Transport Canada Transports Canada

Aviation Safety

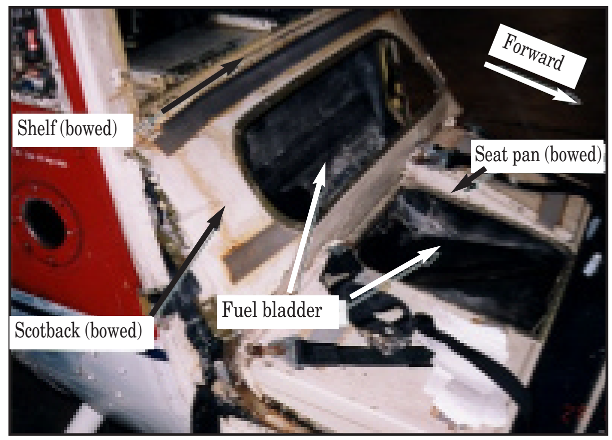
Maintainer

Learn from the mistakes of others and avoid making them yourself . . . **Issue 4/2004**

Static Electricity: An Ever-Present Danger!

ESD stands for electro static discharge. How much do we know about this phenomenon? Should we care? Electronics engineers and technicians working on communication and navigation equipment know a great deal about this ever-present danger, and they take it into account when designing and maintaining such systems. Aircraft maintenance engineers (AME), on the other hand, are not as familiar with ESD, except when a bonding check of an aircraft structure is required, when refuelling aircraft, or for the occasional electrical spark that they encounter at home after walking on a wool carpet with nylon socks and discharge a few thousand volts of static electricity on their wife or children when they accidentally brush against them. But static electricity is everywhere and may have been present earlier this year when a maintenance crew was performing a tail rotor balancing event on a Bell 206B. The maintenance was necessary following the replacement of a tail rotor gearbox bearing and a search to try and rid the helicopter of a vibration in flight. The standard electronic tracking unit was being used and the accelerometer had been placed on the rear gearbox. The technicians were standing outside with the Strobex while the pilot adjusted power to obtain the various readings to meet tracking and balancing requirements.

The electronic tracking unit had been placed on the rear seat and the wiring for the accelerometer passed through the left-hand access door, taped to the belly of the helicopter and onto the tail of the helicopter. The wire-harness stretched along the belly and near the fuel tank vent line. It was a dry, sunny winter day, and the two technicians were standing in the path of the moving air mass created by the rotating main rotor. While the pilot was maintaining power and rotor speed, a technician reached inside the helicopter and touched the electronic unit. At that moment, the fuel tank ruptured as the fuel it contained, approximately 15 gallons, exploded. The technician was thrown several feet away from the helicopter and the pilot felt the blast and was thrown against the cockpit windshield. Fortunately, no one was severely injured. A fire erupted but was soon controlled by the maintenance crew. The helicopter suffered major structural damage, although at first it looked intact. What had happened? Was static electricity the cause of this accident? The aircraft was in a condition that may have exacerbated the risk potential for such an occurrence. The fuel level was low and there may have been poor grounding of various fuel cell components. No one knows for sure, but in another instance, this time in England, static electricity is the suspect and we may find similarities between the two events.



Augusta Bell 206B—Damage to fuel bladder and cabin structure following in-flight explosion.

It was November 24, 1997, and the crew had been on a repositioning flight in Northern Wales to prepare for a training schedule on the following day. They reached their first destination late in the day, where they proceeded to refuel the helicopter after a normal shutdown. There were no apparent aircraft abnormalities noted. They took off again for

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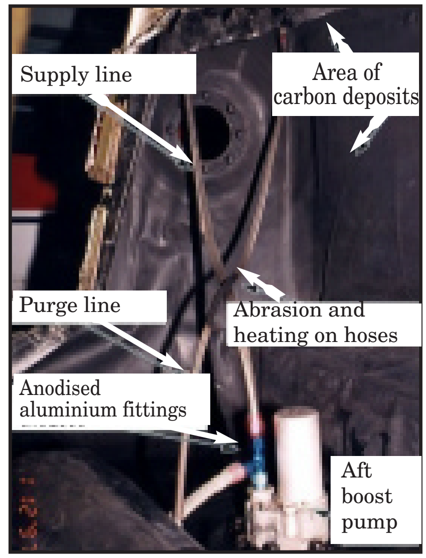
a short flight to a new destination, where they performed a hot refuelling and then flew 10 min to a nearby hotel. The crew had not noted anything unusual, except for a distinct fuel vapour mist coming from the fuel tank as they refuelled the helicopter.

