Lightning Literacy For Ramp Personnel

by
Robert A. Feeler
Editorial Coordinator

Lightning! The word evokes instant images of a brilliant flash of light arcing across the sky with its accompanying clap of thunder. Spectacular to watch from a distance, but hazardous when close by, lightning is a natural phenomenon that evokes respect, and fear, for good reason — it can be a killer.

Information provided by the U.S. National Oceanic and Atmospheric Administration (NOAA) states that nearly 2,000 thunderstorms are in progress over the earth's surface at any given moment. Lightning strikes the earth 100 times each second. Its threat to people is real — each year in the United States, lightning is responsible for more deaths than tornadoes, floods or hurricanes.

According to statistics from the U.S. National Safety Council, an average of 86 fatalities have been attributed to lightning each year since 1985. In the period of 1959 through 1989, 2,936 people in the United States lost their lives as a result of lightning. (Eighty one of this total occurred as a result of a 1963 crash of an airliner that was struck by lightning near Elkton, Md., U.S.)

Injuries attributed to lightning strikes in this same period totalled nearly 8,000. Total property loss in the United States caused by lightning is estimated in the hundreds of millions of dollars. Although specific data is not readily available, deaths, injuries and property damage in other parts of the world where lightning commonly occurs, greatly increase these totals.

Aviation technicians and ramp service personnel are particularly vulnerable to lightning hazards when working outside during periods of storm activity. In order to minimize these risks, it is prudent that technicians have a reasonable understanding of the causes and effects of lightning and be aware of some recent developments in lightning detection and alerting technology.

What Is Lightning?

A lightning bolt is the discharge of a tremendous static charge built up due to interaction between particles in the air, most commonly in cumulonimbus clouds. It can however, occur during sandstorms, snowstorms and has even been reported in the clouds over erupting volcanos.

Lightning occurs cloud-to-cloud as well as cloud-to-ground. It is the latter type which poses the hazard to personnel on the ground, and this discussion will focus only upon the cloud-to-ground variety, most commonly associated with thunderstorms.

Lightning strikes are more prevalent in certain areas of the world, and the frequency of occurrence in various areas has been documented and mapped in great detail. The charts in Figures 1 and 2 depict the number of thunderstorm days within the United States

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Figure 1 — Thunderstorm days (Isokeraunic Level) within the continental United States. Illustration source for Figures 1-3 is "Lightning Protection of Aircraft" by Fisher, Perala and Plumer, published by Lightning Technologies Inc.

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not available.

Fgure 2 — Isokeraunic level of the world.

and around the world. (The number of days on which thunder is heard is called the isokeraunic level.) The count of thunderstorm days can indirectly give an indication of lightning activity; rules of thumb include one that states there will be approximately four flashes to earth per square kilometer per year in an area with 25 thunderstorm days annually. Another rule of thumb states that the ground flash rate varies directly as the square of the isokeraunic level. More specific data is usually available from weather reporting services in your local area.

As a storm develops, interaction of charged particles produces an intense electrical field within the cloud. A large positive charge is usually concentrated in the cooler upper layers of the cloud, and a large negative charge along with a smaller positive area is found in the lower portions.

The earth is normally negatively charged with respect to the atmosphere. As the thunderstorm passes over the ground, however, a negative charge in the base of the cloud induces a positive charge on the ground below for a considerable distance around the storm. The ground charge follows the storm like an electrical shadow, growing stronger as the negative cloud charge increases. The attraction between positive and negative charges causes positive ground current flow up buildings, trees and other elevated objects in an effort to establish a flow of current.

Air, being a poor conductor of electricity, initially insulates the cloud and ground charges from one another, preventing a flow of current. As the intensity of the charge increases, it eventually becomes great enough to overcome the resistance of the insulating air and forces a conductive path to begin. This initiation of the lightning stroke, called the "pilot leader," is the first stage of the stroke that travels from the cloud to the earth; usually it is too faint to be visible. The leader causes ionization of the air path allowing further surges of electrical current, called "stepped leaders," to travel the leader path and continue on for 100 feet or more at a time, pausing and then moving on in continuing cycles until the conductive path of ionized particles is near the ground.

