Transport Canada Transports Canada

Aviation Safety

Maintainer

Learn from the mistakes of others and avoid making them yourself... **Issue 2/2000**

From the Concorde to TC's Flight 2005

Safety lessons from the Concorde to the present and beyond with Flight 2005—the risk-management tools are available for those who accept and use them.

Flight 2005 is a new safety framework for civil aviation in Canada. You might ask why I have brought the Concorde into this. I think it is necessary to review any new proposal in the light of knowledge accumulated from similar successful programs. In Flight 2005, TC is dedicated to challenge the status quo. Among its operating principles, the new framework identifies promoting shared commitments, applying risk-management techniques, and strengthening professional qualifications, skills and knowledge. This also includes the application of regulations and policy fairly, consistently and with clear accountability as well as the improvement of all aspects of aircraft operations. Success depends on clear, concise two-way communication. Communication is also the key for proactive use of aviation safety data, resource allocation, and an organized safety-management system. The key results expected are maintaining a high level of public confidence in TC programs and, through a safety partnership with industry, achieving an overall 25% reduction in both accidents and fatalities by 2005.

I mentioned the Concorde briefly and now I will relate how this operation began with numerous similar problems and a skeptical public acceptance. Thirty-three years ago, the first prototype of the Concorde took flight in the presence of most of those who created it. This ushered in a new era of flight in the stratosphere and all the new problems of supersonic transport (SST) aircraft flying at twice the speed of sound. Yes, people said that it made too much noise and that the sonic boom was hazardous; others worried about reliability. Airport runways were too short. The aircraft had no flaps and it used too much fuel to be economical. Passengers did not like the slim cramped environment inside the fuselage. Maintenance would be a nightmare and expensive. I could go on and on about the protagonists and the mystical problems that were supposed to plague the early Concorde operation, but this is not the story.

This story is about safety, and if we look at all aspects of the Concorde operation from the beginning to the present day, we arrive at the conclusion that it was a safety success story. Those who maintained the Concorde quickly acquired the new technical knowledge and skills to maintain it safely. Those who flew it acquired the special skills and knowledge associated with SST aircraft flight. The air traffic system adapted to the urgency of such a high-speed aircraft that would have little fuel to spare near the end of a mission. Airports that would not antagonize the general public with excessive noise were selected. Through these efforts, the general public acquired confidence in this new aircraft and accepted it as reliable, although expensive, transportation.

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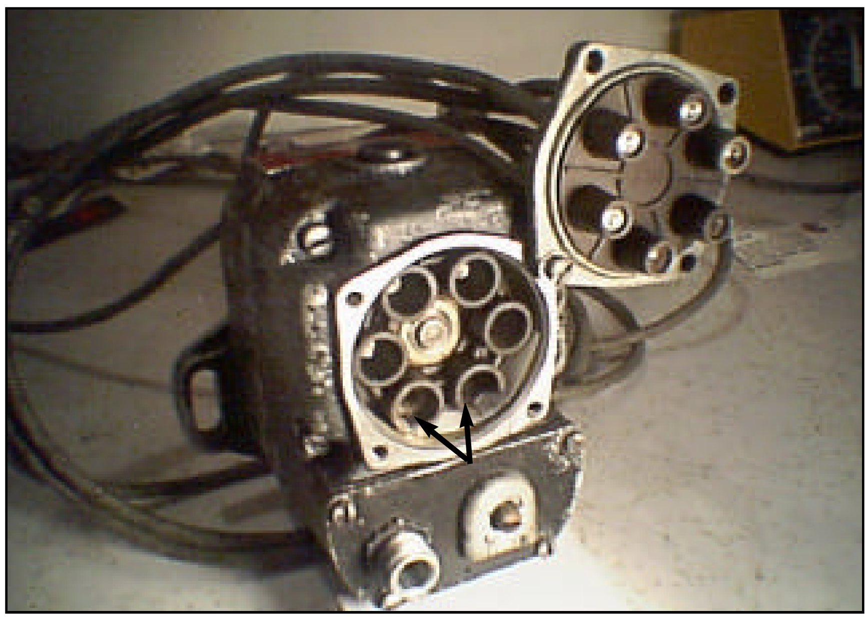
Looking at safety, I think we can say that the operators of the Concorde met all these challenges and many more to fly without the loss of a single hull over the 33-year lifetime of this aircraft. It is now an aging aircraft and will soon be replaced by something different, but, from all accounts, even in its final years it continues with an almost perfect safety record. I know there have been incidents but I am only focusing on the success and the fact that there have been no fatal accidents.

