THE LEE COMPANY

Innovation in Miniature

LEE TECH TALK

TECHNICAL APPLICATION NEWS BRIEF

SEVEN CRITICAL REQUIREMENTS FOR SELECTING VALVES FOR FUEL SYSTEM SHUTDOWN

ECOLOGY VALVES IMPROVE FUEL CONSUMPTION, REDUCE MAINTENANCE, AND BENEFIT THE ENVIRONMENT

Potential Adverse Effects of Residual Fuel in Aircraft Engines Post Shutdown

Unlike the driver of a car equipped with an internal combustion engine, an airline pilot cannot restart a commercial aircraft's engine immediately after landing. It is critical to have fuel in the distribution manifold during engine start-up and during operation. However, residual fuel remaining in the engine's combustion chamber following shutdown may adversely impact the engine and the environment. Issues that may arise include:

- Possible damage to the turbine due to 'hot starts' caused by rich fuel
- Increased maintenance due to fuel coking inside combustion nozzles
- Environmental and safety concerns due to fuel leakage
- Negative impact on the airline's earnings due to wasted fuel

These issues provide sufficient incentive to recover residual fuel in an aircraft engine following landing. Additional reasons to do so are directives for fuel venting and exhaust emissions outlined by the FAA and the EPA Clean Air Act (see Federal Aviation Regulation title 14 part 34). Thankfully, engine design engineers developed a solution: an ecology valve that allows for the safe drainage and storage of working fuel upon aircraft shutdown.

Ecology Valves Are the Answer

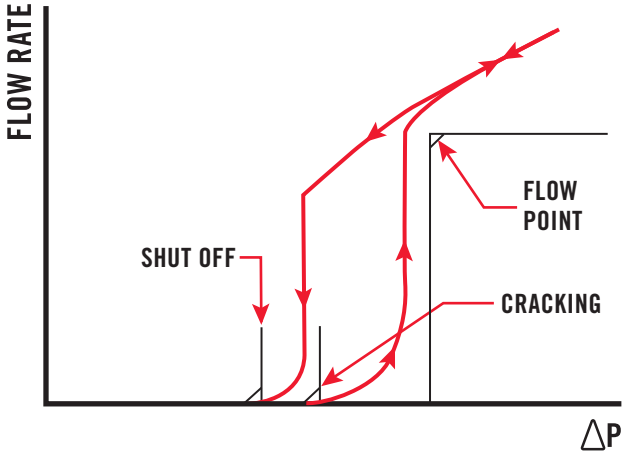
Ecology valves purge residual fuel from the engine during shut down and return that fuel to the engine when it restarts. During engine operation, the ecology valve is closed and unpressurized. At engine shut down, the inlet port to the ecology valve opens, and fuel is suctioned from the flow divider manifold to the sump chamber. This helps prevent injection nozzle coking and stops fuel from draining into the combustion chamber; furthermore, it mitigates the formation of clouds of smoke during the next start-up. During engine start up, the actuation chamber of the ecology valve is pressurized and returns fuel contained in the sump to the fuel divider manifold. To maximize performance, the ecology valve must suction just the right amount of fuel: enough to prevent the issues mentioned above while assuring sufficient fuel remains to allow for a proper restart. This may be accomplished through the use of a valve between the fuel manifold and the ecology valve.

Pressure Relief Valves or Vent Valves Are Critical to Ecology Valve Performance

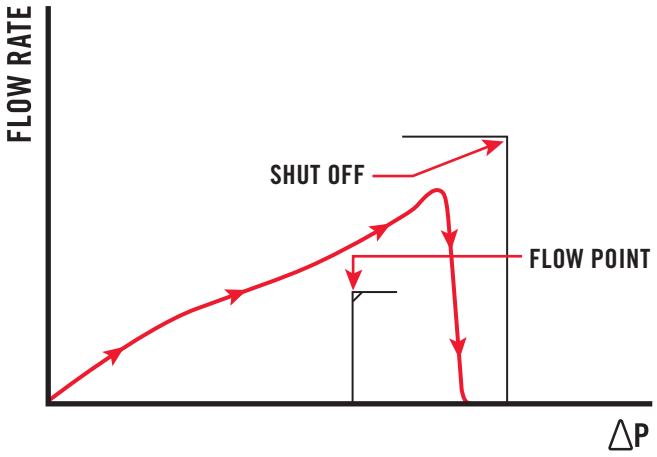
Pressure conditions change during engine shutdown: either a pressure relief valve or a vent valve may be used to precisely control the volume of flow into the sump chamber of the ecology valve. A pressure relief valve is a normally closed valve that opens when the differential pressure across the valve increases above a specified level. This may occur when a pressure differential is generated by suction from the ecology valve as it opens during shutdown; the relief valve will then open and fuel will drain into the ecology valve.

