THE LEE COMPANY

Innovation in Miniature

LEE TECH TALK

TECHNICAL APPLICATION NEWS BRIEF

NOT ALL SOLENOID VALVES CAN PERFORM IN ENGINE BLEED AIR SYSTEMS

ANTI-ICE SYSTEMS IMPROVE AIRCRAFT FUEL CONSUMPTION AND SAFETY

Ice commonly forms during flight, adding costs and compromising safety

If you've flown on a snowy winter day, you have probably seen, or even been delayed by, de-icing trucks removing snow and ice from the airplane prior to take-off. What many people don't realize is that the need for ice removal is even more common during flight. When traveling at hundreds of miles per hour, if there is visible moisture in the air, the temperature only has to drop below 50°F (10°C) for ice to form on the leading edge of an aircraft's wings, horizontal and vertical stabilizers, and engine intake during flight.

The accumulation of ice on an aircraft causes two problems: additional weight and changes in the airplane's aerodynamics. Both issues impact fuel efficiency, resulting in higher costs for the airline as well as passengers. Excessive ice can even hinder the pilot's ability to control the plane, putting everyone on board at risk.

De-Icing Truck Removing Snow and Ice From an Aircraft

Engine bleed air is used to eliminate the problem

Thankfully, aircraft design engineers have created a solution to the unavoidable issue of ice formation during flight by using the engine bleed air system. This system diverts a portion of the air traveling through the compressor section of the engine upstream of the combustion chamber. As the air is compressed, heat is generated, and the temperature of the air rises significantly. Anti-ice valves direct the flow of this hot air through ducts to the surfaces where ice may form. The heated air warms these surfaces, causing any ice to melt or break away.

THE CHALLENGE: RELIABLE, HIGH PERFORMANCE SOLENOID VALVES

Solenoid valves used in the bleed air system must withstand extreme temperature and vibration

To ensure that engine bleed air systems perform correctly, system components must be designed to withstand extremely high temperatures. The compressed air enters the bleed air system at temperatures between 650°F and 1,000°F (340°C - 540°C). Before being transferred to the aircraft's wings and tail, bleed air is passed through a pre-cooler, reducing the air's temperature to between 400°F and 500°F (200 - 260°C). However, the anti-ice valves used for engine intake utilize air diverted prior to the pre-cooler, which may still be at even higher temperatures. Components designed for standard aerospace temperature ranges are typically only rated to operate up to 265°F (130°C) and are likely to fail at these temperatures.

The transfer of large volumes of bleed air is managed by large mechanical control valves piloted by smaller solenoid valves. Mechanical components used in these systems, such as metering orifices and check valves, can be manufactured entirely from metals designed to handle these high temperatures, but solenoid valves have many other complexities to overcome.

In addition to high temperatures, the engine has high levels of vibration due to the constant rotation of the turbine. Based on where a component is mounted, it needs to withstand the associated vibration for the life of the aircraft or engine. Otherwise overhaul schedules, procedures, and associated costs must be considered.

Key considerations for solenoid valves controlling bleed air

When selecting a solenoid valve, an engineer must consider typical specifications, such as two-way vs. three-way porting, flow capacity, operating pressure range, and whether redundant coils are required for added reliability. For solenoid valve applications in the unique environments of engine bleed air systems, there are other requirements that merit close consideration, including:

Fluid Temperature - The materials in contact with the flow path must be able to withstand the elevated temperatures of engine bleed air. This requirement severely limits the materials which can be used for the seals that eliminate leakage through and around the valve. Common sealing materials, including elastomers and other soft seals typically used for pneumatic control, will quickly melt.

Ambient Temperature - Bleed air valves may be mounted on or near the engine. Even when the solenoid valve is located away from the hottest engine zones, the ambient conditions may be much hotter than the typical aircraft design parameter of 265°F (130°C) maximum. The electrical coil of a solenoid valve becomes less efficient as temperatures increase, and at a certain point it will be unable to generate the force needed to open the valve. Without an efficient coil design, thermal control systems may be required to reduce this temperature in order for the valve to operate.

Leakage - Limiting internal valve leakage and external bypass leakage reduces the amount of hot air traveling through the solenoid valve and its surrounding area. This helps maintain lower ambient temperatures, assisting with the issues described above.

Response Time - The mechanical control valves used to transfer large volumes of bleed air often require quick response times by the piloting solenoid valves when performing a shut-off function. Using solenoid valves with fast, repeatable response times may allow less bleed air to be drawn from the engine, improving efficiency and providing similar benefits to those associated with low bypass leakage.