In conclusion, the successful operation of the Concorde must have a legacy of lessons learned and solutions implemented to ensure its flight safety. Since it is very difficult to thoroughly research an operator's experience from a desk, I invite the current Director of Maintenance for the British Airways (BA) Concorde operation to send a letter outlining how risk management might have been used in the maintenance practices for the Concorde. I think we might learn much more about safety and risk management from the long and excellent safety record of this exceptional aircraft.

Likewise, the success of TC's Flight 2005 for maintenance personnel will depend on their acceptance and use of risk-management tools that we have learned about to date and the proactive application of all the knowledge acquired from accident investigations and operational experience in order to reduce accidents by 25% between now and 2005. The safety indicators are not complicated, but they relate to major components of the program, particularly where attitude changes must take place. We believe it can be done by implementing safety-management systems that take humans into account. This requires analysis of problems, safety promotion, feedback and proactive communication between government and industry.

Beech Bonanza Magneto Failure

This is a magneto problem with a slightly different twist. The pilot noticed a magneto drop during run-up, and a maintenance check revealed that the magneto, a Bendix (model No. S6LN-21, serial No. 426019), had some burned lead attachment points on the bakelite collar of the distributor block (see arrows on photo). The magneto had been running only 255.5 hr. since major overhaul.



Note the damaged areas of the distributor block where the leads from the spark plugs attach.

Consultation with a magneto overhaul expert revealed that the burnt collar area was likely caused by the breakdown in a spark plug or ignition lead, which tends to cause arcing, which, in turn, causes burning at some point in the system, in this case the bakelite terminal block lead collars. The leaking current follows the path of least resistance, in this case through the bakelite insulation. It is possible this block may also be brittle after 50 years of operation, during which it was subjected to a wide range of temperature variations. Therefore, it could have developed a small crack, allowing the leak to ground of the high-tension current and resulting in the corresponding damage to the block.

AMEs who work on these old aircraft equipped with 50-year-old magnetos, such as this Bendix S6LN-21 model, need to be on the alert for these problems. Any cracks or burning of the distributor block may be the beginning of a more serious problem or loss of magneto in flight. This story was brought to my attention thanks to the diligence of Mr. Bill Peppler, owner of the Bonanza.

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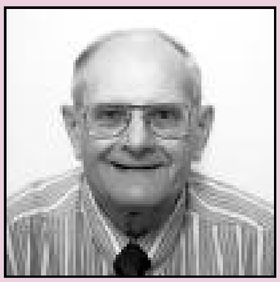

Joe Scoles

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Older Model F28 Circuit Breaker Problems

The following article pertains to actions taken after an alternating current (AC)–essential three-phase circuit breaker (C/B) overheat condition was encountered on an F28 aircraft. The C/B in question (6TC14-10) was sent to the Quality Engineering Test Establishment in Ottawa for further tests. Although the matter is still under investigation, it triggered a fleet-wide check of AC-essential C/Bs within one operator's fleet, which revealed some interesting data.

The inspections completed on 18 of 30 aircraft listed 9 (50%) of the aircraft that had C/B serviceability tests performed and were found to have faulty C/Bs. While different failures occurred to various aircraft, a summary of the failures affecting many of the 18 aircraft included A, B and C phases that would not pop or popped outside time limits. In some cases, none of the phases popped or tripped, and in one case the C/B failed the test completely.

In cases of failure or partial failure, the AC-essential C/B's inability to release may inhibit the ability of the emergency static inverter to power essential equipment.

