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Section 9. Powerplant Fire Protection

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Section 25.1181 Designated fire zones; regions included.

a. **Rule Text.**

(a) Designated fire zones are-

(1) The engine power section;

(2) The engine accessory section;

(3) Except for reciprocating engines, any complete powerplant compartment in which no isolation is provided between the engine power section and the engine accessory section;

(4) Any auxiliary power unit compartment;

(5) Any fuel-burning heater and other combustion equipment installation described in § 25.859;

(6) The compressor and accessory sections of turbine engines; and

(7) Combustor, turbine, and tailpipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases.

(b) Each designated fire zone must meet the requirements of § 25.867, and § 25.1185 through § 25.1203.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-11, 32 FR 6913, May 5, 1967; Amendment 25-23, 35 FR 5677, April 8, 1970; Amendment 25-72, 55 FR 29785, July 20, 1990)

b. **Intent of Rule.** The intent of this rule is to identify areas of the airplane/engine in which a high degree of safety precautions must be taken, recognizing that a fire will occur in these regions, termed "designated fire zones," because of the presence of both ignition sources and flammable fluids. In these zones ignition sources are assumed to be present and, therefore, a single failure releasing flammable fluids may result in a fire. The regulation identifies the necessary precautions to be taken to contain the fire, as well as to detect and extinguish the fire. The precautions are identified in § 25.867 and § 25.1185 through § 25.1203, as required by § 25.1181.

c. **Background.**

(1) The Federal Aviation Administration has always recognized that certain areas of the airplane require a high degree of safety precautions and have defined such areas as "designated fire zones". Section 25.1181 essentially in its present form, later amendments aside, was adopted from the Civil Air Regulations (CAR) 4b, section 4b.480, "Designated Fire Zones." Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations (FAR) and replaced Part 4b of the CAR. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. This regulation was recodified from CAR 4b.480 without substantive changes.

(2) Notice of Proposed Rulemaking 65-43 (31 FR 93, January 5, 1966) proposed the revision of this section as follows:

> Paragraph (c) would be deleted, and the provisions now in that paragraph would be amended as follows:
>
> First, the cross-reference to § 25.863 would be deleted because (1) the remaining cross-references provide adequate fire protection for the portion of the aircraft now covered by § 25.1181(c), and (2) the cross-reference to § 25.863 has caused confusion since that section applies, on its face, only to situations involving the likelihood of fluid system leakage whereas the likelihood of such leakage should not control the applicability of the fire protection provisions intended to be applied under present § 25.1181 (c).
>
> Second, provisions now in paragraph (c) of § 25.1181 would be rephrased to make it clear that the sections referred to in that paragraph apply even though the portion of the aircraft covered by that paragraph is not a designated fire zone. Certain of these referenced sections apply on their face to designated fire zones only. Literal interpretation of these requirements would defeat the intent of the cross-reference, which is to give the nacelle area immediately behind the firewall certain fire protective features required in designated fire zones.
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> Third, the applicability of present paragraph (c) of § 25.1181 to "the nacelle area immediately behind the firewall" would be broadened to include the area that serves the same purpose on airplanes with pod mounted engines. For these airplanes, the portion of the pod attach structure that contains flammable fluid lines serves the same purpose as the nacelle area immediately behind the firewall on other airplanes, and should be similarly regulated.
>
> Finally, the provisions now in paragraph (b) of § 25.1181, together with the amendments in this proposal, would be separated from the rest of § 25.1181 and designated as new § 25.1182. The purpose of § 25.1181(c) is to cover designated fire zones. The area covered by present § 25.1181(c) and its proposal share certain requirements with, but are not designated fire zones.

(3) Amendment 25-11 (32 FR 6906, May 5, 1967) followed Notice 65-43. Comments received to Notice 65-43 were discussed in the preamble to Amendment 25-11 as follows:

> The notice proposed to delete § 25.1181 (c) and place its provisions, with certain amendments, in a new § 25.1182. One commenter objects, stating that the fire protection requirements applicable to nacelle areas behind firewalls need not be extended to engine pod attaching structures because the current requirements have provided a superior level of safety for turbojet-powered large airplanes and no record of fires in these structures is known. The Administrator agrees concerning the superior level of safety and good service record of engine pod attaching structures with respect to fire. However, this level of safety has resulted through the voluntary incorporation by industry of engine pod attaching structure design provisions meeting the fire protection provisions of §§ 25.1195 through 25.1201 (except those requiring fire detection and extinguishing). The Administrator agrees with one comment stating that safety does not require that engine pod attaching structures have fire detection and extinguishing provisions, and that those structures may be distinguished from nacelle areas behind the firewall in this regard. To this extent, the Industry comment is accepted and this amendment is revised accordingly.
>
> The commenter also states that the “firewall definition” paragraphs are not relevant for the fire zone, that the “internal boundaries” are not clearly defined, and that this will lead to ventilation, containment, and fire extinguishing system difficulties. The Administrator finds intent of this comment not to be clear. However, there should be no difficulty in defining the area covered by the term “engine pod attaching structure.” Further, the Administrator does not agree that the firewall provisions are irrelevant to this structure. For this structure, as well as for reciprocating engine installations, the firewall separates the engine nacelle from the airframe in compliance with the provisions of § 25.1191. Finally, the claimed relationship between the firewall defining provisions and possible future difficulties in ventilation, containment, and fire extinguishing is neither supported nor evident. This comment cannot, therefore, be accepted.
>
> One commenter requests that an exception should be provided (1) for engine pod attaching structures where the firewall between pod and pylon extends enough beyond the profile of the pylon to prevent propagation of fire from the pod area around the firewall to the pylon zone; and (2) for installations that have means to prevent contact of leaking flammable fluid with a hot firewall. The Administrator agrees that these safety provisions may be relevant in individual showings of equivalent safety that may justify design alternatives to the sections referenced in § 25.1182. However, within the terms framed by the commenter, these safety provisions are not sufficiently definable to permit a general exception in the regulation. This comment cannot, therefore, be accepted.