At this point, the charge on the ground is attracted upward, sending a streamer up to intercept the leader path from the cloud and complete the conductive path between ground and cloud charges. When this path is completed, the electrical charge in the leader flows to the ground, triggering a return stroke that leaps upward with great intensity, following the ionized path created by the leaders. This upward current flow is so great that it causes the ionized air path to glow, making the lightning stroke visible and producing the intense flash normally associated with lightning. All of this takes place in about one second.

Although the visible return stroke is upward, it usually appears to come downward from the cloud due to the downward forks of the stepped leaders which now conduct the return stroke back into the charged cloud. If the charge build-up was substantial, a return stroke often occurs. This return stroke or restrike, follows the same path of least resistance, actually occurring more quickly as the path has already been established; it is usually of lesser intensity.

The initiation of a lightning strike sometimes begins at the ground from a high point such as a high tower or building, in which case the stepped leaders branch upward from the high point until reaching a point of convergence with the cloud charge and the process of stroke-return stroke occurs the same as for cloud-initiated strokes. If the branching of the ensuing visible lightning flash branches downward, the leader began in the cloud; if it is upward, the leader began at the ground. The process is the same in all other respects.

Current and Voltage of Lightning

The potential energy produced during the formation of a lightning flash can equal a million volts. Current flow can vary from a few thousand amperes to well over 100,000 amperes for a few microseconds. Current continues to flow at decreasing rates until peaking again during return strokes. Figure 3 is a typical plot of a lightning model used in designing the lightning protection devices for the U.S. Space Shuttle.

The peak value of the current is related to the “blasting” or explosive effects of lightning. The duration of the stroke current affects the distance across which side flashes may develop, and affects how severely metal structures may be deformed by magnetic forces or the explosive liberation of energy.

The duration of the stroke, which is measured in microseconds, should not be confused with the total duration of the visible lightning flash. The total duration of the flash is frequently as much as one second and is determined by the number of the return strokes and the time interval between them. Relatively little of the total charge is transferred in any one stroke, but rather is transferred in the continuing current flow between return strokes. The total charge transfer and the amplitude and duration of the continuing currents largely determine the thermal or burning effects of lightning.

Thunder is created by the lightning stroke because it heats the surround-

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Figure 3 — Lightning model for the Space Shuttle

ing air so quickly that it expands with explosive force creating a shock wave close to the return strike channel. Then an ordinary sound wave is generated whose pressure variations produce the characteristic sound heard by observers. Close by, the thunder is a sharp crack. More distant strokes produce grumbling and rumbling noises as the result of the sound being refracted and modified by the turbulent environment of the air surrounding the storm. With the light of the flash travelling almost a million times the speed of sound, the time between the flash and the sound can provide an estimate of the distance to the lightning strike. Dividing the time in seconds, between the flash and the sound, by five, will give an indication of the distance away in miles.

Lightning Can Appear In a Unique Ball Shape

Ball lightning is the name given to a moving globe of electrical charge which is sometimes observed during thunderstorms. A typical example of ball lightning usually is described as the size of an orange or grapefruit with a lifetime varying from a few seconds to as much as 20 seconds, although larger and longer lived instances have also been reported.

Ball lightning is sometimes confused with St. Elmo's fire, the corona discharge induced at a pointed conducting object by a heavy static buildup, which may also assume a spherical shape. St. Elmo's fire differs however, in that it remains attached to a conductor, whereas ball lightning is often reported to float freely through the air or along the ground.

The phenomena of ball lightning is not thoroughly understood by the scientific community, and at present there is no accepted theory which can account for its appearance and actions. Most reported instances of ball lightning do not include damages or injuries. In most cases, the ball was noted to burst or simply disappear upon striking a wall or other fixed object.

There have been reports of ball lightning originating in the cockpit area of an aircraft in flight, travelling harmlessly through the cabin and either decaying within the cabin or passing out of the fuselage and rolling off the wing. In another case, a ball of lightning entered a house, hovered over the dining table while the family was having dinner, and then exploded with a bang like a fire cracker without damaging anything.

