

Aerospace Capabilities

Boeing 777



Powering Business Worldwide

Boeing 777 System Overview

Eaton's Aerospace Product Capabilities

The Boeing 777 is a wide-body, twin-engine airplane with flexibility in range, routes and interior configurations. Its state-of-the-art technology includes fly-by-wire flight controls and digital avionics.

Similar in appearance to the 767, the Boeing 777 is longer and wider with wings that include a folding wing-tip option. The landing gear on the 777 is the largest ever incorporated into a commercial airplane to date. The standard two-post arrangement features six-wheel trucks instead of conventional four-wheel units. A total of 12 wheels support the 777 for better weight distribution during landing and while taxiing to terminals. The cantilever low swept-wing design monoplane is of advanced construction, with a cockpit based on the 747.

The 777 is powered by General Electric, Pratt & Whitney and Rolls Royce engines ranging from 74,000 lbs to 122,965 lbs of thrust. The wide body twin-engine aircraft can carry between 305 and 440 passengers, seating ranges from six to ten abreast with two aisles and has a range of 7,250 to 8,820 nautical miles while traveling at Mach 0.84.

The Boeing 777 is equipped with three hydraulic systems. The left, center and right systems deliver hydraulic fluid at a rated pressure of 3000 psig (207 bar) to operate flight controls, flap systems, actuators, landing gear and brakes.

Primary hydraulic power for the left and right systems is provided by two engine-driven pumps (EDP) and supplemented by two on-demand electric motor-driven pumps (ACMP) manufactured by Eaton.

Two Eaton on-demand air turbine-driven pumps (ADP) power the center system. There are also two Eaton primary electric motorpumps (ACMP) that provides hydraulic power for the engine thrust reversers, primary flight controls, landing gear and flaps/slats in the center system.

Under emergency conditions hydraulic power is generated by the ram air turbine (RAT) which is deployed automatically and drives an Eaton variable displacement inline pump. The RAT pump provides flow to the center system flight controls.

Eaton supplies many critical electro-mechanical actuators for the 777. Eaton provides door mechanisms that consist of flight locks on the eight passenger doors, power drive units to operate the two large cargo doors, rotary actuators to latch the two large cargo doors and a power drive unit to operate the small cargo door. The 777 also utilizes two thrust reverse interlock linear actuators and an auto speed brake control stand linear actuator. Eaton also

supplies the Environmental Control System (ECS) door actuator that will operate the ECS door in flight to control airflow to the ECS system. The 777 contains an Eaton rudder trim switch to control the position of the rudder trim actuator.

The Boeing 777 equipped with GE90 Snecma engines utilize the advance technology of Eaton's Quantitative Debris Monitoring (QDM) system. The QDM is an early warning for potential gear or bearing failure by capturing and indicating the presence of ferrous debris particles in the lube oil. The unit is mounted in a Lubriclone® that effectively separates air from the oil before returning oil to the lube tank.