During start-up the next day, the crew noticed a low fuel boost pump pressure, but it returned to normal shortly after. The helicopter operated normally on the mountain training flight with no indication of boost pump malfunction. About 75 min into the flight, and as the instructor was demonstrating approaches into a mountain bowl, at an elevation of about 2 000 ft AMSL (above mean sea level) in a steady turn in light turbulence, both crew members heard a loud bang and a crumpling noise. The instructor thought that they had flown into some turbulence, but the student turned around and noted smoke coming from behind the rear seat. They immediately flew out of the valley, and as the instructor found that the helicopter was still operating normally, he decided that it was safe to return to the hotel. This decision might have had tragic consequences; nevertheless, they returned and made an uneventful landing. The damage to the helicopter rendered it unairworthy.

The fuel system was standard for this Augusta Bell 206B, and the crew estimated that approximately 43 imperial gallons remained at the time of the explosion. The bladder-type fuel tank was situated under the rear seat, and two electric fuel-boost pumps supplied the engine and were mounted at the base of the tank. They fed through a common supply hose connected to a fitting on top of the tank. Fuel passed through the fuel shut-off valve, the airframe fuel filter, and the engine fuel pump and filter, to the engine fuel control unit. Excess fuel was returned through a purge line hose, which passed through the tank and was attached at the base of the tank to the electronically-operated solenoid drain valve. Parker Airborne Division cartridge/canister type fuel pumps (P/N 206-062-681-101) were used on this helicopter, allowing the cartridge pump element to be replaced without draining the tank.

The helicopter sustained damage to the structure surrounding the fuel bladder. There was upward deformation of the shelf structure and heavy deformation of the rear bench seat and seat back. Structural damage was consistent with an overpressure of the bladder. The vent line was examined and was free of obstruction. There were three splits on the right-hand side of the bladder, close to the fuel hose and in the same lateral plane as the aft boost pump. There was evidence of combustion in the tank; blistering about 25 percent of the interior surface near the three splits in the bladder. In the area where the two fuel hoses crossed and touched one another, there were distinct signs of heating and abrasion—this area had become stiff, and broken strands were noted. The hoses were made of rubber/polymer and were reinforced with steel braids on the outside. Laboratory analysis confirmed that this localized heating damage at the area of contact suggested that this was possibly the source of the flame front. The more extensive damage to the purge line hose indicated that there had been a prolonged smouldering, but it was not possible to ascertain whether this was the cause or a result of the explosion.



Augusta Bell 206B—Fuel bladder cut-out showing fuel pump and fuel line configuration at the time of the accident.

After its return to the maintenance base, the helicopter was defuelled using the boost pumps. During this operation, it was noted that there was a distinct vapour mist within the tank, which was caused by a missing red-coloured umbrella check valve that is normally affixed to the top portion of the fuel pump to direct cooling fuel away from the pump body, and to seal the tank when the pump cartridge is removed. As a safety precaution, the remainder of the fuel was drained through the sump drain. The two boost pumps were examined and tested. They showed no evidence of any damage and passed the normal acceptance test.

The observation of the fountain of fuel produced by the aft pump during the defuelling process prompted a series of tests. The pumps were run under varying conditions: with the level of fuel above and below the top of the pump; with and without the umbrella check valve in place. The missing umbrella did not affect fuel delivery or the cooling efficiency of the pump, but with the umbrella valve missing, when the fuel was below the fuel pump level, there was a fountain of fuel expelled and it easily reached the top of the tank, creating a mist and fuel disturbance—and possibly static electricity. Calculations of the fuel remaining at the time showed that there would have been between 9 and 12 cm of fuel above the pump level in a normal rectilinear flight mode, but under turbulent

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Letter to the editor

Unscheduled Maintenance . . . (Maintainer 2/2004)

The "Unscheduled Maintenance…" article described in detail how a DHC-8 leading edge fell from an aircraft shortly after rotation on departure. The article described the circumstances leading up to the incident, and although it is informative regarding the incident, I think that the *Maintainer* could have been used to re-enforce training that was obviously forgotten or perhaps never given to some apprentices and engineers.

I was instructed a long time ago that it is a dangerous practice to partially install anything on an aircraft. Time and time again, we read or hear about panels that fly off or lines that leak because they were not installed properly. The result of such poor maintenance practices can sometimes be fatal.

