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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 18, 1987
In reply refer to: A-87-71 through A-87-76

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
Washington, D.C. 20591

From 1980 to 1986, there were 71 accidents or incidents involving a loss of engine power due to broken or sticking exhaust valves in Avco Lycoming 0-320 series engines. Sticking exhaust valves are often accompanied by bent push rods. During this same period, the Federal Aviation Administration's National Safety Data Branch also received 219 Service Difficulty Reports regarding such valve problems. The valve problems have occurred primarily in engines installed in several models of Cessna, Piper, and Gulfstream American airplanes, and in Robinson helicopters.

Exhaust valve sticking has been the subject of several Avco Lycoming Service Publications including Service Letter No L197, "Recommendations to Avoid Valve Sticking" (July 2, 1982); Service Instruction No. 1425, "Suggested Maintenance Procedures to Reduce the Possibility of Valve Sticking" (October 21, 1983); and Service Letter L205A, "Warranty/Proration in Event of Stuck Exhaust Valves" (November 23, 1984). Valve sticking, according to Service Letter L197, can be caused by contaminants in the oil and by combustion residues. These cause lead, varnish, and carbon deposits to form on the exhaust valve stem and guide, interfering with the stem's movements and resulting in intermittent engine hesitation or miss. If the deposits are not removed, a valve could become stuck, causing engine damage. Service Instruction No. 1425 elaborates on the problem as follows:

> Since the rate of oil contaminant accumulation is increasd by high ambient temperatures, slow flight with reduced cooling, and high lead content of fuel, owners and operators experiencing these conditions are encouraged to consider the following suggestions for operation and maintenance if they have experienced valve sticking.
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> PART I - OIL AND FILTER CHANGES
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> More frequent oil and filter changes (50-hour) will minimize the accumulation of harmful contaminants, the prime cause of valve sticking. This procedure is advisable whether the engine has a pressure-screen oil filter or a full-flow oil filter. Operating the engine with a clean air filter is also important for keeping dirt from accumulating in the oil supply. Therefore, the entire air-induction system should be well sealed to prevent the entry of unfiltered air.

It is also important that the cooling air baffles and baffle strips be in good condition to prevent localized overheating problems.

When the aircraft cannot be flown frequently, the oil should be changed even sooner than a 50-hour interval. The oil should then be changed every 25 hours to eliminate moisture and acids that collect in the oil of an inactive engine. For aircraft that are not flown for long periods of time, the oil should be changed every six (6) months, if the aircraft is not flown at least 25 hours within this 6-month period. Short ground runs should be avoided.

Exposing the engine to sudden cool down, as in a rapid descent with the power reduced, or shutting the engine down before it has sufficiently cooled down can also induce valve sticking.

PART II

Investigations have shown that exhaust valve sticking occurs more frequently during hot ambient conditions. The lead salts that accumulate in the lubricating oil from the use of leaded fuels contribute to the deposit build-up in the valve guides. They are mostly eliminated each time the oil and filter are changed. Depending on the amount of deposits, sticking between the valve stem and guide can restrict the valve movement. This condition is often identified by an intermittent engine hesitation or miss.

Operating with any of the following conditions present can promote deposit build-up reducing valve guide clearance and result in valve sticking.

a. High ambient temperatures
b. Slow flight with reduced cooling
c. High lead content of fuel.

If any of the above is present or hesitation is observed, then inspection and cleaning is recommended (Refer to Part III of this instruction). Inspection and cleaning intervals can only be determined as a function of individual operating conditions.

In recent years, the extensive use of higher-leaded aviation gasoline (avgas) has exacerbated the valve sticking problem. For example, the 100-octane fuels, 100" low lead" (blue) and 100 (green), contain 4 and 8 times as much tetraethyl lead per gallon respectively as 80-octane fuel (red), which is now unavailable in many parts of the United States. Moreover, most aircraft engines designed during the past decade must be operated only with 100-octane fuel.

