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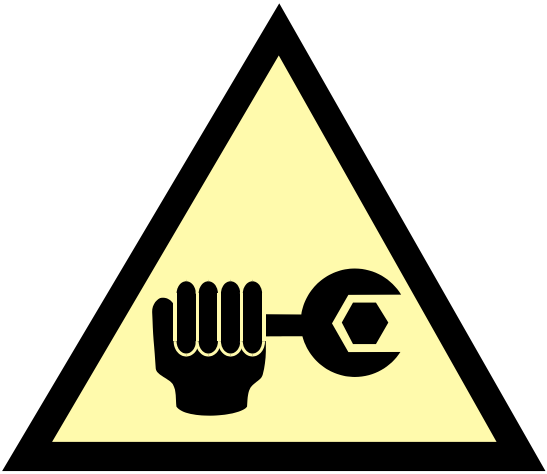

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Subscriptions: One year subscription for six issues includes postage and handling: US$240. Include old and new addresses when requesting address change. • Attention: Ahlam Wahdan, assistant to director of marketing and business development, Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: +1 (703) 739-6700 • Fax: +1 (703) 739-6708

Technicians Receive Minimal Guidance From Operators, Regulators for Managing Some Maintenance

Worldwide, aviation regulations generally do not provide rules for deferring unscheduled maintenance of some abnormal conditions on aircraft. Many maintenance organizations have no formal policies, procedures, standards or training for deferring unscheduled maintenance, and some maintenance personnel lack a complete understanding of the subject.

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Bart J. Crotty

Civil aviation authorities (CAAs) worldwide have not established regulations for control and approval of deferred maintenance for commercial operators of transport aircraft. ("Deferred maintenance," as used in this article, is defined as unscheduled maintenance that is deferred while an aircraft continues in operation.[1]) As a result, maintenance personnel who defer maintenance may have little or no guidance from regulatory authorities in making their decisions. Moreover, operators may have limited information to provide guidance for technicians in accomplishing deferred maintenance, and many maintenance personnel — although they are familiar with the term "deferred maintenance" — do not understand fully its meaning.[2]

Unscheduled maintenance action could include repair, replacement, correction, refurbishment, adjustment, testing, or inspection of an abnormal condition, a questionable abnormal condition or a suspected abnormal condition that may or may not have a direct or indirect effect on aircraft airworthiness or safety.[3]

International Civil Aviation Organization (ICAO) member nations are required to include in their CAA regulations an outline of conditions for issuance of certificates of airworthiness. The CAA conditions should be the equivalent of the ICAO international standards of *Annex 8, Airworthiness of Aircraft. Annex 8* also requires that CAA regulations govern the continuing airworthiness of an aircraft throughout its operating service life and identify the conditions under which temporary loss of airworthiness occurs.[4]

When an aircraft is issued an airworthiness certificate by the CAA of the nation in which the aircraft is registered, the certificate signifies that the aircraft was airworthy at the time of issuance — that the aircraft conformed to the type design and was in condition for safe operation.

During an aircraft's operational service life, pilots and maintenance personnel regularly become aware of abnormal conditions that could affect the airworthiness or safety of an aircraft. Usually the conditions are self-evident, such as inoperative, malfunctioning, worn or broken equipment or components. In those instances, the required corrective action is equally self-evident: Replace or repair the defective item, operationally test the item if needed, record the work performed and the approval of the work, and release the aircraft to return to service.

At other times, the nature of the actual or suspected abnormal conditions — and their effect on airworthiness or safety — is less evident. In these situations, maintenance personnel must clarify unusual, limited or ambiguous reports on abnormal conditions before they can attempt to determine the proper corrective action. If the report about the abnormal condition is accurate, objective and clear, then determining and implementing corrective action will be more effective and efficient.

Maintenance personnel must rely upon their training and experience with a particular type of aircraft or a specific condition or item, debrief the pilot or other person who reported the condition, or identify the problem by troubleshooting. For some abnormal conditions, maintenance personnel may be able to determine acceptable limits by referring to the manufacturer's technical manuals.

In addition to problems involving airframe and powerplant systems and components, abnormal conditions also may involve passenger-cabin items or aircraft-installed cargo-handling equipment, such as lavatory flush motors, galley ovens and electrically powered equipment, passenger-seat flight-attendant call systems, wiring to entertainment components, provisions to restrain or move large cargo items, and water systems.