Regardless of how work is assigned, apprentices and engineers are entitled and obliged to take the time to properly document and hand over work. Companies can provide worksheets and task cards to simplify the work, but the apprentice or engineer that starts a job is obliged to use the logbook or controlled work sheets to detail what has been started and what has not been completed.

Flagging to draw attention to incomplete work is expected, but it should also be documented, and no apprentice or engineer could ever be logically faulted for taking the time to do so. Some apprentices and engineers need to learn that when a superior redirects them to other work or the end of a shift nears, confidence, self-discipline and time management must be used to ensure a clean handover.

Sure, we can blame employer systems and procedures for events that lead up to incidents, but engineers must realize that we are paid a licence premium for a reason. The licence makes us all inspectors for Transport Canada (TC). If we allow companies, customers or weather to pressure us enough to cause us to shortcut procedures, the company is only partially to blame. Engineers must take personal responsibility for what goes right and wrong related to their releases, or our system will degrade to a company approval only system and TC licences will go the way of the dinosaur.

Before apprentices complete and leave an aircraft maintenance/avionics technical school program, they should have learned to recognize certain poor practices that repeatedly lead to incidents, or worse. Regardless of how work is assigned or what circumstances arise during the work's progress, mechanics, apprentices and engineers are all responsible to ensure the clear and orderly handover of such work in progress. Technicians and companies should work together to develop systems of paperwork that suit their operating environment. When the work is ready for release, the engineer is obliged and entitled to take the time to do whatever they feel is necessary to ensure that the task was completed properly, based on the review of paperwork and of the subject-work area BEFORE releasing said work. Thanks for your informative articles.

Name Withheld Upon Request

In This Issue

Mechanical Happenings

The following aircraft incidents are a heads-up for aircraft maintenance engineers (AME). They focus on the maintenance outcome of the incident and do not include all of the facts of each incident. In most cases of component failure, it is assumed that a service difficulty report (SDR) was submitted, as it is a Canadian Aviation Regulations *(CARs) requirement.*

Airbus A320—The aircraft was en route from Victoria, B.C., to Toronto, Ont., when a low engine oil indication was observed. The crew diverted the flight to Vancouver, B.C., and shut down the engine (CFM 56-5-A1) as it reached the short-final phase before landing. There were no further incidents.

Investigation by company maintenance found a loose oil line fitting between the gearbox and the rear bearing case. After the fitting was examined and tightened, a successful run-up was carried out and the aircraft was returned to service.

Beech 200—The aircraft was taxiing for takeoff at Rankin Inlet, NU. The crew noted an oil leak on the left engine (P & W PT6-42). They secured the engine and returned to the ramp. Maintenance found a pinched O-ring on a torque transmitter that had been changed prior to the flight.

Bell 206B—The helicopter was en route from Fort Nelson, B.C., to a point 50 NM east at a cruise altitude of 1 000 ft AGL. About 30 NM east of Fort Nelson, the engine failed, with attendant engine-out light, horn and engine relight showing failure. The pilot conducted an autorotation to a pipeline and during touchdown, the aircraft rocked forward, resulting in minor damage to the transmission spike plate, lower transmission mount cover and main rotor drive shaft. There were no other damages to the aircraft or injuries to the pilot. The emergency locator transmitter (ELT) activated, and was shut off by the pilot. The aircraft was recovered to the company base at Fort Nelson, where maintenance determined that the compressor sustained substantial damage from foreign object damage (FOD) of unknown origin. A hard landing inspection will be conducted on the helicopter.

Bell 206B—The helicopter was descending towards the pad at Tahsis, B.C., when the pilot felt a tap on the pedals. He looked in the sling mirror and noticed that the left-hand bear paw was missing. He landed the helicopter immediately. After shutdown, damage was observed on the tail rotor blades and vertical stabilizer. It was determined that when the skid tubes were replaced three days earlier, the bear paws were not tightened adequately. In addition, a clamp designed to prevent the bear paws from slipping back had not been installed.

Boeing 737-200—The aircraft had taken off from Edmonton, Alta., for a flight to Kelowna, B.C. A short time after levelling off at the cruise altitude of FL 350, the auxiliary power unit (APU) fire and warning lights illuminated and the fire bell sounded. The master caution APU and APU low oil-pressure lights illuminated. The appropriate checklist was completed and the APU fire handle was pulled; however, the APU did not shut down. Only when the APU control switch was selected off, did the unit come off-line. The flight crew declared an emergency and diverted to Calgary, Alta.

