Transport Canada Transports Canada

Aviation Safety Maintainer

Learn from the mistakes of others and avoid making them yourself . . . **Issue 3/2000**

Insufficient Clamping Force

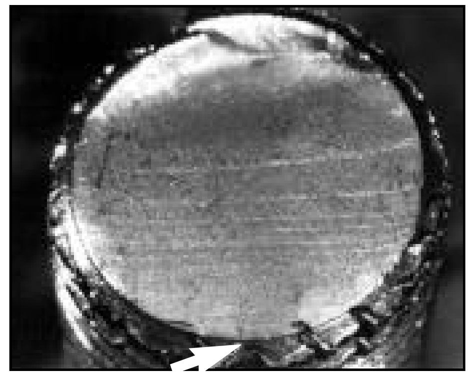
The pilot of a Piper Navajo PA 31-350 was about 30 mi. from his destination when he noticed a change in engine noise and then saw deformation and smoke in the vicinity of the left cowling. He was unable to feather the propeller; therefore, he could not maintain altitude because of the severity of the damage. He completed a successful forced landing in a marshy area where everyone escaped, although five of the ten passengers suffered minor injuries. A post-crash fire, which destroyed the aircraft, ensued.

In this case I will focus mainly on the maintenance-related items and the factual information available. The sequence of events leading to the engine failure apparently resulted from the loss of torque on one or more cylinder hold-down nuts, leading to the destructive failure of the engine and associated parts, which thrashed about after the departure of the No. 2 cylinder.

The engine had about 972 hr. total time in service, and it is interesting to note that 79.5 hr. prior to the accident, the No. 3 cylinder had been changed because of a failure at the studs. The AME who performed this work indicated that all cylinder base nuts on the left engine were checked for proper torque values at this time. The torque wrench used was checked and found to be accurate. The separation of the No. 3 cylinder and failure of the base nuts to hold torque, as reported by the AME, appear very similar to those of the later failure of the No. 2 cylinder, which resulted in the accident.

Laboratory examination of the recovered failed parts revealed the following facts:

* The No. 3 cylinder lower forward through-bolt was missing its nut.
* The 3/8-in. studs and the 1/2-in. through-bolts of the No. 2 cylinder failed from fatigue.
* It is probable that insufficient torque was applied to the No. 2 cylinder nuts at some time.
* Based on the material analysis results and the observation of fatigue propagation on the fasteners, it can be concluded that the probable cause for the fatigue failure of the hold-down studs and through-bolts was that the torque applied to one or more of the nuts was lower than specified. This reduced the pre-load tension in the stud to the extent that the tensile component of the cyclic stress on the fastener could cause a crack to form. The crack progressed in fatigue until a failure occurred and, once a single stud failed, the loading on the others would increase to cause the remaining bolts to fail in a very short time.



Fracture surface from one of the 3/8-in. hold-down studs from the No. 3 cylinder. Beach marks are clearly visible. Arrow points to the origin area.

The fact that the No. 3 cylinder, which is on the opposite side of the engine (but not opposite to No. 2 cylinder), failed in a similar manner earlier suggests that even though the AME had retorqued all the cylinders as claimed at the time the No. 3 cylinder was replaced, possibly this engine was a failure waiting to happen. There is a strong possibility that it had been in service for a long period of time with improperly torqued cylinder hold-down bolts on one or more cylinders and, as the findings suggest, the only known quantity is that the failure initiated at some point in time then progressed to catastrophic.

Although all the applicable bolts and studs were replaced at the time of the No. 3 cylinder change, it is also a good safety precaution to conduct non-destructive testing (NDT) of the studs and bolts whenever a cylinder base nut is found with a loss of specified torque.—Ed.

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Beech 90 Loss of Rudder Control

The pilots of a Beechcraft King Air A90 were on a training flight in level cruise at 11,500 ft ASL in the vicinity of North Bay, Ontario, when the crew experienced a vibration in their aircraft and an uncommanded turn to the right. During the descent after the crew decided to divert to North Bay, a severe vibration developed that violently shook the aircraft, and control was briefly lost. After this severe vibration ceased and control was regained, the aircraft required significant left rudder to maintain co-ordinated flight. An uneventful landing was completed.