Most CAAs outline procedures by which an operator, within limits, may be authorized to reschedule or delay specific planned maintenance inspections or servicing. These procedures, however, do not include deferring unscheduled maintenance to correct abnormal conditions.

Airlines or commercial operators usually are required by a CAA to establish and to follow a maintenance or engineering company manual or a general maintenance manual covering management, policies, procedures, practices, and company authorizations and control systems. An operator can formalize its policies on deferred maintenance if those policies and procedures are included in its manuals and if the CAA accepts or approves those manuals.

ICAO's *Annex 6, Operation of Aircraft*, and *Annex 8* do not mention deferred maintenance in discussing operator maintenance manuals. Nevertheless, safety audits of more than 100 charter operators, airlines and repair stations in North America, Europe, Asia and South America revealed that about 20 percent of those audited have established adequate control practices and management practices and have placed adequate policies and procedures for deferred maintenance in their company manuals.[5]

In the early years of aviation, decisions about what problems needed to be corrected before further flight typically were made by aircraft operators' chief engineers and mechanics. With the advent of national aviation regulations and expanded industry knowledge of design, manufacturing and service experience, some standards evolved to guide decisions on deferred maintenance and other maintenance-management processes (see "Methods of Managing Maintenance," page 4). As aircraft technology, designs, materials and performance became more complex, establishing adequate tolerances or standards for every situation involving wear, deterioration or unusual condition became more difficult.

With no specific regulatory guidance, aircraft operators' maintenance personnel typically decide when to defer maintenance. For example, if a pilot reports a vibration when the

Methods of Managing Maintenance

The following are different types of maintenance-management processes:

- Certification maintenance requirements: prescribe maintenance and inspection schedules according to analyses of system failures;
- Condition-monitoring process: collects and analyzes failure data and other information to determine a schedule for inspection and maintenance;
- Damage tolerance: determines structural inspection intervals by analyzing the growth of cracks that are assumed to occur in an aircraft structural component as a result of fatigue, accidental damage, corrosion or material defects;
- Maintenance review board: designs initial maintenance programs. Maintenance review boards are made up of representatives of the manufacturer, the civil aviation authority of the nation that will approve the type design and the airlines that will be the first operators of the aircraft. Subgroups known as maintenance steering groups generally formulate guidelines in accordance with standard documents;
- On-condition process: periodically monitors the condition of a given component and calls for replacement when standards or limits are exceeded; and,
- Reliability program: uses statistical analysis to help determine a schedule for inspection and maintenance.

In this context, "deferred maintenance" does not include use of a configuration deviation list (CDL) or a minimum equipment list (MEL):

- CDL: identifies nonstructural items, such as small cover plates, service doors, panels, fairings and cowlings, that can be missing from an aircraft while the aircraft continues in operation; and,
- MEL: allows specific items to remain inoperative for specific time periods under specific conditions. The MEL is used at the operator's discretion to keep an aircraft in operational service and to defer corrective maintenance.♦

—Bart J. Crotty

flaps are extended in flight, but maintenance personnel cannot find the cause of the vibration, and there are no airframe manufacturer's limits on allowable vibration, then the operator's maintenance personnel would decide whether to defer maintenance. If the CAA questions that decision, that question could prompt a debate between the CAA and the operator.

Similar debates would be likely in the event that:

- A cabin crew reports smelling burning material and finding discolored wiring but no evidence of fire. If maintenance technicians determine that the unit involved is working properly and if there is no guidance from the manufacturer about replacing suspected wiring, the decision on whether to defer maintenance would be made by the operator's maintenance personnel; or,

- Maintenance technicians determine, during a scheduled inspection, that a component is experiencing wear that is, nevertheless, within the maximum limit. The technicians could decide to defer replacement of the component and to release the aircraft to return to service.

During the past 40 years, CAAs have allowed commercial operators more independence in maintaining their aircraft. Deferred maintenance is advantageous to operators because they can arrange convenient times and places and the necessary staffing and material to perform corrective maintenance work.

Nevertheless, deferred maintenance has drawbacks.

ICAO issued its first guidance on deferred maintenance in 1995, in the *Continuing Airworthiness Manual*.[6] The document said, in effect, that all minor unrepaired damage should be within limits acceptable to the appropriate CAA. The document also recommended referring to structural repair manuals (SRMs) to determine acceptable limits. Within the context of the SRM, damage refers to cracks, corrosion or accidental impacts involving the primary structure. Most maintenance personnel refer to the manufacturer's SRM when they consider deferring structural damage.

