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Atmospheric Monitors Show Safety of Environment For Workers in Airplane Fuel Tanks

Sensors detect hazardous concentrations of jet-fuel vapor and other toxic substances that present the risk of an explosion and endanger the health of maintenance technicians.

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FSF Editorial Staff

For their health and safety, maintenance technicians who repair and clean airplane fuel tanks must know what is in the air around them as they do their work. Generally, they rely on atmospheric monitors to detect the presence of jet-fuel vapor in concentrations high enough to present the risk of explosion, to ensure that an adequate concentration of oxygen is present and — in some situations — to measure concentrations of toxic substances in the atmosphere.

Conventional combustible-gas monitors, known as lower explosive limit (LEL) monitors[1], are descendants of the portable combustible-gas indicators developed in the early 1800s for use in underground mines in Great Britain. The indicators alerted miners when the concentration of methane or carbon monoxide in the air was too high and when the concentration of oxygen was too low.[2] (Before the indicators were developed, miners relied on caged canaries or other small animals that were carried into the mine; if the sensitive creatures died, miners knew that the atmosphere in the mine was deteriorating and that if they did not leave, then they, too, might die.) LEL monitors were introduced into U.S. aviation maintenance on a widespread scale beginning in 1993, when the U.S. Occupational Safety and Health Administration (OSHA) adopted regulations governing work that is performed in confined spaces.[3]

Airplane fuel tanks meet the OSHA definition of a confined space: an area large enough to enter and in which to perform work but one that is equipped with limited or restricted means of entry and exit and that is not designed for continuous human occupancy.

Another type of atmospheric monitor, known as a photo-ionization detector (PID), was developed in the 1960s and 1970s, initially for use in environmental cleanup work.[4] Technological advances in the early 1990s led to production of smaller and more rugged PIDs that could be used during work in confined spaces, such as airplane fuel tanks, to monitor the effectiveness of ventilation controls and to determine the need for personal protective equipment for workers in hazardous situations.[2]

The OSHA confined-space regulations that prompted widespread use of atmospheric monitors by maintenance technicians who work on airplane fuel tanks require certain conditions to be met before workers may enter those confined spaces, including:

- The oxygen concentration within a confined space — such as a fuel tank — must be at least 19.5 percent and no more than 23.5 percent;
- A flammable gas, vapor or mist may not be present at more than 10 percent of LEL; and,
- No substance — such as jet fuel, a sealant or a solvent being used by a maintenance technician — that is defined as a toxic or hazardous substance may be present in excess of its permissible exposure limit. OSHA has not determined permissible exposure limits for all substances; instead, the agency suggests that companies consult material safety data sheets provided by chemical manufacturers and establish their own limits.[3]

Similar regulations exist in many other countries, although specific requirements vary from one jurisdiction to another.

Confined space monitors that measure combustible gases and vapors, as well as oxygen concentration, are used to comply with regulations. If the oxygen concentration is more than 23.5 percent (per OSHA), then the atmosphere is considered oxygen rich, and explosions or flash fires are more likely to occur. If the oxygen concentration is below 19.5 percent (per OSHA), the atmosphere is considered oxygen deficient. People in an oxygen-deficient atmosphere can experience headache, nausea, sleepiness and, ultimately, loss of consciousness and death.[6]

PIDs and LEL monitors measure atmospheric concentrations of jet fuel and other flammable gases, vapors and mists. (High concentrations of these substances in the air can lead to an explosion; long-term exposure to lower concentrations has been linked to a variety of health problems.) Jet-fuel vapor is difficult to measure, but PIDs can detect the vapor at lower concentrations than conventional LEL monitors, and PIDs are especially designed to measure hydrocarbons and volatile organic compounds, which are present not only in jet fuel but also in paints, degreasers and solvents that are used in aircraft maintenance.