Maintenance determined that the hardware connecting the rudder trim actuator push/pull rod to the rudder trim tab horn was missing. The *Beechcraft 90, A90, and B90 Series Illustrated Parts Catalogue* (IPC Fig 54, page 3, Index # 42) specifies that the attachment hardware used to connect the rudder trim actuator include an AN173 bolt (no length specified), two AN320-3 castellated nuts and two AN380-2-2 cotter pins.

The bolt and associated hardware securing the push/pull actuating rod to the rudder trim tab horn was missing after the occurrence. There are several possibilities as to why the bolt failed to remain secure: it was not there on takeoff, it fell out at some point, or it broke during flight. The first hypothesis is not likely because maintenance would have noticed this during pre-flight inspections or the flight crew would have experienced the problem immediately after takeoff. According to the report, in order for the bolt to fall out during flight the cotter pin was either missing or it broke during the flight, allowing the nut to back off and the bolt to move upwards against gravity. The cotter pin was present during the previous free play check and, as there is no force on the pin, it is unlikely that it would subsequently break. Installations of this assembly were inspected on the operator's other King Air aircraft, and it was noted that the bolt threads were painted. This would decrease the likelihood of the nut backing off even if the cotter pin were missing. Furthermore, the bolt is held in place by a bushing in the trim tab horn. The fit between the bushing and the bolt is quite tight. This ensures that the rudder trim will pass the free play check, which demands a tolerance of only 0.021 in.

The third hypothesis, that the bolt broke in flight, is the most likely scenario. The fracture would not have been due to overload stresses because there was no evidence of deformation on the clevis or trim tab horn. However, if there were cyclic loads of sufficient magnitude present, the bolt could have failed in fatigue without damaging the surrounding components.

As the shank of the AN173-5 bolt does not extend all the way through the lower arm of the clevis, a fatigue crack could have developed at the threads because of a stress concentration as a result of the shear load. The shank of the bolt, however, is thicker than the threads and therefore prevents them from coming in contact with the clevis and bearing any load.

The bolt may have been manufactured from substandard material or may not have been an aircraft quality part. As the bolt was not recovered, it was not possible to examine it. Several samples of attaching hardware from the parts bin in the operator's supply section (bolts, washers, castellated nuts and cotter pins) were examined to confirm conformance with respective specifications. Most met the specifications; however, one was found to be non-conforming and many showed evidence of previous use, notwithstanding the operator's policy that only new parts be used when assemblies like this are replaced. It is possible that a sub-standard part, either similar in appearance to the correct part or purposely manufactured to a lower standard and supplied as an aircraft quality part, was mistakenly installed after the aircraft was painted by the operator two years previously.

The bushing was recovered from the aircraft by pressing it out of the horn. It was compared to another bushing from the operator's supply section. The original was 0.002 in. in diameter smaller and had a rougher finish than the new bushing. It was noted that it was difficult to insert an AN173 diameter bolt into it. The normal practice when completing this assembly is to try several bolts in the fitting and use the one that gives the tightest fit. Given the close tolerances required for this fitting and a bushing that had a slightly smaller inside diameter, the possibility exists that a technician might have used a non-conforming bolt in this installation if it resulted in the tightest fit.

In summary, the attaching hardware securing the rudder trim tab to the actuator did not remain secure. The reasons for this could not be conclusively determined.

The following safety actions have been taken:

1. Transport Canada has written the FAA recommending that Raytheon Beech be contacted to have the aircraft maintenance manual amended to include complete assembly instructions and illustrations.
2. Transport Canada does not recognize the illustrated parts catalogue as an authoritative document for the purposes of assembly, only for the identification of appropriate parts.
3. The operator has verified that all parts in their parts supply section conform to the required specifications and are in the appropriate bins. In addition, the operator provided training for all warehouse and procurement staff and AMEs on bogus parts to increase their awareness on this issue.
4. The operator amended the maintenance control manual to enhance parts control procedures.