A vent valve is a normally open valve that allows relief flow during low-pressure conditions and shuts off when the differential pressure across the valve reaches a specified level. The vent valve may be used when there is no pressure differential during shut down, and the valve allows flow of excess fuel to drain. When the engine is in operation, the air in the combustion chamber is pressurized and closes the vent valve to shut off flow. The system architecture will determine which valve is appropriate for the intended application. However, either of these valves will face similar challenges.

TYPICAL PRESSURE RELIEF VALVE PERFORMANCE



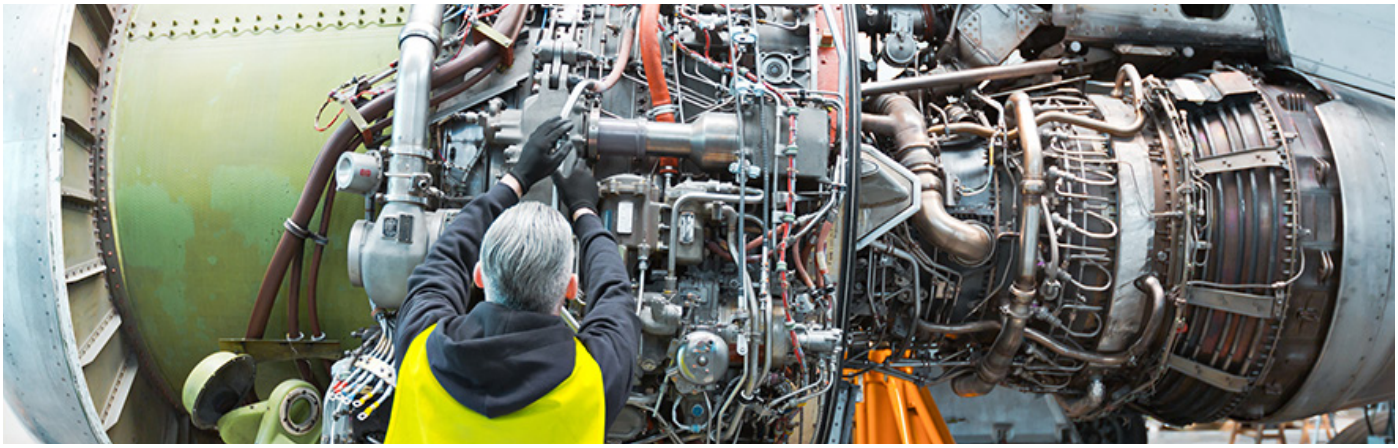
TYPICAL VENT VALVE PERFORMANCE



THE CHALLENGE: PRECISION CONTROL OF FUEL FLOW DURING FUEL SYSTEM SHUTDOWN

Components Used in Ecology Fuel Systems Must Withstand Extreme Conditions

To ensure ecology valves operate properly, design engineers must select durable components capable of precise performance and able to withstand all aspects of the fuel system environment. Fuel system components must provide precise flow and maintain tight leakage when subjected to high levels of vibration, extreme heat, and the high number of endurance cycles required by an aircraft engine.



Critical Requirements for Pressure Relief Valves and Vent Valves Controlling Fuel to Ecology Valves

The unique and challenging environment of engine ecology systems necessitates that careful consideration be given to the selection of valves. It is important to factor in the following requirements prior to making a decision:

1. **Cracking or Shut Off Pressure** — Regardless of the valve configuration, flow regulation is critical to controlling the amount of fuel remaining in or drained from the fuel system manifolds following engine shut off. Therefore, it is also critical to ensure that the valve is precisely calibrated to open and close at the appropriate differential pressure. The opening and closing pressure requirements of the valve may be specified as minimums and maximums or within a given tolerance of nominal. The system designer must understand these requirements and clearly define them prior to component development.