However, in the absence of any definitive knowledge to the contrary, anyone observing the phenomena of ball lightning would be well advised to stay clear of these mysterious balls of fire.

What Happens to Lightning Strike Victims?

Persons struck by lightning receive a severe electrical shock and are sometimes severely burned. Contrary to some beliefs, a strike victim carries no residual electrical charge and can be treated safely. On the other hand, electric power lines are frequently damaged in the area of storms with lightning, so an apparent victim of lightning may instead have come in contact with downed power lines and this should be investigated before initiating first aid action.

Even someone apparently "killed" by lightning can often be revived by prompt action. Artificial respiration is required immediately if the victim is not breathing. In addition, cardiopulmonary resuscitation (CPR) is required if the victim has no pulse. Treatment should be administered by trained personnel and continued until a qualified doctor takes over, because death from the effects of lightning-induced electrical shock is difficult to determine.

Lightning injury is uncommon, and medical journals report that many physicians never see or treat such a victim. A report from the U.S. Army Institute of Surgical Research Burn Center documented the treatment of a few patients that were admitted following lightning associated injuries during the period between 1969 and 1983. There had been a total of 4,153 burn patients admitted to the facility during that period, only five of whom were due to lightning.

In most cases, the victim is not struck by the lightning directly, but is in contact with or adjacent to a conducting object which receives all or a part of the bolt. Examples of lightning strike incidents and resultant injuries reported by the burn center were:

- A 16-year-old boy was injured when a lightning bolt struck a television antenna, arced and struck him. He was thrown to the ground with his clothing aflame, but did not lose consciousness. He suffered burns over nearly 25 percent of his body surface, but survived with no complications.

- A 31-year-old woman was struck by lightning when outside in the rain, and the bolt attached to her metal umbrella frame. She did not lose consciousness and suffered only a severe burn to the hand holding the umbrella.

- A 22-year-old man was one of several people standing near a tree which was struck by lightning. Others received a brief shock, but he was the only one rendered unconscious. He suffered localized burns that covered 14 percent of his total body surface including exit wounds on the toes of both feet. He fully recovered with no ill effects after an extensive hospital stay.

Injuries and fatalities in the aviation environment are equally rare, but they do occur. There have been some fatalities to ramp workers or technicians in the United States within the past 10 years. In one instance, a technician was using a headset connected to an aircraft in preparation for its pushback from a terminal gate. The aircraft was apparently struck by lightning and the current travelled through the headset cord, resulting in massive electrical shock with fatal results.

In another incident, one of a group of technicians was injured when lightning struck nearby while they were on break outside the building; that individual recovered fully.

How to Follow Precautionary and Protective Procedures

Many operators involved in outside work and ramp activities have adopted policies and procedures to minimize their exposure to lightning injuries. Typically, these procedures have two steps or levels of hazard alert with corresponding action required.

Phase I Alert. When thunderstorms or lightning activity are within five miles of the airport, notify all ground personnel to take appropriate precautionary actions. These actions typically include:

- Cease use of headsets connected to aircraft and revert to hand signals for communication with the cockpit.
- Be alert for any indication of local lightning activity and advise supervisory personnel of any observations.
- Cease all fueling activity or attempt to schedule fueling activities earlier or later to preclude the necessity for discontinuing if lightning hazard increases.

Phase II Alert. When lightning activity is overhead or within one mile of the operating area, notify all ground personnel to cease outside activity and take cover in appropriate locations until the all-clear is issued. These actions typically include:

- Cease all outside activity and move inside a building or into an enclosed vehicle. Open cab, convertible or uncovered vehicles are not to considered acceptable protection.

- Cease all fueling activities, disconnect fuel equipment and move fuel trucks well away from aircraft.

- Remain in protected area and stand by for further instructions from supervisors.

Using Tracking and Alerting Devices

Advancements in technology now provide several devices that are capable of tracking electrical disturbances and lightning. Some detect the actual occurrence of lightning, while others detect the conditions which are conducive to a lightning strike. Many installations are in place worldwide at airports, military installations, power plant and electrical distribution centers, and at various government weather research installations.