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Sécurité aérienne — Mainteneur est la version française de cette publication.

Tail-rotor Blade Tip Weight Separation

The pilots of the Bell 212 helicopter were performing power recovery autorotations during a training flight. They had completed two and had just turned to a base leg, lowered the collective and started to reduce the throttles for the third when a loud bang was heard, followed by a severe vibration. The pilot lowered the collective all the way, rolled off both throttles, increased the airspeed to 80 kt and instructed the co-pilot to call a Mayday. The pilot landed the Bell 212, shut down both engines, and stayed at the controls until the blades stopped. When the pilots examined the helicopter, they found that the 90° tail rotor gearbox and blade assembly were missing.

These parts were recovered and it was found that the blade tip weight of one of the tail rotor blades was missing. Examination of the tail rotor blades revealed that the blade tip block had not been properly bonded to the blade. The secondary attachment counter-sunk set screws had failed because the holes had been drilled slightly oversize.

Twin Star Tail Rotor Scrapped

The accompanying photo illustrates the condition of the blades from an AS 350 Twin Star helicopter, as removed for inspection. The overhaul shop assessed its condition as irreparable. The blade is from the tail rotor and includes a trim-tab modification for the upgrade to an AS 355 twin star tail rotor assembly.

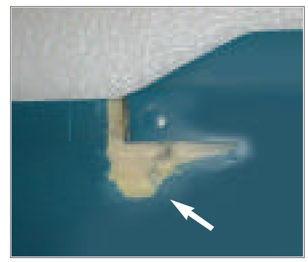


Photo: Robert Streber

Engine Cowl Departs in Flight

The **Boeing 757** experienced a loss of an engine cowl shortly after takeoff, but managed to return for a safe landing.

In this case, the latch assembly that secures the engine cowl in place either failed or was inadvertently left unlatched after maintenance had been carried out.

Some of the issues pointing toward latch failure follow:

- The torque adjustment may not have been correct; it may have been lower than that required by the manufacturer of the latch assembly. On other similar aircraft, the latch torque was found to be lower than specified, which may cause the latch to release by itself. This was most often found in older aircraft.
- The latch may have been damaged as it has been determined that screwdrivers have been used by ground personnel to pry open this latch (not a normal procedure).

Possible reasons for the latch not being secured or noticed prior to flight include the following:

- When the cowl is in the closed position, it is very difficult to visually determine if the latch is in the locked position.
- The latch is painted red to make it more conspicuous; however, in this case, the surrounding surface area was also painted red. Therefore, there was no contrast and it did not stand out.
- The company standard operating procedure (SOP) indicated that closing the cowl is a two-person job. It was found that this procedure was routinely conducted by one person.

The latches in question are being analyzed in an attempt to determine if they were actually in the closed position at the time of failure as well as to determine issues that arise with respect to needing adjustment periodically in order to maintain correct applied torque.

Mechanical Happenings

The following aircraft incidents reported to TC from March 1, 2000, to June 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.

Ayers S2R-R1340—The pilot reported oil on the windshield and returned for landing. Maintenance found that the hydromatic prop installed on this engine has a Teflon wiper on the blade root, which also acts as an O-ring backup. Apparently it is not uncommon for this wiper to be ejected from the prop, allowing oil to pass by the O-ring on the blade root.

Bell 212—The helicopter was conducting slinging operations for a seismic drilling crew when the No. 2 engine lost power at altitude. The pilot released the long line and landed without further incident. Maintenance was unable to re-start the engine (Pratt & Whitney PT 6-3) in automatic or manual fuel control unit (FCU) modes. The cluster incorporating the engine fuel/oil heater, manual FCU, automatic FCU and engine-driven fuel pump was changed and the aircraft returned to service. These components were sent to the overhaul facility for inspection and analysis.