Investigation by maintenance personnel found that an APU tail pipe fire had occurred and was contained between bulkhead station 1156 and the APU exhaust baffle. There were no indications of burnt primer, discoloured metal, or excessive heat. The APU exhaust gas temperature (EGT) and tail pipe fire detection wiring harness was found burnt. The wiring harness and APU fire bottle were replaced and the APU fire detection system was tested for serviceability. The aircraft was returned to service and an SDR was submitted to Transport Canada.

Bombardier CL-6002-B19—The aircraft departed Atlanta, Georgia, for Lester B. Pearson International Airport (LBPIA) in Toronto, Ont. The aircraft was leveling off at FL 290 when the flight crew felt a shudder in the aircraft. The aircraft continued to destination and landed without incident. On arrival, it was discovered that the left lower engine cowling was missing.

Bombardier CL-6002-B19—The aircraft was en route at FL 250 when the aileron flight controls did not respond to flight crew inputs. The *Quick Reference Handbook* (QRH) procedure was carried out and the aileron disconnect was activated. The flight crew was able to maintain aileron control from the left control column only. The aircraft continued to destination and landed without further incident.

Maintenance performed the Job Card 1-412 tasks that require lubrication of the aileron cable assembly system. One of the pulleys in the aileron assembly was found to be faulty and it was replaced. Lubrication of the aileron pulleys and cables is a scheduled maintenance task.

A review by the operator of the aircraft maintenance program revealed that this task was inadvertently left undone during the last scheduled inspection. An in-house audit will be performed to determine if this was an isolated and unique event or if it is a systemic problem. An SDR database search revealed several SDRs where aileron stiffness or binding was reported by flight crews or found during routine maintenance. The repair was normally a thorough cleansing and lubrication of the aileron cable and pulley system, and/or replacement of pulleys and quadrants located within the main landing gear wheel well area. This type of event appears to be more frequent when the aircraft encounters standing water during takeoffs or landings.

Canadair CL215—The aircraft was on a flight from High Level, Alta., to Loon River, Alta., for fire suppression. About 25 mi. from destination the starboard engine (PW WASP CA3) began to lose oil and oil pressure. Due to the loss of oil, the engine began to lose power and the propeller entered an overspeed condition. Attempts to feather the propeller were unsuccessful, and the aircraft could not maintain flight with a windmilling propeller. "Mayday" was declared and a forced landing was completed on Highway 88, with no damage or injuries.

Maintenance determined the brake mean effective pressure (BMEP) transmitter had blown out of the oil gallery, causing the oil leak. The engine was replaced at the landing site and the aircraft was ferried to base.

De Havilland DHC8-102—Shortly after takeoff, the crew observed the No. 1 bleed control circuit breaker popping, and returned for an uneventful landing. Company maintenance personnel inspected the bleed air system and determined that it was the result of a bad cannon plug on the No. 1 side bleed-air regulating valve. The cannon plug was replaced and the system function checked with no further faults found. An inspection of the wiring in the area and a resistance check of the wiring runs were carried out to ensure that there was no wiring damage.

Maintenance personnel reported that this cannon plug is susceptible to deterioration over time, as it is connected to a solenoid valve powered in the off position as long as the aircraft is sitting on the ground with power on. The valve heats up to the point where it is too hot to hold or touch and this action breaks down the insulation within the plug over time.

DHC8-300—The aircraft was on climb-out from Vancouver, B.C., en route to Kamloops, B.C., when the No. 2 engine (P&W 123) oil temperature went into the yellow zone at 120°C. The crew monitored the engine, and when the oil temperature remained high, and after consultation with maintenance control, they decided to declare an emergency and return to Vancouver. The aircraft landed without further difficulty. When clear of the runway, the engine was shut down so as not to exceed the engine hot oil time limitation. Maintenance replaced the No. 2 engine oil temperature bulb and indicator, and returned the aircraft to service.

