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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: September 10, 1985

Forwarded to:

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-85-57 and -58

On October 1, 1983, a Piper Model PA-28R-201T Turbo III Cherokee Arrow, N2541Q, crashed at Smithville, Texas, after sustaining a loss of engine power. The malfunction occurred at night during cruise flight and was accompanied by a loud bang and violent shaking of the engine, a turbocharged Teledyne Continental Model TSIO-360-F. The Safety Board's investigation of the accident disclosed that the loss of engine power was caused by a broken piston connecting rod, which had fractured due to metal fatigue. Based on the Safety Board's metallurgical examination of the failed connecting rod, which disclosed an irregular contour at a flange corner and the presence of inclusions and laps in the connecting rod surface layer, the Board believes that the metal fatigue resulted from improper forging of the connecting rod blank.

An examination of accident data involving the turbocharged Teledyne Continental Model TSIO-360 series engines conducted by the Safety Board for the period 1977 to July 2, 1985 ^{1/} disclosed the occurrence of nine other airplane accidents involving broken piston connecting rods. Five of the accidents involved the Piper Model PA-28R-201T Turbo III Cherokee Arrow; one involved the Piper Model PA-28RT-201T Turbo IV Cherokee Arrow; two involved the Piper Model PA-28-201T Turbo Dakota; and one involved the Mooney Model 231 (M20K).

Service Difficulty Reports (SDR) obtained from the Federal Aviation Administration's (FAA) Maintenance Analysis Center for the period 1979 to 1984 disclosed nine incidents also involving broken connecting rods in these engines. Three of the incidents involved the Piper Model PA-28RT-201T airplane; three involved the Piper Model PA-28R-201T airplane; and the remaining three involved the Piper Model PA-34-200T Seneca airplane. FAA records for the same approximate period indicated that the Piper Model PA-28R-201T also was involved in three additional (non-SDR-reported) incidents involving broken piston connecting rods.

^{1/} Data for five selected airplane models powered by Teledyne Continental Model TSIO-360-E, -F, or -G engines were examined.

Although installation of Teledyne Continental Model TSIO-360-E, -F, or -G engines in these airplanes spans the model years 1975 through 1985, 20 of the 22 airplanes involved in the above incidents were 1977, 1978, or 1979 models. The Safety Board believes that those incidents of broken piston connecting rods occurring in 1977, 1978, or 1979 models may be related to inadequate piston-connecting rod design, or manufacturing or quality control standards. An SDR published in FAA Advisory Circular No. 43-16, General Aviation Airworthiness Alerts of December 1983, also raised this possibility. The SDR referred to piston connecting rods from Teledyne Continental Model IO-360, TSIO-360, and LTSIO-360 engines and stated that: "Connecting rods manufactured to drawing number 626119 are supplied to TCM by more than one vendor. It has been reported that a disproportionate number of rod failures have occurred with rods marked along the beam section with the letter 'C' enclosed within a circle. The submitter has recommended that these rods be replaced at overhaul with connecting rods having different vendor markings." The drawing number of the piston connecting rod forging referred to in the SDR is now obsolete. Teledyne Continental has changed the connecting rod forging drawing twice since 1982.

In addition, reports prepared by the Scanning Electron Analysis Laboratory, Culver City, California, in connection with two Safety Board accident investigations indicate that failed connecting rods taken from a 1979 Piper Model PA-28-201T Turbo Dakota and a 1979 Piper Model PA-28RT-201T Turbo IV Cherokee Arrow were improperly heat-treated. As a result, the hardness of the connecting rod was inadequate due to partial surface decarburization. In view of these factors, the Safety Board believes that the FAA should conduct a directed safety investigation of piston connecting rods in Teledyne Continental Model TSIO-360-E, -F, and -G engines.

Because of the relatively high engine cylinder pressures and temperatures associated with turbocharging, an overstress condition affecting connecting rods, cylinders, cylinder heads, and pistons may be induced readily by the pilot. For example, overboosting (operating at low engine speed and high manifold pressure) can result in broken connecting rods, separated or cracked cylinders, burned or blown pistons, or broken crankshafts. However, these potentially hazardous failures may be the direct or indirect result of specific airplane design features, including design of the turbocharging unit itself. Despite installation of an overboost warning light, the possibility of overboosting the engines inadvertently in these airplanes is substantial since the turbochargers have fixed rather than automatically controlled exhaust waste gates (pressure adjusting valves which control the turbocharger operation).

Accordingly, special consideration may have to be given to the ultimate structural strength and endurance of critical engine components, such as pistons and connecting rods, in turbocharged engines. Additionally, turbochargers generate considerable heat and generally are used in an operating environment which can affect an airplane's engine ignition system adversely. As a result, critical engine components may be subjected to extreme temperatures and dynamic shock loads due to misfiring, preignition, or detonation. In recognition of these factors and in order to provide more precise monitoring of engine cylinder inlet air temperatures and to avoid engine ignition (magneto) misfiring at high altitude, the Mooney Aircraft Corporation has installed compressor discharge temperature gauges and pressurized magnetos as standard equipment in current production turbocharged Mooney Model 231 (M20K) airplanes. Similarly, in 1984, the Piper Aircraft Corporation introduced pressurized magnetos as standard equipment in the turbocharged Piper Model PA-34-220T Seneca III and the Piper Model PA-28RT-201T Turbo IV Cherokee Arrow. Both manufacturers provide magneto pressurization service kits so that earlier applicable models can be retrofitted with the improved ignition systems.

The occurrence of broken piston connecting rods in Piper Model PA-28R-201T Turbo III Cherokee Arrow, PA-28RT-201T Turbo IV Cherokee Arrow, and PA-28-201T Turbo Dakota airplanes may have been exacerbated by turbocharging. Therefore, the Safety Board believes that the FAA should conduct an airworthiness design review of the engines in these airplanes. If appropriate, the installation of compressor discharge temperature gauges, oil intercoolers, pressurized magnetos, or engine cowl flaps should be required to prevent engine overheating, misfiring, preignition, or detonation; other devices may be required to reduce the potential for inadvertent overboosting of the engine.

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

Conduct a directed safety investigation of Teledyne Continental Model TSIO-360-E, -F, and -G engines which were installed in 1977, 1978, and 1979 model airplanes to examine piston connecting rods as they become accessible during engine overhaul and inventories of new or reconditioned connecting rods for these engines. If the investigation discloses significant evidence of metal fatigue, improper heat treatment, manufacturing flaws, or other design-related defects in rods fabricated by one or more vendors, issue an Airworthiness Directive to require that similar connecting rods in the engines of 1977, 1978, and 1979 model airplanes and in parts inventories be removed from service. (Class II, Priority Action) (A-85-57)

Conduct an airworthiness design review of the engines in Piper Model PA-28R-201T Turbo III Cherokee Arrow, PA-28RT-201T Turbo IV Cherokee Arrow, and PA-28-201T Turbo Dakota airplanes directed toward incidents, accidents, and engine service difficulties which appear to have been exacerbated by turbocharging, e.g., those involving broken piston connecting rods, separated or cracked cylinders, burned or blown pistons, etc. If indicated, require the installation of devices to alleviate these occurrences such as compressor discharge temperature gauges, oil intercoolers, pressurized magnetos, cowl flaps, etc. (Class II, Priority Action) (A-85-58)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

by: 
Jim Burnett
Chairman