Air Conditioning System Troubleshooting

Eff.:* *Global Series Aircraft

By:* *Tino Raspa - Customer Support Engineering

ATA 21

Troubleshooting the air conditioning system on the Global Series aircraft can be accomplished with the aid of its self-diagnostic system for most failures. However, there have been instances that have led to tedious and time-consuming troubleshooting. In some of these investigations, Customer Support Engineering (CSE) consulted with Liebherr for a remedy to these complex symptoms, but often, complex symptoms are traced to one or more causes where components were swapped and/or replaced with no resolution at times. CSE is starting to see reoccurrences of the same conditions and for this reason we would like to share with you our experience.

CSE has investigated a number of single Pack Shutdown occurrences, identified by CAIMS as pack under-pressure, that happened in flight usually during descent and a few cases where both cooling packs were operational but the output temperatures delivered by each cooling pack were wide apart from each other. This condition is referred to as Pack Temperature Split.

There are several symptoms that could lead to a pack shutdown but the fault condition that we have focused on is related to a pack under-pressure condition. This condition is sensed by the Pack Discharge Pressure Sensor (PDPS), also known as the Anti-Ice Pressure Sensor. The PDPS has two functions: Detection of icing that can occur downstream of the Air Cycle Machine (ACM) turbine (cold side), and detection of a disconnected cooling pack discharge duct. The PDPS measures the difference in pressures between the cooling pack discharge outlet and the cabin. Under normal condition, the ACM outlet pressure, relative to the cabin pressure, must be slightly greater allowing pressurization of the aircraft. If ice buildup occurs at the ACM discharge outlet, the constriction created by the ice buildup at the ACM outlet causes the discharge pressure to in crease. When the Air Conditioning System Controller (ACSC) detects the increase in pressure as detected by the PDPS, it commands the Temperature Control Valve (TCV) to allow a greater amount of hot bleed air to flow through the ACM discharge outlet to eliminate the ice buildup. In the event that a pack discharge duct becomes disconnected, the ACM output pressure decreases resulting in an under-pressure condition. When the ACSC detects a negative pressure of minus 1.54 psid, as measured by the PDPS when compared to the pressurized area, it commands the associated Flow Control Valve (FCV) to close, causing the cooling pack to automatically shutdown. This under-pressure condition is accompanied by a L-R PACK FAIL caution message on EICAS and the illumination of the amber FAIL lamp on the air conditioning panel Push-Button Annunciator (PBA).

During our investigation, we encountered an unusual scenario where water was found in the PDPS sense line. The PDPS sense line runs from the ACM turbine outlet to the PDPS located within the pressurized cabin, which is located at a lower waterline than the sense port on the ACM. So, if water does accumulate in the PDPS sense line it could freeze when the aircraft is at high altitude, trapping the pressure in the PDPS sense line (Ref. Figure 1). As the aircraft descends to a lower altitude, the cabin pressure increases accordingly and when the cabin pressure exceeds the trapped pressure in the PDPS line by 1.5 psid for a period of 15 seconds, a pack under-pressure condition is falsely created. The ACSC would then command the associated cooling pack to shutdown. There are several reasons that can explain how water collects in the PDPS line.