LEL sensors operate by using a Wheatstone bridge, which resembles an electric stove with two burner elements — one element with a catalyst and the other without a catalyst. When the monitor is activated, a battery supplies current to the Wheatstone bridge circuit to heat the two elements. Combustible gases diffuse through a filter and come in contact with the elements. Gases that can be oxidized by the catalyst then burn on the element with the catalyst but not on the element without the catalyst. The element with the catalyst burns gas at a low level and becomes hotter than the element without the catalyst. The hotter element has more resistance, and the Wheatstone bridge measures the difference in resistance between the two elements. The resulting measurement indicates the concentration of the gas in the atmosphere.[2,5]

LEL sensors generally are calibrated on methane, pentane, propane or hexane, and all readings on the monitors are relative to the specific calibrant gas. When a gas other than the calibrant is present, a monitor with an LEL sensor reacts as though it were measuring the calibrant gas. A maintenance technician using a monitor with an LEL sensor then must use conversion factors or charts provided by the monitor's manufacturer to convert the monitor's numerical indication into the value that corresponds with that of the gas that actually is being measured.[2]

Generally, LEL sensors cannot detect precisely gases that have flash points of more than 100 degrees Fahrenheit (38 degrees Celsius), and the flash points for all jet fuels are in that category. (A flash point is defined as the lowest temperature at which vapor will ignite with an explosion.) Because an LEL sensor generally cannot precisely determine the concentration of high-flash-point jet-fuel vapor, the sensor may underestimate the concentration, giving maintenance technicians no warning that they are working in an area where the concentration is high enough to present a risk.[6]

Many monitors with LEL sensors provide indications in percentages of LEL, rather than in the more precise terms of parts per million. The monitors often do not display indications until a gas or vapor is present at a concentration of 1 percent of LEL or more. Thus, a lower — but still hazardous and potentially toxic — concentration of a gas or vapor may go undetected.[5]

Some chemicals commonly used in aircraft maintenance, especially silicon compounds used in sealers, lubricants and adhesives, can degrade the performance of LEL sensors. Silicon released into the atmosphere can coat an LEL sensor, leaving the device incapable of detecting accurately gases or vapors in the air. Chlorinated hydrocarbons that are used in cleaning and degreasing agents have a similar effect.[2] Corrosive gases, hot vapors and hot gases also may decrease the sensitivity of the LEL monitor; and the presence of magnetic fields, high voltage wires, static electricity, radios and cellular telephones can interfere with the accuracy of the readout.

A PID operates by using ultraviolet (UV) light to separate chemicals in their gaseous or vaporous forms into positive and negative ions. A detector then measures the charge of the ionized gas or vapor, converts the signal into current and reports its findings on the monitor in a digital display that specifies, in parts per million, the amount of gas or vapor that is present.[6]

Like LEL monitors, PIDs also produce indications that are relative to a calibrant gas chosen by the manufacturer, usually isobutylene, and conversion factors must be used to translate the numerical display into a value that corresponds with that of the gas or vapor that is actually present.[2]

Despite their sensitivity in measuring concentrations of hydrocarbon gases and vapors, PID monitors are not selective; they can measure quantities of gas or vapor but cannot determine what chemical is being measured. If the PID alarm is set for the most hazardous chemical gas or vapor — the chemical whose permissible exposure limit is lowest — then the alarm also, by default, will alert maintenance technicians to the presence of other hazardous substances.

Because the operation of a PID is based on transmission of UV light, the effectiveness of a PID monitor can be limited by atmospheric conditions that deflect, scatter or absorb the light, such as[2]:

- Water vapor or humidity, which can scatter UV light and allow less light to reach ionizable contaminants. This results in a lower meter indication. Most manufacturers have taken precautions to minimize the problem;[7]

- Dirt on the ultraviolet lamp, which can decrease the amount of UV light being transmitted and can alter meter indications. The problem can be prevented when PID users comply with manufacturers' instructions for regular cleaning of the lamp;[7] and,

- Dust particles, which can scatter and block the UV light and prevent ionizable material from coming in contact with the UV light. Some manufacturers have addressed the problem by equipping the monitors with dust filters.[7]

PIDs and LEL monitors have been used since the mid-1990s as safety devices in airplane fuel-tank maintenance to alert maintenance technicians if concentrations of jet-fuel vapor — and, in some situations, other toxic substances — are present at hazardous levels and if the oxygen concentration is not adequate. Both PIDs and LEL monitors measure atmospheric concentrations of flammable gases, vapors and mists. But PIDs are designed specifically to measure the low concentrations of hydrocarbon gases and vapors that are present not only in jet fuel but also in solvents and other substances used in fuel-tank maintenance.♦

Notes and References

1. The lower explosive limit (LEL), also known as the lower flammability limit, is the leanest mixture of a combustible gas and air that could result in an explosion if an ignition source were present.