Beech 100—The crew reported a problem with the gear indication during landing. Maintenance, during a post-landing inspection, found that a main landing gear indication switch had lost its securing tension and worked its way loose to some degree, providing intermittent indication. To prevent reoccurrence, the company increased the inspection frequency for security of this particular switch.

Beech B200—The crew declared an emergency because of a fuel leak. Maintenance found a fuel level sensing probe installed in the tank leaking around the centre-wire attachment point.

Beech B99—While the aircraft was parked on the ramp, fuel was noticed leaking from the right-side engine compartment. Maintenance found a minor fuel seepage at the filter housing O-ring and replaced it.

Beech C90A King Air—While taxiing on the ramp, the crew detected an electrical smell and shut down the aircraft. Maintenance found that the 30-amp. current limiter for the ground vent blower was open and that the vent blower was inoperative. The spring for the positive brush was welded to the motor case, causing a short. The manufacturer has been advised that the clearance between the brush spring and the motor case is minimal and may be a safety hazard.

BAe 146 Series 200—The flight crew experienced a significant vibration from the No. 4 engine. They pulled the power back and the vibration level changed. The turbine gas temperature (TGT) then started to climb, so the engine was shut down. Maintenance discovered there was a turbine blade failure. No trend or other issues were identified.

Boeing 737—The pilot could not properly retract the gear after takeoff. Maintenance discovered that ice and slush that had accumulated around the nose gear would not allow the nose gear uplock to enter the full up position. The area required cleaning before further flight.

Boeing 737-2A3—The crew reported hydraulic pressure problems but landed safely. Maintenance found the right-hand hydraulic supply line leaking above the right-hand main landing gear actuator. The line had apparently chaffed through. The damaged line was replaced with a temporary flex line in accordance with MM 20-10-52. The right-hand and left-hand case drain filters were inspected and the hydraulic system reservoir refilled. Engines were ground run and leak checked serviceable.

Boeing 737-210C—The crew experienced a flap problem that resulted in considerable out-of-service time as a result of troubleshooting. Maintenance changed several flap system components, including the Nos. 7 and 8 flap transmission and Nos. 2, 7, and 8 screw jacks. The transmission units had failed the torque check. The aircraft was test-flown and returned to service with no repeat of the problem.

Canadair CL-600-2B19—The crew rejected the takeoff after detecting abnormal engine vibrations. Maintenance found contained damage to the high-pressure turbine blades.

Cessna 172—The aircraft was on a local VFR training flight when the pilot reported smelling smoke in the cockpit. Maintenance found that the wire bundle to the light-dimming rheostat was found to be chaffing on the centre console, with a wire shorting. The wire bundle was repaired and re-routed. A chaff strip was installed on the console. The other aircraft in the fleet were inspected for similar problems but none was located.

Cessna 172—The pilot returned to the airport as a result of an engine malfunction. Maintenance found that the No. 2 cylinder had failed and exited the cowling.

Cessna 421C Golden Eagle—The pilot made an emergency descent from FL 240 to 10,000 ft because of a high level of carbon monoxide contamination in the cabin. Maintenance inspected the turbos for freedom and for oil leaks; they also removed the winterization covers from the heat exchangers and replaced the air-filter intake hoses in the engine compartment. The operator suspects that residual oil in the sonic venturi and heat exchangers may have burned off when the system was operating at higher temperatures while providing maximum pressurization at altitude. The aircraft has had no further in-flight problems.

Convair 340/580—During a test flight after maintenance, the No. 2 engine (Allison 501-D22G) was intentionally shut down and the propeller feathered. The flight crew was unable to unfeather the propeller and restart the engine. Company maintenance found that the propeller oil level was low, which prevented enough pressure from being developed to unfeather the propeller.