(3) Amendment 25-23 (35 FR 5665, April 8, 1970) added a new § 25.1192 to require an engine accessory section diaphragm for reciprocating engines. As a result of this amendment, § 25.1181(a)(3) was amended to exempt reciprocating engines from the requirements of § 25.1181(a)(3). This amendment was based on the proposal made in, and reflects public comments concerning, Notice of Proposed Rulemaking 68-18 (33 FR 11913, August 22, 1968).

(4) Amendment 25-72 (55 FR 29756, July 20, 1990) revised § 25.1181(b) to refer to ". . . the requirements of § 25.867, and § 25.1185 through § 25.1203," because § 25.1205 had been previously recodified as § 25.867 by Amendment 25-23. This amendment was based on Notice of Proposed Rulemaking 84-21 (49 FR 47358, December 3, 1984).

d. **Policy/Compliance Methods.**

(1) The following guidance on Engine Fan Compartment Fire Zone Classification, was excerpted from an FAA memorandum, "Information: Engine Fire Zone Definition, § 25.1181", dated January 27, 1993.

> Section 25.1181 specifically defines those regions of the engine that contain ignition sources and potential flammable fluid leakage as fire zones. These zones include: the engine power section, the engine accessory section, the APU compartment, any fuel burning heater (or combustion equipment described in § 25.859), the compressor and accessory sections of turbine engines and, the combustor, turbine and tailpipe sections of turbine engines that contain lines or components carrying flammable fluids. That these zones contain both ignition sources and flammable fluids is self-evident and compliance with § 25.867 and § 25.1185 through § 25.1203 is required. However § 25.1181(a)(6) has been the subject of some debate with the development and transition of the turbine engine from the turbojet to today's high bypass turbofan engines. This evolution has resulted in inconsistent interpretation of what constitutes a fire zone with respect to the engine fan case.
>
> The earlier turbojet engines had a single compressor case which by itself was considered an ignition source. The regulation at that time specifically defined the compressor, accessory and turbine sections of turbine engines as fire zones. Later technology engines with increased bypass ratio separated the first stage of the compressor (the fan section) from the remainder of the compressor case. The fan case is cool and by itself is not an ignition source, hence the question, "Is the fan compartment a fire zone?."
>
> After reviewing the regulatory history, the certification practices and the intent of the regulation, regarding classification of fire zones per § 25.1181(a)(6), the Transport Airplane Directorate recommends the following guidance:
>
>> Fan compartments of turbofan engines may be considered as flammable fluid leakage zones, instead of a fire zone, provided the accessory gearbox is not located in the zone and the applicant demonstrates that no ignition sources are present within the zone during normal operation and foreseeable failure conditions. The justification for treating the fan compartment as a flammable fluid leakage zone rather than a fire zone must be included by the applicant in the certification documentation.
>
> This policy will allow a compliance finding for these configurations without the need for processing a finding of equivalent safety.

(2) The following guidance on Functionality During a Fire, was provided to FAA certification engineers as part of a Bilateral assessment certification

effort: "FADEC Fire Protection Policy, July 25, 1995, per the Propulsion Team, Indonesian Bilateral Assessment Project., Transport Standards Staff."

In response to your memo: "Fire Protection Requirements for Full Authority Digital Electronic Controls (FADEC)," dated June 12, 1995, the following general guidance is provided:

(1) In accordance with the intent of § 25.901(c) [as well as § 25.603 and § 25.1309(b)], it must be demonstrated that, under anticipated fire conditions, a FADEC system does not jeopardize the safe operation of the aircraft. In assessing compliance with this requirement, it should at least be shown that the FADEC:

(a) does not malfunction in a manner which could cause an uncontained engine failure (e.g., severe mis-scheduling of fuel flow, stator vanes, or stability bleeds; loss of critical case cooling air; etc.);
(b) does not cause a thrust reverser deployment;

(c) does not cause a critical propeller pitch change; and

(d) does not prohibit the safe shut-down of the engine.

(2) In accordance with the intent of § 25.1301 and § 25.1309(a) the FADEC must perform any intended functions during the fire (e.g., engine shutdown, closing cooling air valves when fire handle is pulled to aid fire extinguishing, etc.).

(3) In accordance with the intent of § 25.863 (as well as § 33.17) the FADEC must not exacerbate the occurrence or spread of fire.

(4) In accordance with § 25.1141(e), that portion of the FADEC system "which is located in a designated fire zone and is required to be operated in the event of a fire must be at least fire resistant".