Messerschmitt BO105—The Canadian Coast Guard helicopter was en route from Shippegan, N.B., to Charlottetown, P.E.I., at 1000 ft. At approximately 15 NM from the coast of P.E.I., the pilot noticed an intermittent fluctuation of the No. 2 engine (Rolls-Royce 250-C20B) oil pressure gauge. The pilot elected to continue the flight, monitoring the affected instrument for further fluctuations. Prior to crossing the coast of P.E.I., the pilot noticed fluctuation of the torque indication for the same engine. The pilot elected to land on the shoreline and shutdown both engines for a visual inspection of the aircraft. Upon visual inspection, the pilot noticed that there was no oil visible in the engine sight gauge and that there was oil present on the fuselage below the engine. The aircraft was transported by flatbed truck to the operator's maintenance facility in Charlottetown.

Maintenance inspection revealed that during recent replacement of the No. 2 engine driven fuel pump, wires had been inadvertently jammed between the pump and the engine housing. After repairs were affected, and the aircraft was ground run, it was discovered that the engine was still leaking oil. Maintenance personnel are still troubleshooting the engine to find the cause of the engine leak.

MacDonnell Douglas MD80—The crew of the aircraft rejected the takeoff out of Montreal, Que., due to a left generator failure. The aircraft was later on dispatched for the flight to Cayo Coco, Cuba, under minimum equipment list (MEL) with the left generator inoperative, using the APU generator and the right generator as power sources. On return to Montreal as Flight 839, the right constant speed drive (CSD) unit oil temperature reached 138°C, but was monitored to be in normal range until it seized, leaving only the APU generator as power source. The QRH procedure was applied. An emergency was declared and the aircraft diverted to Newark, New Jersey, where an uneventful landing was carried out. Both generators were replaced and the aircraft was put back in service.

Piper PA-31T (Cheyenne II)—The aircraft was operating as a charter flight from Lethbridge, Alta. to Edmonton, Alta. Just after descent was initiated from FL 190, cabin pressure was lost and the captain requested an emergency descent. The aircraft descended to 8 000 ft and continued to destination.

Maintenance found that a heater hose coupling had detached from the gas combustion heater. The heater is located outside of the pressure vessel in the nose compartment. The hose was reattached and the aircraft was returned to service.

Swearingen Metro 23—The aircraft was en route from Calgary, Alta., to Whitecourt, Alta., at FL 200 when the right hydraulic pressure annunciator began illuminating intermittently. The crew observed that, while the pressure gauge remained within the normal range, the light continued to illuminate for longer periods. Upon descent, the right hydraulic light was on continuously. Extension of 1/2 flaps, followed by the landing gear resulted in hydraulic pressure readings fluctuating between 300 and 2 000 psi. The left hydraulic pressure annunciator illuminated with the gear in-transit indicator on. The auxiliary gear extension checklist was completed and full flap selected. The flap slowly extended into position and a normal landing was carried out. A post-flight inspection revealed that the hydraulic line had chaffed through.

Robinson R-22B—Only a few minutes after takeoff from the Campbell River, B.C., helipad, the helicopter was observed descending rapidly towards the lake. The pilot, the sole occupant, was fatally injured and the helicopter sank in 60 ft of water. The Transportation Safety Board of Canada (TSB) is investigating.

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conditions such as in the mountain training area, a vertical efflux of fuel could have occurred.

Electrical bonding of the aircraft was checked and found satisfactory at first. A continuity check of the hose and fitting of the two fuel lines revealed that one of the lines acted as an insulator. The purge line had the conventional grey steel nozzle and nipple fittings at the ends, and had good electrical continuity, but the blue and red anodized fittings of the fuel supply line acted as insulators. This prevented continuity between the hose and its connection to the boost pumps and the outlet to the engine. The hose manufacturer confirmed that it was an Aeroquip 601-type hose that met Military Specification MIL-H-83797. In the smaller diameter lines, such as for the purge line, the fittings are steel and provide good electrical continuity, but in the larger diameter configuration, the end fittings are of anodized aluminium, and they are non-conductive until the finish is worn. Military Specification MIL-H-83797 does not contain specific provisions regarding electrical conductivity along the hose or across the end fittings. The manufacturer states that it can be provided when the customer asks for it and this is done for particular applications. More recent designs of hoses and fittings include specific provisions for this conductivity factor on this type of helicopter and most other aircraft designs.

The UK's Aircraft Accident Investigation Branch (AAIB) discussed the topic of conductivity with other aircraft manufacturers and all agreed that the fuel hoses within the tanks should be electrically bonded, and that the majority of designs today apply this principle either by electrical continuity within the hose assembly or by adding extra bonding leads and clamps. The two fuel lines had been manufactured in-house under the operator's maintenance manual approval using Aeroquip materials.