Dassault Mystere-Falcon 200—The U.S.-registered aircraft, recently purchased by a Canadian operator, developed a hydraulic leak en route to its new base of operation. Maintenance found a ruptured hydraulic hose and replaced it.

de Havilland DHC-8-102—The pilot advised of No. 1 engine shutdown and landed with no further incident. Maintenance found an internal spur-gear failure (teeth missing) and sent the engine for overhaul.

de Havilland DHC-8-311—The crew reported that the No. 1 fuel filter bypass warning light illuminated in flight. Maintenance replaced the No. 1 engine HP fuel filter, which solved the problem.

Douglas DC-9-32—The crew noticed a gradual loss of pressurization, but was unable to control the cabin altitude manually. The checklist procedures were carried out and the aircraft descended to 10,000 ft. The flight continued without further incident. Apparently the problem was located within the flow control valve, the air data computer, and the left air-conditioning pack, which were all replaced by maintenance before returning the aircraft to service.

Fokker F28 MK1000—The pilot reported a cracked windshield followed by a safe landing. Maintenance found that the heater element in the captain's windshield had overheated and burned out and that the outer layer of the (three-layer) windshield cracked as a result.

Fokker F27—The pilot had problems with the nose gear. Maintenance found that the nose landing gear mechanism had accumulated wear that allowed the centring micro-switch to stop making contact. The problem is common in the F27. The AME's corrective action was to adjust the centring micro-switch.

Fokker F28 MK1000—The crew rejected the takeoff because a master caution warning light (No. 2 constant speed drive (CSD) overheat warning light) illuminated. Maintenance later found the fill port on No. 2 CSD unserviceable (leaking). The fill port was replaced, the system reset, the fluids topped up and the aircraft ground run serviceable.

Hawker Siddeley HS 748 Series 2A—The crew observed smoke coming from the centre console at the base of the throttles just after takeoff and returned to the airport. Maintenance discovered and repaired a loose wire in the water/methanol control circuit.

Hawker Siddeley HS 748—The crew advised that the aircraft had a hydraulic failure. Maintenance found that the right-hand nacelle hydraulic pump return line was leaking at the fitting and at a kinked area in the braid. The line was replaced and the aircraft returned to service. This is a flex line that was installed under a limited supplemental type certificate to prevent recurring failures that resulted when a rigid line was installed per the standard fit.

Pilatus PC-12/45—Shortly after departure, the aircraft returned with oil on the windshield. The aircraft had some checks performed before this flight on the angle-of-attack sensors that required loosening the lines on the torque pressure transmitter. The lines were re-torqued and it is believed that this action repaired the leak. An investigation by maintenance revealed that the line 577.11.12.105B at the torque-limiter connection was loose. This system had recently been disturbed for a routine 100-hr. stall-warning inspection. Tightening the nut and subsequent ground runs and test flights showed no further leaks. The operator is initiating a more thorough post-inspection ground run into their maintenance procedures.

Pilatus PC-12/45—As a result of frozen brakes, the tires were damaged because of a long skid on landing. The operator reported that the carbon brake pads used on this aircraft were prone to absorbing water, which probably froze after the aircraft taxied through snow with warm brakes. At least two other similar occurrences were reported.

Piper PA-31-350 Navajo—The pilot reported an engine failure and returned to the airport. Maintenance found that the left magneto had failed. The magneto was replaced, a ground run checked OK, and the aircraft was returned to service.

Piper PA-38-112—On takeoff, the pilot of the PA-38 heard a loud bang followed by a loss of power and landed immediately. Maintenance found the lower spark plug had "blown away" from the No. 2 cylinder. The spark plug threaded insert was also damaged and necessitated the replacement of the cylinder.

Piper PA-44-180—The aircraft returned with one engine feathered because of an inability to control the power. Maintenance reported that the engine remained at maximum RPM after the left throttle cable broke during takeoff. The break in the cable was located in the centre console area at the point where the cable enters the housing. This was the first failure in this area of the control system, but cable failures have occurred in other areas.

