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# **FIRE SAFETY IN TRANSPORT CATEGORY AIRCRAFT: LITIGATING A POST-CRASH OR IN-FLIGHT AIRCRAFT FIRE**

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## **I. INTRODUCTION**

**F**IRES HAVE CAUSED the deaths of many aircraft passengers, even though the accidents were otherwise survivable.<sup>1</sup> Post-accident investigation indicates that often these deaths do not result from fire per se; rather, death results from the inhalation of smoke and/or other gases.<sup>2</sup>

The Federal Aviation Regulations (FAR's) set forth safety standards pertaining to aircraft fire safety.<sup>3</sup> In order to obtain an airworthiness certificate, an aircraft manufacturer must comply with these FAR's;<sup>4</sup> likewise, operators of transport category aircraft must meet certain standards in the op-

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<sup>1</sup> For purposes of this article, we define "survivable" or "impact survivable" as an accident in which passengers and crew survive the deceleration of stopping.

<sup>2</sup> See *infra* notes 140-147 and accompanying text.

<sup>3</sup> FAA Airworthiness Standards: Transport Category Airplanes, 14 C.F.R. §§ 25.-851, 25.1181, 25.1207, 25.1451 (1984).

<sup>4</sup> *Id.* at §§ 25.1 - .1587 (1984).

eration of such aircraft.<sup>5</sup> These regulations are the starting point in an analysis of fire safety liability.<sup>6</sup>

This article will discuss those FAR's which relate to aircraft fire safety in transport category aircraft.<sup>7</sup> It will then briefly focus on liability for violation of FAR's, as well as other standards of care to which investigation of aircraft cabin fires relates.<sup>8</sup> This article will conclude with a discussion of whether the FAR method of testing fire resistance increases the likelihood that passengers will survive a "survivable" accident.<sup>9</sup>

## II. CERTIFICATION STANDARDS FOR TRANSPORT CATEGORY AIRCRAFT

In order to obtain an airworthiness certificate for a transport category aircraft,<sup>10</sup> certain federal requirements must be met. These include, *inter alia*, flight capability, performance characteristics, maneuverability, stability, power plant requirements and fire protection. These standards, the Federal Aviation Regulations, have been established by the Federal Aviation Administration (FAA) and the Department of Transportation. They are published in the Code of Federal Regulations.<sup>11</sup>

### A. *General FAR's Applicable to Transport Category Aircraft*

Although a commercial aircraft may be legally produced and operated once the FARs have been satisfied, a component which meets the regulations may not necessarily meet an objective "reasonable man" standard.<sup>12</sup> Compliance alone,

<sup>5</sup> *Id.*

<sup>6</sup> *Id.* §§ 25.851, 25.1181, 25.1207, 25.1451 (1984).

<sup>7</sup> See *infra* notes 57-75 and accompanying text.

<sup>8</sup> See *infra* notes 76-105 and accompanying text.

<sup>9</sup> See *infra* notes 63, 72, 132, 154 and accompanying text.

<sup>10</sup> A transport category airplane is any airplane certificated under 14 C.F.R. § 25. FEDERAL AVIATION ADMIN., DEPT OF TRANSP., FAA GLOSSARY 40 (1975).

<sup>11</sup> Title 14, Aeronautics and Space, includes all FAR's. Section 25 governs airworthiness standards for transport category airplanes. 14 C.F.R. §§ 25.1-.1587 (1984).

<sup>12</sup> It would be a stout-hearted manufacturer indeed that would rely on having met the letter of a FAR as its primary defense at trial. In *Noel v. United Aircraft Corp.*,

therefore, may not shield a manufacturer or an operator from liability.

Several general certification standards apply to fire safety as well as other areas of flight safety. In general, to meet certification standards, the manufacturer must show that the design features of its transport aircraft are not "hazardous" or "unreliable."<sup>13</sup> The cabin must have at least one door which can be opened from outside or inside *even if* people are crowded against the door.<sup>14</sup> Furthermore, the door must be marked and located so that it can be found and operated in darkness.<sup>15</sup> Ventilation must ensure that the crew and passenger compartments are kept free from harmful concentrations of gases or vapors even with malfunctions.<sup>16</sup>

B. *Specific Fire Safety Requirements Applicable to Transport Category Aircraft*

The composition of parts which could adversely affect safety must be of suitable and durable material.<sup>17</sup> Crew and passenger compartment interior materials must meet specific

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219 F. Supp. 556 (D. Del. 1963), *aff'd in part and rem'd in part*, 342 F.2d 232 (3rd Cir. 1964), *appeal on other grounds*, 359 F.2d 671 (3rd Cir. 1966), the district court stated:

The fact that the propeller system on [the subject aircraft] was certified by FAA is certainly evidence in favor of United but it is not controlling. It did not relieve United from the continuing duty to improve its propeller system in view of the factor of human safety involved. If certification were a defense, United need never have attempted to improve its propeller system after the date of certification. United concedes that certification is not binding on the Court but that the circumstances of each case control. It would be futile to defend an auto crash for the defendant to rely on the fact that he had taken a driver's training course and held an operator's license. The defense of certification per se is equally futile.

219 F. Supp. at 574.

<sup>13</sup> 14 C.F.R. § 25.601 (1984).

<sup>14</sup> *Id.* § 25.783(b). Most transport category aircraft manufacturers base the number of doors in a given aircraft on seat capacity.

<sup>15</sup> *Id.* § 25.783.

<sup>16</sup> *Id.* § 25.831.

<sup>17</sup> 14 C.F.R. § 25.603 provides that:

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must

(a) Be established on the basis of experience or tests;

(b) Conform to approved specifications (such as industry or military specifications, or Technical Standard Orders) that ensure their having the strength and other properties assumed in the design data; and

criteria for self-extinguishing qualities and flammability.<sup>18</sup> Items such as ceiling panels, storage compartments, floor coverings, seat cushions, galley furnishings, electrical conduit, insulation, air ducts, motion picture film, windows and waste disposal receptacles must satisfy these requirements.<sup>19</sup>

Cargo and baggage compartments are also subject to fire safety regulations. Those compartments which are not accessible by crew or passengers must have interiors that meet oxygen, flammability, and/or detection and protection requirements.<sup>20</sup> Furthermore, each cargo compartment must comply with the requirements of section 25.857,<sup>21</sup> which establishes separate standards for compartments by class. A class "A" cargo compartment is one which is readily observable and accessible by a crew member who could easily discover a fire. A class "B" cargo compartment is not necessarily observable, but permits access so that a crew member could reach any part of the compartment with a hand-held fire extinguisher. Smoke or heat detectors are required in order to provide notice to crew members. Class "C" compartments are remote, inaccessible compartments which, consequently, must contain smoke or fire detection systems and provide fire extinguishing equipment. A class "D" compartment, also remote, is one designed to extinguish fire by suffocation.<sup>22</sup> The compartment must therefore be constructed so that hazardous quantities of smoke, flames, noxious gases and extinguishing agents cannot enter the crew or passenger portion of the aircraft.