During the investigation, several Bell 206B were examined and at least two other boost pumps were lacking the umbrella check valve. It seems that some may have been discarded during installation, incorrectly identified as "packing blanks." It was also noted that a diversity in hose configuration between helicopters, and in some cases "P" clip arrangement, prevented abrasion between hose assemblies in the fuel tank. Others had different purge lines that did come close to the supply line. There have been recorded instances of fuel tank explosions during refuelling operations, but there does not appear to be other instances of this type of event within the Bell 206B fleet. The Canadian Aviation Safety Board [now known as the Transportation Safety Board of Canada (TSB)] recorded an incident at Buttonville Airport in 1989, of a Messerschmitt Bolkow Blohm BK117. The report concluded that the most probable cause was the generation of a heated flammable fuel-air vapour in one tank due to the draining of heated fuel from the engine return lines following engine shutdown. The ignition source was believed to be a static discharge generated between the fuselage and an unbonded portion of the fuel vent pipe.

Research has shown that the flammability level of a fuel is markedly lowered by dynamic conditions where fuel is agitated. The risk of a build-up of a static charge between two lines with a difference in electrical potential is likely to have occurred in these three instances and caused the explosions.

For Bell 206B operators, it would be prudent to ensure that fuel lines are properly tested for electrical bonding, that they are secured by "P" clips when necessary to prevent abrasion and that the fuel pump umbrella check valves are secured and perform as designed. When unchecked, static electricity can have a devastating effect on an aircraft.

Static electricity can be deadly; control it with the recommended maintenance instructions.

Call for Nominations for the 2005 TC Aviation Safety Award

Do you know someone who deserves to be recognized?

The Transport Canada Aviation Safety Award is presented annually to stimulate awareness of aviation safety in Canada by recognizing persons, groups, companies, organizations, agencies, or departments that have contributed in an exceptional manner to this objective.

You can obtain an information brochure explaining award details from your Regional System Safety Offices, or by visiting the following Web site: www.tc.gc.ca/CivilAviation/SystemSafety/brochures/tp8816/menu.htm.

The closing date for nominations for the 2005 award is December 31, 2004. The award will be presented during the seventeenth annual Canadian Aviation Safety Seminar (ww.tc.gc.ca/CASS), which will be held at the Fairmont Vancouver Hotel in Vancouver, B.C., April 18 to 20, 2005.

"Housekeeping" in Your Work Environment

by Norbert Belliveau, Aircraft Maintenance Engineer (AME) and System Safety Regional Inspector, Atlantic Region, Transport Canada

Remember when you were growing up and your parents kept telling you, "Please pick up after yourself" or, "keep your room clean." Those words of wisdom were not only meant for us to learn about good housekeeping practices at a young age, but hopefully they would be carried through our adult and professional lives.

Aircraft maintenance is a profession that requires meticulous craftsmanship and organizational skills. Hangars and repair facilities are where most of us spend a good part of our working career ensuring the airworthiness of thousands of aircraft all over the world; therefore, good housekeeping and cleanliness should always be on our list of priorities.

A tidy, clean and well-organized maintenance facility projects a safety culture, professionalism and furthermore a sense of pride. It also prevents equipment or aircraft damage and provides a healthy working environment for all.

Housekeeping Tips

1. Take time to return tools and equipment to their original place at the end of each shift.
2. Keep flammable and hazardous substances stored in clean and secured areas.
3. Repair or replace damaged air hoses, electrical cords or any item that may represent a potential hazard in the workplace.
4. Maintain clean floor areas through regular maintenance.
5. Ensure clear access to all safety and health stations at all times.
6. Clean up after yourself and think of others.
7. Make use of movable floor tables during inspections instead of laying items on the floor.
8. Maintain a professional standard.

Keep up the good work and remember that the safety of every person boarding that next flight is in your hands.

Second Look: Double-Check Your Work!

There was a time in Frobisher Bay (Iqaluit, NU) when I was called upon to carry out a 7-day inspection on a Twin Otter, and one of my tasks was to check the quantity of oil in the engines. This I did, but somehow, I got sidetracked with something else that I thought was important and finished it first. Later during the night, I woke up and tried to remember if I had put the oil cap back on the last engine that I had checked. It was bugging me. I was really worried, as I couldn't remember for sure if I had done it. I didn't want to face the embarrassment of having to recheck it after bringing the airplane to the front of the dispatch area where the passengers would have been boarding by early morning. After thinking about it, I reasoned that it was more important to make sure that everything was secure and safe than to lose a little pride along the way. So I got up two hours early and walked down to the aircraft, got up on top of the wing and opened up the oil panel. There it was—the dipstick/oil cap was lying there on top of the engine where I had left it. I learned a very important lesson from that mistake—always double-check the area where I had worked and do not let any fear of embarrassment get the better of me and increase the risk factor. I also understood then, that nothing should get in the way of doing things right, no matter what! It certainly would have been much more embarrassing if the flight would have had to return with a seized engine and a cowling covered in engine oil or worse, if it would have caused an accident.