Discussions with the manufacturer, Texas Instruments, revealed that age may play an important role in the C/B's serviceability. Internal corrosion is a likely problem as C/Bs age. The U.S. Navy, based on an internal report, found it practical to recycle and check C/Bs annually.

Based on this knowledge, the operator concerned initiated a fleet-wide campaign to check dates on all three-phase C/Bs. If the C/B was manufactured more than five years previous, it would be replaced. Also, if no date stamp could be found on the C/B, it would be replaced in order to err on the side of caution. The operator also initiated the following requirements to:

* pull and recycle all AC-essential three-phase C/Bs on a yearly basis.
* replace all AC-essential three-phase/bus breakers at five-year intervals.

Finally, and of interest to AMEs, is the fact that similar C/Bs causing similar problems may be located on a variety of aircraft types, not just the F28. The safety message is simply check aged C/Bs of any type for serviceability very carefully during inspections.

Pilot Landed Safely Despite Both Engines Dead

Imagine the difficulty faced by the pilot of the Cessna 421 while en route at 13,000 ft. when the right engine (Continental GTISO 520 hp) began running rough and had to be shut down. Then, after declaring an emergency and being vectored for a landing by air traffic control (ATC), the left engine failed without warning. The pilot continued to fly the aircraft and, after seeing a grass runway ahead, conducted a successful dead-stick approach and landing.

During a preliminary inspection of the engines after the forced landing, maintenance found at least two failed connecting rods in the right engine and a failed quill shaft in the reduction gear system of the left engine.

Mechanical Happenings

The following significant aircraft incidents reported to TC from December 1, 1999, to March 1, 2000, are a heads-up for AMEs; they mainly focus on the maintenance outcome of the incident and do not include all the circumstances of each flight. In most cases of component failures it can be assumed that a service difficulty report (SDR) was submitted.

Airbus A340 —During the initial cruise flight, the No. 3 engine (CFM56-5C4) would not respond to throttle movement so it was shut down. Maintenance found faults in both the engine control unit (ECU) and the variable stator vane (VSV) actuators and replaced them.

Airbus A320-211 —While in cruise flight, the flight crew observed a low pressure/low quantity cockpit indication for the "green" hydraulic system and diverted for a safe landing. Company maintenance found that the "green" hydraulic safety valve began to leak and hydraulic fluid was vented overboard. The valve was replaced.

Beech 1900D —The crew had difficulty with the nose-gear indication. Company maintenance found that a light bulb had burned out for the nose landing gear indication system and replaced it.

Beech 1900 —The pilot reported a vibration during and shortly after takeoff. Maintenance found that an out-of-balance tire caused the vibration.

Beech 99 —The first officer heard a bang then a clanging/thumping noise under the seat/cabin area. Maintenance found that the heater blast-tube clamp had loosened, allowing the tube to fall and cause the irregular noise.

Beech 99 —The crew was unable to retract the gear. Maintenance traced the problem to a broken wire behind the instrument panel. This wire connects the safety switch to the gear-handle solenoid.

Beech A100 —The pilot shut down the left engine because of low oil pressure. Maintenance found that the chip detector plug in the reduction gearbox had sheared for unknown reasons, allowing the oil supply to deplete.

Beech King Air 200 —The pilot noticed a fluctuating fuel flow and selected the standby pump "on." At that time, the pilot noticed that there was minimal fuel indicating on the gauge for the right-hand side so the engine was shut down. The pilot was also surprised to note that only a little fuel remained after shutdown. Maintenance found that the fuel drain fitting for the firewall fuel filter bowl had failed. The main body of the valve is attached to a bracket with a nut. The manufacturer secured the actual valve in place in the main body by staking the edges of the body. The staking had failed two thirds of the way around the body and this allowed the valve to bow out or fail, allowing rapid fuel venting thus explaining the low fuel quantity on landing.

Boeing 767-233 —The flight crew observed a trailing edge flap malfunction indication after takeoff and was unable to fully retract the aircraft trailing edge flaps. Company maintenance replaced the flap slat electronic unit and the aircraft was returned to service.