Precautions are also required in areas where flammable

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(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

"Suitable" and "durable" are not further defined within the regulations themselves. Hence, the courts must be the ultimate arbiter of these terms.

<sup>18</sup> *Id.* § 25.853.

<sup>19</sup> *Id.*

<sup>20</sup> *Id.* §§ 25.855, .857.

<sup>21</sup> *Id.* § 25.857. Section 25.857 classifies cargo compartments based on their accessibility, the availability of smoke and fire detection equipment, whether the fire extinguishing equipment is built in, the type of ventilation, the ability to exclude smoke, flame or gases, and the ability to confine fire. Flight tests must be performed to demonstrate compliance with these provisions. *Id.* § 25.855(e).

<sup>22</sup> *Id.* §§ 25.855, .857.

fluid system leaks could present a danger from fluids or vapors. Precautions taken must minimize the chances for ignition of fluids or vapors and/or minimize the danger which could result if such ignition occurs.<sup>23</sup>

The regulations designate various parts of the engine and accessory section as fire zones. As such, these areas must meet rigid fire safety standards.<sup>24</sup> All fire zones must be designed to provide drainage and ventilation to minimize the hazards from flammable fluids and vapors.<sup>25</sup> Components which carry flammable fluids in an area potentially subject to fire conditions or in a designated "fire area" must be made of fire resistant materials.<sup>26</sup> Generally, tanks or reservoirs which contain flammable fluids may be placed in a fire zone as long as safety features provide the same level of safety which would be likely were the component outside the zone.<sup>27</sup>

Fire zones must be equipped with shut-off valves which stop the flow of flammable fluids where necessary, yet allow for continuing operation of the aircraft.<sup>28</sup> The engine and nacelle area must be equipped with a fire extinguishing system.<sup>29</sup> The extinguishing system employed must be capable of putting out the fire, while at the same time isolating toxic fumes from the crew and passenger compartments.<sup>30</sup> All fire zones must contain fire detection systems.<sup>31</sup>

The failure of certain aircraft systems and components pose a threat to flight safety; these systems and components must be designed so that failure due to fire is extremely improbable.<sup>32</sup> Consequently, flight controls and other struc-

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<sup>23</sup> *Id.* § 25.863. Flammable fluids include hydraulic fluids and oils, as well as engine fuels.

<sup>24</sup> *Id.* § 25.1181.

<sup>25</sup> *Id.* § 25.1187.

<sup>26</sup> *Id.* § 25.1183.

<sup>27</sup> *Id.* § 25.1185. The FAR's do not specifically define the level of safety which must be met.

<sup>28</sup> *Id.* § 25.1189. For example, fuel valves can stop the flow of fuel through one area, yet permit fuel to still reach the engine by using an alternate route.

<sup>29</sup> *Id.* § 25.1195. The nacelle is the engine housing.

<sup>30</sup> *Id.* § 25.1197.

<sup>31</sup> *Id.* § 25.1203.

<sup>32</sup> *Id.* § 25.1309(b).

tures which could fail if subjected to the effects of the fire must be shielded or constructed of fireproof material.<sup>33</sup> To protect the electrical system from fire and smoke, the electrical cables which are used during emergency procedures must be fire-resistant.<sup>34</sup> Main power cables must function even with "a reasonable degree" of deformity and stretching. All wire insulation must be self-extinguishing. Likewise, oxygen systems must not be located in a designated fire zone nor installed so that escaping oxygen could cause ignition.<sup>35</sup> As previously discussed, hydraulic systems utilizing flammable fluids must meet applicable fire protection requirements.<sup>36</sup>

C. *Recent Developments and Proposed Regulations in the Area of Fire Safety for Transport Category Aircraft*

Recent developments in the area of aircraft fire safety illustrate certain deficiencies, as well as efforts on the part of interested groups<sup>37</sup> and the FAA to require stricter standards. The FAA is now considering a proposed regulation requiring smoke detection equipment in aircraft lavatories, recognizing that, statistically, this is a likely place for cabin fires to originate. In December 1983, Pan American World Airways began installing automatic fire extinguishers in all aircraft lavatory waste bins.<sup>38</sup> The project was scheduled for completion in spring of this year.<sup>39</sup>

The FAA has issued a notice of proposed rulemaking which would establish more stringent flammability requirements for seat cushions used in transport category aircraft.<sup>40</sup> FAA accident investigation and tests suggest that some aircraft seat cushions and upholstery which presently appear to

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<sup>33</sup> *Id.* § 25.865.

<sup>34</sup> *Id.* § 25.1359.

<sup>35</sup> *Id.* § 25.1451.

<sup>36</sup> *Id.* § 25.1435(c); for discussion, see *supra* notes 23-28 and accompanying text.

<sup>37</sup> See *infra* notes 133, 157-160 and accompanying text.

<sup>38</sup> *Pan American Installing Smoke Detectors*, AV. WEEK & SPACE TECH. 26 (January 2, 1984).

<sup>39</sup> *Id.*

<sup>40</sup> FAA Flammability Requirements for Aircraft Seat Cushions, 48 Fed. Reg. 46,250 (1983).

satisfy the requirements of section 25.853 of the FAR's<sup>41</sup> nonetheless rapidly decompose, permitting the interior foam cores to burn.<sup>42</sup> The cushions are characteristically constructed of a fire-retardant polyurethane foam core covered with upholstery. Although both materials are certified to have passed the flammability tests of section 25.853, the upholstery cannot withstand the flame of a significant fire and the foam core spreads the fire rapidly.<sup>43</sup>

In response to findings and recommendations of the Special Aviation Fire and Explosion Reductions (SAFER) Advisory Committee,<sup>44</sup> the FAA is considering proposed requirements for the use of materials in aircraft seat cushions which would form a fire blocking layer, thereby reducing the spread of fire, smoke and toxic gas emissions.<sup>45</sup> Fire blocking involves the use of a thin layer of markedly more fire resistant material to encapsulate and protect the foam core of a seat cushion.<sup>46</sup> This delays the ignition of the cushion and significantly slows the spread of fire.<sup>47</sup> These proposed requirements would add to the flammability requirements now contained in the FAR's.<sup>48</sup>

Possibly in answer to the need for more effective fire safety regulations, the Civil Aeronautics Board has adopted new rules to regulate smoking on board aircraft.<sup>49</sup> The rules ban smoking altogether on small aircraft and ban cigar and pipe

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<sup>41</sup> See *supra* notes 18-19 and accompanying text.

<sup>42</sup> 48 Fed. Reg. 46,250 (1983).

<sup>43</sup> *Id.*

<sup>44</sup> *Id.* See *infra* notes 150-165 and accompanying text.

<sup>45</sup> 48 Fed. Reg. 46,250 (1983).