Following is a partial listing of the equipment available and a brief description of each device. Flight Safety Foundation does not endorse any product or attest to the accuracy of any of the data presented here. This information is provided in the interest of safety and to inform the aviation community about available lightning detection and protection equipment. More detailed information and references to experienced users can be obtained from the sources indicated below:

Atmospheric Research Systems Inc. (ARS)
2350 Commerce Park Drive NE
Suite 3
Palm Bay, FL 32905 U.S.
Telephone: (407) 725-8001

Supplier of the National Lightning Position and Tracking System that detects and tracks the location and occurrence of lightning in the United States on a real-time basis. Data is processed and transmitted via satellite transmission to users for display on video screens. Users can select and manipulate the data to focus on local areas as well as observe the overall national pattern of storm developments and movements. This system uses time-of-arrival (TOA) from multiple sensors to pinpoint the location and strength of each lightning strike.

ARS also produces the Lightning Danger Alert System that uses individual detectors to sense the intensity of the electrical field and measure the potential difference between cloud and ground. Up to six detectors can be connected to a standalone personal computer to provide a real-time lightning hazard warning system. Various alerting and recording features are available, and the system can be programed to alert the user when the potential exceeds a prescribed limit.

ARS also markets the Flash Warning System that alerts the user of the approaching danger from lightning discharges. This unit provides an audible warning of approaching lightning flash activity and an indication of the approximate distance.

Lightning Location and
Protection Inc.
2705 East Medina Road, Suite 111
Tucson, AZ 85706 U.S.
Telephone: (602) 741-2838

Supplier of the Lightning Location and Protection system which senses and displays on a personal computer the intensity and movement of lightning storms over any land mass, on a real-time basis. The system can detect only cloud-to-ground strikes via the radio impulse generated. With multiple detectors, the location, polarity and number of return strokes in each flash can be recorded and displayed. This system is currently in use in the United States, much of western Europe and parts of the Far East and Australia.

The company also supplies a single-station Thunderstorm Sensor system which is capable of sensing thunderstorm activity within a 100-mile radius of the installation. Immediate information on lightning activity and related thunderstorm intensity is displayed on a personal computer monitor in the operator's facility.

Weather radar maps of the local area can be overlayed with the lightning activity data.

Also provided is the Electrical Storm Identification Device (ESID) which is a solar-powered sensor, with battery backup, to provide short-range thunderstorm detection and alerting. This unit provides an alphanumeric display of the range and flash count of lightning activity within a 25-mile radius. A remote alarm/warning unit is available with the system.

B.F. Goodrich Aerospace/Foster
Airdata (formerly 3M Aviation
Safety Systems)
6530 Singletree Drive
Columbus, OH 43229-9674
Telephone: (614) 885-3310

Manufacturer of the StormScope Series II weather-mapping system that also includes a ground-based installation. This system detects the electrical and magnetic fields emitted from lightning discharges and provides range and azimuth heading to each discharge. With range selectable at 25, 50, 100 or 200 nautical miles, the location and movement of lightning strikes can be pinpointed.

Data can be displayed on a standard display as used in the company's airborne installations or wired into a compatible video monitor. The system is selectable to focus on a 120-degree field of view in a particular quadrant as well as a 360-degree area.

Electrosensors Inc.
P.O. Box 523772
Miami, FL 33152
Telephone: (305) 594-0304

Supplier of the Thor-Guard lightning hazard level indicating system. This system is a self-standing unit that senses the charged ions in the atmosphere and electronically compares these readings with stored data. The system predicts the percentage of probability of a lightning discharge in an area up to 10 miles in radius.

The unit displays, via color bar graphs, the lightning hazard level in the overall area, as well as the dynamic index or probability in the immediate area. Alarm levels can be varied according to clients' needs, and battery back-up is available.