Boeing 767-233 —During cruise climb, the flight crew observed a slow decrease in oil quantity on the No. 1 engine and returned to the airport of departure. Maintenance found a faulty No. 4 bearing scavenge pump. They replaced it and replenished the associated lines and the engine oil system.

Boeing 737-217 —The pilot reported an "A" system hydraulic-pressure problem and landed safely without the use of normal landing gear extension, inboard brakes, nose-wheel steering, thrust reverser and four ground spoilers. Maintenance found a bleed-valve failure, which allowed the system to bleed off the required pressure.

Boeing 737-275 —While in cruise flight, the Boeing 737-275 flight crew observed the loss of the No. 3 hydraulic pressure followed on approach by a total loss of hydraulic pressure. Company maintenance found a chafed hydraulic line, which had allowed a loss of all hydraulic pressure because of leakage when the engine power was reduced for landing.

Boeing 747-475 —The crew felt a heavy vibration from the No. 1 engine just after takeoff and returned for landing. Maintenance found a severely damaged engine. One compressor blade was missing and debris from the engine had exited the tailpipe. The engine is contracted power-by-hour and had 7021.49 hr. since its last shop visit with a total time since new of 38,725.4 hr.

Boeing B737 —On climb-out after takeoff, the pilot declared an emergency and shut down the right engine because of low oil pressure. Maintenance found an oil fitting on the gearbox cross-threaded, allowing the oil to leak.

British Aerospace BAE 146 Series 200—The crew reported hearing a loud noise followed by a complete loss of thrust from the No. 3 engine (Allied Signal LF 502). Maintenance found that a T1 blade had failed approximately 1/8 in. from the platform and replaced the engine.

British Aerospace Jetstream Model 3112 —The crew was unable to control the left engine power and shut the engine down. Maintenance found that the threads on the rod end of the propeller control were stripped, requiring replacement of the rod end.

Canadair CL-600-2B19 —On climb-out after takeoff, the flight crew observed the No. 1 hydraulic system fluid quantity indicator indicating "0," declared an emergency, and landed without further incident. Company maintenance found a hydraulic line from the engine-driven hydraulic pump leaking, replaced it, including a new filter, and replenished the hydraulic fluid.

Cavalier SA —The nose gear collapsed on landing and, according to maintenance, this was the result of a fatigue crack in the mount base.

Cessna 172 —The pilot reported that the Lycoming engine ran rough in flight. Maintenance found a cracked cylinder, which required replacement.

Cessna 414 —The pilot reported an engine failure during flight. Maintenance found the right outboard crankcase deformed and cracked; an internal failure is suspected.

Cessna 550 —The aircraft returned to the ramp after reporting smoke trailing in the vicinity of the engines. Maintenance found two fuel nozzles in the right engine were coked. This would affect the fuel spray pattern, especially at idle power settings, resulting in incompletely burned fuel and the production of the smoke.

Cessna 177 —The aircraft was on approach when the pilot reported a problem controlling the power. Maintenance discovered that the throttle cable fitting had stripped threads, allowing it to become detached from the engine throttle arm.

Cessna 650 —The flight crew performed a precautionary engine shutdown because of low oil pressure. Maintenance replaced the oil ring on the right-engine oil filter and that stopped the leak.

Dassault Falcon Mystere 20 —This aircraft was involved in three events relating to pressurization problems. One event was believed to be caused by a stuck ground–flight switch. The other events were traced to a stuck rotary actuator in the air supply system. The aircraft was returned to service under the provisions of the minimum equipment list until part availability. The aircraft departed and again and experienced a pressurization problem requiring a return to the airport. Maintenance discovered that the replacement rotary actuator installed earlier that day was positioned incorrectly. The valve was repositioned and the aircraft returned to service.

de Havilland-8-102 —The crew returned to the airport because a low oil pressure warning light illuminated. Maintenance added one quart of oil and returned the aircraft to service. The engine had the same problems previously and had been returned to the manufacturer twice for corrective action. During the repair, a gearbox seal was changed and further testing indicated that the problem was solved but because of the later incident the engine was again removed and sent back to the manufacturer after maintenance suspected that the same seal may have failed again.