<sup>46</sup> *Id.*

<sup>47</sup> *Id.*

<sup>48</sup> *Id.* at 46,250-51 (1983). In fact, a recent FAA study indicates that the use of a blocking material could increase survivable evacuation time as much as 60 percent. FEDERAL AVIATION ADMIN., DEP'T OF TRANSP., DOT/FAA/CT-83/43, AIRCRAFT SEAT FIRE BLOCKING LAYERS; EFFECTIVENESS AND BENEFITS UNDER VARIOUS FIRE SCENARIOS 33 (1984) [hereinafter cited as AIRCRAFT SEAT REPORT]. According to this report, if seat blocking had been used in the 1980 Saudi Arabian Airlines loss, for example, see *infra* note 134, approximately \$49,000,000 and 301 lives would have been saved. *Id.* at 35.

<sup>49</sup> Smoking Aboard Aircraft, 49 Fed. Reg. 25,420 (1984) (to be codified at 14 C.F.R. § 252) (effective July 10, 1984).



smoking on all flights.<sup>50</sup> All smoking is banned when an aircraft's ventilation system is not functioning properly.<sup>51</sup>

### III. LIABILITY FOR FIRES IN TRANSPORT CATEGORY AIRCRAFT VIS A VIS THE FEDERAL AVIATION REGULATIONS

There are three primary avenues of liability arising from fire in transport category aircraft. One is against the government for negligence or carelessness in the course of inspecting the aircraft pursuant to regulations or for certification under the regulations. In addition, the operator and/or the manufacturer may be liable for violations of the regulations or other standards.

FAR certification requirements are adopted by the government in its discretion. Under the present day interpretation of the "discretionary function defense" of the Federal Tort Claims Act,<sup>52</sup> the government has no liability for failure to promulgate a regulation or for a regulation which is not as good as it might be.<sup>53</sup> A recent decision has held the FAA immune from suit where it exercised its discretion *not* to inspect.<sup>54</sup> Liability arguably attaches when the government

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<sup>50</sup> *Id.* at §§ 252.4-.5.

<sup>51</sup> *Id.* at § 252.3.

<sup>52</sup> 28 U.S.C. §§ 1346(b), 2671 (1982) [hereinafter cited as FTCA]. The discretionary function exception is found at 28 U.S.C. § 2680(a) (1982). For the language of the exception, see *infra* note 53. The seminal cases on the subject of the discretionary function defense are *Delehite v. United States*, 346 U.S. 15 (1953), and *Indian Towing Co. v. United States*, 350 U.S. 61 (1955).

<sup>53</sup> *Garbarino v. United States*, 666 F.2d 1061 (6th Cir. 1981). The United States is protected from claims which are "based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty . . . whether or not the discretion involved be abused." *Id.* at 1064.

28 U.S.C. § 2680(a) (1982) states that:

The provisions of this chapter and section 1346(b) of this Title shall not apply to . . . [a]ny claim based upon an act or omission of an employee of the government exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of a federal agency or an employee of the government whether or not the discretion involved be abused.

<sup>54</sup> *United States v. S.A. Empresa de Viacao Aerea Rio Grandense (Varig Airlines)*, 104 S. Ct. 2755 (1984).

performs an actual inspection and does so in a negligent manner.<sup>55</sup> But when the FAA omits an inspection for policy reasons, the discretionary function exception completely bars actions brought pursuant to the Federal Tort Claims Act.<sup>56</sup>

An airline, as a common carrier, customarily owes the highest degree of care to passengers.<sup>57</sup> Compliance with the letter of the FAR's does not necessarily shield an operator from liability.<sup>58</sup> Conversely, violation of the FAR's can, in certain jurisdictions, constitute negligence *per se* or otherwise act to shift a burden of proof.<sup>59</sup> Thus, an unexcused violation of these standards may enhance operator liability.<sup>60</sup>

In many states, a manufacturer may be liable under strict liability concepts which frequently require less effort to assert than negligence. Circumstances may exist, however, which limit actions against a manufacturer to negligence concepts.<sup>61</sup> While the manufacturer is exposed to traditional standards of

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<sup>55</sup> *Id.* at 2765-69.

<sup>56</sup> *Id.* at 2768.

<sup>57</sup> *United Air Lines v. Wiener*, 335 F.2d 379, 389 (9th Cir. 1964).

<sup>58</sup> Dillingham, *Crashworthiness FAR's and the Effect of Compliance in Product Liability Actions Involving Airplanes*, 33 FED'N INS. COUNS. Q. 55, 57 (1982).

<sup>59</sup> In *Gantenby v. Altoona Aviation Corp.*, 407 F.2d 443 (3d Cir. 1968), the plaintiffs' decedents were passengers on a single engine charter flight operated by defendants. The pilot involved operated the aircraft below Visual Flight Rule minimums, in violation of FAA regulations. *Id.* at 447. In applying Pennsylvania law, the court held that "a common carrier owes its passengers the duty of exercising the highest degree of care. This duty is violated by negligence *per se* which arises from the violation of a governmental safety regulation." *Id.* at 446 (citations omitted).

There are two forms for instructing a jury regarding violations of FAR's. In one form, the jury is instructed that if a violation of a FAR is found, and is causal, negligence is thereby established without further analysis of the defendant's conduct. In the other, the jury is instructed that once violation of a FAR is shown, the defendant must establish that the violation did not proximately cause the loss.

<sup>60</sup> *Delta Air Lines v. United States*, 561 F.2d 381 (1st Cir. 1977), *cert. denied*, 434 U.S. 1064 (1978). See also *supra* notes 12, 52 and accompanying text.

<sup>61</sup> An example of such circumstances can be found in a suit instituted by a large air carrier against a large air carrier manufacturer in the Ninth Circuit. Strict liability is not available as a liability theory as between sophisticated commercial entities where the entities negotiated the sale between themselves. *Scandinavian Airlines v. United Aircraft*, 601 F.2d 425 (9th Cir. 1979); *c.f.* *Delta Airlines v. Douglas Aircraft Co.*, 238 Cal. App. 2d 95, 47 Cal. Rptr. 518 (Cal. Dist. Ct. App. 1965); *Delta Airlines v. McDonnell Douglas Corp.*, 503 F.2d 239 (5th Cir. 1974), *cert. denied*, 421 U.S. 965 (1975) (actions in negligence and strict liability barred by exculpatory clause in contract).

care imposed by law, it, like the operator, may bear a heavier obligation where FAR's are violated.