Piper PA-31 Chieftain—The No. 2 propeller began an uncommanded transition to course pitch and required feathering prior to landing. Maintenance found that a spin on oil-filter gasket (Champion part number LW13904) had failed, allowing all but three quarts of oil to drain overboard.

Piper PA-31 Navajo—The pilot encountered fuel pressure problems and feathered one engine. The TSB reported that a fuel line fitting on the engine-driven fuel pump was loose, an indication of improper torque possibly during the installation procedure.

Possibly Preventable Incidents

The following maintenance incidents are grouped together to illustrate that things that may have been preventable happen on a daily basis. It is deemed possible to eliminate most of these types of occurrences by following procedures and taking more care during installation or maintenance of components.

I have chosen the title for this column considering that there is always doubt associated with human behaviour, and by using the word *possibly* we give the benefit of doubt to the individual who may have done everything right but the unforeseen event still happened. The events speak for themselves and provide an opportunity for AMEs to ponder similar situations in their own environment and implement procedures to prevent such occurrences. Human factors training is designed to reduce human error, and all AMEs are encouraged to take advantage of this training.

1. A **Cessna 15** had just departed from the runway when sparks were observed coming from behind the instrument panel. Maintenance reported that a small loose brass nut was found behind the instrument panel. New fuel guages had recently been installed by an apprentice AME. The nut had been dropped during the installation of the new guages; an unsuccessful search for the nut was done, but supervisors were not informed of the loose nut until after the occurrence.

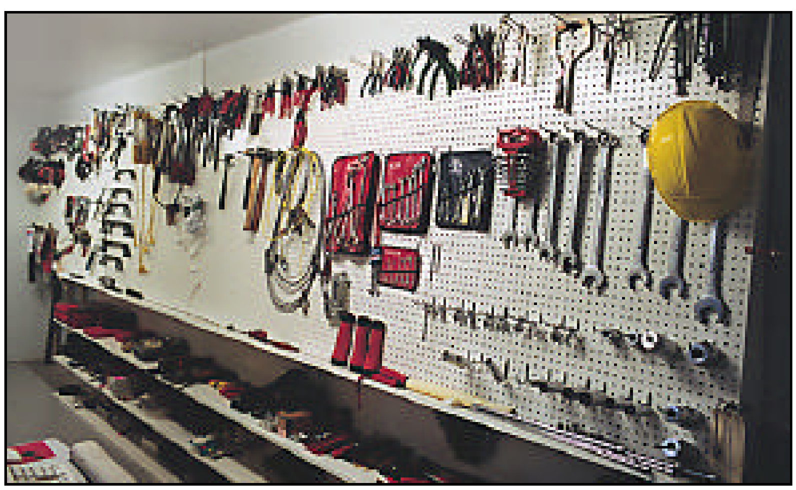
2. The **Convair** twin-engine aircraft experienced an airborne generator overheat condition. Maintenance discovered a loose wire on the back of a canon plug that required repair to eliminate the problem.

3. The pilot reported overhead the field and advised that the aircraft's oil temperature gauge increased to redline and the oil pressure gauge dropped to near zero. Maintenance reported that the winterfronts that control the airflow over the engine were removed prior to the flight. Unfortunately the winterfront located under the cowling that is mounted on the baffle was not removed. This winterfront reduced the airflow to the oil cooler, thereby causing high-oil-temperature and low-oil-pressure indications. The engine had recently been installed after overhaul. The operator decided to remove the engine and have it re-inspected by the engine overhaul facility.

4. The flight crew of a **Fokker F28 MK1000** reported smoke in the cockpit and deplaned the passengers. Maintenance found the cause to be the cockpit generator control unit (GCU) and replaced it. On February 2, 2000, the GCU was installed on the same aircraft (by coincidence), and three days later the same unit was removed because a smoke smell was reported in the cockpit. The Reliability Department has requested that the unit be overhauled at the manufacturer, followed by a findings report.

