NB Log 2343

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 2, 1992
In reply refer to: A-92-10

Honorable Barry L. Harris
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

On Saturday, July 12, 1991, at about 8:02 p.m. eastern daylight time, a Piper PA-32RT-300T, N36272, collided with the terrain while on approach to the Barnstable Municipal Airport near Yarmouth, Massachusetts. The airplane was destroyed by impact forces and postaccident fire, and the two pilots were fatally injured. The engine, model TIO-540-S1AD, S/N L-5375-61A, was manufactured by Avco Lycoming, now Textron Lycoming (Lycoming). At the time of the accident, the engine had accumulated 1,477 total service hours, 20 of which were after the last engine overhaul. A representative of Lycoming indicated that the engine was shipped to the Piper Aircraft Corporation on May 4, 1978.

Disassembly of the engine, performed at the Lycoming facility in Williamsport, Pennsylvania, revealed that the fuel injector line between the fuel manifold and the No. 1 cylinder fuel nozzle, P/N LW-12098-0-100, was broken.

According to the TIO-540 parts catalog, the engine contains four 10-inch-long fuel injector lines, P/N LW-12098-0-100. These lines provide fuel to cylinders Nos. 1, 3, 4, and 6. Two other lines, P/N LW 12098-0-170, each 17 inches long, provide fuel to cylinders Nos. 2 and 5. The fuel injector lines are made from a 1/8-inch outside diameter stainless steel tubing. Each end of the tube contains a fitting that is brazed to the tube. The lines are located on the underside of the engine and a separate line supplies fuel to the intake port of each cylinder.

When the fuel lines are installed on the engine, they are customarily bent to fit in the system. The broken fuel line from the accident airplane was bent along its length near the brazed joints into an approximate S-shape. Examination at the Safety Board's materials laboratory revealed that separation of the line occurred in the bent portion of the tube about 0.5 inch from the orifice end of the fitting. Further examination indicated that the fracture of the tube originated at the outer diameter surface in the location immediately adjacent to the brazed joint.

Almost the entire fracture surface contained crack arrest positions, characteristic of fatigue crack propagation. Examination of the fracture surface at higher magnification, performed with the aid of a scanning electron microscope, indicated that the fatigue fracture zone contained closely spaced striations, typical of fatigue cracking from high cycle vibration. Intergranular facets, characteristic of intergranular separation, were found in the area where the fracture originated. Metallographic examination of a cross section through the fracture origin revealed chromium carbide precipitation at the grain boundaries indicative of a sensitized condition in stainless steel.[1] Metallographic examination also confirmed that the fatigue fracture had originated from an intergranular cracking area.

According to the engineering drawing for the fuel injector line assembly, the tube portion of the line was made from a type 304 stainless steel. This type of steel becomes sensitized and susceptible to intergranular corrosion when exposed to temperatures ranging between 1,000° F and 1,550° F. A representative of Lycoming stated that the fuel injector line was fabricated by Wolf Aircraft Manufacturer by using a torch brazing technique during the tube-to-fitting assembly. The technical literature shows that torch brazing for the specified filler metal is performed at temperatures between 1,295° F and 1,550° F. This temperature range is within the sensitizing range of type 304 stainless steel, thus indicating that the tube might have become sensitized during the brazing operation.

The Safety Board is aware through Federal Aviation Administration Service Difficulty Reports (SDR) that, since 1985, there have been two other incidents of cracking in Lycoming P/N LW-12098-0-100 fuel injector lines between the fuel manifold and the nozzle. In both cases, the cracking reportedly occurred in the tube portion of the lines at the brazed fitting joints. Further, two additional SDRs for the same period document separations in the longer P/N LW-12098-0-170 fuel lines, one of which had also developed at the brazed joint. Although the location of the other break was not indicated, fracture of that line had reportedly caused an engine fire.

On April 14, 1972, Lycoming issued Service Bulletin No. 335A recommending a fuel line inspection and support clamp installation on TIO-540-A model engines with serial numbers lower than 1931-61. The bulletin advises that (a) during the inspection, the fuel lines should be checked visually for evidence of physical damage and for stains caused by fuel leakage; and (b) after inspection, a fuel line support kit, specially designed by Lycoming, should be installed. The overhaul manual for Lycoming direct drive aircraft engines refers service personnel to this service bulletin for instructions relative to clamping the nozzle lines. However, engines that were manufactured after 1972 are not covered by the existing bulletin and installation of a clamping kit onto the newer engines can be easily overlooked. The on-site investigation of the accident airplane in

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[1]Sensitization results in less than 12 percent chromium content in a narrow region adjacent to grain boundaries. A minimum of 12 percent is required for good corrosion resistance.

Yarmouth and examination of the broken fuel line revealed no evidence that the fuel line was clamped or otherwise secured to the engine. As a result of this accident, Lycoming is preparing another service bulletin, which will reportedly include all fuel-injected engines manufactured after 1972.

The Safety Board believes that failure of the fuel injector line from the accident airplane initiated at an intergranular corrosion crack and propagated by cyclic loading as the result of excessive tube vibration due to lack of support in the engine assembly. The Safety Board is concerned that, without adequate fuel line support, vibratory loads can induce fatigue cracking even on a line with no damage or defect, and that the cracking or separation of the fuel injector line could cause a serious accident. The P/N LW-12098-100 and -170 are the only fuel lines used on the engine model for the accident airplane. However, several additional dash number fuel lines are used on the other Lycoming fuel injected engines. Lycoming expressed a concern that fuel lines used on all of its fuel injected engines may be subjected to excessive vibrational stresses if unsupported by clamps. The Safety Board is also concerned about this and believes that fuel lines on all fuel injected engines manufactured by Lycoming should be examined for cracking and supported by clamps.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Issue an Airworthiness Directive to require (a) visual inspection, after a specified number of service hours, of fuel injector lines between the fuel manifold and the nozzles in all fuel-injected engines manufactured by Lycoming for evidence of cracking, particularly in the areas of brazed joints; and (b) installation of support clamps to secure the fuel lines to the engine. (Class I--Urgent Action) (A-92-10)

Acting Chairman COUGHLIN and Members LAUBER, HAMMERSCHMIDT, and KOLSTAD concurred in this recommendation. Member HART did not concur.

By: Susan M. Coughlin
Acting Chairman