma</u> <u>LOOP ELECTRONICS: Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: <u>Recirculating</u> - PRESSURE: <u>1000 psi</u> - FLOW: <u>1.64 gpm</u> - FLUID: <u>MIL-H-5606</u> - SEALS: <u>Nitrile</u> - FILTER: <u>10 µm</u> <u>SERVOVALVE</u> - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage jet pipe</u> <u>ACTUATOR</u> - LINEAR: <u>1.5 in² balanced area</u> - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: <u>Fixed vane</u> • POWER SOURCE: <u>Turbine driven gearbox</u> - ENERGY SOURCE • BATTERY: _____ • OTHER: <u>Engine fuel</u> - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES Performance; hydraulic fluid used to maintain actuator temperature during orbit coast phase via a second electrically driven pump
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Condor</u> - TYPE: <u>Air-to-surface</u> - CONTROL: <u>Aerodynamic fin (4 actuators)</u> - COMPANY: <u>Rockwell</u> - PROGRAM: <u>Development, 1964-1977</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Conductron</u> - TYPE PROGRAM: <u>Development, 1964-1977</u> - TYPE DESIGN: <u>Electromechanical</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: <u>Electronic</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-65 to +195 °F; -54 to +91 °C</u> <u>LOAD</u> - TRAVEL: <u>±30 deg</u> - TYPE: <u>Inertia</u> - INERTIA: <u>1.56 lb-in-s²</u> - I_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: _____ - STALL LOAD: <u>1000 lb-in</u> - DESIGN RATE: _____ - NO LOAD RATE: <u>85 deg/s</u> <u>DUTY CYCLE</u> - DURATION: <u>12 min</u> - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: _____ - HYSTERESIS: _____ - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u>: _____ <u>WEIGHT</u>: _____ <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Film potentiometer</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: _____ <u>LOOP ELECTRONICS</u>: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: <u>28 V compound brush</u> • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: <u>Mag particle clutch</u>	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Copperhead (M-712)</u> - TYPE: <u>Battlefield Support (Gun Launched)</u> - CONTROL: <u>Aerodynamic fin (4 fins/3 actuators)</u> - COMPANY: <u>Martin/Orlando</u> - PROGRAM: <u>Production, 1981-</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Chandler Evans</u> - TYPE PROGRAM: <u>Production, 1981-</u> - TYPE DESIGN: <u>Pneumatic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: <u>None</u> - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-25 to +145 °F; -32 to +63 °C</u> <u>LOAD</u> - TRAVEL: <u>Pitch: ±16 deg; Yaw & roll: ±20 deg</u> - TYPE: <u>Inertia and aero</u> - INERTIA: <u>Pitch: 0.0052 lb-in-s²; Yaw & roll: 0.0026 lb-in-s²</u> - f_n: _____ - OTHER: <u>Aero: 1.25 lb-in/deg</u> 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: <u>Pitch: 190 lb-in; Yaw & roll: 95 lb-in</u> - STALL LOAD: <u>Pitch: 150 lb-in; Yaw & roll: 75 lb-in</u> - DESIGN RATE: <u>120 deg/s</u> - NO LOAD RATE: <u>Pitch: 500 deg/s; Yaw & roll: 450 deg/s</u> <u>DUTY CYCLE</u> - DURATION: <u>65 s @ -25 °F</u> - DESCRIPTION: <u>±5° deflection at 1 Hz</u> <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: <u>12 Hz based on -3 dB</u> - STEP RESPONSE: <u>80% max overshoot at ±5 and ±10° steps</u> <u>STATIC PERFORMANCE</u> - RESOLUTION: <u>Pitch: ±16 deg; Yaw & roll: ±20 deg</u> - THRESHOLD: <u>17.5 lb (with fins)</u> - HYSTERESIS: _____ - CLOSED LOOP STIFFNESS: _____ <u>STROKE: Pitch: ±16 deg; Yaw & roll: ±20 deg</u> <u>WEIGHT: 