2. **Leakage** — During engine operation, a valve may be required to seal against air to maintain proper conditions within the combustion chamber pressure. While the engine is shut down, a valve may be required to seal in the fuel remaining in the manifold to maintain the proper fuel level for start up. In either case, minimizing leakage is critical to valve performance.

3. **Flow Rate** — When either a pressure relief or a vent valve is in the open position, it is critical the valve has enough flow capacity to discharge the necessary volume of fluid; this avoids the issues associated with residual fluid in the engine. Insufficient flow through a valve may cause it to become unstable and lead to excess wear and damage to the valve. It is, therefore, important that the range of potential flow rates be defined to ensure the valve is appropriately sized.

4. **Envelope** — As is the case with any aircraft component, using low weight valves is critical to minimizing fuel consumption; this also applies to valves that support the ecology valves. If space is limited or if there is a concern for accessibility for aircraft maintenance, repair, and overhaul (MRO), then special envelopes may be required.

5. **Fluid and Ambient Temperature** — Ambient temperature near the combustion chamber of an aircraft engine may exceed 450°C (842°F). Based on the location of the valve relative to the engine, it may also experience elevated ambient and fluid temperatures. The valve must be constructed with materials that can withstand the entire temperature range. Fluid properties can vary dramatically between a cold start and the heat generated during operation. It is critical that the valve be designed to perform under the full range of operating conditions.

6. **Vibration and Life** — The engine generates the highest levels of vibration on an aircraft. Vibration and metal fatigue may cause a component to wear earlier than expected. Airframers currently target 90,000 cycles and 180,000 flight hours for engine life cycle requirements. This is a threefold increase from the life offered twenty years ago; therefore, components mounted on or near the ecology system must be qualified for operation under these conditions.

7. **Resistance to Contamination** — The number one failure mode for miniature components is contamination. Fuel systems typically have dirtier fluids as compared to enclosed hydraulic systems. Therefore, anticipated high levels of debris inherent to the system demand a robust valve design and adequate protection for the valve.

THE SOLUTION

The Lee Company offers a wide range of miniature pressure relief valves and vent valves qualified to exceed aircraft engine standards. We meet the performance requirements for miniature valve configurations intended for applications where the valve must quickly respond when specified differential pressure is reached. These valves are designed to have very low internal leakage when in the closed position; they are also durable and handle high levels of vibration and extreme temperature for the life of the engine.

Standard Lee valves employ a patented locking end for easy installation. The Lee Company can supply valves as line removable units (LRUs) in standard line-mount fittings or in custom-designed envelopes to help reduce costs associated with MRO. We also offer the option to include integral safety screens on all valve designs as additional protection from rogue contamination or debris. Download the Technical Hydraulic Handbook for more information about our fluid control solutions, including vent valves, pressure relief valves, and more.

To obtain more detailed information about selecting pressure relief valves, performance trade-offs, and common failure modes, download our eBook: An Engineer's Guide to Selecting a Pressure Relief Valve.

A variety of pressure relief valves and vent valves available from The Lee Company

ADDITIONAL AIRCRAFT ENGINE APPLICATIONS FOR LEE COMPONENTS

The Lee Company supplies thousands of parts on every commercial and military aircraft flying overhead. In addition to their location upstream of ecology valves, they can be found throughout the fuel, lubrication, and bleed air systems. Click here to view our Aircraft Engine Solutions Brochure and learn where Lee components are used on other engine applications.

FIELD-PROVEN INNOVATION

The Lee Company has been at the forefront of fluid control technology since 1948, supplying millions of innovative products worldwide from our state-of-the-art manufacturing facilities in Connecticut, USA. We transform complex problems into deliverable solutions through ongoing research, design, development, and our commitment to quality and innovation. Our in-depth application knowledge enables us to collaborate with customers and provide personal, technical support through a wide network of experienced sales engineers who are ready to address any challenge.

WHAT'S NEXT?

Contact us today to learn more about our products and experience as the leading provider of miniature fluid control components. To learn more about The Lee Company's aerospace solutions, click here.