The Thor-Guard system is said to be the only unit capable of warning in advance of a "bolt-out-of-the-blue" lightning strike which is not associated with a visible thunderstorm. ♦

NEWS & TIPS

Standards Revised for Grounding/Bonding During Aircraft Fueling Operations

The National Fire Protection Association (NFPA), headquartered in Quincy, Mass., U.S., a recognized source of information and standards relating to fire safety in aircraft fueling operations, has published information on a new procedure related to aircraft fuelling. NFPA publications No. 77, "Static Electricity," and No. 407, "Aircraft Fuel Servicing," have recently been revised — and an important change in grounding procedures was incorporated.

Before discussing the change however, it is important that technicians understand the definition of two terms involved in the procedure.

Bonding is the process of connecting two or more conductive objects by means of a conductor. It is done to minimize potential differences between conductive objects.

Grounding (or *earthing*) is the process of connecting a conductive object to the ground, and is a specific form of bonding. Grounding is done to minimize potential differences between objects and the ground.

Historically, industry standard procedures for grounding and bonding of the servicing vehicle and the aircraft have recommended that;

- The vehicle be bonded to the aircraft, and
- the vehicle be grounded to an approved ramp grounding point, and
- the aircraft be grounded to an approved ramp grounding point.

NFPA studies have found that *grounding the aircraft or the fuel*

Aviation Fuel Publications Available

The following publications may be obtained form the sources indicated:

National Fire Protection Association (NFPA),1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101
NFPA Number 77 Static Electricity
NFPA Number 407 Aircraft Fuel Servicing
NFPA Number 415 Aircraft Fueling Ramp Drainage

American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103
Manual of Aviation Fuel Quality Control Procedures
ASTM D910-76, Specifications for Aviation Gasolines
ASTM D1655-77, Specifications for Aviation Turbine Fuels

Air Transportation Association of America (ATA), 1709 New York Avenue, N.W., Washington, DC 20006, telephone: (202) 626-4000
ATA Spec Number 103 - Standards for Jet Fuel Quality Control at Airports

American Petroleum Institute, 2101 L Street, N.W., Washington, DC 20037
Bulletin 1529-1982, Aviation Fueling Hose
RP 2003-1982, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.

British Standards Institution, Linford Wood, Milton Keynes MK 146 LE, United Kingdom
BS 3158-1985 Rubber Hoses and Hose Assemblies for Aircraft Ground Fueling and Defueling.

TMI Accumetric, P.O. Box 11289, 2700 Nuttman Avenue, Fort Wayne, IN 46857, telephone: (219) 747-0587
Brochure on TMI Accumetric Fuel Contamination Detector

Gammon Technical Products, P.O. Box 400, 235 Parker Avenue, Manasquan, NJ 08736, telephone: (201) 223-4600
Wide variety of publications and brochures on fuel testing equipment and procedures.

Figure 1

truck during aircraft or refueler loading is no longer required.

NFPA No. 407 — Aircraft Fuel Servicing, Appendix A, states:

"No amount of bonding or grounding will prevent discharges from occurring inside a fuel tank. Bonding will ensure that the fueling equipment and the receiving tank (aircraft or fueler) are at the same potential and provide a path for the charges separated in the fuel transfer system (primarily the filter/separator) to combine with and neutralize the charges in the fuel. Also, in overwing fueling and in top-loading of cargo tanks, bonding will ensure that the fuel nozzle or the fill pipe is at the same potential as the receiving tank, so that a spark will not occur when the nozzle or fill pipe is inserted into the tank opening. For this reason, the bonding wire must be connected before the tank is opened."

In response to this publication, the U.S. Federal Aviation Administration (FAA) issued a notice to its field offices directing the attention of airport certification program inspectors to the change in procedure.

Bonding of the refueler vehicle to the aircraft still is required and NFPA publications emphasize the importance of connecting the bonding wire *prior to opening the tank fill cap or initiating any fuel flow.*

Technicians involved in aircraft fueling operations may wish to obtain applicable publications and review their procedures to ensure that local operations are in compliance with the desired standards. (A list of applicable publications is shown in Figure 1.)

Further details about this subject are available in the FSF *Airport Operations* bulletin, March/April 1991.