The *Continuing Airworthiness Manual* does not address other conditions, such as fluid leaks; suspected wiring problems; deformation, intermittent or erratic operation of instruments, components and systems; vibration from different sources; component wear not addressed by manufacturers; and air leaks. Maintenance personnel sometimes are under pressure to make decisions about the extent of an item's deterioration and about whether the problem affects airworthiness or safe operation. Some manufacturers' manuals or reference information are better than others in providing standards for acceptable conditions, but they do not specifically address deferred maintenance.

Reported problems must be considered "fix-before-flight" conditions until a qualified maintenance person examines them and determines their

actual status. In some instances, photos should be taken by the person who decides to defer maintenance to support a report about an abnormal condition. The condition may be more serious or less serious than reported; by comparing the photo with some standard or criterion, such as a manufacturer's manual or a CAA-approved or CAA-accepted reference source, maintenance personnel may determine whether deferral is allowable. The person who signs the maintenance release or airworthiness release must be assured that the condition at the time of return to service meets CAA regulations or requirements.

Qualified maintenance personnel usually can determine if abnormal conditions are related to airworthiness or safety of flight. Nevertheless, other situations may warrant the additional expertise of a second person, such as a qualified employee of a quality control department or engineering department or a manufacturer's technical representative:

- If maintenance is deferred because a specific abnormal condition is not considered to affect adversely the aircraft's airworthiness, then a subsequent decision must be made to schedule time for corrective maintenance or to decide how to monitor the condition for possible further deterioration. The maintenance planning department or scheduling department must be included in the management process to allow scheduling of maintenance or monitoring; and,

- If maintenance is deferred, another decision must be made to determine what information should be included in a description of the abnormal condition so that records will include enough information to allow an accurate assessment of possible changes in the condition, especially if a different person conducts a subsequent inspection.

Records must be maintained to include results of periodic monitoring of the abnormal condition until final maintenance corrective action is implemented. Operators should list deferred maintenance items (abnormal conditions) in a specific section of the aircraft-carried maintenance logbook or flight logbook so that both maintenance personnel and flight crews are aware of the condition. This practice prevents flight delays in situations in which a maintenance technician or flight crewmember discovers an abnormal condition (a condition that has been identified previously as one accepted for deferred maintenance**)** and believes that the condition must be corrected before further flight.

Unless the cited condition has deteriorated, the condition should not prevent further flight of the aircraft.

Operators should have written policies and procedures that specify factors to be considered in deciding to defer maintenance actions. Because the decision process for deferring maintenance can be complicated, the people with authority to defer maintenance should receive company training on the operator's written policy and procedures.

The subject of deferred maintenance must be better understood by aircraft operators, maintenance organizations, maintenance personnel and CAAs. Better understanding — including an understanding of the technical aspects of airworthiness and safety to be considered in any decision to defer maintenance and the accepted procedures for maintenance deferral — would lay the groundwork for specific procedures, standards and training for deferring unscheduled maintenance.♦

Notes and References

1. Among the other terms used for deferred maintenance are the following: deferred rectification maintenance, carried-forward maintenance, carried-over maintenance, continued items, allowable items, maintenance deferrable, acceptable defects, and allowable deficiency.
2. In this article, deferred maintenance does not refer to the use of CAA-approved minimum equipment lists and configuration deviation lists to allow aircraft to remain in operation with specific items inoperative or missing. The term also excludes delays of scheduled maintenance activities that may be part of maintenance or inspection programs or schedules.
3. "Abnormal condition" means an item that is damaged (cracked, fractured, broken, corroded, distorted, burned, etc.); deteriorated; inoperative; unserviceable; missing; malfunctioning; leaking; worn; vibrating; or emitting hazardous odors or unusual noises. The abnormal condition would not have existed when the aircraft was issued its first airworthiness certificate, and the degree of the abnormal condition would be determined to be beyond the limit established by the manufacturer or beyond the limit of good judgment. Abnormal conditions can become apparent during operational service, during scheduled maintenance, during servicing

of the aircraft or while preparing to place the aircraft in storage or to remove the aircraft from storage. Abnormal conditions generally are reported in writing, but oral reports also are possible.