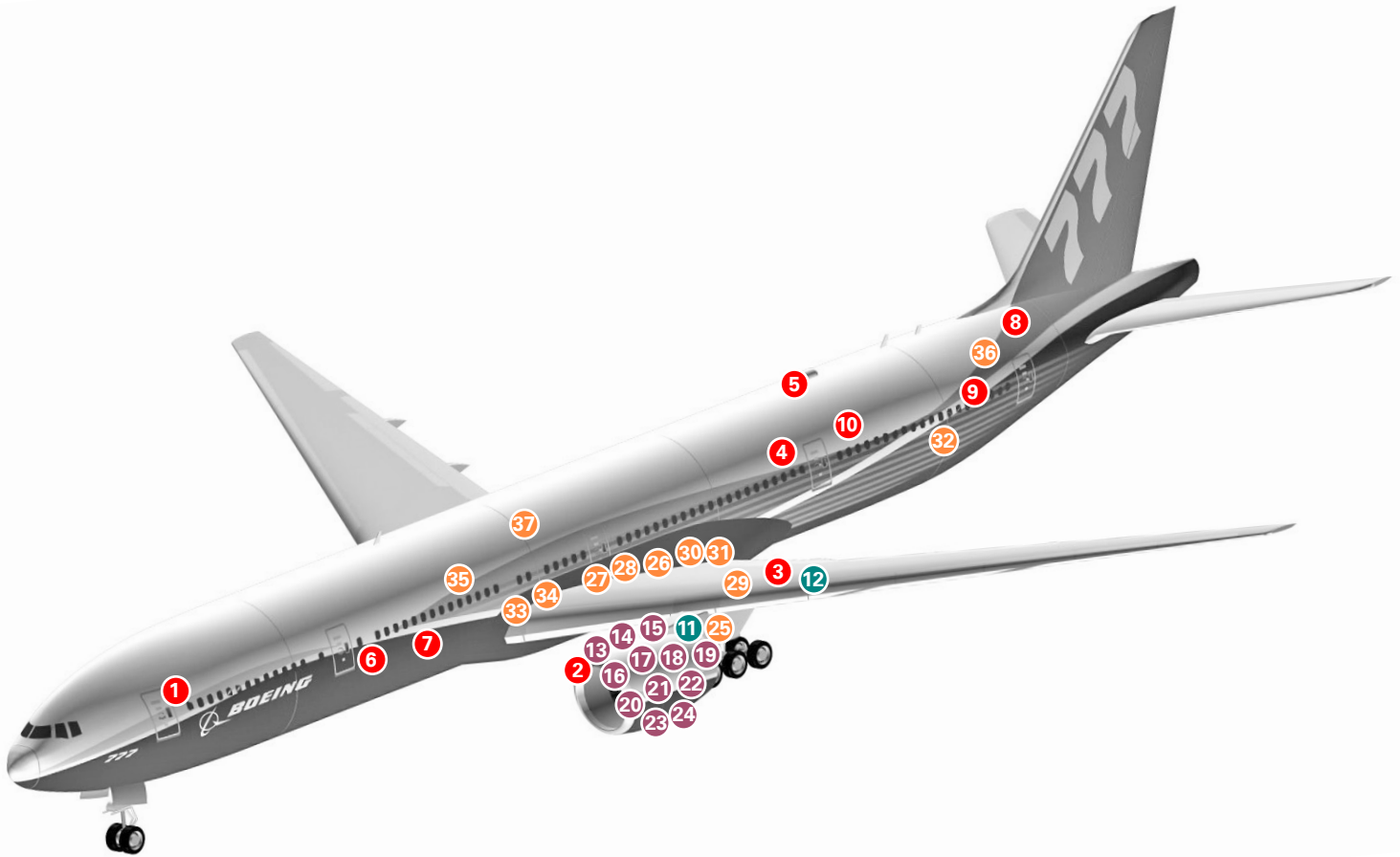
Eaton chip collectors are on the engines and manual level indicators in many of the secondary power systems.

Each hydraulic system utilizes Eaton's integrated hydraulic filter module, which performs the critical task of filtering pressure and case drain hydraulic fluid for use in the hydraulic system.

Within the center system, Eaton's brake metering valve (BMV) controls hydraulic pressure to the aircraft brakes. Eaton's main landing gear priority valve (MLGPV) performs a critical function during peak hydraulic power demands, such as landing. Also, playing a critical role in aircraft safety, Eaton's emergency passenger door actuator (EPDA) assembly is used to open a door when activated by nitrogen gas pressure.

Eaton's Aeroquip® product line includes the fluid quick disconnect coupling and self-sealing "B" nut fittings that are used in the Boeing 777 hydraulic system. They are also integrated in the hose assemblies reducing weight and eliminating potential leak paths on the aircraft.