In *McGee v. Cessna Aircraft Co.*,<sup>62</sup> the plaintiff sustained injuries in the crash of a 1968 Cessna 177 Cardinal. The plaintiff asserted in part that the fuel system of the aircraft was unsafe. Although McGee and three other passengers occupied the aircraft when it crashed, no occupant suffered major injuries as a result of the crash itself.<sup>63</sup> McGee suffered extensive third degree burns and other injuries which were a result of the ensuing post-crash fire.<sup>64</sup> McGee sued on a crashworthiness basis, seeking in part to shift the burden to the manufacturer to show the product was not defective once the claimant made a prima facie showing that her injuries were proximately caused by the product's design.<sup>65</sup> The trial court entered judgment in favor of the manufacturer, but the appellate court reversed.<sup>66</sup> After a second trial, judgment was once again entered for the manufacturer and another appeal taken.<sup>67</sup>

The plaintiff appealed the second time in part from the trial court's refusal to give a proffered instruction which stated that if the jury found that the defendant-aircraft manufacturer had violated one or more of the regulations contained in Part 23 of the FAR's,<sup>68</sup> the burden of proof on the issue of proximate cause shifted from the plaintiff to the defendant. Thus, the defendant would have the burden of proving that the plaintiff's injuries and damages were not the proximate result of any violation of the FAR's.<sup>69</sup> The appellate court again ruled for the plaintiff and against the manufacturer. The court stated that by proving that the defendant-manufacturer violated the FAR and that the in-

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<sup>62</sup> 82 Cal. App. 3d 1005, 147 Cal. Rptr. 694 (1978).

<sup>63</sup> 147 Cal Rptr. at 695.

<sup>64</sup> *Id.*

<sup>65</sup> *Id.* at 702.

<sup>66</sup> *Id.* at 704.

<sup>67</sup> *McGee v. Cessna Aircraft Co.*, 139 Cal. App. 3d 179, 188 Cal. Rptr. 542 (Cal. Ct. App. 1983).

<sup>68</sup> Section 23 governs airworthiness standards for normal, utility and acrobatic category airplanes. 14 C.F.R. § 23 (1984).

<sup>69</sup> 188 Cal. Rptr. at 547 n.6.

jury resulted from an occurrence which the FAR was designed to prevent, the plaintiff brought herself within the class of persons to be protected by the statute. The only remaining issue was whether violation of the FAR proximately caused the injury.<sup>70</sup> The court determined that violation of the FARs is sufficient to make a prima facie showing that the injury was proximately caused by the product's design, thus shifting the burden to the defendant to show that the product was not defective.<sup>71</sup>

McGee had presented evidence to show that the ensuing fire caused her injuries and that the fire was able to enter the cockpit of the aircraft due to components which were not in compliance with the FAR's.<sup>72</sup> The appellate court held that this violation was sufficient evidence to shift the burden of proof to the manufacturer.<sup>73</sup> The FAR's then in force required engine fires to be isolated from the cockpit by the fire-wall for fifteen minutes.<sup>74</sup> This regulation set a standard for safety which the manufacturer failed to meet.<sup>75</sup>

#### IV. AIRCRAFT FIRE INVESTIGATION

Aircraft fire investigation is an art unto itself. Generally, when an aircraft accident is investigated, efforts are focused on the cause of the crash. Crash investigators historically have *not* been fire investigators. In order to effectively evaluate and litigate aircraft fires, it is necessary to separate the crash from the fire. Determining fire causation, origin and manner of propagation frequently have little to do with traditional aircraft accident investigation. Hence, a fire specialist is needed. Once causation, origin and manner of propagation are determined, possible liability under the FAR's can be assessed. Only then can it be determined whether the regulations were satisfied and whether operators and manu-

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<sup>70</sup> *Id.* at 547.

<sup>71</sup> *Id.* at 548.

<sup>72</sup> *Id.*

<sup>73</sup> *Id.* at 549.

<sup>74</sup> *Id.* at 546. The requirement has not changed. 14 C.F.R. § 23.1191 (1984).

<sup>75</sup> *McGee*, 188 Cal. Rptr. at 542, 550.

facturers of transport category aircraft have complied with statutory standards.

### A. *Determining the Origin of a Fire*

The first step in fire investigation is securing the scene against entry until the investigator arrives. Whenever possible, the fire scene should be preserved until the fire investigator has completed his work.<sup>76</sup> All available information about the fire should be gathered, including information from the fire department personnel responding to the fire and information from eyewitnesses.<sup>77</sup> Efforts should be made to isolate the material that was first ignited, noting both its composition, such as fabric or liquid, and its form or use, such as fuel, paint or component.<sup>78</sup> Efforts should also be directed to determine precisely how the heat and material combined to ignite.<sup>79</sup>

In some instances, the point of fire origin is obvious.<sup>80</sup> If the structure is totally destroyed prior to extinguishment, however, the point of origin can be difficult to determine.<sup>81</sup> In such cases, a thorough investigation of the exterior and interior of the structure must be conducted.<sup>82</sup> Fire damaged areas which show charring and smoke deposits should be examined. Smoke, along with char patterns, will help to determine whether the fire started on the inside or the outside of the structure and which elements influenced the spread of the fire.<sup>83</sup> The interior examination generally begins with the least damaged area, working towards the area of most severe

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<sup>76</sup> NATIONAL BUREAU OF STANDARDS, U.S. DEPARTMENT OF COMMERCE, HANDBOOK NO. 134, FIRE INVESTIGATION HANDBOOK 1 (1980) [hereinafter cited as FIRE INVESTIGATION HANDBOOK].

<sup>77</sup> *Id.*

<sup>78</sup> *Id.* at 2. An example of the source of heat ignition would be the particular piece of equipment that provided the heat required to start a fire; examples of the form of such heat include flame, spark or hot surface. *Id.*

<sup>79</sup> *Id.*

<sup>80</sup> *Id.* at 3.

<sup>81</sup> *Id.*

<sup>82</sup> *Id.* at 1, 3-7.

<sup>83</sup> *Id.* at 1, 3-4.

damage.<sup>84</sup> The most severely burned or damaged area is generally near the point of fire origination.<sup>85</sup> To precisely determine origin, the investigator will attempt to establish the lowest point of burning.<sup>86</sup> The lowest point of burning is important because fire generally travels upwards and outwards as it propagates from the lowest point, leaving a v-shaped pattern on nearby or adjacent walls.<sup>87</sup> This pattern can, however, be influenced by pressurization systems and their resultant airflow.<sup>88</sup> A trained fire investigator can also determine whether the fire developed slowly or rapidly by studying patterns on the areas exposed to fire as well as ceiling damage.<sup>89</sup>

The ceiling, light fixtures, and light bulbs over the apparent area of fire origin may provide information regarding the direction of heat flow and the degree of heat.<sup>90</sup> For example, the condition of glass objects and window glass may give some indication as to the location of the fire and its intensity as well as the rate of build-up.<sup>91</sup> Light bulbs swell and distort when exposed to high temperatures.<sup>92</sup> This distortion may cause the glass bulbs to bubble out in the direction of heat.<sup>93</sup> Soot, smoke deposits and crazing of glass are all indicators of fire location, intensity and rate of heat buildup.<sup>94</sup>

Flashover, the rapid propagation of flame, occurs where heat builds up at the ceiling level, causing rapid ignition of materials below. This can cause a fire to propagate signifi-

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<sup>84</sup> *Id.* at 4.