4. The following International Civil Aviation Organization (ICAO) annexes, documents and manuals cover areas of contracting states' responsibilities or regulations related to aircraft maintenance, maintenance personnel or organizations performing maintenance: *Annex 8, Airworthiness of Aircraft; Annex 6, Operation of Aircraft; Annex 1, Personnel Licensing; Continuing Airworthiness Manual* (Doc. 9642-AN/941), which provides explanatory material about the concept of continuing airworthiness and guidance about proper control of continued airworthiness; and *The Continuing Airworthiness of Aircraft in Service, Circular 95*, which contains codes of airworthiness used by contracting states and methods of handling information related to service difficulties, defects and airworthiness directives.

5. The author conducted the safety audits, including 55 audits in the past two years. Of the total of more than 100 audited operations, about 20 percent had adequate provisions for management of deferred maintenance, another 20 percent had substandard management provisions, and 60 percent had no management provisions.

6. *ICAO. Continuing Airworthiness Manual* (Doc. 9642-AN/941), Part IV, Chapter 3, "Maintenance of the Validity of the Certificate of Airworthiness." Montreal, Canada, 1995.

About the Author

Bart J. Crotty is an airworthiness, maintenance and safety consultant and chairman of the maintenance human factors committee of the International Society of Air Safety Investigators. He is a former U.S. Federal Aviation Administration (FAA) airworthiness inspector and trainer and a former International Civil Aviation Organization airworthiness specialist. Crotty has worked for repair stations, airlines, a large aircraft manufacturer, law firms, consulting firms, a safety organization and several national civil aviation authorities. His career spans 39 years, with about half of that time in countries other than the United States. He has an FAA

airframe and powerplant mechanic certificate and a bachelor of science degree in aeronautical engineering. Crotty resides in Springfield, Virginia, U.S.

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Casting Defect in GE CF6-80A Engine Blamed for Fatigue Crack Growth

The flight crew of a Boeing 767 heard a "bang" during the takeoff roll and rejected the takeoff from an airport in Australia. The airport safety officer and fire fighters found fuel and engine components on the runway, and the airplane was towed to the company maintenance facility, where metal particles were found in the engine's tailpipe. The engine was replaced.

The failed General Electric CF6-80A engine was subsequently disassembled, and investigators determined that a blade in the second-stage high-pressure turbine (HPT) had failed, causing catastrophic secondary damage to other engine parts, said the report by the Australian Transport Safety Bureau, formerly the Bureau of Air Safety Investigation.

"The manufacturer's design features for failure containment prevented damage to the aircraft or other systems by trapping high-velocity debris within the engine," the report said. "Some low-velocity debris was ejected from the tailpipe."

The blade failure was attributed to fatigue cracking, which was initiated at "a discontinuity created by a casting defect in a cooling-air channel web within the region of the blade firtree root," said the report.

The bureau recommended that General Electric identify the source of the casting defect of the failed HPT blade and review the turbine-blade manufacturing process to reduce the risk that blades with casting defects will be released into service.

Operator Changes Maintenance Procedure After Part Falls From B-757, Striking House

A Mansfield, England, homeowner told authorities in early December 1999 that his back door had been struck by a 25-pound (11-kilogram) metal object, about 1.5 meters (5 feet) long and 0.5 meters (1.6 feet) wide. Two days later, a maintenance technician at London (England) Heathrow Airport was conducting a ramp inspection when he noticed that the strut-to-aft fairing-seal assembly was missing from an engine pylon on a Boeing 757.

An analysis by the airline, which was not identified in the report by the U.K. Air Accidents Investigation Branch (AAIB), revealed that the seal had

fallen from the airplane as it was flown over Mansfield on a flight from Heathrow to Glasgow, Scotland. The crew was unaware that the seal had detached.

The detached part forms a seal between the afterbody fairing, which is part of the engine, and the engine pylon. The assembly is installed by being slid into position from the rear so that four locating bushings engage with four slots in the lower surface of the seal assembly.

To keep the seal in position, a retention bushing fixed to the seal assembly is inserted into a hole in the afterbody fairing, and a bolt is inserted through the bushing into an anchor nut in the engine afterbody fairing.

In a report on the incident, the AAIB said that maintenance technicians found no evidence that the seal retaining bolt had been engaged, and the bolt was not recovered. The associated engine had been changed in November 1999, and that was the last time the seal was disturbed.

After the incident, the airplane operator began requiring that a hole be placed in the bolt to allow the bolt to be wirelocked or that the airplanes be equipped with a different type of bolt with a hole for the same purpose.

FAA Orders Change in Flight Manual for Some Learjet Model 45s

The U.S. Federal Aviation Administration (FAA) has ordered revisions of the airplane flight manual for certain Learjet Model 45 airplanes to provide new instructions for exterior preflight inspections and ground operations.

