

Lockheed Martin/Boeing
F/A-22 Raptor



Powering Business Worldwide

Lockheed Martin/Boeing F/A-22 Raptor Component & Systems Overview

Eaton's Aerospace Group Product Capabilities

The Lockheed Martin F/A-22 Raptor is a swept-winged fighter with blended engine intake/wing leading edge root extension. The aircraft is powered by two Pratt & Whitney F119-PW-100 afterburning turbofans, each fitted with a two-dimensional thrust-vectoring nozzle.

The advanced tactical fighter's engines produce more thrust than any current fighter engine, especially in the military power regime, allowing the F/A-22 to cruise efficiently in excess of Mach 1.5 without the use of fuel-guzzling afterburners. This capability greatly expands the F/A-22's operating envelope in both speed and range over current fighters.

It's key feature is an advanced avionics architecture using the most advanced fiber-optic and digital electronic flight and weapon and control system in development. All weapons are carried internally.

The F/A-22 is intended for an air superiority role, providing much greater range, payload, time on station, and agility than the F-15 and F-16 fighters of today. A combination of improved sensor capabilities, improved situational awareness and improved weapons provides first-kill opportunity. The F/A-22 features a sophisticated sensor suite that allows the pilot to track, identify, and shoot opposing aircraft at beyond-visual-ranges while having the ultimate in close-in dog-fight capabilities. No other aircraft has had this combination of characteristics.

The F/A-22 Raptor replaced the venerable F-15 Eagle as America's premier front-line fighter jet, starting in 2005. It is the air-dominance fighter of the 21st century. "The Raptor is a flexible, adaptable, versatile combat aircraft capable of seeing all, knowing all, and shaping all that occurs on or above the battlefield," says Chief Test Pilot Bret Luedke, one of the pilots responsible for flight-testing the F/A-22. "And do all that while flying supersonic and all but invisible to radar," he added.

Eaton, a recognized leader in the design and manufacture of hydraulics, fuel, conveyance and actuation products, was chosen to provide key products for the F/A-22. The 4100 psi (28,300 kPa) hydraulic system on the F/A-22 incorporates Eaton's main engine-driven pumps, auxiliary power pump, air recharge compressor motor, gun drive motor, fuel transfer motor, and main and side weapons bay door motors.

The F/A-22 employs a hydraulic gun drive, which is comprised of two discrete component subassemblies integrated into one assembly. This provides mechanical rotary power to the gun when commanded by electric signal or manual input. The fuel transfer motor, a variable displacement 4000 psi (27,600 kPa) inline hydraulic motor, is used in combination with a centrifugal fuel pumping element to provide a fuel pressure compensated fuel boost pump. The 5.9 gpm (22.33 L/min.) hydraulic motor/fuel pump is used on the F/A-22 to boost fuel from the main fuel tanks to the main fuel pumps at essentially constant fuel pressure. This is the first time that a variable displacement motor has been used to provide pressure compensation for a centrifugal fuel pump.

With the auxiliary power unit, emergency power is provided by a 27 gpm (102 L/min.), 6,000 rpm, variable displacement, 4000 psi (27,600 kPa), pressure-compensated inline piston pump with an electrical depressurization valve (EDV). Design features include a one-piece housing and solenoid valve with pigtail for vibration isolation from the pump.

Eaton's components provide fluid control and actuation for the rudder control, landing gear, electronic warfare emergency power generator, and nose wheel steering systems. The rudder shuttle valve is designed for use at up to 4100 psi (28,300 kPa) operating pressure, and automatically shuttles hydraulic power to the aircraft's rudder system from one of two independent hydraulic systems by utilizing the differential pressure between the two independent system pressures to initiate the shuttle. Eaton also provides the hydraulic motor/control valve packages for the weapons bay doors. These consist of a one-piece aluminum manifold within which the hydraulic motor and various control valve components are mounted and interconnected.