<sup>85</sup> *Id.*

<sup>86</sup> *Id.*

<sup>87</sup> *Id.*

<sup>88</sup> Strong airflow can cause fire to move downward, sideways, or in other abnormal patterns, thereby creating a trap for the unwary. Normal airflow patterns within the aircraft must consequently be ascertained. See FIRE INVESTIGATION HANDBOOK, *supra* note 76, at 1, 83-85.

<sup>89</sup> *Id.* at 1, 5-7.

<sup>90</sup> *Id.* at 5.

<sup>91</sup> *Id.*

<sup>92</sup> *Id.*

<sup>93</sup> *Id.*

<sup>94</sup> *Id.* at 5. "Crazing" describes the small cracks which appear in the surface of glass as result of heat.

cant distances.<sup>95</sup> Flashfire is a mild explosion caused by the ignition of combustible gases given off by burning material. Once the build-up of gas reaches its flammable limit, the fire itself will cause ignition; ignition is usually at the ceiling level because most gases rise.<sup>96</sup> Put simply, flashover depends on the amount of heat which collects and radiates at the upper level of the cabin while flashfire is governed by the amount of flammable gases which collect in the cabin.<sup>97</sup> Airflow through the cabin can disperse these build-ups and reduce or postpone the chances of flashfire.<sup>98</sup> When ceiling temperatures reach the flashover point, the resulting fire may appear to have multiple fire origins.<sup>99</sup>

### B. *Determining the Cause of the Fire*

When determining the cause of a fire, the investigator will customarily gather available evidence for later evaluation, including samples from locations within the fire area.<sup>100</sup> The investigator's visual observations should be documented by the use of photographs. In particular, he seeks to document fire development characteristics for later use.<sup>101</sup>

Determining cause is frequently accomplished by the process of elimination: the investigator attempts to eliminate potential causes until only one or two remain.<sup>102</sup> Another approach is the reverse, whereby the investigator may seek to

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<sup>95</sup> Official Transcript at 603, *In re* Investigation of Accident Involving Air Canada DC-9, of Canadian Registry CF-TLU, at the Greater Cincinnati Airport, Covington, Kentucky, June 2, 1983, No. SA-480, Nat'l Transp. Safety Bd. (August 16, 1983) (testimony of Richard G. Hill, FAA Fire Investigator) [hereinafter cited as *Investigation of Air Canada Accident*].

<sup>96</sup> *Id.* at 603-05.

<sup>97</sup> *Id.* at 607.

<sup>98</sup> *Id.*

<sup>99</sup> See FIRE INVESTIGATION HANDBOOK, *supra* note 76, at 6. Since the heat of the fire is generally concentrated at the ceiling level, floors seldom receive damage similar to that received by ceilings. A large, damaged area of floor, however, could indicate the use of accelerants, or that plastics or other decorations were consumed in the fire, giving the appearance of flammable liquid burn. *Id.* at 5.

<sup>100</sup> *Id.* at 22-23.

<sup>101</sup> *Id.* at 27.

<sup>102</sup> *Id.* at 8.

directly discover what produced ignition.<sup>103</sup> Both approaches have merit and may be used in combination.<sup>104</sup>

Regardless of the method employed in determining cause, the investigator should always keep in mind the fundamental physics and chemistry of a fire.<sup>105</sup> Three elements are necessary for fire to exist: fuel, oxygen and sufficient source of heat to cause the fuel and oxygen to react and ignite.<sup>106</sup> Once combustion begins, heat transfer can take place by convection (the movement of hot fire gases away from the fire source), by conduction (the heating of solid surface in contact with hot gases), or by radiant heat transfer (the heating caused by electromagnetic radiation or waves, such as the warming of the earth's surface by the sun's rays).<sup>107</sup> These three methods are classic examples of heat transfer or fire extension. Another method by which fire can spread, however, is the movement of flaming or heated material.<sup>108</sup> This movement occurs when burning materials such as paper are carried aloft by the hot plume of the fire and then deposited in another location.<sup>109</sup> This transfer can mislead a fire investigator into postulating that multiple fires occurred.<sup>110</sup>

Another basic principle is that fire develops from the ignition of combustible substances. Flaming ignition occurs when ignition is caused by matches, heating equipment, cooking equipment or other types of flame.<sup>111</sup> Non-flaming ignition occurs from smoldering combustion such as a carelessly discarded cigarette.<sup>112</sup> Smoldering combustion can reach the point where flames erupt, making it difficult to determine whether a smoldering ignition or a flaming ignition

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<sup>103</sup> *Id.*

<sup>104</sup> *Id.*

<sup>105</sup> *See id.* at 9.

<sup>106</sup> *Id.* at 146. Heating equipment, cooking equipment, smoking materials, electrical equipment, appliances, bleed air of engines, and wiring are all possible heat sources in transport aircraft. *Id.* at 9.

<sup>107</sup> *Id.* at 155-56.

<sup>108</sup> *Id.* at 157-59.

<sup>109</sup> *Id.*

<sup>110</sup> *Id.*

<sup>111</sup> *Id.* at 88-90.

<sup>112</sup> *Id.* at 91.



was the initial cause in cases where both were potentially present.<sup>113</sup>

Spontaneous ignition is the ignition of material without any external application of heat. This usually involves the build-up of heat within the subject material over a period of time.<sup>114</sup> This can occur because materials themselves either are reactive or become active through the use of additives.<sup>115</sup> Heat buildup can also result from the storage of hot materials.<sup>116</sup>

Electricity is also a common ignition source, for heat is customarily produced within electrical systems and may build to the point where it can cause damage.<sup>117</sup> This may result in a system failure or ignition of the system itself.<sup>118</sup> The two main categories of electrical fires are those originating within an electrical distribution system and those originating within electrical equipment.<sup>119</sup> The occurrence of an electrical short can produce sparks sufficient to ignite some combustible materials.<sup>120</sup> If it is possible that the fire was electrical in origin, the investigator should attempt to focus on the particular mechanism that could have caused ignition.<sup>121</sup>

Some of the elements which determine the speed of development and growth of fire include the ignition source, proximity, type and amount of fuel and other combustible material, as well as the quantity of air available.<sup>122</sup> Growth involves the spread of flame along the ignited material as well as spread from one item to another.<sup>123</sup> The type of material

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<sup>113</sup> *Id.* at 93.

<sup>114</sup> *Id.* at 94.

<sup>115</sup> *Id.* at 94-96. For example, if vegetable oil on a rag is exposed to air, it reacts to oxygen, releasing heat in the process. It can thereby ignite. *Id.* at 96.

<sup>116</sup> *Id.* at 95.

<sup>117</sup> *Id.* at 99.

<sup>118</sup> *Id.* Heat buildup may damage some portion of the system, resulting in the failure of the system itself or ignition of the system or both. *Id.*

<sup>119</sup> *Id.* at 99.