The revisions are intended to provide crewmembers with procedures to detect uncommanded brake-application conditions during taxi and takeoff, the FAA airworthiness directive (AD) said. The condition could result in a wheel/brake fire or a rejected takeoff at high speed, or both.

The flight manual revisions apply to all Learjet Model 45 airplanes that are equipped with a Crane Hydro-Aire brake control unit, part number 42-933-2, the AD said.

FAA issued the AD after a report of an incident involving an uncommanded brake application that was not annunciated in the cockpit. The uncommanded action involved a dragging brake after the pilot released the parking brake.

"Not realizing the severity or cause of the problem, the pilot increased the thrust control to taxi the airplane," the AD said. "During takeoff, the airplane

failed to accelerate properly, and the pilot rejected the takeoff. After the airplane returned to the ramp, investigation revealed that one or more brake pistons had failed, causing a small brake-oil fire."

The manufacturer issued temporary flight manual changes April 6, 2000, providing instructions on the detection of possible brake problems during preflight inspections and ground operations. The manufacturer also is developing a modification to address the braking problem.

The AD, which took effect May 15, requires operators of the affected airplanes to incorporate the temporary flight manual changes into the limitations and normal procedures sections of their airplane flight manuals by May 25, 10 days after the effective date.

FAA Orders Inspections Of B-727s for Cracks in Exterior Body Skin

The U.S. Federal Aviation Administration (FAA) has ordered operators of certain Boeing 727 (B-727) and B-727C series airplanes to inspect the airplanes' exterior body skins at the forward corners of the mid-galley door hinge cutouts to detect cracking and to take corrective action if needed.

The airworthiness directive (AD) requires that operators modify the body skin of the mid-galley door hinge cutouts.

Both actions are intended to prevent fatigue cracks in the body skin, FAA said. The cracks could reduce the structural integrity of the airplane's fuselage and lead to a loss of cabin pressurization.

FAA issued the AD after a report that, during fatigue testing of a B-727, a crack was found in the body skin at the lower forward corner of the mid-galley door hinge cutouts because of cabin pressurization cycles.

The AD takes effect June 5, 2000, for B-727 and B-727C series airplanes with line numbers 153, 290 and 339. FAA estimated that three airplanes of U.S. registry are affected by the AD but that 1,516 airplanes of the affected design are being operated worldwide.

The AD requires that the inspections be conducted before the airplanes accumulate 60,000 flight cycles, or within 3,000 flight cycles of the date the AD takes effect. The inspections should be conducted in accordance with Boeing Service Bulletin 727-53-0054, Revision 1, which was issued Nov. 16, 1989.♦

Slow-starting Screwdrivers Prevent Cross-threading of Screws

A slow-start option is being offered for ASG electric torque-controlled screwdrivers to help prevent cross-threading of screws, said the manufacturer.

CB-10SS Slow-start Control Box

ASG said that its CB-10SS slow-start control box varies the length of time that the screwdriver takes to reach full speed. The time can be adjusted from 0.01 second to 4.01 seconds. The CB-10SS works with any ASG power-control box.

For more information: ASG, 15700 South Waterloo Road, Cleveland, OH 44110-3898, U.S. Telephone: +1 (216) 486-6163.

Heavy-duty Baskets Introduced for Cleaning Small Parts

Heavy-duty non-galvanized steel baskets have been introduced for cleaning and storing small parts.

The baskets can be used with caustic cleaners, mineral spirits, aqueous and ultrasonic cleaners and light-duty blasters, said the manufacturer. Small holes give the baskets an open area of 63 percent. The bottoms of the baskets and the flip-top caps are made of plastic.

Heavy-duty Baskets

Two models are available, both 7.25 inches (18.4 centimeters) high; one model has a diameter of 2.25 inches

(5.7 centimeters) and the other, a diameter of 4.375 inches (11.1 centimeters).

For more information: Cuba Specialty Mfg. Co., P.O. Box 195, Fillmore, NY 14735, U.S. Telephone: (800) 991-2822 (U.S.) or +1 (716) 567-4176.

Flexible Abrasive Tapes Polish Hard-to-reach Surfaces

Flexible flat abrasive tapes can reach around machined, drilled or punched openings and are designed for grinding, deburring and polishing hard-to-reach surfaces, said the manufacturer.