The heart of the package is an Eaton fixed displacement and variable displacement hydraulic motor, which is configured as a cartridge. The manifolds also provide the hydraulic interface between the side weapons bay door/main weapons bay door (SWBD/MWBD) and aircraft hydraulic supply systems. Hydraulic-mechanical power conversions for the side weapons bay door and the main weapons bay door are provided by the fixed displacement hydraulic motor and variable displacement hydraulic motor. Speed and direction for both the SWBD and MWBD are

controlled by the flow limiter/directional control valve, which is a 4-way variable position, slide, and sleeve type metering valve that is spring centered to its normally-closed position where the control ports are overlapped.

Eaton is also providing the electro-mechanical seat actuator for the aircraft's Advanced Concept Ejection System (ACES II).

As well, Eaton also supplies Aeroquip® Kevlar® hoses, Rynlok® tube fittings, high performance fuel tubes, mini-modular cooling couplings, cockpit air couplings, rotomold ducting, landing gear swivels and E-Seals.

Aircraft systems monitoring components such as Eaton's Tedeco® oil level sensors, debris screen chip collectors, and a Lubriclone® air/oil separator system can be found on this versatile aircraft as well. The oil level sensor can detect three levels of oil: full, add, and low. Magnetic reed switches have a redundant circuit for high reliability. A reservoir pickup tube is installed in the Airframe Mounted Accessory Drive (AMAD) to assure proper oil flow with minimum air intrusion when the aircraft becomes inverted. Its magnetic chip collector is located in the lubricating fluid flow of the AMAD and traps ferrous wear debris of magnetic attraction, preventing the particles from causing damage to key components. The analysis of these particles may provide an early warning of abnormal wear or breakdown of components within the AMAD, thus increasing its life.

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Engine Solutions

1. Magnetic Chip Collector
2. Lubriclone
3. Mini-Modular Coolant Couplings
4. Oil Level Sensor

Motion Control

5. Main Weapons Bay Door Motor/Package
6. Side Weapons Bay Door Motor/Package
7. Gun Drive Motor
8. Landing Gear Sequence Valve
9. Landing Gear Control
10. Landing Gear Brake Swivels
11. Rudder Shuttle Valve

Hydraulic Systems

12. Main Engine-Driven Pump
13. Rynglok Tube Fittings
14. Reservoir Pick Up Tube
15. Kevlar Hose Assemblies
16. Stainless Steel Reinforced Hose Assemblies
17. Auxiliary Power Unit Pump
18. Utility Isolation Valve
19. Electronic Warfare Control Valve
20. Pressure Switches
21. Pressure Transducer

Fuel & Interting

22. Fuel Transfer Motor
23. Main Engine Fuel Line Assemblies



Kevlar® Reinforced Hose Assemblies

Eaton's Aeroquip product line Kevlar® hose assemblies are utilized extensively throughout the F/A-22 aircraft to optimize weight reduction throughout the hydraulic system. The AE319 and AE355 hose assemblies are rated to 4000 psi (27,600 kPa) and are used in the low pressure hydraulic return system. The AE319 is a heavy duty hose and is used in areas that experience more severe service.



Stainless Steel Reinforced Hose Assemblies

Stainless steel reinforced hose assemblies for the F/A-22 include the 666 smooth bore, medium pressure hose assemblies and the AE641 convoluted hose assemblies which are used in the low pressure return side of the hydraulic system and in the fuel system.

Eaton's Aeroquip wire reinforced medium pressure hose assemblies are rated for pressures up to 1500 psi (10,343 kPa) and feature a wire reinforced, Teflon® hose with light weight, low profile crimp fittings.

Convoluted hose assemblies provide increased flexibility and are excellent for use in areas that require a tight bend.



ECS Air Valves

Cockpit video display units are kept cool using Aeroquip ECS Air Valves. The valves are made from lightweight injection-molded nylon material and aluminum castings. Internal valving automatically closes upon removal of the video display units and creates an equivalent pressure drop across the valve that simulates the pressure drop as if the video display unit were still installed.



Mini Modular Coolant Couplings

Eaton's miniature modular self-sealing coolant couplings are used extensively in the F/A-22 to help keep the aircraft's state of the art electronic systems cool. These couplings were developed in response to today's need for liquid flow through avionics packaging technologies. The design of these couplings provide unequalled performance in pressure drop and superior reliability in sealing out dust, particulates and foreign matter, while preventing fluid leakage during connection/ disconnection of system components.