Lycoming, in their May 1982, issue of "Flyer", emphasized the importance of proper "leaning" of the air-fuel mixture at cruise power settings. Leaning promotes complete burning of the fuel and minimizes the deposit of lead sludge in the oil resulting from the use of high lead fuels. Since the lead salts or sludge that does accumulate is mostly eliminated each time the oil and filter are changed, the Safety Board believes that frequent oil and filter changes are imperative in all Lycoming 0-320 series engines.

The problem of sticking or stuck exhaust valves occurs primarily in Cessna Models C-172M, C-172N, and C-172P, which use the 0-320-E2D 1/, 0-320-H2AD, and 0-320-D2J engines, respectively; in Piper Model PA-28-161, using the 0-320-D3G engine; and in Robinson Model R-22-HP helicopters with 0-320-B2C engines. Since a clean lubrication system is essential in preventing valve sticking, the Safety Board believes that any of these engines that use only a pressure screen for oil filtration should be converted to use a full-flow oil filter for more effective cleaning of the oil. The conversion is relatively easy to perform and should be accomplished in accordance with Avco Lycoming Service Instruction No. 1319 B, "Engine Mounted Oil Filter Kits and Replacement Filters." Additionally, the Safety Board believes that certain precautionary engine service measures are also necessary to determine the effect of the increased fuel lead levels on the valve stems and guides of these engines and to ensure that proper exhaust valve guide clearances are maintained.

Avco Lycoming Service Bulletin 388A, "Procedure to Determine Exhaust Valve Condition" (April 14, 1978), outlines an inspection procedure for quickly checking the condition of valve guides without removing the valves from the cylinders. By this procedure, the degree of lead, varnish, or carbon build-up can be determined by measuring the clearance between the exhaust valve stem and the guide. The Safety Board believes that the FAA should mandate such an inspection procedure. The bulletin indicates that this inspection should occur at the mid-point of airplane engine service time (1,000 hours for 0-320 series engines) and at 300-hour intervals for helicopter engines. However, service experience indicates that valve malfunctions in the 0-320 series engines frequently occur after 400 to 500 hours of airplane engine operation. Therefore, for the aforementioned Avco Lycoming 0-320 series airplane engines, the Safety Board believes that the inspection should be performed within the next 25 hours of operation and at subsequent engine intervals of 300 hours, or triennially, whichever occurs first; for the Avco Lycoming engines installed in the Robinson Model R-22-HP helicopters, the inspection should be performed within the next 10 hours of operation and at subsequent engine intervals of 150 hours, or biennially, whichever occurs first. If inadequate valve guide clearances are found, the exhaust valve and valve guide pairs should be replaced as necessary, or the valve guides should be cleaned (reamed) in accordance with Service Instruction No. 1425, Part III, "Cleaning Procedure."

Another problem relating to the use of the higher leaded fuels in certain Avco Lycoming 0-320 series engines involves valves broken as a result of severe wear, localized heating, erosion, and cracking. The problem occurs primarily in the low compression, 80/87--octane rated, 0-320-E series engines using Lycoming part number 75068 exhaust valves. According to Lycoming, when this valve is subjected to high leaded fuels, the valve shows mild to severe head erosion and cracks that can progress to valve failure. To prevent this, Lycoming in 1976 began installating high compression type sodium cooled exhaust valves, part number 74541, into some new and remanufactured engines, and issued Service Bulletin No. 404, "Exhaust Valve Inspection (High Lead Fuel Operation)" (September 17, 1976). The bulletin was applicable to all low compression 80/87-octane rated 0-320-A, 0-320-E, IO-320-E, A-320-E, IO-320-E, and 0-540-B series engines using part number 75068 exhaust valves. The new high compression exhaust valve, which replaces part number 75068, is identical to it except for the material of the valve head, which is highly resistant to corrosion. Lycoming recommended that the inspection outlined in Service Bulletin No. 404 be performed at each 100-hour engine inspection and that the newer high compression type exhaust valves be installed during engine overhaul.