Flat Abrasive Tapes

Mitchell's Flat Abrasive Tapes are impregnated with aluminum oxide or silicon carbide abrasives. They are packaged on 50-foot (15-meter) spools and are available in widths of 1/16 inch (0.16-centimeter) or 1/4 inch (0.6-centimeter). Round abrasive cords from 0.012-inch (0.30-millimeter) to 0.15-inch (3.8-millimeter) in outside diameter also are available.

For more information: E.C. Mitchell Co., Michael D. Kelly, Marketing, 88 Boston St., Middleton MA 01949-0907, U.S. Telephone: +1 (978) 774-1191.

Portable Battery Chargers Designed for Corrosive Environments

Two industrial-grade portable battery chargers are available to charge batteries safely during the bulk, absorption and float (or maintenance) stages, said the manufacturer. Guest chargers 2606-B and 2612A-B are designed for use

Portable Battery Chargers

in corrosive, hostile environments and are potted in waterproof, shockproof epoxy to protect their electronics. The 2606-B, which provides an output of six amps, and the 2612A-B, which provides 10 amps, work with a range of 12-volt batteries.

The company also has introduced three new maintenance chargers to keep batteries fresh during periods in storage.

For more information: Guest International, 95 Research Parkway, Meriden, CT 06450, U.S. Telephone: +1 (203) 235-4421.

Angled Eyepiece for Borescopes Gives Wearers a Side View

The Hawkeye Angled Eyepiece AE9003, designed for inspectors and maintenance technicians who use borescopes in close quarters and do not have enough headroom for comfort, lets wearers look at an object from a more comfortable position, the manufacturer said.

Hawkeye Angled Eyepiece

The angled eyepiece clamps onto the borescope eyecup and reflects the image 90 degrees. The eyepiece has adjustable focusing and works with any rigid borescope or flexible borescope.

For more information: Gradient Lens Corp., 207 Tremont St., Rochester, NY 14608, U.S. Telephone: (800) 536-0790 (U.S.) or +1 (716) 235-2620.

Anti-corrosion Compounds Protect Aerospace Metals

A line of corrosion-inhibiting compounds has been designed to protect commonly used aerospace metals and alloys, said the manufacturer.

Five Dinitrol AV products are intended for use on airframes to protect areas exposed to corrosion-causing conditions. The products can be applied by dipping, brushing or spraying, said the manufacturer.

For more information: Dinol, Box 149, S-281 22 Hassleholm, Sweden. Telephone: + 46 451 88000.

Retainers Help Keep Protective Eyewear In Place

Willson Croakies retainers keep protective eyewear secure and in place and can be used with any brand of protective eyewear, said the manufacturer.

The retainers have an adjustable bead or a slide to allow a custom fit that prevents eyewear from slipping or moving. During work breaks, the retainers allow the wearer to remove the protective eyewear so that it hangs comfortably, said the manufacturer.

For more information: Dalloz Safety, 2nd and Washington streets, P.O. Box 622, Reading, PA 19603-0622, U.S. Telephone: +1 (610) 376-6161.

Heat-shrink Tubings Protect Cables, Electronic Components

Two new heat-shrink tubing products have been introduced to insulate and protect cables, harnesses and electronic components.

Raychem Interconnect said that ZHTM thick-wall and ZH-100 thin-wall 2:1 shrink ratio flexible tubings are low-fire-hazard products designed for aerospace and other transportation uses. ZH-100 thin-wall flexible tubing is intended for use in enclosed spaces or in spaces where toxic fire emissions would endanger safety or sensitive equipment. Both products can be used in temperatures ranging from –30 degrees to 105 degrees Celsius (–22 degrees to 221 degrees Fahrenheit).

For more information: Raychem Interconnect, 300 Constitution Drive, MS 110/7568, Menlo Park, CA 94025, U.S. Telephone: (800) 926-2425 (U.S.) or +1 (650) 361-3333.

Portable Evaporative Cooler Lowers Workplace Temperatures

The Coolspace portable evaporative cooler is designed for spot cooling in open spaces, including aircraft hangars and service facilities, the manufacturer said.

The cooler, which is available with a 36-inch (91-centimeter) fan in a single-speed model and a three-speed model, uses evaporative cooling pads to reduce air temperatures by as much as 26 degrees, the manufacturer said. The unit operates with a 115-volt electrical supply and a garden hose to supply water.

For more information: Advanced Radiant Systems, 12910 Ford Drive, Fishers, IN 46038, U.S. Telephone: (800) 557-5716 (U.S.) or +1 (317) 577-0337.♦