Rynglok® Tube Fittings

The fittings for the F/A-22 are the 4000 psi (27,600 kPa) titanium and the low pressure aluminum Rynglok® fittings. The titanium, axial swage fittings provide the link to join fluid delivery tubing, while minimizing system weight. Fittings include permanent and arc seal connections in straight elbow and tee configurations.

Landing Gear Brake Swivels

These 4,000 psig (27,600 kPa) operating pressure swivels are used on the F/A-22 landing gear system to help deliver fluid to the aircraft's braking system. Manufactured from high strength 7075 aluminum material to help keep weight to a minimum, these swivels are capable of a full 360 degrees of rotation.

2055 Series Coolant Couplings

Eaton's 2055 series push-pull coolant couplings are used exclusively throughout the F/A-22 PAO coolant system. The 2055 Series were specifically designed for light weight, low profile demanding applications like that needed on the F/A-22.

Rotomold Ducting

Eaton's center console and canopy defog ducts provide environmentally controlled air to the cockpit. These ducts are made of seamless lightweight rotationally-molded nylon material. There is one each of these ducts per aircraft.





E-Seals

The lower exit duct seal is a metallic E-Seal that is installed between the primary heat exchanger and the exit duct of the F/A-22 aircraft.



Main Engine Fuel Line Assemblies

Fuel is supplied to each of the engines in the F/A-22 via two main engine fuel line assemblies. Each assembly is three inches in diameter, and approximately two to three feet long. The fuel lines are made from aluminum material and each contains three articulating ball joints. Each ball joint is capable of 20 degrees of angular movement.



Electronic Warfare Control Valve

The solenoid controlled pilot-operated spool valve provides two independent spools for controlling hydraulic pressure and return fluid flow for extension and retraction of two hydraulic actuators. There are two of these valves per aircraft.



Side Weapons Bay Door (SWBD) Motor/Control Valve Package

This motor/control valve package is used to control and limit the flow of hydraulic fluid to the 4000 psi (27,600 kPa) fixed displacement hydraulic motor (FDHM), which in turn will be used to drive the geared rotary actuator to position the side weapons bay door of the aircraft.

Main Weapons Bay Door (MWBD) Motor/Control Valve Package

This motor/control valve package is used to control and limit the flow of hydraulic fluid to the 4000 psi (27,600 kPa) variable displacement hydraulic motor (VDHM), which in turn is used to drive the geared rotary actuator to position the main weapons bay door of the aircraft.

Landing Gear Sequence Valve

The landing gear sequence valve is used to control hydraulic pressure and fluid flow for sequencing the main landing gear with the main landing gear door. A pneumatically actuated override feature is provided for emergency operation, which interconnects both the "DOWN" and "LG EXT" ports. Since there is no direct pressure source, the operating pressure comes from either the "DOWN" or "UP" hydraulic command lines via a logic circuit which consists of four miniaturized check valves.

Rudder Shuttle Valve

The rudder shuttle valve is designed for use up to 4100 psi (28,300 kPa) operating pressures. It automatically shuttles hydraulic power to the aircraft's rudder system from one of two independent hydraulic systems by utilizing the differential pressure between the two independent system pressures to initiate the shuttle. The valve is electrically operated through a 28 solenoid valve for primary system isolation and has a return system check valve and flow limiter for downstream functions.

Utility Isolation Valve

The utility isolation valve provides emergency tow brake operation for the F/A-22 aircraft. During emergency stop conditions, the solenoid-operated, two-position, three-way valve is commanded open to provide hydraulic system 2-reservoir accumulator pressure to the aircraft's brake circuit.





Landing Gear Door Sequence Valve

The landing gear door sequence valve is a mechanically-operated, two-position, four-way hydraulic sequence valve that controls hydraulic supply and return fluid flow for sequencing the main landing gear door with the main landing gear.