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5. RAE Systems. *AP-200 Application Note*. Sunnyvale, California, U.S., August 1999.
6. Vendetti, Victor J.; Allen, James W. "Aircraft Fuel Tank Maintenance." *Occupational Health & Safety* (August 1999): 34–43.
7. Vendetti, Victor J., international sales and marketing manager, Mine Safety Appliances. Telephone interviews by Werfelman, Linda. Alexandria, Virginia, U.S. Nov. 11, 1999, and Dec. 15, 1999. Flight Safety Foundation, Alexandria, Virginia, U.S.

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FSF Editorial Staff. "Knowledge of Hazardous Chemicals in the Aviation Workplace Can Help Prevent Work-related Illness and Injury." *Aviation Mechanics Bulletin* Volume 45 (July–August 1997).

Feeler, R.A. "One Cure for Workplace Safety Complacency: Safety Checklists." *Aviation Mechanics Bulletin* Volume 43 (September–October 1995).

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MAINTENANCE ALERTS

NTSB Recommends Changes in MD-11 Cargo Control Units

The U.S. National Transportation Safety Board (NTSB) has recommended modifications of the cargo control units in McDonnell Douglas MD-11 aircraft as the result of a fire in the forward cargo compartment of an MD-11 that was parked at a gate at Hartsfield Atlanta International Airport, Georgia, U.S.

The NTSB investigation of the Nov. 11, 1998, fire revealed that wiring damage in an external electrical connector of the cargo control unit (CCU) led to excessive electrical current when power was applied to the CCU.

"As a result," NTSB said, "several electrical pins inside the CCU were vaporized, which created hot gases that escaped through the CCU's back cover and ignited the adjacent Mylar-covered insulation blanket."

The manufacturer of the CCU, Lucas Aerospace Cargo Systems, said that the original electrical pins have undersized diameters and use a copper alloy with higher resistance than desired. Lucas had identified the problem before the Atlanta fire and had begun installing modified connector pins on newer CCUs. Lucas also issued a service bulletin April 17, 1998, that recommended "replacing the motherboard … at the next aircraft layover where the maintenance action can be accomplished … to reduce the chances of secondary damage … as a result of an external short to ground."

The CCU involved in the Atlanta incident had not been modified.

Data compiled by Lucas showed that 43 CCU failures had been reported since 1993 involving pin failures and other internal electrical problems. All but one of the failures involved pins of the original design.

The airplane involved in the Atlanta incident received minor damage; no passengers or crewmembers were aboard the airplane at the time of the fire.

NTSB is investigating two other incidents involving failures of the Lucas cargo control system on MD-11s. During the investigation, the Boeing Commercial Airplanes Group said that the company would issue a service bulletin to recommend installation of nonflammable material between the CCU and the adjacent Mylar-covered insulation blanket. (Boeing acquired McDonnell Douglas in 1997.)

In a letter to the U.S. Federal Aviation Administration (FAA), NTSB recommended that FAA issue an airworthiness directive to require operators of MD-11s to modify their CCUs as outlined in the Lucas service bulletin. NTSB also recommended that FAA:

- Issue an airworthiness directive to require MD-11 operators to "install a protective thermal barrier behind the cargo control unit in accordance with Boeing's service bulletin immediately upon its release;" and,
- Require Boeing to modify the MD-11 cargo control system circuit protection to decrease the likelihood of electrical fire.

Inspections of Wiring, Fuel Lines Recommended on Beech 1900s

The Australian Bureau of Air Safety Investigation (BASI), citing a post-landing fire in a Beech 1900, has recommended inspections of the wiring and fuel lines in all Beech 1900s. BASI asked both the Australian Civil Aviation Authority and Raytheon Aircraft to alert operators of Beech 1900s to initiate the inspections and recommended to the U.S. Federal Aviation Administration (FAA) that FAA take similar action.

"Certain electrical wiring in the wings of Beech 1900 airplanes may have missing or ineffective loom restraint, allowing contact with adjacent fuel pipes and resulting in a high risk of arcing and fire," BASI said.

BASI's action followed a September 1999 fire that began soon after a Beech 1900 landed at the airport in Williamstown, Australia. As the flight crew prepared to taxi the airplane to the gate, they observed that the master warning light, the right alternating current (AC) electrical bus warning light and the right low fuel pressure warning light were illuminated. After completing company checklist actions for the AC electrical bus failure, the first officer smelled smoke and saw flames beneath the right engine nacelle. Crewmembers observed no fire-warning indicators during the incident. The captain stopped the airplane, both engines were shut down, both engine fire "T" handles were operated, and unsuccessful attempts were made to discharge the right-engine fire bottle before the passengers were evacuated. Two maintenance engineers awaiting the airplane's arrival saw the flames and ran toward the airplane carrying hand-held dry-chemical-powder fire extinguishers, which they used to extinguish the fire.