Ted Mead, Civil Aviation Safety Inspector, AME Licensing and Training, Transport Canada

This article recounted an interesting story that an AME experienced in the course of his professional career. Please feel free to forward similar stories, for posterity and for safety. —Ed.

Continuing Airworthiness: An Endless Responsibility

How effective is your maintenance evaluation program?

The flight of a Beech 1900D did not get off to a successful start; shortly after becoming airborne, the tower controller advised the pilot that a wheel assembly had been seen falling from the aircraft. The crew immediately returned to the airport and made an uneventful landing. The failed No. 3 position wheel assembly had approximately 400 hr in service. It was recovered and inspected in order to establish the cause of failure. It had been serviced 425 hr earlier, as the maintenance had coincided with a tire replacement schedule. This interval met the manufacturer's recommendation, and although there had been no other servicing requirements for this type of wheel assembly, it seems to have led to several similar occurrences in the past.

Following this last incident, the operator initiated an evaluation program to help identify the cause. Every one in maintenance participated and several issues came to light as possible elements leading to the premature failure of the bearings. For instance, a new landing gear cleaning process was adopted. It took into account the compatibility of the cleaning agents and the resistance of the wheel assembly seals and bearing lubricants to high pressure washing techniques. A new synthetic wheel bearing lubricant was chosen because of its resistance to load, high temperature and various chemical agents present in corrosive environments. The serviceability of aircraft wheel assemblies is influenced by the quality of the maintenance carried out; the type of lubricant used; the environmental conditions to which they are subjected, such as corrosive air and gases, dust, and water; the frequency of the use of chemical solvents for cleaning; and the normal wear and tear from take-off and landing cycles.

Not all lubricants are created equal; some will give improved life to bearings under very specific conditions and others will not. Operators who experience serviceability problems should review their aircraft maintenance evaluation program to ensure that it meets current operational conditions. *Canadian Aviation Regulations* (CARs) Standard 726.07 was initiated to ensure that operators would have a system, irrespective of the type of operations, to adequately control all airworthiness matters that could affect the operation of aircraft. It states that, "the program should provide an unbiased picture of the Air Operator's performance, to verify that activities comply with the MCM [maintenance control manual] and confirm that the systems and procedures described in the MCM remain effective and are achieving the Air Operator's requirements." The aircraft maintenance evaluation program serves to review reported maintenance occurrences and to determine, in a timely manner, if changes are required in order to enhance the continuing airworthiness of aircraft, thus safety.

In another example, a large Canadian air carrier was experiencing tire failure at a rate that surpassed that established in their servicing schedule. A review of the compiled data showed a trend in the frequency of failure that clearly established a rate that was unacceptable for the type of operations carried out by this operator. These unplanned failures were compounding the tire problem, as they often created other hazards, such as damage to airplane structure from debris, risk of engine foreign object damage (FOD) and parallel assembly tire failure. There was an unplanned loss of revenue, unhappy customers, and increased costs associated with maintenance. This operator decided to restrict the use of tires to those that had been recapped a maximum of three times (R3). It also required the recording on the tire sidewall of every addition of nitrogen gas to bring the pressure up to specifications in order to identify any chronic slow-leaking wheel. Following the last failure of a tire that had been recapped 6 times, the aircraft had to divert the flight to an alternate airport. It experienced flap and gear door damage from FOD, and it was grounded for several days for repairs, leading to a substantial loss of revenue.

Your aircraft maintenance monitoring program will save you money and keep your aircraft flying safely, but you have to tailor it to your operation and tweak it so that it can readily inform you of any recurring failure that nullifies your effort to keep your aircraft maintenance and operations on schedule. An aircraft maintenance evaluation program is part of a safety management system (SMS), and we know from experience that an SMS will save you money, make your operation more efficient and make your employees feel that they are part of a pro-active organization. How much effort have you put into it lately?