de Havilland DHC-8-102 —The crew discovered a major oil leak in the right engine while taxiing. Maintenance found that the engine oil filler cap was left off inadvertently so the oil came out the filler neck.

de Havilland DHC-8-102 —The crew reported flight through some severe turbulence and control problems. Maintenance concluded that the left inboard roll spoiler had deployed in flight. Maintenance replaced the left inboard roll spoiler actuator and three of four roll spoiler declutch actuator wire switch cables because of internal separation.

de Havilland DHC-8-301 —The crew reported a loss of hydraulic fluid. Maintenance discovered the right-hand spoiler valve had failed, which resulted in the loss of fluid. This valve (p/n 65960-3, s/n 419) has been on the aircraft since manufacture, accumulating 25,541.4 hr. and 31,889 cycles. The current mean time between unscheduled removal (MTBUR) for this component is 22,205.33 hr.

de Havilland DH8A —The aircraft returned to the gate when smoke was noticed coming from the right-hand wheel area. Maintenance discovered that the wheel bearings for No. 3 main wheel had failed. Some scoring of the axle was also detected. The axle damage was inspected and cleaned.

Diamond DA 20-A1 —Maintenance found that the mixture control needle valve broke off in one carburetor, causing the engine to run rough.

Douglas DC-9-32 —The flight crew advised of an intermittent unsafe landing gear indication on the left main gear. Maintenance found an incorrect bulb installed in the "left gear unsafe" socket, which was shorted out. The bulb was replaced with the correct one.

Douglas DC-10-30 —About two hours into the flight, the cockpit crew noticed voltage spikes and pulsing on the battery charging system. The captain pulled the battery charging system circuit breaker and diverted to a nearby airport after dumping fuel. Maintenance found problems with the battery charging system circuit breaker. The battery charger was replaced owing to component failure and the circuit breaker and batteries were changed as a further precautionary measure.

Embraer EMB-110P1 —The pilot reported that the takeoff was rejected because a low left-hand fuel pressure light came on. Maintenance replaced the left-hand auxiliary fuel pump.

Embraer EMB-110P1 —The crew returned because of smoke in the cockpit. Maintenance found a fuel leak on the right-hand engine, which allowed fuel to be ingested by the engine bleed air system and subsequently enter the cabin as smoke. The fuel leak was found at the fuel nozzle inlet adapter. The fuel line elbow has an O ring, a plastic back-up ring, and a recessed nut. The back-up ring was not properly seated, and after several cycles the leak developed. This fuel nozzle had been replaced the previous day during routine maintenance.

Fairchild SA227-DC Merlin IV — The crew said they were having problems controlling the aircraft trim tab and had to exert excessive pressure to land safely. Maintenance found that the electric trim motor was not operating within its normal time frame and replaced the assembly.

Fokker F28 MK 100 —As the aircraft flight crew was taxiing to position on the runway, the horizontal situation indicator (HSI) malfunctioned. While taxiing to the ramp, the crew further reported smoke in the cockpit and galley. Company maintenance found a circuit breaker located on an electrical panel behind the first officer had overheated and was the source of the smoke in the aircraft.

Fokker F28 MK 1000 —The crew noticed a vibration on the No. 2 engine and shut it down. Maintenance found that the low pressure turbine had failed. This is not the first time this type of failure has occurred. To address the problem, Rolls Royce has designed a new type of low pressure turbine blade, which is scheduled for certification in the second quarter of 2000. Furthermore, it is Rolls Royce's intent to have the blade retrofit carried out in the field.

Fokker F28 —The crew reported smoke in the cockpit after starting the engines. Maintenance located the problem and changed a generator control unit and an AC bus contactor for the main circuit breaker panel.

Hawker Siddeley HS 748 —As the aircraft began to taxi for departure after de-icing, the port engine fire warning system activated. Maintenance replaced one fire wire section and one ferrule (connector): the components failed a megger check.