This regulation establishes a minimum standard, which is adequate for components where operability is not required after the first 5 minutes of any fire, and then infers that more fire resistance should be provided as necessary. Given the variability of possible fire scenarios, system functional hazards, and fire protection provisions, compliance standards are needed to apply this regulation in a manner whereby each component is qualified for the fire exposure that it is intended to withstand. Consequently a standard engine fire protection model has been established based on service experience with traditional engine fire threats and protection provisions. This model assumes that: the fire will be detected and isolated from "hazardous quantities" of flammable materials within 5 minutes; and the residual flammable material will either be consumed, drained away, or extinguished within a total fire duration of 15 minutes.

If, for a particular design, the fire threats and protection provisions are such that these assumptions are reasonably valid, then the minimum "fire resistant" standard is adequate for any components where operability is not required following functioning of the last "shut off means" (see § 25.1189). Correspondingly, components for which operability is required throughout the duration of the fire must be fire proof. For operability requirements in between these two "standard" durations, or for designs with novel fire threats or protection provisions, individual justifications for the qualification levels must be provided.

The following are some specific observations on the subject project and your memo:

(1) It appears that, while the FADEC is not in the fire zone, it is subject to overheat as a result of a fire. Therefore, compliance with the general guidance provided above could be demonstrated by a FADEC "Overheat Test" (given the component temperatures anticipated to exist during a fire) plus an analysis of the fire effects anticipated on the rest of the system.

(2) It is assumed that the FADEC fuel "shut-off" feature that you referred to is the one at the engine fuel control unit and not the "fire-wall shut-off". If this is true then your application of § 25.1189 is inappropriate. The primary function of the "shut-off" feature in most fuel controls is to provide for engine shut-down. If fuel leaks into the fire zone can occur upstream of this valve, then this valve is not a "shut-off means" as described in § 25.1189. However, since it is presumed that this feature is called upon to function (i.e. shut down the engine) during the engine fire procedure, compliance with § 25.1141(e) would require that this be protected to at least the "fire resistant" level.

(3) Given the general utility of § 25.1141(e) in this policy, I wouldn't confuse the issue by referencing § 25.903(c) or § 25.869(a)(2).

(4) The appropriate qualification level for the propeller controls will depend on the particular design and the anticipated failure modes (e.g., if loss of the signal would result in the propeller feathering without risk of engine overspeed or excessive asymmetric drag, then perhaps no fire resistance is required; if loss of the signal would result in the propeller feathering, but this is only safe with the engine at idle, then perhaps "fire resistant" would be appropriate (it is suspected that this is the case); and if loss of the signal would never be considered safe, or the propeller needed to be feathered after engine shutdown, then perhaps it would need to be fire proof.)

(5) Your proposed requirement, that "the FADEC, including its interfacing wiring, should continue to provide its intended engine and propeller control functions when subjected to fire conditions," is unprecedented and unwarranted. When an engine fire occurs we intend to shut the engine down anyway. If this occurs as a natural result of the fire, so be it! There are a number of other engine components which may not allow continued normal engine operation under fire conditions. What we don't want is for the control to create a greater hazard.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Amendment 25-11 (32 FR 6913, May 5, 1967).

(4) Amendment 25-23 (35 FR 5677, Apr. 8, 1970).

(5) Amendment 25-72 (55 FR 29785, Jul 20, 1990).

(6) FAA Memorandum “Information: Engine Fire Zone Definition, § 25.1181”, dated January 27, 1993.

(7) FADEC Fire Protection Policy, July 25, 1995

Section 25.1182 Nacelle areas behind firewalls, and engine pod attaching structures containing flammable fluid lines.

a. **Rule Text.**

(a) Each nacelle area immediately behind the firewall, and each portion of any engine pod attaching structure containing flammable fluid lines, must meet each requirement of §§ 25.1103(b), 25.1165 (d) and (e), 25.1183, 25.1185(c), 25.1187, 25.1189, and 25.1195 through 25.1203, including those concerning designated fire zones. However, engine pod attaching structures need not contain fire detection or extinguishing means.

(b) For each area covered by paragraph (a) of this section that contains a retractable landing gear, compliance with that paragraph need only be shown with the landing gear retracted.

(Amendment 25-11, 32 FR 6913, May 5, 1967)

b. **Intent of Rule**. The intent of this rule is to ensure that the compartments in and around the engine fire zones housing flammable fluid carrying lines and components are designed to prevent the occurrence and spread of fire and to preclude additional hazards arising from a fire in the designated fire zone. These regions are therefore required to comply with the respective regulations providing for flammable fuel shutoff; fire resistant / fire proof fluid lines; components and induction systems; use of non-absorbing insulation; and compartment drainage and ventilation. For compartments such as a wheel well located immediately behind the engine firewall, the requirements for fire detection and extinguishment need to be addressed; while engine pod attaching structures need not contain fire detection or extinguishing means. The provision of § 25.1182(b), addressing compliance with § 25.1182(a) only with the landing gear retracted, is intended to apply to such wheel well compartments. Should fire extinguishing systems be installed in the wheel well, the required agent concentrations would apply only with the compartment closed, i.e., gear retracted. Generally, however, only fire detection is provided and gear extension suffices for the fire extinguishment requirements.

c. **Background.** This regulation was proposed in Notice of Proposed Rulemaking 65-43 (31 FR 93, January 5, 1966) and adopted as Amendment 25-11 (32 FR 6906, May 5, 1967). It replaced § 25.1181(c), which had been essentially unchanged from the time it was recodified from the Civil Air Regulations (CAR) 4b.480(c). [See the Background section under "**Section 25.1181 Designated fire zones; regions included**"(above) for a discussion of both Notice 65-43 and Amendment 25-11.

d. **Policy/Compliance Methods**. In general, the fire protection requirements identified in the applicable regulations are to be demonstrated by suitable tests. Advisory Circular (AC) 20-135 identifies those tests for demonstrating fire resistant and fire proof properties. The following excerpt from AC 20-135 provides definitions of terms and methodology for compliance.