5. The pilot of **PA-31-350 Navajo** reported a problem with the nose gear and advised he was returning for landing. Maintenance found that the undercarriage uplock would not engage, probably because of the extreme cold (-25°C) weather; therefore, the gear kept coming down. There is a lubricated and covered slide tube assembly on older Navajos. On examination, this tube was found to be stiff. The tube was cleaned and lubricated with a lighter grade of lubricant. Later model PA-31s have a different installation with this tube. There is a kit for older aircraft to modify the tube to a cable assembly, but it is not a requirement.

6. The pilot of a **PA-28 Cherokee** was departing on a local flight when he aborted takeoff because of a power loss. Maintenance inspected the aircraft and found that the flexible air duct from the air filter had come loose and collapsed, resulting in a loss of engine power. It is suspected that the duct was not properly attached when the cowling was last installed.



The quality of repairs often depends on locating the correct tool. The board above, inclined slightly ***out*** *at the top, is an excellent way to locate and track tools where multiple users are involved. A silhouette or number system on the board can be used to quickly verify that no tools have been left in the work area after each day's use.*

Photo courtesy of The Aerospace and Industrial Technology Centre, Slemon Park, P.E.I.

Cessna 310 Carpet Installation Impairs Seat Rail Integrity

During the investigation of a recent Cessna 310 accident, a separate issue arose concerning re-upholstery work performed about two years previous. During the impact sequence, all occupied seats detached. The centre row of passenger seats not only detached from the seat rails, but the seat rails also broke free from the cabin floor.

Apparently, the installer did not cut away the carpet from where the seat rails attach to the cabin floor. Maintenance found 1/2 in. carpet with 5/8 in. foam underlay between the seat rails and the cabin floor. This oversight contributed to the seat rail's detachment from the airframe.

There is limited guidance and information available on aircraft upholstery; however, there is plenty of information about the proper installation of rivets or bolts in high-stress areas, such as the seat retention system. Placing carpet between the rail and metal floor attachment points would certainly not be an approved installation. AMEs need to verify upholstery installation very carefully before certifying the aircraft for return to service to avoid such oversights.

Failure Pattern in Radial Engine Cylinders

Two pilots were flying two float-equipped de Havilland DHC-2s to their main camp after refuelling at separate docks prior to departure. The pilot of one aircraft cleared the line of any water within the hose, but the pilot of the other aircraft pumped fuel directly from the hose at the dock into the aircraft. The engine of one aircraft began misfiring and running rough while en route. The pilots both landed on a lake and, since the pilot of the affected aircraft had not checked the hose for water during refuelling, he may have assumed this was the cause of the engine misfiring and drained the fuel system to remove any contaminants. The two pilots then departed the lake and landed safely at the main camp. *There is a maintenance message at this point for pilots who make assumptions that could have had more serious consequences.—Ed.*

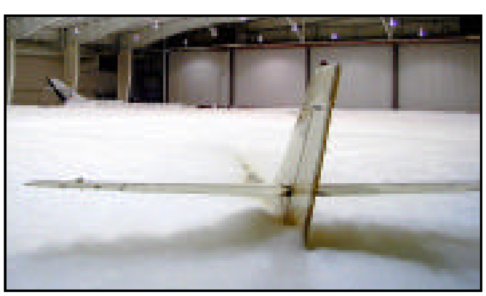
The engine problem was further investigated by the company maintenance and subsequently by a representative of the engine overhaul facility. Information provided indicated that a valve in one of the engine's cylinders had been sticking; the cylinder head to cylinder barrel joint was showing evidence of the initial phases of separation and a cylinder change was required.

Two safety messages appear in this incident. First, the pilots should not have assumed that water may have been the problem. Maintenance should have been contacted to check the problem, which may have prevented further flight with a faulty engine. Second, AMEs need to be vigilant for the early signs of a failing cylinder and replace it.

Photo: Langley Aero Engines

Note the discoloration where the barrel joint and head join on this failed cylinder, which is similar to that of the affected aircraft.