1/ Also used in Model Year 1968 Cessna Cardinal 177 airplanes

The Safety Board's directed review of accidents, incidents, and service difficulty reports, as mentioned previously, disclosed a propensity for broken valves. The problem was noted particularly in airplanes with low compression Avco Lycoming 0-320-E series engines, i.e., in the Piper PA-28-140, which uses the 0-320-E2A or -E3D engines; in the Piper PA-28-151 with the 0-320-E3D engine; in Cessna Models C-172I, C-172K, C-172L, and C-172M using the 0-320-E2D engines; and in Gulfstream American AA5 and AA5A airplanes with 0-320-E2G engines. Because exhaust valves continue to break in these engines, which are now operated primarily with higher-leaded fuel, many of them apparently are still operating with the older Lycoming part number 75068 exhaust valves. Therefore, the Safety Board believes that the FAA should require that any of the aforementioned airplanes with these exhaust valves be inspected in accordance with Avco Lycoming Service Bulletin No. 404, "Exhaust Valve Inspection (High Lead Fuel Operation)," within the next 50 hours of operation and at subsequent 100-hour or annual inspections, whichever occurs first. Additionally, Lycoming high compression type sodium cooled exhaust valves, part number 74541, should be installed in the engines of these airplanes at the next engine overhaul.

Broken exhaust valves have also been related to the use of high lead fuels in Avco Lycoming engines with solid stem exhaust valves, such as those in the early production 0-320-A, C, and E series engines. These engines, which were designed for operation with 80-octane fuel, were installed in certain older Piper Model PA-18-150, PA-22-150, PA-25-150, and PA-28-140 airplanes; in Champion Model 7-GCB airplanes; in Beech Musketeer A-23-19 Sport airplanes; and in Mooney Mark 20 airplanes. The use of higher leaded fuels in these engines, according to Lycoming Service Instruction No. 1070 K (November 17, 1978), is limited to 25 percent of their operating time. If this limitation is exceeded, Lycoming recommends that the valve stems be inspected at 150-hour flight intervals for erosion or "necking". The inspection is accomplished by removing the exhaust manifold and visually inspecting the valves through the exhaust ports. The exhaust valves in some of these engines have been replaced with the newer Avco Lycoming high compression type sodium cooled exhaust valves, a measure that prevents both necking of the valve stem and erosion of the valve stem and head.

Because 80-octane fuel is not generally available in the United States, most of the aforementioned airplanes operate routinely with higher leaded fuels than they were designed to use. Therefore, the Safety Board believes that the engines in those airplanes that still use solid stem exhaust valves should be inspected as outlined in Service Instruction No. 1070 K. Additionally, they should be inspected for valve head erosion or cracking, as outlined in Lycoming Service Bulletin No. 404, and Avco Lycoming part number 74541 high compression type sodium cooled exhaust valves should be installed at the next engine overhaul.

The general problem of sticking valves in Lycoming engines has been noted in the August 1985, and July 1986, issues of the FAA's Advisory Circular (AC) No 43-16, "General Aviation Airworthiness Alerts". However, in view of the above facts and circumstances, the Safety Board believes that a subsequent alert containing information specifically related to broken and sticking valves in the Lycoming 0-320 series engines is also warranted. The alert should cite those aircraft and engine models having a significant propensity for these valve malfunctions and should emphasize remedial measures that may be taken to alleviate such problems.