Solenoid Operated Switching Valve

The hydraulic switching valve control module, is a 6-way 2-position, solenoid-operated, non-interflow type, selector valve, with position indicator. The function of the switching valve is to direct pressure and return fluid flow from a secondary hydraulic system of the aircraft (System 1), during maintenance of the aircraft, to power utility functions normally dedicated to the primary system (System 2) for these functions.



Oil Level Sensor

Eaton's oil level sensor senses three levels of oil - full, add, and low. Magnetic reed switches have a redundant circuit for high reliability.



Magnetic Chip Collector

The 1D7092 and 1D7093 magnetic chip collector is located in the lubricating fluid flow of the Airframe Mounted Accessory Drive (AMAD) and traps ferrous wear debris by magnetic attraction. This prevents the particles from causing damage to the drive components. The analysis of these particles may provide an early warning of abnormal wear or breakdown of components within the AMAD, this increasing its life.

Reservoir Pickup Tube

Installed in the Airframe Mounted Assembly Drive (AMAD) to assure proper oil flow with minimum air intrusion when the aircraft becomes inverted.

Pressure Switch

Eaton's pressure switches are used for main engine and Auxiliary Power Unit (APU) pump pressure indication/monitoring.

Pressure Transducer

Eaton's pressure transducer monitors hydraulic system pressure in the aircraft.





Lubriclone®

Separates entrained air from the scavenged lube system oil by centrifugal force. Unique internal design affords separation efficiencies up to 99%. Wear particles are also directed to an area where a debris monitor can readily capture and indicate their presence.



Main Engine Driven Pump

Hydraulic power for the F/A-22 is provided for all flight control and utility functions by four 72 gpm (273 L/min.) 4411 rpm, variable displacement, 4100 psi (28,300 kPa), pressure-compensated eleven-piston pumps. Each pump is equipped with an Electrical Depressurization Valve (EDV) and features a one-piece housing, 11 piston-rotating group, and solenoid valve. Displacement is 4.1 cu. in/rev. (67.15 ml/rev.). Dry weight is 34 lbs (15.42 kg).



Side Weapons Bay Door Motor

Hydraulic mechanical power conversion for the side weapons bay doors is provided by two 4000 psi (27,600 kPa), 11,200 rpm fixed displacement motors. Displacement is .36 cu. in/rev. (5.89 ml/rev.). Dry weight is 3.11 lbs (1.41 kg). The motor is integrated with the Motor/Control Valve Package.



Auxiliary Power Unit Pump

Emergency power is provided by a 27 gpm (102 L/min.), 6,000 rpm, variable displacement, 4000 psi (27,600 kPa), pressure-compensated inline piston pump with electrical depressurization valve (EDV). Design features include a one-piece housing and solenoid valve with pigtail for vibration isolation from pump. Displacement is 1.12 cu. in/rev. (18.35 ml/rev.). Dry weight is 14.1 lbs.

Gun Drive Motor

The hydraulic gun drive employs a 4000 psi (27,600 kPa), 7250 rpm, fixed displacement inline hydraulic motor and control valve which is integrally mounted to automatically control hydraulic motor speed, acceleration and deceleration. Valves are also included to allow control of the gun port and purge door actuators. Displacement is 0.642 cu. in/rev. (10.5 ml/rev.). Dry weight is 16.25 lbs (7.37 kg).

Fuel Transfer Motor

This variable displacement 4000 psi (27,600 kPa) inline hydraulic motor is used in combination with a centrifugal fuel pumping element to provide a fuel pressure compensated fuel boost pump package. The 5.8 gpm (21.96 L/min.) hydraulic motor/fuel pump is used on the F/A-22 to boost fuel from the main fuel tanks to the main fuel pumps at essentially constant fuel pressure. This is the first time that a variable displacement motor has been used to provide pressure compensation of a centrifugal fuel pump. Displacement is 0.13 cu. in/rev. (2.13 ml/rev.). Dry weight is 9 lbs (4.08 kg).

High Pressure Actuator Pump

Eaton's Model 841200 high pressure actuator pump provides the "fueldraulics" on the Pratt & Whitney F119 engine, which is the most advanced engine in production and is used on the U.S. Air Force's F-22 Raptor.