Hawker Siddeley HS 748 Series 2a—The crew was unable to retract the flaps after takeoff. Maintenance found the flap control relay socket wiring defective and repaired it.

Lockheed 382G Hercules —The pilot reported an engine oil-pressure fluctuation. Maintenance discovered that the bonding agent for a blade seal back-up ring failed, causing an oil leak. The propeller had approximately 400 hr. since overhaul.

Piper PA-30 Twin Comanche — The pilot could not retract the gear after takeoff and returned for a safe landing. The landing-gear motor had recently been replaced because it was burning out, and the replacement failed for the same reason. The AMO in this instance reported that the gear was improperly rigged, putting an excessive load on the motor.

Piper PA-30 Twin Comanche — The Twin Comanche was on a local training flight when the gear failed to extend and the aircraft landed gear up with some damage to the airframe and propellers. An examination of the aircraft after the occurrence revealed that the tow bar was still connected to the nose wheel and that it was wedged between the nose-gear doors and the fuselage. This prevented the gear from fully retracting or extending and overheated the retraction motor during the attempt.

Piper PA-23-250 —The aircraft returned with an engine problem and maintenance found a "B" nut on the fuel injection deck pressure sense line had backed off. This caused too much air in the fuel/air distribution system, which caused a higher-than-normal cylinder head temperature. The line was tightened and torqued to proper value. There was no explanation of why the "B" nut may have backed off.

Piper PA-31 Navajo —After the engine failed in flight, maintenance discovered metal in the filter, the result of a failed crankshaft gear. The engine had only about 80 hr. since overhaul.

Slingsby T67C Firefly —The pilot experienced a runaway trim control. Maintenance found that the co-pilot's trim switch was unserviceable and the wheel had travelled hard against the limit switch, preventing manual operation.

Saved by a Leatherman Tool!

The following is the first-person account of a U.S. Forest Service employee who was a passenger in a Hiller 12E helicopter on February 13, 1997, when the collective control linkage became disconnected at the rotor hub and the aircraft started an uncontrollable climb. The Forest Service employee/passenger climbed out of the airborne helicopter and managed to reconnect the linkage using the awl of a Leatherman tool, then held the makeshift repair in place until the chopper could land safely. Incredible, but true! The linkage bolt was located by the pilot immediately after the emergency landing; it had fallen into the engine pan, but the nut that went into the bolt was missing.

Since this story was widely published at the time, I will deal mainly with the drama of the event and human factors that could relate to the maintenance of any aircraft or helicopter. The first question that comes to mind is why the bolt came out of a vital control link. The answer is that a locking device was lacking. Either the safety device was faulty or it had not been installed during maintenance. This is the maintenance part of the story; now for the drama as described by the crew during the emergency.

The Forest Service employee tells his story about the ordeal:

"I unbuckled from the seat, opened the door and carefully stepped out onto the skid. I wrapped the shoulder harness of the seat belt several times around my left wrist. I kept a hold of the seat belt with my left hand. I found that I could not reach the collective linkage unless I let go of the seat belt and climbed up from the skid onto the cargo basket. I had some communication with the pilot since I kept the headset on. It was very difficult to communicate, though, because of the rotor, engine and wind noise. I heard him tell me to push the collective arm up slowly. I tried to do this and the helicopter fell violently (the pilot estimated more than 100 ft.). The pilot and passenger yelled to pull the other way, and so I pulled back down on the collective arm and the helicopter stopped falling. I have no idea why I did not fall off the helicopter at that point.

"I asked for a pin or something that I might be able to reconnect the linkage arm with. They said that they had nothing. The pilot then said to pull down on the collective arm. We found that if I pulled down *very* hard, we would shed elevation very slowly, but I couldn't pull down hard enough for a long enough time to significantly lower the helicopter's altitude. The pilot was flying the helicopter in full forward speed to slow our ascent. He later told me that he had had the rotor rpm 100 lower than the red line and we had had a forward speed of 100 kt.—10 over maximum, I guess. Under these conditions, I started to get *very* cold, since the outside air temperature was about 20°F (-7°C). The wind force had blown a contact lense out of one of my eyes and blown my hat and sunglasses off. I also lost both gloves because I used them over the collective arm to try to pull harder. I asked if there was something that I could use to pry down on the collective lever and the passenger handed out the fire extinguisher. I tried that a little and felt unstable pulling on it. I thought that the fire extinguisher could go through the tail rotor, and so I threw it down with force to get rid of it. The whole time, the pilot communicated the urgency of the situation by calmly saying, 'You've got to do it, buddy, or we are going to die.'