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

Issue an Airworthiness Directive applicable to all aircraft with Avco Lycoming 0-320 series engines, requiring that the oil and filter be changed after each 50 hours of flight operation or every six months, whichever occurs first. (Class II, Priority Action) (A-87-71)

Issue an Airworthiness Directive applicable to Cessna Models C-172M, C-172N, and C-172P; to Cessna Model 177 (1968 model year only); to Piper Model PA-28-161; and to Robinson R-22-HP helicopters, without full-flow engine oil filters, requiring the installation of Avco Lycoming full-flow canister type or spin-on type oil filter kits. The kits should be installed in accordance with Avco Lycoming Service Instruction No. 1319 B, "Engine Mounted Oil Filter Kits and Replacement Filters," at the next 100-hour or annual inspection, whichever occurs first. (Class II, Priority Action) (A-87-72)

Issue an Airworthiness Directive applicable to Cessna Models C-172M, C-172N, and C-172P; to Cessna Model 177 (1968 Model Year Only); to Piper Model PA-28-161; and to Robinson R-22-HP helicopters, requiring compliance with Avco Lycoming Service Bulletin 388A, "Procedure to Determine Exhaust Valve Condition". Exhaust valve guide clearances in the airplane engines should be checked within the next 25 hours of operation and at subsequent engine intervals of 300 hours, or triennially, whichever occurs first. Similar clearances in the helicopters should be checked within the next 10 hours of operation and at subsequent engine intervals of 150 hours, or biennially, whichever occurs first. If the valve guide clearances are found to be inadequate, exhaust valve and valve guide pairs should be replaced as necessary, or the valve guides should be cleaned (reamed) in accordance with Avco Lycoming Service Instruction No. 1425, Part III, "Cleaning Procedure". (Class II, Priority Action) (A-87-73)

Issue an Airworthiness Directive applicable to Piper Models PA-28-140 and PA-28-151; to Cessna Models C-172I, C-172K, C-172L, and C-172M; and to Gulfstream American Models AA5 and AA5A, which utilize Avco Lycoming Part No. 75068 engine exhaust valves, requiring: (a) compliance with Avco Lycoming Service Bulletin No. 404, "Exhaust Valve Inspection (High Lead Fuel Operation)" within the next 50 hours of operation and at subsequent 100-hour or annual inspections, whichever occurs first (the exhaust valves in the engines of these airplanes should be inspected for evidence of erosion, cracking, and other defects and replaced as necessary); and (b) installation of Avco Lycoming Part No. 74541 high compression type sodium cooled exhaust valves in the engines of these airplanes at the next engine overhaul. (Class II, Priority Action) (A-87-74)

Issue an Airworthiness Directive applicable to Piper Model PA-18-150, PA-22-150, PA-25-150, and PA-28-140 airplanes; Beech Musketeer A-23-19 Sport airplanes; Mooney Mark 20 airplanes; and Champion Model 7-GCB airplanes with engines using solid stem exhaust valves, requiring: (a) inspection of the engine exhaust valve stems for erosion or "necking"

within the next 50 hours of operation and at subsequent intervals of 150 flight hours (if any evidence of erosion is found in the area of the valve between the guide and the seat, the valves and guides should be replaced); (b) compliance with Avco Lycoming Service Bulletin No 404, "Exhaust Valve Inspection (High Lead Fuel Operation)" within the next 50 hours of operation and at subsequent 100-hour or annual inspections, whichever occurs first (the exhaust valves should be inspected for evidence of erosion, cracking, and other defects and replaced as necessary); and (c) installation of Avco Lycoming Part No. 74541 high compression type sodium cooled exhaust valves in the engines of these airplanes at the next engine overhaul. (Class II, Priority Action) (A-87-75)

Publish in Advisory Circular (AC) No 43-16, "General Aviation Airworthiness Alerts", an article regarding broken and sticking valves in Avco Lycoming 0-320 series engines. The article should identify those aircraft which experience these valve problems most frequently; emphasize remedial measures that should be taken to alleviate such problems, e.g., frequent oil and filter changes, proper leaning of the air-fuel mixture, etc.; and advise owner/operators that very rough engine operation at start up followed by smooth operation as the engine warms up, is a warning that preventive maintenance may be required to correct sticky valves and prevent a loss of engine power. (Class II, Priority Action) (A-87-76).

BURNETT, Chairman, GOLDMAN, Vice Chairman, and LAUBER, NALL, and KOLSTAD, Members, concurred in these recommendations.

By: Jim Burnett
Chairman