<sup>120</sup> *Id.* at 102.

<sup>121</sup> *Id.* at 125.

<sup>122</sup> *Id.* at 159.

<sup>123</sup> *Id.* at 160.

involved and its location are important to the analysis.<sup>124</sup> The more closely spaced the combustible materials are to each other the greater the potential for rapid fire spread.<sup>125</sup>

Once the fire has developed and has begun to grow, its power is determined, in part, by the enclosure in which it is contained.<sup>126</sup> Reradiation and ventilation are the primary influences imposed by the enclosure.<sup>127</sup> Reradiation takes place when trapped hot gases in the upper portion of the room heat the ceiling and walls, causing the surfaces to radiate heat onto unburned fuel, thus making the fire spread faster.<sup>128</sup> When radiation levels become high enough, flashover occurs,<sup>129</sup> causing combustible materials within the room to burst into flames.<sup>130</sup>

The air supply to a fire, a key determinant of growth, is also a function of the enclosure. The rate of burning within an enclosed area will often become so great that the amount of air may be inadequate. Thus, flames may reach out through an opening in the enclosure, seeking more air and materials to burn. The effects of this "ventilation-controlled fire" should be apparent to the investigator because fire characteristically consumes all available fuel. Consequently, a ventilation-controlled fire is not easily confused with a fire of multiple origins.<sup>131</sup>

#### V. SOME OBSERVATIONS ON THE RELIABILITY OF FAR'S IN PROMOTING AIR SAFETY

An FAA study of aircraft cabin fire safety published in June, 1980 concluded that thirty-nine percent of all fatalities in survivable accidents were the result of fire.<sup>132</sup> The report

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<sup>124</sup> *Id.* For example, carpeting is very combustible while oak flooring is not as combustible. *Id.*

<sup>125</sup> *Id.* at 161.

<sup>126</sup> *Id.*

<sup>127</sup> *Id.* at 162.

<sup>128</sup> *Id.*

<sup>129</sup> See *supra* notes 95-99 and accompanying text.

<sup>130</sup> FIRE INVESTIGATION HANDBOOK, *supra* note 76, at 162.

<sup>131</sup> *Id.* at 162-163. For a discussion of flashover, see *supra* notes 95-99 and accompanying text.

<sup>132</sup> FEDERAL AVIATION ADMIN., DEP'T OF TRANSP., FAA-ED-18-7, TECHNICAL RE-

also states that the FAA emphasized research in the area of the post-crash cabin fire as opposed to an uncontrollable in-flight fire because most in-flight fires can be controlled by crew members.<sup>133</sup> In view of the Saudi Arabian Airlines losses of August 1980, where 301 persons died, and the DC-9 Air Canada accident of June 1983, where twenty-three persons died,<sup>134</sup> we think this conclusion is subject to criticism.

A modern wide-body jet contains approximately 11,000 pounds of non-metallic material including various plastic foams used for aircraft seating.<sup>135</sup> These foams are classified as highly flammable.<sup>136</sup> Much of this foam is treated with a fire retardant which changes the foam's initial reaction to fire. Although the treated foam is harder to ignite, once ignited it may burn more rapidly than untreated foam. Treated foam may produce more smoke and as much carbon monoxide and hydrogen cyanide as the untreated version.<sup>137</sup> Thus, although treated foam may pass ignitability tests, such tests do not disclose the treated foam's performance in a major fire.<sup>138</sup>

The major problems evolving from a cabin fire — smoke, high temperatures, depletion of oxygen and production of toxic gases — are all hazards of fire involving foam. Burning plastic produces hot, dense smoke with a temperature sometimes as high as 900 degrees centigrade. Such temperatures can be fatal even if only a thin layer of smoke collects near

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PORT, ENGINEERING AND DEVELOPMENT PROGRAM PLAN, AIRCRAFT CABIN FIRE SAFETY, v, 1 (1980).

<sup>133</sup> *Id.* at 1.

<sup>134</sup> On August 19, 1980, a Lockheed L-1011 TriStar, operated by Saudi Arabian Airline, had to return to Riyadh Airport, Saudi Arabia. Investigators determined that an uncontrolled fire developed in a cargo compartment of the aircraft. PRESIDENCY OF CIVIL AVIATION (SAUDI ARABIA), AIRCRAFT ACCIDENT REPORT: SAUDI ARABIAN AIRLINE, LOCKHEED L-1011, HZ-AHK, RIYADH, SAUDI ARABIA, AUGUST 19, 1980, 1 (1982). Toxic fumes, including carbon monoxide, were produced by burning materials. These fumes were inhaled by the aircraft occupants. *Id.* at 77. The 301 persons on board the aircraft were killed. *Id.* at 1. For a discussion of DC-9 Air Canada accident, see *infra* note 166 and accompanying text.

<sup>135</sup> Horsfall, *Reducing the Fire Hazards in Modern Aircraft Cabins*, FIRE, November, 1980, at 299.

<sup>136</sup> *Id.*

<sup>137</sup> *Id.*

<sup>138</sup> *Id.*

the top of the cabin.<sup>139</sup> The oxygen depletion caused by fire can be fatal. Some foams, when burned within a confined area, reduce the oxygen level significantly in a short period of time.<sup>140</sup>

Synergism, the combining of toxic gases, is also an aspect of a cabin fire that must be considered. The effects of synergism were recognized almost twenty years ago. On November 11, 1965, a Boeing 727 carrying eighty-five passengers and six crewmembers crashed while landing at Salt Lake City Municipal Airport. Forty-eight people survived.<sup>141</sup> Correspondence attached to this accident report among the FAA's Director of Flight Standards Service, the Bureau of Safety and the FAA indicated that emissions of heavy smoke and toxic gases caused by burning of interior furnishings contributed to many deaths.<sup>142</sup> The correspondence further reflected that deficiencies were discovered in materials then used for aircraft cabin interiors although superior materials were available.<sup>143</sup> The author of the correspondence made no mention of specific deficiencies, other than to state that the cabin materials produced various toxic gases and heavy smoke which contributed to fatalities.<sup>144</sup> Another piece of correspondence dated almost twenty years ago opined that

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<sup>139</sup> *Id.*

<sup>140</sup> *Id.*

<sup>141</sup> CIVIL AERONAUTICS BOARD, DEP'T OF TRANSP., DOCKET NO. SA-388, FILE NO. 1-0032, AIRCRAFT ACCIDENT REPORT 1 (1966). The aircraft impacted 335 feet short of the runway threshold shearing the main landing gear and causing the aircraft to slide approximately 2,838 feet on the nose gear and the bottom of the fuselage. Approximately one to two seconds after impact, those survivors seated in the aft portion of the cabin observed a fire erupt in the cabin. *Id.* at 8. Although all emergency exits were available for use, passengers attempted to exit primarily by the entry door, thereby delaying efforts to open it. *Id.* at 8. Of the ninety-one persons on board the aircraft, fifty were evacuated after the crash. The remaining forty-one occupants were overcome by smoke, heat and flames, rendering them unable to escape from the aircraft. Altogether there were forty-three fatal injuries and forty-eight survivors including the crew. *Id.* at 3. The Civil Aeronautics Board concluded that the physical impact did not render the passengers incapable of escaping the aircraft. In fact, the passengers reached the forward exit ahead of the stewardess and delayed her from commencing evacuation. *Id.* at 12.