Investigations determined that two "substantial" fuel leaks from fuel lines outboard of the right-wing engine nacelle had fed the fire and that a breakdown in the insulation on a landing light power wire had allowed the wire to arc against a fuel transfer tube, causing a hole in the tube. Heat from the resulting fire apparently melted the insulation on other wires, which then came into contact with the fuel supply tube, and leaking fuel from that tube further intensified the fire.

"This fire could have quickly intensified to a point where the aircraft would have been destroyed," BASI said. "Had the fire occurred in flight, the intensity — and therefore the risk of loss — would have been much greater."

BASI said that the design of fuel plumbing and electrical wiring in panels 531AT and 631AT of the Beech 1900 wing had "some serious shortcomings:

- "Once the integrity of the two fuel pipes is breached, there is no means available to the crew to shut off the flow of fuel;
- "There is no fire-warning indication or protection in this [location] to alert the crew to a problem;
- "There is no indication that a serious problem exists until the resulting fire damages electrical and monitoring components of other systems (such as the right AC bus failure and right fuel pressure low indications observed by this crew); [and,]
- "An airborne fire in this location would place the wing spar at high risk of rapid and severe fire damage and ultimately lead to the in-flight loss of a wing."

Landing Gear Problem Reported on Fairchild Metros

Fairchild has issued service letters establishing overhaul criteria for the hydraulic power packs on Model SA226 and SA227 Metros and for ground operating procedures after two Metros experienced uncommanded landing-gear retractions during ground operations. A report by the U.S. Federal Aviation Administration (FAA) said that each incident was traced to a malfunction within the landing-gear control valve, which is a component of the hydraulic power pack.

The repetitive overhaul procedures outlined by Fairchild's service letters are intended to eliminate the "latent failures" that led to the uncommanded gear retractions.

"These failures are not necessarily detectable in the normal landing-gear functional checks and could occur at any time on high-time hydraulic power packs unless the preventive maintenance required by the service letter is performed," FAA said. "Although the reported malfunctions have thus far occurred with the affected aircraft in a ground static position, it is possible that such an uncommanded gear retraction could occur during an approach if electrical power to the hydraulic power pack is interrupted."

Crack Found in Cessna Citation's Hydraulic System Reservoir

During a Cessna Citation's landing roll, a flight crew experienced a failure of the primary brake system. They used the emergency brake system and the thrust reversers to stop the aircraft. A maintenance technician saw hydraulic fluid leaking from a drain hole in the nose landing gear, and when he inspected the primary brake system, he found a four-inch crack adjacent to the forward inboard welded seam in the hydraulic system reservoir. He found no plumbing obstructions and detected no other cause for the defect. The hydraulic system reservoir was sent to Cessna for evaluation.

Hydraulic System Leak Reported on Hawker Siddely HS-125-700A

A maintenance technician saw hydraulic fluid leaking from the rear fuselage of a Hawker Siddely HS-125-700A as he was parking the airplane. He inspected the airplane and found that the fluid was leaking from the aft equipment bay, where the auxiliary power unit and other electrical panels are located. A report distributed by the U.S. Federal Aviation Administration said that after the technician cleaned the area and pressurized the hydraulic system, hydraulic fluid sprayed from an area near the left pylon. Further inspection revealed that two stainless steel hydraulic lines were rubbing against each other and that there was a small hole in one of the lines.♦

General-purpose Solvent Is Biodegradable, Nonhazardous

SkyKleen 1000 is a general-purpose cleaner for removing oil, grease and other fluids commonly used in aviation, for preparing surfaces before applying sealants or primers and for removing solvents, the manufacturer said.

SkyKleen 1000 is biodegradable; has low volatility resulting in low hazardous emissions; is noncaustic and nonflammable; and is classified by the U.S. Transportation Department as nonhazardous. SkyKleen is not odorous and is comfortable for workers to use, the manufacturer said.

For more information: TBM, 950 Kingsland Ave., St. Louis, MO 63130 U.S. Telephone: (800) 825-1128 (U.S.) and +1 (314) 721-5590 (international).

Engine-balancing Machines Enable Quick Setup

Heins Balancing Systems manufactures engine-balancing machines for turbine engines, reciprocating engines and light- to medium-jet engines. They are designed to be set up quickly, and the operation requires little training, the manufacturer said.