Aircraft Bubble Bath



According to the story about this photo, a new aircraft wash facility had just been established. In keeping with the computer age, all you need to do to wash an aircraft in the new facility is push the aircraft into place, make the necessary settings on the equipment, shut the door and presto!—the aircraft is automatically washed.

On a serious note, apparently this aircraft was placed in a cleaning hangar for a wash job. The water hose, which was equipped with a foam nozzle and quantity of soap in the applicator, was accidentally left with the water running over the weekend and this was the Monday morning result.

Piper PA-31 Seat Rail Deficiencies

In a recent PA-31 accident, severe distortion and breakage of the seat retention rails resulted in the release of one of the seats from its secure mounting. The passenger in that seat was thrown around the cabin but, fortunately, was not seriously injured. Seat rails under two other seats were distorted, but those seats, along with their passengers, remained in place. Rail distortions coincided with locations where at least one seat rail retention screw was missing. An examination of a number of other Piper PA-31 aircraft revealed that it is common for screws to be left out of the seat retention rails, probably as a result of changing the cabin between passenger and freight configurations. Seat extraction requires removal of the screw-retained seat stops. It is likely that the loose screws and seat stops are misplaced and are not installed when the seats are returned to the aircraft. Also, variation between model years occurs with respect to floor holes and nut plates, which could result in gaps of as much as 12 in. between screws. Where gaps exist, there is more likelihood of rail distortion and breakage in a sudden decelleration.

AMEs responsible for maintaining this aircraft type must review pertinent seat installation requirements after any configuration change and ensure that the rails are properly re-attached. There should be no missing screws where nut plates are installed in the floor to accept them.

Should-have Done Factors

There is a tremendous amount of information available about human factors and the application of these factors in aircraft maintenance to prevent accidents. After an accident caused by a missing item or left-out vital assembly seal, it is easy to say "I should have done that" because what caused the accident becomes obvious. The problem is to identify these *should-have dones* and develop a system of work habits that will absolutely ensure that such human mistakes cannot happen. First we have to be very familiar with the industry practices and methods of doing the tasks in order to determine what particular tasks are most vulnerable. The most important items, which we have already learned about through the experiences of others and from investigative reports, are listed below:

- Forget to replace a fluid cap
- Forget to install a seal
- Reverse the connection of a vital flight control
- Reverse or incorrectly reconnect wires
- Neglect to check switches before working on electrics
- Leave aircraft with oil or other fluids drained and neglect to leave a log entry or cockpit warning
- Neglect to check tire pressure because of time pressures
- Complete a complicated installation without help
- Neglect to recheck the apprentice's work
- Sign off based on word of others
- Forget to torque or secure fasteners, bolts, B-nuts
- Miss safetying a component in place
- Misinterpret documents, such as airworthiness directives, because the text is not clear (Airworthiness directives and service bulletins are also safety tools provided they are understood and followed correctly)
- Leave jet engine-cowling fasteners loose and out of torque specs
- Neglect to follow procedures when taxiing, moving or performing a power run-up on large aircraft

I think you see the picture: any *should-have done* is an accident or incident waiting to happen. We need a system to avoid forgetting or missing these daily repetitive chores that tend to breed complacency. The rules and checklists are already in place and can be very reliable provided they are always followed. Technical manuals have specific details for installation of components and work very well provided the instructions are understood and followed. There are three or more cases in North America of large aircraft getting out of control with technicians at the controls for the purpose of taxiing the aircraft or performing power run-ups. There are even cases of technicians inadvertently starting an engine. Evidence in these cases indicated that the technicians involved did not have adequate knowledge of all the systems necessary to maintain control of the aircraft under the particular circumstance. If you would like to review a recent case complete with photos go to the following Web site:
<*http://www.avweb.com/articles/newgate/images/01.jpg*>.
Up to 12 photos can be viewed by changing the numbers 01.jpg, 02.jpg, etc.

So the concept of applying human factors to avoid all of these potential traps is to never have to look back at an accident where something was left *undone* and think, "I *should have* done that."