<sup>142</sup> *Id.*

<sup>143</sup> *Id.*

<sup>144</sup> *Id.* The correspondence also noted that combinations of various toxic gases produce a more serious effect than one gas alone.

the FAR's should be updated to require more fire resistant materials.<sup>145</sup> Moreover, the Civil Aeronautics Board recommended to the FAA that research be undertaken to decrease the flammability and smoke characteristics of materials used in aircraft cabins.<sup>146</sup> Although the effects of synergism are not completely understood, it is postulated that exposure to combinations of gases can produce a more serious effect than exposure to each of the gases alone.<sup>147</sup>

Problems also result from a practice whereby operators customarily purchase aircraft seats directly from the seat manufacturer for installation by the airframe manufacturer. Boeing eliminated the use of certain plastics from production of their aircraft because of smoke considerations, even though these plastics passed ignition tests.<sup>148</sup> Seat manufacturers, however, continue to use these same materials in their products.<sup>149</sup>

### The Special Aviation Fire and Explosion Reduction

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<sup>145</sup> *Id.* The correspondence was dated December, 1965.

<sup>146</sup> *Id.*

<sup>147</sup> *Id.* at 299. Synergism also played a role in a 1973 occurrence near Orly Airport, France. On July 11, 1973, near Orly Airport, a Varig Boeing 707 experienced an in-flight fire which had commenced in a rear lavatory. Department of Transp. (Fr.), *Final Report of the Investigation Committee on the Accident of the Boeing 707 PP-VJZ of the Varig Company at Saulx-les-Charteaux, on July 11, 1973*, 1976-No.17 OFFICIAL J. FRENCH REPUBLIC (AD. DOC. ED.) 3 (April 6, 1976) (Berlitz Services Trans.) The pilot made an emergency descent and intentionally crash landed approximately five kilometers short of the airport with 117 passengers and seventeen crew members on board. *Id.* at 3, 22. The landing was a success, and the fuselage received little damage. *Id.* at 15, 20. Witnesses reported that the fire in the cabin was "not a raging fire." It nonetheless advanced slowly but steadily from the rear of the fuselage to the front, and generated a great amount of smoke. *Id.* at 22. According to two survivors, smoke coming from the lavatory filled the aircraft cabin. Eventually a flashfire occurred from the buildup of combustible gases. *Id.* at 21.

Pathological findings resulting from this accident indicated that approximately seventy-eight percent of the deaths were the result of carbon monoxide inhalation; carbon monoxide inhalation could not be ruled out as a cause of the other thirteen percent of the deaths. *Id.* at 18.

The Board concluded that the accident was survivable. The majority of occupants, however, were unable to leave the aircraft under their own power even though all exits were usable. *Id.* at 22-23. The Board believed that occupants of the cabin were unconscious at the time of landing or otherwise incapable of reacting, although the majority were believed alive at touchdown. Only the cockpit crew and two stewards were physically able to leave the aircraft unassisted. *Id.* at 23.

<sup>148</sup> See Horsfall, *supra* note 135, at 299.

<sup>149</sup> *Id.* at 299-300.

(SAFER) Advisory Committee<sup>150</sup> conducted a study into the factors affecting aircraft fire safety, occupant survivability and safety improvement.<sup>151</sup> The Committee concentrated its efforts on survivable accidents where control of fire and explosion would enhance the ability of occupants to escape the aircraft.<sup>152</sup> They gave specific attention to problems which affect the ability to escape a post-crash fire and to possible solutions.<sup>153</sup>

The SAFER Advisory Committee found that the safety record of U.S. scheduled air carriers showed a general decrease in accident and fatality rates over the past fifteen years. The Committee found, however, that there have been a significant number of fatal or serious injuries in survivable accidents where post-crash fires occurred.<sup>154</sup> It determined that the primary cause of post-crash fire was spilled fuel.<sup>155</sup> In-flight cabin fires producing fatal injuries were determined to be relatively rare events.<sup>156</sup> The Committee felt that the available data base on aircraft fire accidents and incidents was inadequate to isolate the critical chain of events and that information on the hazards presented by combustible cabin materials vis-a-vis spilled fuel was not defined to the point where the degree of safety improvement obtainable from improved materials could be judged.<sup>157</sup> The Committee determined that there was no accepted method to test and predict how various materials will behave in a large scale fire. The

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<sup>150</sup> The FAA established the SAFER Advisory Committee on June 26, 1978. The Committee examined the factors which affect an aircraft passenger's ability to survive in a post-crash environment and possible solutions for reducing the severity of occurrence of aircraft fires and explosions. 1 FEDERAL AVIATION ADMIN., DEP'T OF TRANSP., FINAL REPORT OF THE SPECIAL AVIATION FIRE AND EXPLOSION REDUCTION (SAFER) ADVISORY COMMITTEE 1 (June 26, 1980) [hereinafter cited as SAFER REPORT].

<sup>151</sup> *Id.*

<sup>152</sup> *Id.* at 2.

<sup>153</sup> *Id.* at 12.

<sup>154</sup> *Id.* at 12-13.

<sup>155</sup> *Id.*

<sup>156</sup> *Id.* It should be noted the Committee published this report prior to the Saudi Arabian Airlines loss of 1980 and DC-9 Air Canada loss of 1983. For a discussion of the Saudi Arabian Airlines loss, see *supra* note 134. For a discussion of the DC-9 Air Canada loss, see *infra* note 166.

<sup>157</sup> SAFER REPORT, *supra* note 150, at 13.

test methods currently in use allow for a comparative test of the materials and do not actually assess the effectiveness of the material vis-a-vis cabin fire.<sup>158</sup> The Committee found that the bunsen burner tests for testing flammability of cabin materials as now specified in the FAR's are valid tests, except for analyzing those materials which melt and shrink away from the flame.<sup>159</sup> The Committee concluded that there were not yet adequate test standards to measure the toxicity produced by the burning of cabin interior materials, nor a complete data base on the hazards these toxic materials present to humans.<sup>160</sup>

The Committee recommended that a determination of how cabin interior materials contribute to the post-crash fire hazard be made. The Committee also recommended that fire blocking or fire barriers be developed for aircraft seats in order to retard fire spread.<sup>161</sup> The Committee suggested that toxic research efforts should be stepped up with a research program assigned the goal of providing a basis for future regulatory action.<sup>162</sup> The Committee proposed that FAR Part 25 on Flammability Test Methods be modified to account for the melt and drip away behavior of various materials.<sup>163</sup> The Committee also recommended that the FAA look into the use of self-contained smoke masks, gloves, clothing or other items of personal protection for crew members to allow better supervision of evacuation procedures.<sup>164</sup> More importantly, the Committee recommended that the National Transportation Safety Board (NTSB) and FAA improve and standardize post-crash accident investigations as well as emphasize design features of materials which affect the spread of post-crash fires.<sup>165</sup>

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<sup>158</sup> *Id.*

<sup>159</sup> *Id.* at 14.