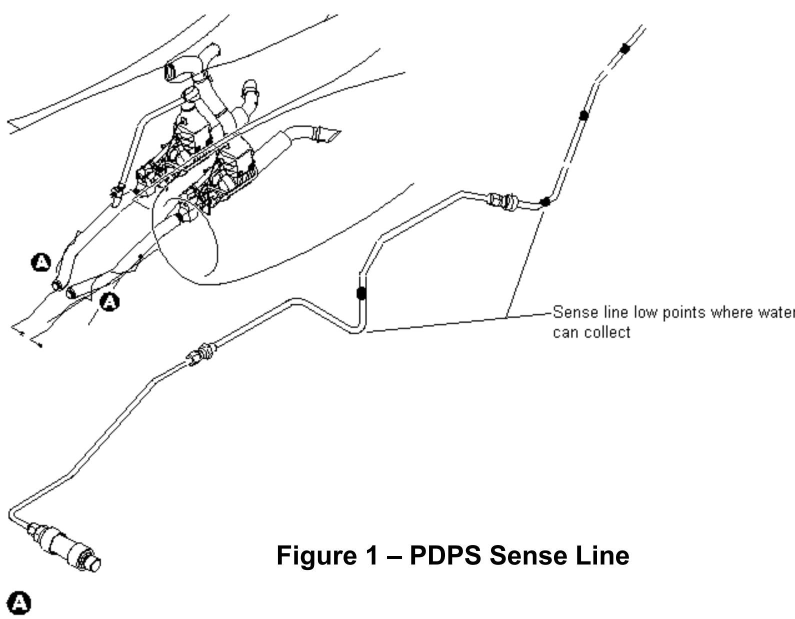

Figure 1 – PDPS Sense Line

Cont'd on Page 7

Air Conditioning System Troubleshooting*…Cont*

Firstly, the PDPS line is susceptible to condensation within the line. Secondly, the air conditioning system incorporates a water extractor to remove water vapor content before the air enters the ACM turbine. However, the extractor is not 100% effective and a portion of air leaving the water extractor still contains a small percentage of water vapor. As the air is cooled further at the ACM turbine stage, the remaining water vapor condenses to form water droplets. Most of the water droplets are expelled through the discharge duct and the cooling pack drains but some may enter the PDPS line. Over time, there may be enough water accumulation in the PDPS sense line to cause complete obstruction when it freezes at altitude. Thirdly, the cooler a pack runs, so does the effects of condensation increase, which brings us to the next topic.

Pack Temperature Split is a topic that we are asked about by maintenance and flight crews. What range of temperature split is considered to be “normal”? There is no control logic to ensure that the cooling packs operate in a synchronized manner, so it is normal to have a temperature split between the two cooling packs provided that the selected zone temperatures are being achieved.

The ACSC controls the operation of the packs to achieve the selected cabin and cockpit temperatures in the respective zones. In general, each ACSC controls the respective cooling pack discharge temperature to obtain a common Mix Manifold target temperature, which is 3 degrees C to 8 degrees C lower than the coldest selected temperature in all three zones. However, there is no control logic to synchronize the discharge temperatures between each cooling pack, therefore, it is not uncommon to see a split as much as 30 degrees between the pack discharge temperatures.

The performance of a cooling pack may differ from one to another. The air conditioning system is controlled by the ACSC using output signals sent by different sensors to control the FCV and TCV positions in an effort to achieve specific temperature and flow performance. The sensors are manufactured within a specific tolerance range and in some cases, they can be at the end of the spectrum but still within limits. The stack up of tolerances from the different sensors defines the equilibrium point of a cooling pack, which explains why there is a difference in discharge temperature between two cooling packs. In addition to the sensors’ influence on the cooling pack equilibrium, there is also the mechanical wear of the system that must be taken into consideration. This is mostly true for an ACM that has been in service for some time. The internal components begin to degrade at different rates thus affecting performance, which can be considered as a positive attribute, as it decreases the probability for both packs to fail simultaneously. For example, a cooling pack that has a turbine with a high resistance torque loses its efficiency, resulting in a pack that is discharging warmer air. The ACSC will, in turn, cause the opposite cooling pack to provide colder discharge temperature in an effort to compensate and meet the acceptable mix manifold temperature. As previously discussed, a cooling pack will produce more water droplets the colder it runs, thus increasing the chances for water to enter the PDPS line.

The causes for the conditions described are not recent discoveries but were part of our focus study in an effort to understand the pack under pressure and pack temperature split conditions. The investigation has helped us to develop new troubleshooting procedures and improve on the existing ones. The Fault Isolation Manual (FIM) will be revised to include additional information based on lessons learned for a pack under pressure condition and a pack temperature split condition. The revised FIM should be available in the fourth quarter of 2006.