> **BACKGROUND.** Although § 1.1 of the FAR provides general definitions for the terms "fireproof" and "fire resistant," these definitions do not specify heat intensity, temperature levels, duration (exposure time), or an appropriate wall thickness or other dimensional characteristic for the purpose intended. With the advent of surface coatings (i.e., ablative/intumescent), composites, and metal honeycomb for acoustically treated ducting, cowling, and other components which may form a part of the nacelle firewall, applicant confusion sometimes exists as to how compliance can be shown, particularly with respect to the definition of "fireproof" and "fire resistant" as defined in § 1.1.
>
> **FIRE PROTECTION PRINCIPLES AND OBJECTIVES.**
>
> a. The primary objectives of fireproof and fire resistant materials and components are to contain and isolate a fire and prevent other sources of fuel or air from feeding the existing fire, and to ensure that components of the engine control system will function effectively to permit a safe shutdown of the engine or APU and safe feathering of the propeller.
>
> b. To demonstrate satisfactory containment capability, the materials or components must have adequate strength for the foreseen flight and operating loads under the conditions of a fire to allow proper fire detection, flightcrew recognition, and subsequent corrective action. In addition gaseous emissions from fire protection materials shall be precluded from entering the cabin air conditioning system.
>
> c Fire testing should simulate the likely fire environment to prove the materials and components will provide the necessary fire containment to meet the above objectives when exposed to a fire situation in service.
>
> d. The descriptors "fireproof" and "fire resistant" differ only in the time duration that the material or component should maintain its integrity or perform its function. "Fire resistant" means the material or component will function and maintain its integrity for a minimum of 5 minutes when exposed to a 2000 Degree F flame temperature. "Fireproof" means the material or component will maintain its integrity and function for a minimum of 15 minutes when exposed to a 2000 Degree F flame temperature.

e. **References.**

(1) Notice of Proposed Rulemaking 65-43 (31 FR 93, January 5, 1966).

(2) Amendment 25-11 (32 FR 6906, May 5, 1967).

(3) Advisory Circular 20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria," February 14, 1990.

Section 25.1183 Flammable fluid-carrying components.

a. **Rule Text.**

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions, and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 25-quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) of this section does not apply to --

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in, or add to, a fire hazard.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-11, 32 FR 6913, May 5, 1967; Amendment 25-36, 39 FR 35461, Oct. 1, 1974; Amendment 25-57, 49 FR 6849, Feb. 23, 1984)

b. **Intent of Rule.** The intent of this rule is to prevent the burnthrough and subsequent flammable fluid leakage of fluid lines, components, and tanks. The regulation is intended, therefore, to prevent feeding flammable fluids to an engine or APU fire

c. **Background.**

(1) Notice of Proposed Rulemaking 65-43 (31 FR 93, January 5, 1966) proposed amendment of this section to make it clear that the specified inapplicability of this section to “lines and fittings forming an integral part of an engine” is not intended to relieve those components from any substantive requirement, but to expedite aircraft type certification by not requiring duplication of engine certification standards already met under Part 33. Discussion of the proposal from its preamble is provided as follows:

> Subparagraph (b)(1) of § 25.1183 would be amended to make it clear that the specified inapplicability of paragraph (a) . . . to “lines and fittings forming an integral part of an engine” is not intended to relieve those components from any substantive requirement, but rather to expedite aircraft type certification by not requiring duplication of engine certification standards already met under part 33.

(2) Amendment 25-11 (32 FR 6913, May 5, 1967) accepted the proposals of Notice 65-43.

> No adverse comments having been received, the proposed change to §§ 23.1183, 25.1183, 27.1183, and 29.1183 (concerning lines and fittings approved as part of an engine) is issued as proposed.

(3) Amendment 25-36 (39 FR 35461, October 1, 1974) discussed the following changes:

> <u>Proposal 8</u> - Section 25.1183(a) has been further amended in connection with changes to § 25.1013(a) as noted under Proposal 4. The exemption contained in the last sentence of § 25.1013 (a), concerning fireproofing of an integral oil sump of less than 20-quart capacity on a reciprocating engine, has been removed from this section and placed in § 25.1183(a). This action involves no substantive change and achieves consistency with the parallel Part 23 section.

(4) Amendment 25-57 (49 FR 6849, February 23, 1984) discussed the following changes:

> <u>Proposal 35</u>. For a discussion of comments on and disposition of the proposed amendment to § 25.1183(b)(1), see the proposal for § 23.1183(b)(1).
>
> <u>Proposal 15</u>. The amendment to § 23.1183 would raise the limiting capacity of reciprocating engine oil sumps from 20 to 25 quarts before fireproofing or shielding is required. Also, the regulation exempts components, as well as lines and fittings that have been approved as part of the engine, from these requirements. These changes remove unjustified engine design limitations and afford increased range capabilities.
>
> One commenter recommends that the 20-quart capacity limit required by paragraph (a) be retained. The proposal is seen as an arbitrary accommodation of a particular application for type certification, but the commenter does not supply specific information or data to support this claim. A search of FAA records has not disclosed such an application.
>
> Neither service with 20-quart capacity oil systems nor any other evidence has shown that there would be any compromise of safety associated with a sump capacity of 25 quarts of oil as opposed to 20 quarts in the case of a powerplant fire. The amendment is adopted as proposed.