Computerized Accident Investigation Data Source Being Developed at ERAU

Two graduate students attending Embry-Riddle Aeronautical University (ERAU) recently won a grant from the U.S. Federal Aviation Aviation Administration (FAA) to initiate work on a computerized accident investigation program. John Nyutu and Dave Ryan have titled the project "FILE" (Field Lightweight Investigator's Expert). Their intention is to develop a program that will enable a field investigator, using a personal computer, to have immediate access to information about pertinent aircraft information. Also, a logic tree would pose various alternatives relative to possible causes and factors that will help develop explanations for what may have caused an accident.

Nyutu and Ryan will first develop a model of the project which is to be analyzed by the FAA and the U.S. National Transportation Safety Board (NTSB). The researchers began work last August to create a data bank on the design, structure and engineering aspects of two sample aircraft in the school's fleet. They will also compile a data bank on aircraft accident investigation procedures, and finally will develop a procedure that allows a field investigator to input pertinent accident data to be correlated with the information on the aircraft.

The most challenging task, according to ERAU, will be that of creating program instructions which will interpret the data and guide the investigator toward logical conclusions.

Phase one of the project was scheduled for completion in April 1991, after which it will be analyzed at the university's Prescott, Ariz., U.S. campus, and at the Transportation Safety Institute in Oklahoma City, Okla., U.S. The school also has a campus at Daytona Beach, Fla., U.S.

Pending approval of the government agencies involved, the follow-on phases will be pursued. Phase two will involve expanding the data base to include a wider range of general aviation and commercial aircraft. Phase three will work on linking FILE with other computerized aviation information sources such as airports, air traffic control, weather, aircraft records, crew records and other accident-related information.

Employers Expanding Use of Computers in Technician Training

American Airlines has signed an agreement with FlightSafety International (FSI) to use an FSI instructor-led, computer-assisted instructional program that provides technicians with a foundation of work-related, troubleshooting skills. The course is intended to become an integral part of a new, four-week avionics program that will be attended by more than 3,000 American Airlines technicians over the next five years. FSI will provide courseware and instructor support services for the program.

This special program will utilize methodology similar to that currently in use by FSI for teaching troubleshooting in a wide variety of aircraft maintenance training programs offered at its 36 learning centers in the United States, Canada and Europe. A version of this troubleshooting program is also used by McDonnell Douglas Corporation's Douglas Aircraft

Co. for in-house training of its airframe manufacturing personnel. ♦

MAINTENANCE ALERTS

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Maintenance alerts are based upon preliminary information from government agencies, aviation organizations, press information and other sources. The information may not be accurate.

Tail Rotor Shaft Bearing Failure Cause Of Helicopter Accident

The U.S. National Transportation Safety Board (NTSB) investigated a non-fatal, hard-landing accident involving an emergency medical service (EMS) helicopter after the pilot experienced loss of directional control. Post-accident examination of the Agusta A109A helicopter's drive train indicated that the loss of directional control was caused by failure of the number three tail rotor drive shaft support bearing because of lack of lubrication. The rotational damage to the tubular driveshaft in the area of the number three bearing had caused the driveshaft to separate at the bearing journal, resulting in a loss of directional control when collective pitch was applied to cushion the landing of the rotorcraft.

The failed bearing, part number 109-0424-01-3, had been developed by the manufacturer and was offered to Agusta A109A operators to relieve periodic inspection and 600-hour lubrication requirements on the original (-01-1) bearing. The newer (-01-3) bearing had no recommended overhaul limit or periodic lubrication requirement, although a daily visual examination of all seven of the tail rotor driveshaft support bearings and a more detailed visual examination at 1,800 operating hours was specified.

Examination of the records of the accident aircraft revealed that the bearings had accumulated about 1,675 operating hours at the time of the accident. Examination of the remaining six bearings also revealed signs of overheating because of inadequate lubrication.

The NTSB has recommended a one-time inspection of all Agusta A109A series tail rotor driveshaft support bearings for evidence of overheating or inadequate lubrication. The agency has further recommended that the manufacturer establish a periodic inspection and lubrication interval for the support bearings.