"I was rapidly losing strength and mobility in my hands. The pilot remembered that he had a Leatherman tool in his first-aid kit. It was quickly located and handed out to me with the file part opened. The collective linkage rod had a bearing-like ball in the end of it with a hole in the ball. Because of the vibration of the rotor, engine and wind, the ball was moving around in circles, making it difficult to start any sort of makeshift pin unless it was pointed. I handed the Leatherman back in and asked the passenger to open the leather awl part, which had a pointed tip.

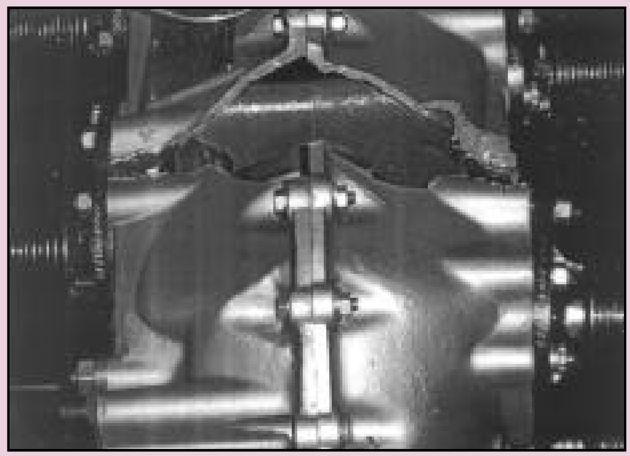
"I noticed that we had gained enough altitude that we were getting into the clouds. The pilot said that we had reached an altitude of 9500 ft. . . . about 5000 ft. AGL. He also said that the carb temp had dropped dangerously low, as had the fuel quantity.

"When I got the Leatherman tool back with the leather awl opened, I first tried to get it started with my right hand since I am right-handed. The forward airspeed must have been too great; I tried many times to get it started and I could not bring my arm forward accurately. I switched the tool to my left hand to attempt to align the leather awl and have the wind from our forward airspeed help push my hand toward where I was working. I could not really feel the Leatherman tool since I had lost feeling in my hands owing to the cold. I was getting *very* frustrated and angry because I could not get the awl started into the linkage rod. The pilot and passenger helped me focus and keep trying by constantly saying, 'You almost got it,' and 'You can do it.' After several tries, I got the leather awl started. I wiggled it in as much as I could and, at the same time, I heard the pilot say, 'We are going to live!' I knew that I barely had the point of the leather awl started into the linkage rod. I held as much inward force onto the Leatherman tool as I could muster so that it did not slip out. The pilot descended now that he had collective control, and we quickly landed on a scab flat near the Forest Boundary. I had to stay outside the helicopter to hold the tool in place through the entire descent to landing. He made a *very* soft and normal landing. The time from the start of the incident to landing was approximately 25 min."

The story and comments of the persons involved have been shortened to capture the maintenance factors and the drama of these people working as a team throughout the emergency. The human factors involving the missing bolt and the way that it came out in flight are of concern to all aircraft maintenance engineers.

The teamwork demonstrated by this crew and the passengers in their effort to save their lives is commendable and shows the value of everyone's contributing his or her utmost at a critical time. It is always *a critical time when work is performed on aircraft control systems, and so every member of the maintenance team must work together to ensure safety during flight. —Ed.*

Suspected Hydraulic Lock



A recently overhauled IO 520M engine installed in a Cessna 310 failed in flight after 2.9 hr. of operational service. The damage was extensive, as illustrated in the accompanying photos of the broken connecting rod (left) and punctured crankcase. Preliminary information suggests that the failure may have been caused by a "hydraulic lock," the result of overpriming. Broken connecting rods are often caused by a hydraulic lock.