<sup>160</sup> *Id.* at 15.

<sup>161</sup> *Id.* at 17. This latter recommendation is the subject of recent notice of proposed rulemaking by the FAA. See *supra* notes 40-43 and accompanying text.

<sup>162</sup> SAFER REPORT, *supra* note 150, at 17.

<sup>163</sup> *Id.*

<sup>164</sup> *Id.* at 18.

<sup>165</sup> *Id.* at 18-19.

Not all experts agree with the SAFER Advisory Committee's determinations. For example, Dr. James G. Quintiere, the group head of fire research at the National Bureau of Standards testified at the NTSB hearing following a 1983 accident which involved Air Canada.<sup>166</sup> Dr. Quintiere pointed out that current fire protection criteria concerning flammability resistance requirements of materials set forth in the FAA regulations rely primarily upon bunsen burner type tests.<sup>167</sup> He classified these tests as only measuring ignitability, which is not necessarily related to evaluation of how materials will spread fire in a significant fire or delay onset of flashover or flashfire.<sup>168</sup> Dr. Quintiere added, however, that fire growth depends on more than just ignitability of materials. He stated that the fire scenario, flame spread, energy release and flame configuration are also determinative and must be analyzed in conjunction with material tests.<sup>169</sup>

Mr. Richard G. Hill, Project Manager in charge of full-scale fire testing for the FAA, also testified at the Air Canada hearing.<sup>170</sup> When asked to discuss test criteria for fire resistance set forth by the FAA, Hill stated that these tests evi-

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<sup>166</sup> On June 2, 1982 a DC-9, operated by Air Canada, experienced an in-flight fire while enroute from Dallas/Ft. Worth to Toronto, Canada. Investigation of Air Canada Accident, *supra* note 95, at 6. The in-flight fire originated in the area of the aft lavatory. The captain initiated an emergency descent and was forced to execute an emergency stop on a runway at Greater Cincinnati Airport. *Id.* at 6-7. As smoke filled the cockpit and cabin, the aircraft lost all electrical power except emergency battery back-up. *Id.* at 7. Only 18 passengers and 5 crew members were able to evacuate the aircraft, the other 23 passengers died. *Id.* The passengers presumably died from the fire and its effects. The report, however, is not specific about the cause of death.

<sup>167</sup> *Id.* at 480, 570.

<sup>168</sup> *Id.* at 570-71.

<sup>169</sup> *Id.* at 571.

<sup>170</sup> *Id.* at 591. Hill stated that the fire in the subject aircraft originated in the aft outboard corner of the rear lavatory. *Id.* at 593. Hill discussed the use of fire detection systems and fire extinguishers in lavatory areas and concluded that smoke detectors could be effective if placed in a proper position. *Id.* at 599. Hill said, however, that there are many places a fire could start in a lavatory that a detector placed in a given position or set at a given sensitivity could not detect. *Id.* at 599. He also discussed application of a fixed extinguisher in lavatories and observed that the Air Canada aircraft did have a Halon extinguisher which uses a chemical that is most effective in putting out fire in the aircraft lavatory trash can. *Id.* at 601. Hill observed that there are areas in the lavatory not accessible by a gaseous agent in the trash can, hence an extinguisher so located may not combat a fire elsewhere. *Id.*



dently did not simulate fire scenarios such as that in the Air Canada aircraft.<sup>171</sup> Some of the major component materials used in the interior of Air Canada DC-9s were tested by Hill using the standard tests of the FAR's.<sup>172</sup> He reported that a portion of the urethane foam seat cushion so tested failed to meet flammability requirements.<sup>173</sup> Hill opined that the failure may have been due to wear and body moisture on the outer surface of the seat cushion causing the loss of fire retardant properties.<sup>174</sup>

Hill also reported on his testing of a simulated wide-body aircraft using materials commonly found in such aircraft under a post-crash fire scenario. He concluded that fires were sometimes survivable until flashover occurred. Flashover rapidly decreased survivability because of heat, flame and toxic gases.<sup>175</sup> Hill concluded, therefore, that the most important factor in post-crash fires is to reduce or delay the onset of flashover or flashfire.<sup>176</sup>

In Hill's opinion, the greatest obstacle to better cabin fire safety is state-of-the-art and suitable materials. Wall panels were chosen as an example. Hill stated that there are no standard off-the-shelf side wall materials better than those currently used in new aircraft.<sup>177</sup> Hill believed that it is difficult to qualitatively rank materials because a material which tests well in one situation may rate poorly in another. Furthermore, Hill concluded that there are no tests that can be correlated to actual full-scale fires because so many variables are involved.<sup>178</sup>

## VI. CONCLUSION

FAR's establish the standards that the government has determined to be important. They are consequently of signifi-

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<sup>171</sup> *Id.* at 612-13.

<sup>172</sup> *Id.* at 618-19.

<sup>173</sup> *Id.* at 619.

<sup>174</sup> *Id.* at 620.

<sup>175</sup> *Id.* at 626.

<sup>176</sup> *Id.* at 628.

<sup>177</sup> *Id.* at 642.

<sup>178</sup> *Id.* at 642-43.

cance to the litigator, first as irrefutable standards, second as standards which may influence requirements of proof, and third as points of focus in the course of fire investigation. These regulations are the logical starting point in any analysis of a fire related accident.

A prerequisite to the successful prosecution or defense of a fire related accident, however, is the correct determination of fire origin and cause. Because this is a specialized discipline requiring unique skill and training, a fire expert is mandatory. Interested parties should endeavor to insure that fire experts are retained as soon as possible after an accident occurs. The expert should be given complete access to the scene before evidence is disturbed. Preserving the evidence is as important as obtaining specialized assistance.

Studies, commissions and public testimony demonstrate that there are divergent opinions in connection with many aspects of fire safety. Consequently, the careful litigator must survey the literature, accident reports and studies on matters related to his circumstance to enable a complete analysis of the potential opinion range. Because there are differing opinions in many areas of fire safety, litigants will discover that many situations are not the subject of "conventional wisdom." If the litigation is sizable enough, it may be necessary to conduct original research to verify hypotheses promulgated and to enable the provision of persuasive evidence to the fact-finder of the correctness of a given approach.

This is an area of aviation accident litigation that has the potential, through research, to be eradicated. Speaking for those of us that spend substantial time aboard commercial aircraft, it will not be missed.