Human Factors Cited In Engine Failure Accident of DC-10

The U.S. National Transportation Safety Board (NTSB) final report covering the much publicized accident involving the DC-10-10 that suffered a catastrophic failure of the tail-mounted engine was recently released. The NTSB determined that the probable cause of the accident involving United Airlines Flight 232 was the inadequate consideration given to human factors limitations in the inspection and quality control procedures used by the operator's engine overhaul facility. The investigation disclosed that the inspector(s) failed to detect a fatigue crack originating from a previously undetected metallurgical defect located in a critical area of the stage one fan disk.

There had been six maintenance inspections of the accident fan disk, including an inspection 760 cycles before the accident. Although the operator's selection, training and qualification of inspection personnel was found to be consistent with industry practices and in compliance with regulatory standards, examination and testing of the recovered portions of the failed disk confirmed that the crack had existed at the time of the previous inspection(s) and could have been detected by the nondestructive inspection (NDI) processes then utilized.

As a result of these findings, the NTSB issued Safety Recommendation A-90-117 which stated in part, "… it is clear that the adequacy of the inspections is dependent upon the performance of the inspector. That is, there are human factors associated with the NDI processes that can significantly degrade inspector performance. Specifically, NDI inspectors generally work independently and receive very little supervision. Moreover, there is minimum redundancy built into the aviation industry's fluorescent penetrant inspection (FPI) process to prevent human error or other task or workplace factors that can adversely affect inspector performance.

Because of these and other similar factors, the Safety Board is concerned that NDI inspections in general, and FPI in particular, may not be given the detailed attention that such a critical process warrants." One of the key factors mentioned in the NTSB recommendation was providing redundant inspection oversight (second set of eyes) for critical part inspections.

The NTSB had previously addressed the issue of human factors in NDI inspector reliability following the Boeing 737 fuselage failure accident near Maui, Hawaii, in 1988. The

NTSB has called upon the U.S. Federal Aviation Administration (FAA) and the aviation industry to intensify research to identify emerging technologies for non-destruction inspections that simplify or automate inspection processes, and improve techniques and equipment.

The flight crew's actions as a result of Flight 232's fan failure are detailed in the June issue of FSF's *Accident Prevention* safety bulletin.

Maintenance of Emergency Equipment Cited as Safety Factor

The collision of a Boeing 727 and a McDonnell Douglas DC-9 at the Detroit Metropolitan airport in Romulus, Mich., U.S., resulted in several passenger fatalities on the DC-9. During the investigation conducted by the U.S National Transportation Safety Board (NTSB), it was found that the aft tail cone exit did not deploy and one flight attendant and a passenger succumbed from smoke inhalation in the area of the tailcone exit.

Examination of the tail cone release mechanism and testing of the system disclosed that it would not jettison with the specified pull on the release handle. Several problems in the design and maintenance of the tail cone release mechanism on this particular type of aircraft have been addressed by the NTSB, the U.S. Federal Aviation Administration (FAA) and the aircraft manufacturer.

A review of this accident can serve as a particularly vivid illustration of the critical importance of proper maintenance and inspection of emergency equipment. Emergency equipment is rarely used, and most airplanes go through their entire useful life without ever having an emergency exit used in a "real" survival situation. However, as this unfortunate accident proved, every piece of emergency equipment must operate freely and correctly the first time — there may be no second chance.

Door Trouble Defies Crew

While the McDonnell Douglas DC-10 was cruising at FL370 en route from Denver, Colo., U.S., to Boston, Mass., the center cargo compartment "B" warning light illuminated. The "irregular" procedures were followed and everything appeared to be normal.

Approximately 10 minutes later, the center cargo compartment warning light again went on. The same procedures were again followed. While discussing the situation with the first and second officers, the captain was told that maintenance had been pulling and resetting the circuit breakers on the door system and then had trouble closing the door.

The crew decided to descend to 15,000 feet and continued to the destination airport. Maintenance replaced a connector at the door-close-limit switch.

Multiple Problems Ground Mooney

The pilot of the Mooney M20K was on a flight from Biggin Hill to Bembridge, U.K., with one passenger aboard.