Other Eaton products included on the 777 are main engine fuel pumps, pressure refueling level control valves and special main landing gear swivels that were designed to meet the additional side loads during deployment of the landing gear.



Motion Control

1. Flight Lock Actuator
2. Thrust Reverse Interlock Actuator
3. Auto Speed Brake Control Stand Acuator
4. Pneumatic Actuators
5. Cargo Door Rotary Actuator
6. Lift Latch Power Drive Unit
7. Power Drive Unit Assembly
8. Rudder Trim Switch
9. Environmental Control System Door Actuator
10. Emergency Passenger Door Actuator

Fuel Systems

11. Main Engine Fuel Pumps
12. Pressure Refueling Level Control Valve

Engine Solutions

13. Low Profile, Self-Sealing Fittings
14. Kevlar® Hose Assembly
15. Low Profile Ratchet Lock Couplings
16. Low Profile Ball Bearing Plane Swivel Joints
17. Absolute/Gauge Pressure Switch
18. Pressure Altitude Switch
19. Differential Pressure Switch
20. Sight Gauge
21. Chip Collector
22. Quantitative Debris Monitor
23. Lubriclone
24. Prismlite Level Indicator

Hydraulic Systems

25. Engine-Driven Pumps
26. Air-Driven Pumps
27. Inline Motor
28. Fluid Cooled AC Motorpumps
29. Rotary Actuator
30. Brake Metering Valves
31. Main Landing Gear Priority Valve
32. Filter Modules
33. Solenoid Valves
34. Shut-Off Reservoirs
35. Priority/Flow Limiting Valve
36. Stabilizer Trim Motor
37. Ram Air Turbine Pump



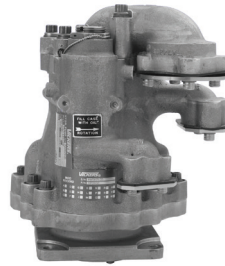
MF1-095-6 Stabilizer Trim Motor

Eaton's Stabilizer Trim Motor is a 3000 psi (207 bar), 2320 rpm bent axis fixed stroke piston motor. Displacement is 0.803 cu in/rev (12.15 ml/rev). Dry motor weight is 9.75 lbs (4.42kg)



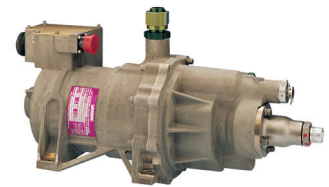
PV3-300-16 Main System Engine and Air Motor Driven Pump

Hydraulic power for the left and right systems is supplied by two 48 gpm (182 L/min), 4315 rpm, variable displacement, 3000 psi (207 bar), pressure compensated inline pumps. Displacement is 3.0 cu.in./rev. (49.14 ml/rev). Dry pump weight is 40.10 lbs (18.18 kg).



PV3-115-34 Ram Air Turbine Pump

Eaton's 3025 psi (208 bar) inline piston pump provides 20 gpm (76 L/min) at 3920 rpm hydraulic power for the priority flight control surfaces in the event power is lost in both engines or a total electric power failure occurs. Displacement is 1.25 cu in/rev (20.47 ml/rev). Dry pump weight is 15 lbs (6.8 kg).



MPEV3-040-10 AC Motorpump

Auxiliary power is provided by a 3110 psi (214 bar), 12 gpm (45 L/min), 8000 rpm, fluid cooled motorpump. Features include ceramic electrical feed through design and a non-metallic diffuser. Eaton's integrated motorpump completed the longest qualification test on a single product in the history of Eaton's Vickers® product line.

1800 & 1801 Series Low Profile Ratchet Lock Couplings

Eaton's Aeroquip product line of self-sealing ratchet lock couplings offer dependable service in aircraft for both low and high pressure applications. These couplings are available in both aluminum and stainless steel.

AS1896 Low Profile, Self-Sealing Hydraulic "B" Nut Fittings

Eaton combined a small envelope size with minimal weight to develop the low profile, self-sealing hydraulic "B" nut fittings. The "B" nut design is for both high and low pressure hydraulic systems on the Boeing 777.