Propeller Guide Collar—A Close Shave!

The pilot of a Beech 1900 first reported the snag as large fluctuations in engine torque and indicated that the corresponding propeller was not changing pitch properly.

Maintenance cycled the propeller but could not duplicate the problem; however, they changed the prop governor and ordered a flight test. The pilot rejected the next takeoff, blowing some tires when the propeller feathered without command. Maintenance re-examined the situation and discovered that the propeller had been overhauled recently and, as a result of this overhaul inspection, one of the four low-stop collar bushings for the guide rods was reamed to 0.180 in., where 0.181 in. to 0.184 in. is called for. This caused the propeller to become stuck on the rod. Also, the low-stop nuts were incorrectly adjusted. There was a $^{1}/_{32}$ in. gap between the cylinder and guide collar, and the spring assembly was not bottomed to the cylinder.

As a result of this incident, the maintenance manager at the overhaul facility implemented some program changes to prevent a reoccurrence of this safety deficiency. The program included training for all employees; supervisory staff workload reduction; increased supervision of junior maintenance staff; relocation of service manuals to the work stations; and a commitment by management to hire more maintenance staff.

Landing Gear Failures

Mr. Keith Walker, a professional aircraft engineer, makes reference to previous articles in the Maintainer about undercarriage maintenance and has taken the time to prepare this detailed article from his experience and knowledge of aircraft structures and metal fatigue. The Maintainer appreciates in-depth articles such as this. —Ed.

Most transport category aircraft landing gear have a fatigue life as compared to that of the aircraft structures, which is usually damage-tolerant. Fatigue life and damage tolerance are built into the structure to ensure safety by requiring that parts be discarded at the end of their predicted life or by inspections designed to locate problems before an actual failure occurs.

Sometimes things don't work out, as can be seen by the accompanying photos of a failed main landing gear oleo as removed from a regional jet that was in service with a foreign carrier.

The in-service failure of this "fatigue-lifed" gear was due to a premature fatigue failure. This appears to be an isolated case; however, the start of the failure can be seen in the cross-section elliptical area (arrow) of the photo.

This is typical of fatigue failure and it shows how the failure progressed across the section by the beach marks, a term used to describe fatigue progression. The failure occurs when the fatigue damage reduces the cross-section strength below that which is required for its static and operational strength.

Landing gear are fatigue-tested before being put in service to establish a fatigue life, but occasionally a variation in the operational use of the part, a manufacturing anomaly or an unknown factor can result in premature fatigue failure. A premature failure of this nature, although an isolated case as this appears to be, is always the subject of an investigation and often results in the issue of an airworthiness directive.

This is something that inspection will not usually find nor is it expected to find except by directed NDT (non-destructive testing). AMEs and inspectors should still keep a sharp eye out during routine inspections, focusing on high-wear and high-stress components, such as main and nose gear legs. A fatigue crack is usually very hard to spot with the naked eye, but if you locate something suspicious you always have the option of calling for NDTs to either substantiate your suspicion or rule out any concern.

Damage Caused Troublesome Gear Extraction

During approach when the crew of the a Fairchild SA-226-TC Metro III selected gear down, the nose gear and left gear extended normally, but the right main gear did not. The crew began a series of unsuccessful attempts to extend the stuck right landing gear. The aircraft diverted to a field to enable a fly-by of the control tower. The tower observer confirmed that the gear was only partly extended. After about an hour of burning off fuel and conducting all the sequence of steps in the published emergency gear lowering procedure, they then made an emergency landing with no injuries but some damage to the aircraft.

Maintenance inspection found that the right landing gear was damaged on the outside of the inboard gear door, consistent with an impact from ground equipment. The damage had bent the door, partly jamming the outboard right gear door, and had compromised the operation of the door opening mechanism. Also, tire marks were observed on the inside of the doors where the landing gear had partly pushed the gear doors open from the inside; later gear swings with the gear doors removed confirmed normal operation.