When the pilot switched on the weather radar, the aircraft lost electrical power. The pilot continued the flight while he tried unsuccessfully to restore electrical power. He headed for Lydd airport and, as he approached that facility, the engine began to run roughly.

With no radio available, the pilot flew back and forth to the south of the airport to get the attention of the tower controllers. He then flew directly at the tower at a height of about 800 feet before climbing out to the south again. The engine began to lose power and the pilot decided to land as soon as possible. He selected gear down using the normal system and made an approach for landing while watching the control tower for visual signals. The pilot observed no signals and landed — with the gear up. The pilot and his passenger departed the aircraft without injury.

Later examination revealed that the battery charge was low, the alternator was not producing any charge and the engine turbocharger was inoperable. Adding to the mechanical condition of the aircraft was the fact that the light signalling equipment in the control tower was not operating properly and the controllers were not able to warn the pilot that they saw that the gear was retracted.♦

NEW PRODUCTS

Magnetic Sweepers Reduce Litter and Extend Tire Life

The O. S. Walker Co. Inc. of Worcester, Mass., U.S., has published an eight-page brochure describing a line of magnetic sweepers for use by hand

Photograph not available.

or for mounting on vehicles normally used in ramp and shop areas.

The manufacturer claims that these magnetic sweepers will collect ferrous metal objects which might otherwise be ingested into turbine engines or cause damage to tires of aircraft and ground vehicles. Various models include both permanent magnet types which require no external power, and electromagnetic units, either of which may be towed or suspended below existing vehicles. Units are offered in sizes said to be capable of sweeping widths from six inches to 10 feet in a single pass.

For more information, contact O.S. Walker Co. Inc., Rockdale St., Worcester, MA 01606 U.S. Telephone: (508) 852-8649.

Video Analyzer Enhances Remote Visual Inspection

Industrial Fiberoptics Division of the Olympus Corp. has developed a video analyzer unit for use with borescopes, fiberscopes or video-imaging equipment. The unit is portable and can be powered by a self-contained battery pack in any environment, according to the manufacturer.

The model VA-2 combines an eight-inch color television monitor with a sealed alphanumeric membrane keyboard, menu-driven, built-in software, 100-megabyte hard disk and a three and one-half inch floppy disk drive. The unit couples with any NTSC-standard video camera to process images derived from various inspection devices.

Photograph not available.

The manufacturer claims that the unit provides the ability to view the actual image or to manipulate the image to enhance desired details. Images can be stored in digitized format complete with textual comment, measurement data, and other user- imprinted text. With the optional modem feature, the unit is said to be capable of transmitting images to another similar unit by dial-up telephone line.

For additional information, contact the Olympus Corp., IFD, 4 Nevada Drive, Lake Success, N.Y., U.S. 11042. Telephone: (800) 446-5260.

Safety Cable — An Alternative to Lockwire

Bergen Cable Technologies, Lodi, N.J., U.S., has developed a new fastener retention system for aircraft and engine assembly that is said to be faster, safer, and easier to learn than conventional lockwiring of bolts, the industry standard since the early 1900s.

Developed in conjunction with the General Electric Aircraft Engine Group, the safety cable system is claimed to reduce fastening time by 50 percent. Pre-twisted safety cable is intended to be installed anywhere on an aircraft where lockwire is presently used. It comes in various lengths of .020, .032 and .040 thousandths inch diameter of stranded stainless steel cable with a fitting crimped to one end. The cable is installed with a specially designed tool, which is claimed to fit into tight spaces and to minimize operator fatigue.

Photograph not available.

Installation procedures call for the operator to thread the safety cable through the fasteners the same as is presently done with lockwire. The special tool then tightens the assembly and automatically crimps a fitting to the other end of the safety cable and cuts the excess cable flush with the fitting.

A mechanical version is available for small volume users and a pneumatically powered version is available for high-volume, repetitive operations in production environments.

For more information, contact Bergen Cable Technologies, 170 Gregg Street, P.O. Box 1300, Lodi, NJ 07644 U.S. Telephone: (201) 487-3521, Fax: (201) 368-0532. ♦