Low Profile Ball Bearing Plane Swivel Joints

To meet the demanding side load requirements on the Boeing 777 landing gear, Eaton has improved the performance of the 1817 Series low profile ball bearing plane swivel joints to take up to three times the MIL-J-5514 side load requirements. The resulting swivel design has superior reliability and ultra low swivel torque.

AS1975 & AS4623 Kevlar® Hose Assemblies

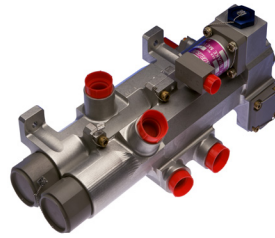
Eaton's Kevlar hose assemblies optimize weight throughout the hydraulic system.





71425 Filter Module

The Boeing 777 integrates Eaton's hydraulic filter module within each of the three main hydraulic systems. The module filters the pressure and case drain hydraulic fluid for use in the hydraulic system. System pressure is monitored and controlled through a series of integrated valves, sensors, pressure transducers, check valves, and relief valves. Also provided are ground service connections.



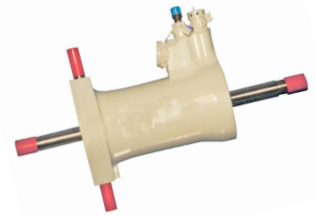
71404 Brake Metering Valve

Eaton's brake metering valve controls hydraulic pressure to the aircraft brakes. Using spool and sleeve technology, the brake valve has two separate normally-closed metering valves, a de-spin actuator, and a common input shaft for both metering valves. The metering valve for the left hydraulic system is opened by rotation of the input shaft or for the right system by actuation of the de-spin actuator.



71444 Main Landing Gear Priority Valve

Installed within the main landing gear hydraulic system, this valve performs a critical function during periods of peak hydraulic power demands. The lap assembly piston, spool and sleeve valve is a pressure sensitive flow limiter with a solenoid over-ride feature. With the solenoid de-energized, the valve senses control pressure and responds by restricting flow from fully open at 2475 psi (171 bar) to fully restricted at 2000 psi (138 bar). Flow at the restricted position is 1.0-1.2 gpm (3.79 - 4.54 L/min.).



71476 Emergency Passenger Door Actuator

Playing a critical role in aircraft safety, the emergency passenger door actuator assembly extends to open a door when actuated by nitrogen gas pressure. Eaton's actuator extends 4.44 inches (113mm) (minimum) to open the door when gas is applied at the inlet fitting. Maximum inlet pressure is 4125 psig (284 bar). The assembly will reach full extension in 2.75 to 4.16 seconds with an output force of 2507 to 2830 lbs (1137 to 1284 kg).

21C1 Series Absolute/Gauge Pressure Switch

Eaton's 21C1 type pressure switches have all-welded, stainless steel construction suitable for use with most corrosive media, including lube oils, hydraulic fluids, fuels, air and others. Wetted materials are 300 series stainless steel. The switch with a pressure-sensing element stainless steel diaphragm. The absolute pressure type switch is hermetically sealed.

211C223 Series Pressure Switch

Eaton's small, lightweight, pressure switches are designed for use in any fluid that is compatible with stainless steel, aluminum or titanium. Typical fluid applications include hydraulic oils per MIL-H-5606 and MIL-H-83282, Phosphate Ester, AO2-CTFE and water. The Eaton pressure switch design incorporates a snap-action electrical microswitch, which is actuated by a piston-sensing element. The snap-spring design is very reliable and has excellent vibration resistance.