d. **<u>Policy/Compliance Methods.</u>** Current FAA policy is reflected in the following excerpts:

(1) ***Engine Oil Tank Fire Proof Demonstration***. The following guidance is based upon discussions between the Engine and Propeller Directorate and the Transport Airplane Directorate concerning test conditions for demonstration of the oil tank fireproof requirements of paragraph (a) of this § 25.1183. The need for additional guidance was determined during certification of an engine for use on a turbopropeller-powered airplane. The engine manufacturer conducted fireproof tests of the engine oil

tank to show compliance with § 33.17(c). However, review of the test conditions showed that the tank had been tested with oil flowing in the oil system at a rate not expected for the particular engine installation during fire conditions. Retesting of the oil tank was required to demonstrate compliance with § 25.1183(a). This situation shows the need for coordination between the engine and airframe manufacturer to assure that the definition of test conditions for certification will substantiate compliance with this section.

The intent of § 25.1183 is to ensure that the engine oil would not become added fuel to an existing fire within the engine fire zone. This is of particular interest for turbopropeller airplanes which have the engine located forward of the wing leading edge causing propeller downwash to impinge (with any flames) on the wing. The condition for which the oil tank must meet the fireproof requirements depends upon the engine application. For example, a turbofan engine will windmill when it is shutdown and therefore an assumed oil flowrate at engine windmill speed is appropriate. The crew procedure following a fire indication in a turboprop engine is to shutdown the engine and feather the propeller. This greatly reduces the oil flow rate. (The engine flight idle oil flow rate is 25 gal/min. versus 1 gal/min. with the propeller feathered.)

The policy regarding fire testing of engine components for compliance with § 25.1183 is described in general terms in AC 20-135, Paragraph 6.d.(4), which recommends that an analysis be conducted of potential fire scenarios and provides examples of considerations for establishing the appropriate fire test criteria. For a turboprop installation, the oil flowrate, if any, should be no more than that provided by the engine with a feathered propeller.

Additional test parameters should include fire testing at the worst case flow condition for an operating engine and 1) the lowest dispatchable oil quantity, 2) highest heat rejection to the oil. The overseeing office therefore approved the test plan with oil flow rate into and out of the tank (and airflow through the nacelle) which simulates flight idle power. (See AC 20-135 and AC 33-2B for additional guidance regarding demonstrating compliance to this section.)

(2) ***APU Compartment Considerations:*** The primary objectives of § 25.1183 are to contain and isolate a fire and prevent other sources of combustible fluid, in this case oil, from feeding the existing fire, and to ensure that components of the APU control system will function effectively to permit a safe shutdown of the APU.

The test conditions should simulate an APU compartment fire scenario where the fire has a 15 minute duration. When determining the conditions for the oil tank fire test, the applicant should demonstrate by test, the most critical operational conditions, based upon analysis of all possible conditions within the flight envelope.

Option 1: The oil tank fire test may be performed at the maximum oil temperature for not less than 15 minutes at the most critical oil tank operating condition from the tank net heat absorption/removal standpoint, which is normally defined as a zero oil flow rate through the tank

Option 2: Alternatively, the oil tank fire test may be run at the minimum APU operational rotor speed oil flow rate with its associated maximum oil temperature for 5 minutes, then immediately followed by a period of ten minutes with an oil tank flow rate representative of APU shutdown, which is normally considered to be a zero flow rate for APU's which normally don't windmill.

(a) The tank pressure shall be the working pressure of the equivalent oil tank operating conditions under test, in all cases.

(b) The test flame temperature should be 2000° F ±150°F measured within .25" of the test component for 15 minutes minimum.

(c) The test flame should apply to the oil tank location that is determined by analysis and/or test to be the most critical to fire susceptibility, i.e. the specific location of the tank where it is least likely to survive the effects of a fire.

(d) The flame heat content should be at 9.3 BTU/ft^2 - sec or 4500 +200/-100 BTU/hour using BTU heat transfer device calibration.

(e) The fire test burner to be used should provide the required flame temperature, be of sufficient size, be at an energy level (heat content) and cover a representative portion of tank test location.

(f) The air velocity and temperature over the test assembly should be a simulated airflow through the nacelle for the engine operating conditions under test. However, the test may also be run in still air with appropriate air temperature. The latter condition is more severe than in service where any flowing air removes heat.

(g) The fire test acceptance criteria is that 1) there should be no burn-through of the tank, and 2) there should be no leakage of oil sufficient to cause combustion or to feed the existing fire.

(h) The oil carrying components of the lubrication system of an engine other than oil tank should also be subject to a fire test with the same test conditions and criteria of an oil tank if these components, when damaged by the effects of a fire, could leak sufficient quantity of oil to create a combustion source or to feed the existing fire. For certain components, the fireproof test using the critical engine operating conditions (not including engine shutdown) may be acceptable, subject to approval of the responsible ACO on the case by case basis if the component and the oil loop connected to it would not carry and leak sufficient oil to create fire hazardous conditions stated above when the engine is shutdown.