17.5 lb (with fins)</u> <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Film potentiometer</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>30 V & 4 amps</u> <u>LOOP ELECTRONICS: Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: <u>Helium regulated to 550 psi</u> • SUPPLY PRESS: <u>10 000 psi</u> • PROOF PRESS: <u>15 000 psi</u> • BURST PRESS: <u>23 600 psi min</u> • VESSEL TYPE: <u>Cylinder</u> • VESSEL VOL: <u>25 in³</u> • SEALS: <u>Nitrile</u> - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: <u>3-way Solenoid</u> - CONFIGURATION: <u>Open center</u> <u>ACTUATOR</u> - LINEAR: <u>2/1 unbalanced area</u> - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: <u>Helium</u> - GAS PRESSURE: <u>10 000 psi</u> - BURST FACTOR: <u>2.36</u> - DOT APPROVAL: <u>DOT-E 6672</u> 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES - 10 year storage - 10 000 G's launch shock
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1. GENERAL DESCRIPTION VEHICLE - NAME: <u>Delta, 1st stage</u> - TYPE: <u>Stage Launch Vehicle</u> - CONTROL: <u>Gimbaled nozzle (2 actuators)</u> - COMPANY: <u>McDonnell Douglas/Huntington Beach</u> - PROGRAM: <u>Production, 1958-</u> ACTUATION SYSTEM - COMPANY: <u>McDonnell Douglas/Huntington Beach</u> - TYPE PROGRAM: <u>Production, 1958-</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw</u> - COMPENSATION: _____ - REDUNDANCY: <u>No</u> - TEMP. RANGE: <u>-65 to +275 °F; -54 to +135 °C</u> LOAD - TRAVEL: <u>±7 deg</u> - TYPE: <u>Combination</u> - INERTIA: <u>5880 lb-in-s²</u> - f_n : _____ - OTHER: <u>Aero: 27 400 lb-in; Spring: 8000 lb-in/deg;</u> <u>Coulomb fric: 10 600 lb-in</u> 2. ACTUATION SYSTEM DESIGN RATED CONDITIONS - DESIGN LOAD: <u>96 000 lb-in</u> - STALL LOAD: <u>153 500 lb-in</u> - DESIGN RATE: <u>17 deg/s</u> - NO LOAD RATE: <u>30 deg/s</u> DUTY CYCLE - DURATION: <u>225 s</u> - DESCRIPTION: <u>±0.5 deg at 0.5 Hz for full duration</u> DYNAMIC PERFORMANCE - BANDWIDTH: <u>10 Hz based on -3 dB</u> - STEP RESPONSE: _____ STATIC PERFORMANCE - RESOLUTION: <u>0.04 ma</u> - THRESHOLD: <u>0.04 ma</u> - HYSTERESIS: <u>0.40 ma</u> - CLOSED LOOP STIFFNESS: <u>>200 000 lb-in/deg</u> STROKE: <u>3.3 in</u> WEIGHT: <u>136 lb</u> FEEDBACK - TYPE: <u>Position</u> - METHOD: <u>Wire wound potentiometer</u> ELECTRONIC CONTROLLER - TYPE: <u>DC</u> - SIGNAL LEVEL: <u>20 V</u> LOOP ELECTRONICS: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC SYSTEM - TYPE: <u>Recirculating</u> - PRESSURE: <u>3200 psi</u> - FLOW: <u>4 gpm</u> - FLUID: <u>MIL-H-5606</u> - SEALS: <u>Nitrile</u> - FILTER: <u>15 µm</u> SERVOVALVE - OPERATION: <u>4-way flow control</u> - CONFIGURATION: <u>2-stage jet pipe</u> ACTUATOR - LINEAR: <u>2 in² balanced</u> - ROTARY: _____ POWER SUPPLY - PUMP • TYPE: <u>Variable displacement piston</u> • POWER SOURCE: <u>Turbine driven gearbox</u> - ENERGY SOURCE • BATTERY: _____ • OTHER: <u>Engine fuel</u> - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS SYSTEM - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ CONTROL VALVE - OPERATION: _____ - CONFIGURATION: _____ ACTUATOR - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Dragon</u> - TYPE: <u>Battlefield Support</u> - CONTROL: <u>Solid Rocket Thrusters</u> - COMPANY: <u>Raytheon</u> - PROGRAM: <u>Production, 1978-</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Raytheon</u> - TYPE PROGRAM: <u>Production, 1978-</u> - TYPE DESIGN: _____ - AXES: <u>Pitch, yaw</u> - COMPENSATION: _____ - REDUNDANCY: _____ - TEMP. RANGE: _____ <u>LOAD</u> - TRAVEL: _____ - TYPE: _____ - INERTIA: _____ - f_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: _____ - STALL LOAD: _____ - DESIGN RATE: _____ - NO LOAD RATE: _____ <u>DUTY CYCLE</u> - DURATION: _____ - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: _____ - HYSTERESIS: _____ - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u>: _____ <u>WEIGHT</u>: _____ <u>FEEDBACK</u> - TYPE: <u>None</u> - METHOD: _____ <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC with 50 μs pulse</u> - SIGNAL LEVEL: <u>22-41V</u> <u>LOOP ELECTRONICS</u>: _____ 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: _____ - PRESSURE: _____ - FLOW: _____ - FLUID: _____ - SEALS: _____ - FILTER: _____ <u>SERVOVALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: _____ - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES - Spinning vehicle with small thrusters that provide steering and sustaining thrust - Thrusters are fired in pairs - Near equilibrium maintained between sustaining thrusters and aerodynamic drag
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1. GENERAL DESCRIPTION <u>VEHICLE</u> - NAME: <u>Falcon (AIM - 4D)</u> - TYPE: <u>Air-to-air</u> - CONTROL: <u>Aerodynamic fin (2 actuators)</u> - COMPANY: <u>Hughes/Tucson</u> - PROGRAM: <u>Production, 1952-1961</u> <u>ACTUATION SYSTEM</u> - COMPANY: <u>Hughes/Tucson</u> - TYPE PROGRAM: <u>Production, 1952-1961</u> - TYPE DESIGN: <u>Hydraulic</u> - AXES: <u>Pitch, yaw, roll</u> - COMPENSATION: _____ - REDUNDANCY: <u>No</u> - TEMP. RANGE: _____ <u>LOAD</u> - TRAVEL: _____ - TYPE: _____ - INERTIA: _____ - I_n: _____ - OTHER: _____ 2. ACTUATION SYSTEM DESIGN <u>RATED CONDITIONS</u> - DESIGN LOAD: _____ - STALL LOAD: <u>150 lb-in</u> - DESIGN RATE: _____ - NO LOAD RATE: <u>600 to 750 deg/s</u> <u>DUTY CYCLE</u> - DURATION: _____ - DESCRIPTION: _____ <u>DYNAMIC PERFORMANCE</u> - BANDWIDTH: _____ - STEP RESPONSE: _____ <u>STATIC PERFORMANCE</u> - RESOLUTION: _____ - THRESHOLD: <u>0.3 ma</u> - HYSTERESIS: _____ - CLOSED LOOP STIFFNESS: _____ <u>STROKE</u>: _____ <u>WEIGHT</u>: _____ <u>FEEDBACK</u> - TYPE: <u>Position</u> - METHOD: <u>Wire wound potentiometer</u> <u>ELECTRONIC CONTROLLER</u> - TYPE: <u>DC</u> - SIGNAL LEVEL: _____ <u>LOOP ELECTRONICS</u>: <u>Analog</u> 3. ELECTROMECHANICAL - MOTOR • DC: _____ • AC: _____ • STEPPER: _____ - ACTUATOR • LINEAR: _____ • ROTARY: _____	4. HYDRAULIC <u>SYSTEM</u> - TYPE: <u>Blow down</u> - PRESSURE: <u>2000 psi</u> - FLOW: <u>0.093 gpm</u> - FLUID: <u>Brayco 762</u> - SEALS: <u>Nitrile</u> - FILTER: <u>No</u> <u>SERVOVALVE</u> - OPERATION: <u>3-way</u> - CONFIGURATION: <u>1-stage</u> <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: <u>Push-push</u> <u>POWER SUPPLY</u> - PUMP • TYPE: _____ • POWER SOURCE: _____ - ENERGY SOURCE • BATTERY: _____ • OTHER: _____ - STORED GAS: <u>He at 7400 psi accumulator</u> - GAS GEN/ACCUM: _____ 5. PNEUMATIC/WARM GAS <u>SYSTEM</u> - STORED GAS • TYPE GAS: _____ • SUPPLY PRESS: _____ • PROOF PRESS: _____ • BURST PRESS: _____ • VESSEL TYPE: _____ • VESSEL VOL: _____ • SEALS: _____ - GAS GENERATOR • PROPELLANT: _____ • FLOW RATE: _____ • REG. VALVE: _____ • TEMP @ ACT: _____ • PRESS @ ACT: _____ <u>CONTROL VALVE</u> - OPERATION: _____ - CONFIGURATION: _____ <u>ACTUATOR</u> - LINEAR: _____ - ROTARY: _____ - ROTARY/LINEAR: _____ 6. STORED GAS VESSEL SHIPMENT - TYPE GAS: _____ - GAS PRESSURE: _____ - BURST FACTOR: _____ - DOT APPROVAL: _____ 7. SELECTION CRITERIA AND/OR SPECIAL FEATURES
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