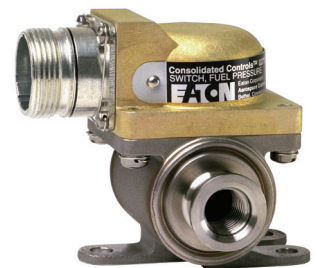
214C40 Series Pressure Altitude Switch

This small, lightweight altitude switch can be set to actuate at any altitude from -1,000 feet (15.25 psia/1.05 bar) to 70,000 feet (.649 psia/.045 bar). Qualified to MIL-STD-810C, its performance and reliability are assured. The 214C40 Series switch utilizes an aneroid-type capsule, which operates a snap-action electrical switch. The 214C40 can be used for gas density and has hermetically sealed electrical contacts.

21SN04 Series Differential Pressure Switch

Eaton's 21SN04 differential pressure switch is an all-welded, stainless steel snap-action pressure element, hermetically sealed switch that operates up to 400°F (205°C) for system pressures to 750 psi (52 bar). The switch meets flame-proof requirements of commercial aircraft and is lightweight, compact and rugged.

The switch may be used to detect fuel or oil filter clogging or to detect low-fuel booster pump pressure and closing and warning indicator circuit.





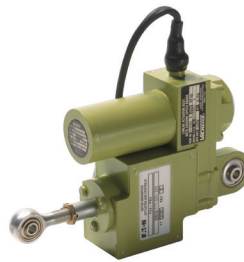
**692D100
Rotary Actuator for Large
Cargo Door**

Eaton's rotary actuators are designed to provide maximum weight to power efficiency for operation in harsh environments. The design options include potentiometer, synchro, resolver or RVDI feedback, mechanical overrides and redundant motors.



**931D100
Lift Latch Power Drive Unit**

This actuator consists of an AC 3-phase brushless motor with integral brake, a primary torque limiting device, a manual drive provision with torque limiter and six stages of reduction gearing, resulting in a final drive ratio of 1572.34 to 1. Extremely powerful for its size, this unit functions in a load range of between 9500 in lbs to 14,000 in lbs. Full extend or retract time is under 8 seconds.



**684D100
Thrust Reverse Interlock
Actuator**

Eaton's model 684D100 operates the speed brake spoilers on the Boeing 777. The Thrust Reverse Interlock Actuator has a 28 VDC reversible design with intermittent duty and integral brake. It has non-jamming mechanical stops with adjustable limit switches and a ball screw design with anti-rotation for better performance. The standard operating load for this unit is 140 lbs. (63.5 kg) and a maximum load of 350 lbs. (158 kg).



**924D100
Auto Speed Brake Control
Stand Actuator**

The Eaton linear actuator is a component of the speed brake system. The device functions on command from the Primary Flight Computer (PFC). At landing touchdown, the PFC sends an extend command to the Actuator Control Electronics (ACE) that signals the ACE to provide power to the actuator. The actuator drives the speed brake handle and speed brake transducer to the extend position. The resulting transducer change signals the ACE to provide power to the spoiler actuators to fully extend the spoilers for ground speed braking.

**1A6473
Chip Collector**

Eaton's chip collector probe is installed in the lube oil system of an engine or gearbox to trap, magnetically, any ferrous particles generated by wear in bearings or gears. Manual examination of the debris is required to determine the extent of damage.

**1L2984/1C2977-2
Quantitative Debris Monitor
System & Lubriclone®**

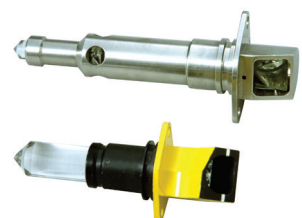
Eaton's QDM® generates an electrical pulse proportional to the mass of ferrous wear particles to signal an early warning of potential failure of lubricated engine gears and bearings. The sensor is mounted in a Lubriclone® cyclonic separator that removes entrained air from the scavenged oil while providing a quiescent area for the sensor to capture the debris with high efficiency.