The turbine-engine balancing machines are available for engines manufactured by Allison, Garrett, General Electric, Lycoming, Pratt & Whitney and Turbomeca.

For more information: Heins Balancing Systems, 820 Railroad Ave., Santa Paula, CA 93060 U.S. Telephone: +1 (805) 525-5445.

Ultrasonic Portable Flaw Detectors Measure Thickness of Tanks, Piping

Krautkramer's portable ultrasonic flaw detectors are designed for a variety of measuring tasks. Two rotary knobs and menu keys control the functions, and liquid crystal display technology helps make the instrument screen easy to read, the manufacturer said.

The USM 22 model, with a frequency range of 0.5 megahertz to 15 megahertz, is suited for thickness measurements of tanks and piping, as well as for lamination tests or flaw tests on sheets and plates. The USM 25, with a selectable frequency range to 20 megahertz, can be used for weld testing and other applications.

Portable Ultrasonic Flaw Detector
Krautkramer Branson

For more information: Krautkramer Branson, 50 Industrial Park Road, Lewistown, PA 17044 U.S. Telephone: +1 (717) 242-0327. Web site: www.krautkramer.com.

Firm Offers Grommet Edging to Shield Wires, Cables

Device Technologies has designed Spring-Fast composite grommet edging to solve problems of frayed or exposed wires. Composite grommet edging smooths the sharp edges that come in contact with wires and protects wires and cables from abrasion.

Spring-Fast composite grommet edging locks quickly onto two-axis contours and four-axis contours with pressure applied by hand, eliminating the need for solvents, adhesives, ancillary materials and volatile organic compounds, the manufacturer said.

For more information: Device Technologies, 3 Brigham St., Marlborough, MA 01752 U.S. Telephone: (800) 669-9682 (United States) and +1 (508) 229-2000 (international). Web site: www.devicetec.com.

Ramp Test Set Assesses Weather/Wind Shear Radar

MPD Technologies' WRT-100 weather/wind shear radar ramp test set simulates weather, turbulence and wind shear conditions on the flight line to check proper operation of aircraft radar systems before daily operations.

The system performs a thorough test of the aircraft radar system and records radar parameters and antenna patterns. By comparing antenna patterns with those recorded in previous tests, the system can determine the necessary level of repairs, the manufacturer said.

For more information: MPD Technologies, 49 Wireless Blvd., Hauppage, NY 11788 U.S. Telephone: +1 (516) 231-1400.

Protective Masks and Tapes Safeguard Radomes, Leading Edges

PM Research's polyurethane erosion-protective masks and protective tapes are designed to shield radomes and leading edges.

The protective masks and tapes are 0.012 inch (0.30 millimeter) thick, and after they are applied, they are nearly invisible, the manufacturer said. The masks are available for more than 200 models of aircraft and can be installed in about 15 minutes to 30 minutes.

For more information: PM Research, 4110 Niles Hill Road, Wellsville, NY 14895 U.S. Telephone: +1 (716) 593-3169. Web site: www.pmresearchinc.com.

Air-purifying Respirators Provide Several Hours of Airflow

Dalloz Safety has introduced the Marathon and Turbopak powered air-purifying respirator systems with panoramic, distortion-free lenses.

The Marathon respirator system provides airflow for up to eight hours and has a field replaceable power cord and a low-cost single filter with a dual-function cover, the manufacturer said. The Marathon respirator is interchangeable with supplied air, air purifying and belt-mounted powered air-purifying respirator versions.

The Turbopak system also delivers airflow for up to eight hours. The Turbopak is compact, requires no power and is equipped with a single filter and a nickel cadmium battery and battery charger.

For more information: Dalloz Safety, P.O. Box 622, Reading, PA 19603 U.S. Telephone: +1 (610) 371-7865. Web site: www.cdalloz.com.

Recycling Parts-washer Limits Solvent Waste

SystemOne Technologies' recycling parts-washer delivers cleaning solvent, recovers used cleaning solvent and eliminates cleaning-solvent waste. Each parts-washer includes a wash basin that supports up to 500 pounds (227 kilograms) and a distillation chamber and a condenser to recycle used solvent for future use.

Each SystemOne parts-washer eliminates about 300 gallons (1,136 liters) of hazardous waste per year, the manufacturer said.

For more information: SystemOne Technologies, 8305 NW 27th St., Suite 107, Miami, FL 33122 U.S. Telephone: +1 (305) 593-8015.♦