The full implications of shattered or burning fiber composite materials sometimes are not considered adequately in the protective measures, strategies and tactics of civilian aircraft rescue and fire fighting (ARFF) services and accident investigators, says a report by the Australian Transport Safety Bureau (ATSB). Tapping readily available information, however, airports and airlines can raise awareness of composite-specific risks before conducting evacuations/rescues from damaged large commercial jets, aircraft fire fighting, accident investigations and site cleanup operations. The report also discusses fiber composites in light general aviation aircraft and military aircraft, and accident investigation techniques for all types of composite aircraft.

Since the earliest industry experience with fiber composites 50 years ago, standards have evolved in aircraft design, manufacturing and maintenance that enable the aerospace industry to safely capitalize on composite materials’ greater strength and stiffness, lighter weight, durability and resistance to fatigue relative to aluminum and other metals (ASW, 3/07, p. 17). Fiber composite refers to laminates made of alternating layers of long, strong reinforcing fibers — usually glass or carbon — woven into a ply with a binder, a tough plastic glue that shapes the fibers into a carbon/epoxy or glass/phenolic matrix, for example. The binder also bonds the plies of matrix together into stiff structures of the desired thickness. In many applications, two sheets of laminate are bound to a core of plastic foam, aluminum or Nomex honeycomb to create structures of the required shape and strength.

Material safety data sheets list the precautions for normal handling, fabricating and repair for each type of fiber composite, and those relevant to other possible activities involving human proximity to fiber composites in fires, crashes and other emergencies.

“There is a lot of conflicting or incorrect information in the aviation community about the safety and capability of fiber composite
Australian study summarizes post-crash health risks from fiber composites in transport aircraft.

BY WAYNE ROSENKRANS

The report said, “First responders involved in post-crash cleanup operations [in the late 1990s] expressed concerns about the long-term effects from exposure to carbon fibers released from burning composites. Fiber dust can pose an inhalation risk similar to asbestos. Released fibers or splinters are needle-sharp and can cause skin and eye irritation. In the event of a post-crash fire, smoke and toxic gases are also released from decomposing composites, presenting further health risks.”

From the standpoint of firefighter/investigator response to transport aircraft crashes, a rule-of-thumb distinction between two broad categories of composites has proven useful. Major load-bearing structures and skins for fuselages, wing boxes, control surfaces and empennages typically are made of carbon/epoxy materials. Many cabin fixtures and furnishings are made of glass/phenolic materials.

The carbon/epoxy materials will “burn easily and produce thick, toxic smoke” and possibly noxious gases as the epoxy bonding matrix burns away. “Carbon/epoxy … has poor fire resistance, easily igniting and burning when exposed to fire,” the report said. “The smoke from epoxies and vinyl esters can be extremely dense, making it difficult and disorienting for first responders to fight the fire. Toxic gases produced by decomposing bonding matrix materials are one of the most serious hazards for first responders and people in the vicinity of the accident site. … The greatest [toxic gas] hazard is the carbon monoxide released in the fire … epoxy-based composites release the highest amount of carbon monoxide.”1

In contrast, the composite cabin materials have intrinsically low flammability. “Glass/phenolic structures have excellent fire-resistance properties, superior to most next-generation advanced composite materials,” the report said.
**Airborne Fiber Debris**

The report makes distinctions between crash impact/fire scenarios involving an aircraft built largely of structural composites and those involving an aircraft built primarily with an aluminum structure (ASW, 4/08, p. 37). For fiber composites, a key concern is the physical characteristics of fiber shards and debris at ground level, and fibers and dust released into the air from structures shattering during impact, explosions or fire because of potentially serious skin and eye irritation. “More importantly, glass fibers can pose an inhalation threat … if handled improperly,” the report said. “Less is known about the health effects of inhaled carbon fiber dust; however, laboratory tests show that unlike glass fibers, carbon fibers do not cause pulmonary fibrosis in animals.\(^2\)

“After an accident, fiber composite materials can reduce passenger survivability of an accident due to the unique hazards they pose. … [Composite] fibers are very small and lightweight, and are likely to be in the atmosphere. They are also easily carried by wind currents and may travel substantial distances from the crash site. … In the event of a crash and post-impact fire, it is critically important for emergency services to evacuate passengers to a location upwind of the accident and away from fiber composite debris. Timely action will minimize passengers’ exposure to these risks.”