(3) ***Component shielding:*** Section 25.1183(a) also requires *"Components must be shielded or located to safeguard against the ignition of leaking flammable fluid."* This requirement is identical to that of § 33.17(b), which applies to the components of the engine. The intent of this requirement is to keep liquid flammable fluids from contacting ignition sources. Ignition sources include hot surfaces or any component that produces an electrical arc.

Compliance with this paragraph has been shown by installation of shrouds around the entire high pressure fuel manifold, installation of shrouds around only fittings and only installation of spray shields to deflect leaking fuel away from hot surfaces. The level of shielding that is necessary depends upon the types of leaks possible and the ignition sources present. A thorough analysis of the flammable fluid leak sources and relationship to any ignition sources should be conducted. The analysis should show that leaked flammable fluid will not impinge upon ignition sources. Local conditions within the compartment may be considered, such as ventilation and drainage provisions. Shielding should be provided for any component that would be an ignition source if contacted by leaked fluid.

Service history has shown that complex shroud arrangements have been difficult to maintain and in some cases resulted in increased incidents of fuel leaks. Sharp edges of spray shields have also caused damage to fuel lines. Therefore, maintainability of the shroud/shielding system should be evaluated.

e. **References.**

(1) Amendment 25-11 (32 FR 6913, May 5, 1967).

(2) Amendment 25-36 (39 FR 35461, October 1, 1974).

(3) Amendment 25-57 (49 FR 6849, February 23, 1984).

(4) Advisory Circular 20-135, “Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria,” February 6, 1990.

(5) Advisory Circular 33-2B, “Aircraft Engine Type Certification Handbook,” June 30, 1993.

Section 25.1185 Flammable fluids.

a. **Rule Text.**

(a) Except for the integral oil sumps specified in 25.1013 (a), no tank or reservoir that is a part of a system containing flammable fluids or gases may be in a designated fire zone unless the fluid contained, the design of the system, the materials used in the tank, the shut-off means, and all connections, lines, and control provide a degree of safety equal to that which would exist if the tank or reservoir were outside such a zone.

(b) There must be at least one-half inch of clear airspace between each tank or reservoir and each firewall or shroud isolating a designated fire zone.

(c) Absorbent materials close to flammable fluid system components that might leak must be covered or treated to prevent the absorption of hazardous quantities of fluids.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964 as amended by Amendment 25-19, 33 FR 15410, Oct. 17, 1968)

b. **Intent of Rule.** This section requires that fuel, flammable fluid or vapor tanks, reservoirs or collectors be sufficiently isolated from engines, engine compartments, and other designated fire zones so that hazardous heat transfer from these areas to fuel, flammable fluid, and vapor tanks, reservoirs or collectors is prevented in either normal or emergency service. In summary, the intent is to ensure that design precautions are taken to minimize the hazards from flammable fluid tanks located outside the fire zone following a fire within a fire zone.

c. **Background.**

(1) The regulatory history shows that this requirement originated from section 4b.445 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.445 without any substantive changes.

(2) Amendment 25-19 (33 FR 15410, October 17, 1968) followed Notice of Proposed Rulemaking 68-3 (33 FR 3641, March 1, 1968) and introduced the exception of integral oil sumps noted in paragraph (a) of the rule. It was noted in the preamble to Amendment 25-19 that § 25.1185(a) contains powerplant fire protection requirements for tanks and reservoirs containing flammable fluid which, in some

respects, parallel the oil tank requirements of § 25.1013(a). Therefore, in order to fully implement the proposed regulation, it also was necessary to exclude the integral oil sumps (covered by this amendment) from the requirements of § 25.1185(a).

d. **Policy/Compliance Methods.** The following guidance is extracted from material contained in AC 29-2B, July 30, 1997. (Although that AC provides guidance for transport rotorcraft, it may provide insight into acceptable compliance methodology useful for other category aircraft.)

(1) The fuel, flammable fluid and vapor system designs should be reviewed early in the certification process to insure that all fuel or flammable fluid or vapor tanks, are properly identified and isolated from engines, engine compartments and other designated fire zones during both normal and emergency operations such as in-flight engine compartment or other fire zone fires. In some cases fuel or flammable fluid components must be located in an engine compartment or other designated fire zone. In these cases, the applicant must show that the design provides an equal level of safety (considering the design, construction, tank supports, materials, fuel lines, fittings, and controls used in the system, or system segment, contained in the engine compartment or other designated fire zone) to that of locating the flammable fluid source outside the fire zone. In all cases, the flammable fluids, fuels, and vapors should be sufficiently isolated from hazardous heat fluxes during both normal and emergency operations to prevent autoignition.

(2) This regulation requires at least one-half inch of clear airspace between each flammable fluid or vapor tank, and each firewall or shroud that isolates the system, unless equivalent means (such as fireproof insulation) are used to prevent hazardous heat transfer from each engine compartment or other fire zone to the flammable fluid or vapor mass (or its container surface) at the fluid or vapor's minimum autoignition temperature. If in-service structural deflections are significant, they must be taken into account when certifying the one-half inch minimum clear airspace requirement. For example, if a one-half inch clearance exists on the ground but in some normal and emergency flight conditions the one-half inch is reduced to one-fourth inch at a critical time (in-flight engine fire), then the design (static) configuration should have at least a one-half plus one-fourth equals three-fourths inch static clear airspace to insure the regulation's intent is met. Alternatively, fireproof insulation or additional stiffeners could be used to insure the regulation's intent is met (i.e., the thermal equivalent of one-half clearance is maintained at all times). Any material used as insulation on or used adjacent to flammable fluid or vapor tank, should be certified as chemically compatible with the flammable fluid or vapor and to be non-absorbent in case of fuel or vapor leaks. Otherwise, the material should either be treated for compatibility and non-absorbency or not accepted.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Amendment 25-19 (33 FR 15410, October 17, 1968).