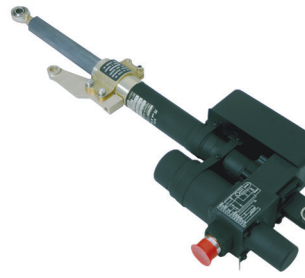
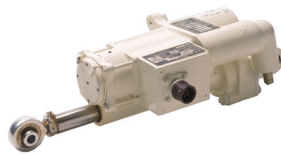
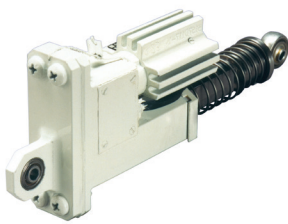
**2D666B
Sight Gauge**

Eaton's sight gauge mounted to the exterior of a tank or housing to provide visual indication of a liquid over a wide range.

**2D6559
Prismalite®**

Prismalite is a level indicator probe inserted in a tank or housing to indicate the presence of a liquid at a fixed level. Manual inspection will reveal all incident light when the point is not covered and a dark condition when liquid covering the point refracts the incident light into the liquid. Can be mounted in any orientation.





933D100 Flight Lock Actuator

Eaton's 28VDC linear actuator operates the eight in-flight passenger door locks on the Boeing 777 aircraft. The rated operation load for this unit is 8.0 lbs (3.48 kg) and a maximum static load of 100 lbs (43.5 kg). The motor is designed for continuous stall and has an integral clutch design.

964D100 Power Drive Unit Assembly

This Eaton Power Drive Unit (PDU) lift/latch actuation system operates the small cargo doors. It unlatches and translates (lifts) the door in an upward direction, clear of the stop fittings. At this point, the Hinge Drive System (HDS) can continue opening the door by rotating it upward and outward. The 964D100 is equipped for backup (manual) operation.

138400 ECS Door Actuator

Sold to Hamilton-Sundstrand, this compact linear actuator operates (opens and closes) the fresh air intake door in their Environmental Control System (ESC).

Type 8410 Fuel Boost Pump and Type 8411 Canister

Eaton's canister-mounted fuel boost pump was designed for the A320 to provide exceptional performance for high climb rates and at high cruising altitudes.

Summary Eaton's Aerospace Products

MODEL	PART NUMBER	DESCRIPTION
933D100	S135W171-1	Flight Lock Actuator
684D100	S253T402-4	Thrust Reverse Interlock Actuator
924D100	S254W911-1	Auto Speed Brake Control Stand Actuator
692D100	S135W132-3	Rotary Actuator For Large Cargo Door
931D100	S135W160-3	Lift Latch Power Drive Unit
964D100	S135W261-1	Power Drive Unit Assembly
6707	S231W262-1	Rudder Trim Switch
138400		ECS Door Actuator
71476	S131W187-4	Emergency Passenger Door Actuator
71425	S271W221-1	Filter Module
71404	294W1111-4	Brake Metering Valve
71444	S271W814-1	Main Landing Gear Priority Valve
MF1-095-6	342381	Stabilizer Trim Motor
MPEV3-040-10	848037	AC Motorpump
PV3-115-34	848330	Ram Air Turbine Pump
PV3-300-16	847999	Main System Engine & Air Driven Pump
AS1896		Low Profile, Self-Sealing "B" Nuts Fittings
AS1975 & AS4623		Kevlar® Hose Assemblies
1800 & 1801 Series		Low Profile Ratchet Lock Couplings
1817 Series		Low Profile Ball Bearing Plane Swivel Joints
21C1 Series		Absolute/Gauge Pressure Switch
211C223 Series		Pressure Switch
214C40 Series		Pressure Altitude Switch
21SN04 Series		Differential Pressure Switch
2D666B		Sight Gauge
1A6473		Chip Collector
1L2984		Quantitative Debris Monitor System
1C2977-2		Lubriclone®
2D6559		Prismalite Level Indicator
721400/72330/828500/830800		Main Gear Fuel Pumps
8410	568-1-27202	Fuel Boost Pump
8411	568-1-27203	Canister



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