The Australian study learned from an informal telephone survey that a disparity existed among states and emergency services in their levels of awareness of fiber composite issues in aircraft accidents. International\(^3\) and national health and safety information on relevant equipment choices, procedures and training was used extensively by military services but not consistently by civilian agencies. “This survey found that knowledge of composite hazards and appropriate response methods are very disjointed between different emergency services in different states,” the report said.

**Aircraft-Specific Briefings**

The report recommends that personnel sent to the site of a composite aircraft accident be briefed on the aircraft type and its major composite components before they begin this phase of their work. “There should not be any rush for accident investigators to enter the site until personnel have been briefed on the hazards present and the risks posed by fiber composites,” the report said.

In the current fleet of large commercial jets built since 1985 and operating in Australia, the report said, first responders and accident investigators could encounter examples of composite materials in structures such as:

- Vertical fins made of carbon-fiber reinforced plastic on the Airbus A310 and A300-600 series, and other types of composites forming the wing leading edge, control surfaces and fairings;
- Empennage, control surfaces and engine cowlings on the A320 series;
- Empennage, control surfaces, keel beam and engine cowlings on the A330/A340 series;
- A composite center wing box and an extensive list of other fiber-composite components on the A380;
Empennage, control surfaces and engine cowlings on Boeing 777s;
- Floor panels of cabins and cargo holds in 767s and some 747s;
- The fuselage and wing of the 787;
- Vertical fin box and ailerons on the Lockheed L-1011; and,
- Composite upper rudder on the McDonnell Douglas DC-10/MD-11.

In the near future, some large commercial jets also will have a new generation of engines built with composite fan blades, containment casings and cowlings. Cabin components molded from glass/phenolic materials typically comprise overhead lockers, cabin ceiling and paneling, galley structures, cabin partitions and doors, the report said.

**Dressed for Success**

Personal protective equipment should include breathing apparatus, specially designed clothing and related procedures for decontamination. Health and safety require “wearing appropriate protective equipment, protecting electrical equipment, moving bystanders away from the crash site and applying fixant solution to all damaged composite structures to limit dust dispersal.” A fixant is a substance — such as water-diluted liquid floor wax or polyacrylic acid — that traps dust and fiber dust over a wide area before the fixant has been applied to damaged or destroyed composite structures.

“After entering the crash site, the investigators’ first priority should be to prevent news media and other air traffic from inadvertently dispersing composite fiber dust over a wide area before the fixant has been applied to damaged or contaminated items. The ATSB also specifies that anything used at the accident site be suitable for on-site decontamination, so some items typically taken to the site of an all-metal aircraft crash — such as writing pads and tool kits — must be excluded. The guidelines also call for the establishment of a temporary restricted airspace in the vicinity of the accident to prevent news media and other air traffic from inadvertently dispersing composite fiber dust over a wide area before the fixant has been applied to damaged or destroyed composite structures.

“Released composite fibers are highly conductive, and their small size means that they can easily interfere with and damage electrical components.”

The report provides a comprehensive list of Australian and international source material with advice on the types of information each can provide. Among these is the ATSB’s “Fire Safety of Advanced Composites for Aircraft,” published in 2006, which “compares the fire resistance of composite materials against key criteria: time to ignition, limiting oxygen index, heat release rate, flame spread rate, smoke and toxic gas release.”

**Notes**


4. The dimensions of respirable glass fibers determine the degree of hazard. “Glass fibers with diameters smaller than 3 microns and shorter than 80 microns [0.0031 in] can be inhaled deep into the alveolar region of the lungs,” the report said. “Fibers shorter than 15 microns [0.0006 in] are cleared naturally from the lungs by cellular activity. However, glass fibers between 15–80 microns remain in the lungs and can lead to pathological effects such as pulmonary fibrosis, which causes diseases such as mesothelioma and asbestosis. Respirable fibers may in addition adsorb toxic chemicals from the decomposing matrix material, which then enter the lungs and possibly cause acute or chronic effects. Temporary skin and eye irritation can be caused by exposure to sharp, fragmented fibers longer than 4–5 microns [0.00016–0.00020 in].”