(4) Advisory Circular 29-2B, "Certification of Transport Category Rotorcraft," July 30, 1997.

Section 25.1187 Drainage and ventilation of fire zones.

a. **Rule Text.**

(a) There must be complete drainage of each part of each designated fire zone to minimize the hazards resulting from failure or malfunctioning of any component containing flammable fluids. The drainage means must be --

(1) Effective under conditions expected to prevail when drainage is needed; and

(2) Arranged so that no discharged fluid will cause an additional fire hazard.

(b) Each designated fire zone must be ventilated to prevent the accumulation of flammable vapors.

(c) No ventilation opening may be where it would allow the entry of flammable fluids, vapors, or flame from other zones.

(d) Each ventilation means must be arranged so that no discharged vapors will cause an additional fire hazard.

(e) Unless the extinguishing agent capacity and rate of discharge are based on maximum air flow through a zone, there must be means to allow the crew to shut off sources of forced ventilation to any fire zone except the engine power section of the nacelle and the combustion heater ventilating air ducts.

b. **Intent of Rule.** The intent of this rule is to ensure that flammable fluid drainage and compartment ventilation is provided to safely control flammable fluid leakage and vapor that may be present in a fire zone.

c. **Background.** The regulatory history shows that this requirement originated from section 4b.445 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.445 without any substantive changes.

d. **Policy/Compliance Methods.** Guidance for this section was made available for public comment in draft Advisory Circular (AC) 25-1187-1, "Minimization of Flammable Fluid Fire Hazards (Flammable Fluid Fire Protection)." The guidance provided below considered comments received and is being published within this AC instead of within a separate AC.

Advisory Circular 25-1187-1

Minimization of Flammable Fluid Fire Hazards (Flammable Fluid Fire Protection)

1. **PURPOSE.** The information and guidance provided in this Advisory Circular provides a means, but not the only means, of compliance with the portions of Part 25 of the Federal Aviation Regulations (FAR) (14 CFR part 25) pertaining to certification requirements for compartments in transport category airplanes that contain flammable fluid leakage sources. The primary regulations include § 25.1187 and § 25.863. Accordingly, this material is neither mandatory nor regulatory in nature and does not constitute a regulation. In lieu of following this method, the applicant may elect to establish an alternative method of compliance that is acceptable to the Federal Aviation Administration (FAA) for showing compliance with the requirements of the sections of the FAR listed below.

2. **RELATED DOCUMENTS.**

a. Related Federal Aviation Regulations.

§ 25.863,	"Flammable fluid fire protection"
§ 25.901(b)(2) and (c),	"Powerplant - General, Installation"
§ 25.954,	"Fuel system lightning protection"
§ 25.1091(d)(1),	"Air induction"
§ 25.1121(b) and (d),	"Exhaust System - General"
§ 25.1163 (b),	"Powerplant accessories"
§ 25.1181,	"Designated fire zones: regions included"
§ 25.1182,	"Nacelle areas behind firewalls, and engine pod attaching structures containing flammable fluid lines"
§ 25.1183,	"Flammable fluid-carrying components"
§ 25.1185(c),	"Flammable fluids"
§ 25.1187,	"Drainage and ventilation of fire zones"
§ 25.1189,	"Shutoff means"
§ 25.1191,	"Firewalls"
§ 25.1192,	"Engine accessory section diaphragm"
§ 25.1193,	"Cowling and nacelle skin"
§ 25.1195,	"Fire extinguishing systems"
§ 25.1207,	"Compliance:

b. Technical Standard Orders (TSO).

TSO-C53a, Fuel and Engine Oil System Hose Assemblies.

Technical Standard Orders can be obtained from the Federal Aviation Administration (FAA), Aircraft Certification Service, Aircraft Engineering Division (AIR-120), 800 Independence Ave., SW, Washington, D.C. 20591

c. Advisory Circulars (AC).

AC 25-8	Auxiliary Fuel System Installations.
AC 25-16	Electrical Fault and Fire Prevention and Protection.
AC 20-53A	Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning.
AC 20-135	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria.
AC 25.981-1A	Guidelines for Substantiating Compliance with Fuel Tank Temperature Requirements.
AC 43.13-1A	Acceptable Methods, Techniques, and Practices -- Aircraft Inspection And Repair.

Advisory Circulars can be obtained from the U.S. Department of Transportation, M-443.2, Utilization and Storage Section, 400 7th Street SW, Washington, D.C. 20590

d. Technical Publications.

(1) Military Specifications, MIL-SPEC-810C, Method 511.1 Procedure II, (Explosion Proof) . (This document can be obtained from Defense Printing, Customer Service, 700 Robbin Avenue, Building 4, Section D, Philadelphia, PA 19111.)

(2) Latest version of Radio Technical Commission for Aeronautics (RTCA) Document DO-160, "Environmental Conditions and Test Procedures for Airborn Equipment." (This document can be obtained from the RTCA, One McPherson Square, Suite 500, 1425 K. Street Northwest, Washington, DC. 20005.)

