Design, functions and space present an ongoing challenge in every new installation of aircraft hydraulic equipment. In the integrated gearbox driven hydraulic package described here, several basic requirements beyond reliability and cost had to be achieved. These included:

- **Design simplicity**
- **Speed and ease of replacement**
- **Minimum opportunity for leakage**
- **Low overall system weight**

Eaton has designed and developed this package to meet the unique needs of the Agusta Westland EH-101 helicopter and fulfill all the critical design goals while still achieving reliability and cost objectives.

Integration of essential valves, filters, sensors and transducers reduces system weight, virtually eliminates any opportunity for external leakage and simplifies troubleshooting.

The gearbox-mounted package described here provides the hydraulic power to the flight control system (main and tail control servos) and the utility functions like landing gear actuation, nosewheel steering, rotor brake, wheel brakes and sonar winch.

Three integrated hydraulic power systems, P/N 861000 (Model PPV3-056-2B), are used on each EH-101.

The EH-101 helicopter project is a joint venture between Agusta of Italy and Westland of the United Kingdom to produce a multi-purpose helicopter. Its missions include: antisubmarine warfare surveillance, commercial offshore oil support with 30 passenger seats and transportation and air ambulance roles.

Power is generated by three GE CT7-6 turboshafts for the Italian version and Rolls-Royce Turbomeca RTM322s for the United Kingdom helicopter versions.

The hydraulic package described here contains the following components:

**Basic Pump** — P/N 861000 (Model PPV3-056-2B), pumping element consists of a nine-piston rotating group adapted from an existing and well proven axial design variable positive displacement aircraft pump.

**Inlet Boost Impeller** — Used to supercharge the pump inlet on the Model PPV3-056-2B pump. The impeller permits full-flow operation with inlet pressures as low as 6 psia (41.3 kPa).

**Compensator Valve** — Controls the pump displacement from zero flow to a rated flow of 16 gpm (60.57 L/min) at a constant 3000 psi (20685 kPa).

**28 VDC Solenoid Valve** — An electrically operated two-piston valve that can, when actuated;
- Block the outlet flow of the pump
- Reduce the pump output pressure to minimize power loss
- Connect outlet line pressure to reservoir

**Fluid Reservoir** — A unique design of great simplicity utilizing a flexible membrane that provides continuous sealing with only one dynamic seal.

**Miniature Sensor that provides**:
- **Visual indication**
- **Electrical indication**
- **Prevented to actuate at cold temperature**
- **Resettable only by filter element removal**
- **Two sensors are provided for both pressure and return filter**

**Fluid Level Sensor** — Microswitch electrical sensor activated by the flexible reservoir membrane.

**Air/Oil Heat Exchanger** — Provided to maintain the temperature of the fluid (low pressure side) within the specified values.
- **Cooling Fan** — driven by the pump shaft, it forces external air through the heat exchanger.
- **Temperature Sensor** — a thermo resistive type to provide continuous reading of the reservoir fluid temperature
- **Pressure Transducer** — a strain gauge type to provide continuous reading of outlet pressure.

**Normal Operating Mode**

The helicopter’s gearbox rotates the pump’s drive shaft and the connected cylinder block pistons, impeller and fan. Pumping action is generated by the movement of piston shoes, which are restrained and slide on the shoe bearing plate in the yoke assembly. Because the yoke is at an angle to the drive shaft, the rotary motion of the shaft is converted to reciprocating piston motion.

The impeller boosts inlet fluid pressure by 30 – 40 psi (206.85 – 275.79 kPa) to ensure that sufficient inlet pressure is available at the cylinder block face to prevent cavitations on the inlet stroke of each piston.

At 2850 psi (19650.75 kPa) the compensator begins to meter fluid from the pump outlet to the yoke actuator piston. This reduces the yoke angle and consequently the pump displacement while maintaining pressure.

When the pump reaches 3000 psi (20685 kPa) outlet pressure, the yoke will be close to zero degrees stroke angle. At this point the pump displacement will be just enough to accommodate the system leakage. Therefore, at an outlet pressure of between 2850 psi (19650.75 kPa) the pump will be at full displacement.

During operation the pump receives replenishing fluid from the integrated reservoir. In the event of line breakage or fluid loss, the solenoid valve can be energized, which ports pilot pressure to the pilot-operated check valve, thus blocking flow to the system.

Pilot pressure is also ported to the end of the compensator spool, thus reducing the setting of the compensator from 3000 psi (20685 kPa) to 900 psi (6205.5 kPa). At that point, the pump is isolated from the system and provides the lowest power loss.

The reservoir design concept required the ultimate in simplicity and reliability, while at the same time remaining reasonable in cost.

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**Integrate Hydraulic Power Supply, P/N 861000 (Model PPV3-056-2B)**

- **Speed and ease of troubleshooting**
- **Design simplicity**
- **Pressure Transducer** — a transducer reduces system leakage and simplifies troubleshooting.
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**Basic Performance Characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>0.56 in³/rev (9.18 ml/rev)</td>
</tr>
<tr>
<td>Rated output pressure</td>
<td>3000 psi (20685 kPa)</td>
</tr>
<tr>
<td>Full flow pressure</td>
<td>2850 psi (19650.75 kPa)</td>
</tr>
<tr>
<td>Rate Speed</td>
<td>7500 rpm</td>
</tr>
<tr>
<td>Rated Flow at Rated Speed</td>
<td>6.0 gpm (60.57 L/min)</td>
</tr>
</tbody>
</table>

**Electrical Ratings**

- **EDV Valve Nominal**
  - Voltage: 28 VDC
  - Current: 0.6 ampere

**Pressure Transducer**

- **Excitation**: +10 VDC
- **Output**: 0.022 mV/psi

Temperature Transducer Resistance Type, Output per MIL-T-7999