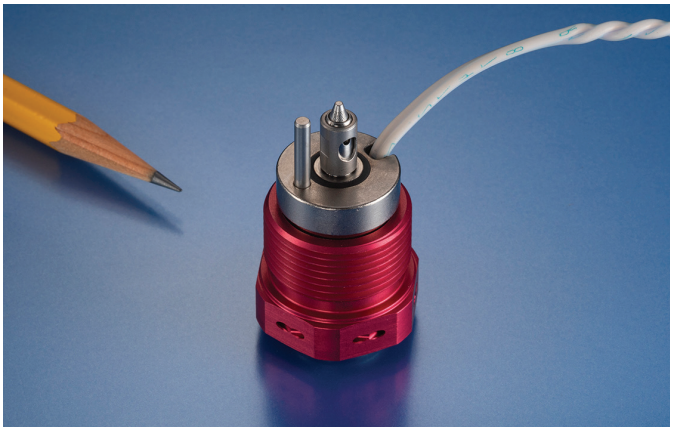
Envelope - As with any aircraft part, reducing weight also reduces fuel consumption and operating costs. In addition, the anti-ice valves controlling bleed air to the engine intake must be mounted on the engine, where space is very limited. Some solenoid valves have large coils that extend out from their housing, making it easier to generate higher force. However, this requires more weight and space, and can impact the valve's resistance to vibration.

Vibration - The engine generates the highest levels of vibration on an aircraft. Components mounted on or near engine, including solenoid valves, must be qualified for operation under these conditions. Vibration is often specified with a root-mean-square acceleration (grms) value. However, the system design engineer should consider a required safety factor above this value to ensure the valve can handle the worst case vibration, not just the average.

Force Margin - Pressure and temperature conditions, vibration, flow rates, and response time requirements all impact either the amount of force that the solenoid coil can generate or the forces acting on the moving components within the valve. It is critical that the valve be designed with enough of a force margin across the entire range of potential conditions found in an engine bleed air system to eliminate the possibility of the valve failing to open or close when necessary.

THE SOLUTION

The Lee Company has developed a metallic MultiSeal® proven to eliminate bypass leakage and survive the high temperature environments found in engine bleed air systems. The high temperature rating of the seal reduces the need for cooling lines that would be required to use elastomeric O-ring seals. The patented MultiSeal technology simplifies port layout while offering significant space savings and higher reliability than traditional sealing methods. While the MultiSeal eliminates bypass leakage, the fluid control components of the solenoid valve provide low internal leakage - ideal for these pneumatic applications - with a highly reliable design protected by an integral safety screen and proven through extensive use in Lee check and shuttle valves. The internal components are also extremely small and



Lee Solenoid Valve with a Metallic MultiSeal® Installed

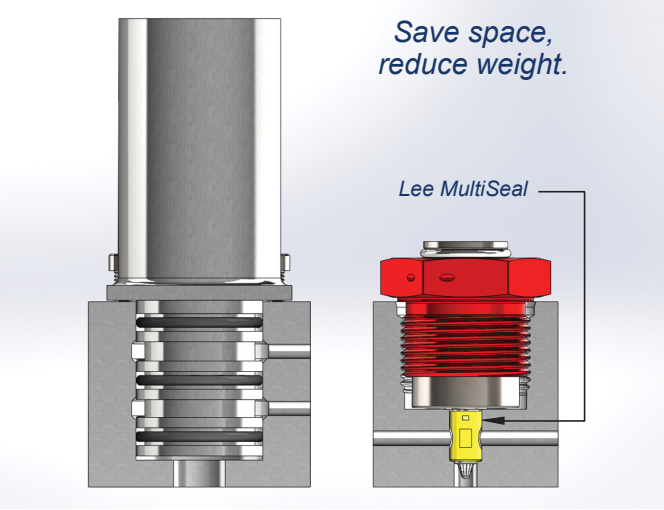
lightweight, which helps eliminate performance issues related to vibration because vibration loads are proportional to the mass of the moving components. Lee valve designs are qualified to withstand vibration levels far exceeding those found on aircraft engines. The Lee Company's innovative, compact, and efficient solenoid coil design provides fast response times (below 15 ms), low power consumption (less than 7.8 Watts), and light weight (as low as 0.14 pounds).

Utilizing MultiSeal technology and an ultra-compact coil design, The Lee Company offers the smallest solenoid valves available to the market. Lee products have performed for decades in systems designed for the harshest conditions, ranging from subsea oil wells to the depths of outer space, and have pedigree in every hydraulic, fuel, or pneumatic system critical to commercial or military aircraft performance. Lee solenoid valves are available in a variety of configurations, including options for polymeric seals to reduce internal leakage, latching designs to reduce power consumption, triple coils for added reliability, and a wide range of envelopes.

LEARN MORE

VIEW OUR MINIATURE PILOTING SOLENOID VALVE BROCHURE

TRADITIONAL VS. LEE



Traditional Flange Mounted Solenoid Valves

Lee Miniature Piloting Solenoid Valve

ADDITIONAL ENGINE BLEED AIR APPLICATIONS FOR LEE SOLENOID VALVES

Along with their use in anti-ice valves, Lee solenoid valves are ideal for many other functions in engine bleed air systems. Instead of using anti-ice systems to heat the aircraft's surfaces, smaller aircraft use de-icing systems with pneumatic control valves that inflate boots to break ice. Aircraft bleed air is also used for cabin temperature and pressure control, engine start-up, and the pressurization of other fluidic systems. Emergency shut-off valves on air conditioning systems ensure that superheated air does not enter the airplane cabin. Bleed air valves control the RAM air flow into the pre-cooler. All large valves used in these systems may be operated by piloting solenoid valves flowing high temperature air with similar environmental and performance requirements.

LEARN MORE

VIEW OUR AIRCRAFT ENGINE BROCHURE

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 solenoid valves, click here.