(3) Handbook of Aviation Fuels Properties, Coordinating Research Council (CRC) Document 530 (This document can be obtained from the Society of Automotive Engineers, Inc., General Publications Department, 400 Commonwealth Drive, Warrendale, PA 15096.)

(4) Kuchta, Joseph M., Summary of Ignition Properties of Jet Fuels and Other Aircraft Combustible Fluids, Air Force Aero Propulsion Laboratory Technical Report AFAPL-TR-75-70, US. Bureau of Mines PMSRC, 1975. (This document can be obtained from the National Technical Information Service (NTIS), US. Department of Commerce, Springfield, VA 22151.)

3. **DEFINITIONS.** Areas of the airplane and engine are segmented into zones to provide separation and isolation of flammable fluids from ignition sources and to

prevent the spread of fire. Each zone that contains sources of flammable fluids is required to provide features to prevent the accumulation of flammable fluids and vapors in order to reduce the likelihood of ignition and to minimize the hazards should ignition occur. Areas of the airframe, engine, and auxiliary power unit (APU) are classified as fire zones or flammable fluid leakage zones based on inherent features, as shown in the definition of terms list shown below:

a. Flammable fluid leakage zone. Any compartment where flammable fluids or vapors and ignition sources are not normally present, but where flammable fluids or vapors might escape by leakage of a fluid system. In general, it has been recognized that a flammable fluid leakage zone requires at least two independent failures to result in a fire:

- one for the fluid leak and
- the second for the presence of an ignition source.

b. Fire zone. Any compartment that contains both a flammable fluid leakage source and an ignition source.

Areas that have been designated as fire zones are listed in § 25.1181 as:

- the engine power section,
- the engine accessory section,
- the APU compartment,
- any fuel burning heater (or combustion equipment described in § 25.859),
- the compressor and accessory sections of turbine engines,
- and the combustor, turbine, and tailpipe sections of turbine engine installations that contain lines or components carrying flammable fluids.

(Note: Although the wheel well is not designated as a fire zone within the Federal Aviation Regulations, this area on certain airplane types contains flammable fluid leakage sources, hydraulic fuel, and adjacent fuel tank.)

Under certain conditions, the landing gear and brakes may provide an ignition source.

In addition, on certain installations, such as turbopropeller type airplanes, the wheel well may be within the lower portion of the engine nacelle [§ 25.1182(b)]. A fire within the engine may result in hot surfaces and an ignition source for any flammable fluids within the adjacent wheel well compartment. For the purpose of this AC, the wheel well should be considered as containing both flammable fluids and ignition sources.) Appropriate protection features such as wheel well overheat indication and flight crew procedures to extend the landing gear may be necessary to show compliance.

c. Telltale drain. A drain outlet system that allows identification of a leaking accessory in a compartment that contains many accessories; or a manually activated device that is used to determine whether fluid has flowed through a drain line or shroud.

d. Vapor barrier. A barrier installed to confine vapor within a fire zone or flammable fluid leakage zone.

e. Baffle rib. A vapor barrier or dam that segments the leading or trailing edge of the wing such that leaking flammable fluids and associated vapor are controlled to reduce the likelihood of ignition. Baffle ribs provide a means to control drainage and ventilation within zones and divert fluids away from the fuselage, thereby limiting propagation of fire.

f. Autogenous ignition (Auto-Ignition) temperature. The minimum temperature at which an optimized flammable vapor and air mixture will spontaneously ignite.

g. Ignition source. A heat source of sufficient temperature and energy to initiate combustion of the flammable fluid(s) under the consideration for the given design features, such as geometry, ventilation rate, ventilation temperature, etc., of the installation. Hot surfaces, electrical arcs, and friction sparks are also common ignition sources.

h. Maximum surface temperatures. There is a general industry/FAA practice that a temperature providing a safe margin under all normal or failure conditions is at least 50°F below the lowest expected auto-ignition temperature of the flammable fluid within the zone. The autogenous ignition temperature of fuels will vary because of a variety of factors (ambient pressure, dwell time, fuel type, etc.), but the value generally accepted without further substantiation for kerosene type fuels, under static sea level conditions, is 450°F. This results in a maximum surface temperature of approximately 400°F for an affected component. If a higher auto-ignition temperature boundary can be substantiated for the particular design installation, taking into account factors such as geometry, ventilation rates, etc., then the maximum allowable surface temperature may be higher than the maximum surface temperature determined on the basis of the nominal values for the auto-ignition temperature of the fluid listed in this AC.

NOTE: The FAA has approved installations that experience surface temperatures in excess of 400°F. Manufacturers have substantiated that the conditions (ambient pressure, dwell time, fuel type, etc.) within certain flammable fluid leakage zones are such that a higher value may be used. For example, maximum allowable pneumatic bleed duct surface temperatures of 450°F, with a transient excursion up to 500°F for a maximum of two minutes, has been approved. The excursion above 450°F occurs only during failure conditions, such as an engine pneumatic high stage bleed valve failure or duct rupture. Approval of these elevated temperatures has been based on compensating design features, such as:

- cockpit indication of overtemperature and associated procedures to shutoff the overheated system;
- insulated ducts;
- zone ventilation airflow that produces a lean fuel to air mixture; and
- an automatic overtemperature shutoff of the pneumatic system so that the temperature cannot exceed the accepted 450°F value for more than two minutes.

i. Flash point. The minimum temperature at which a flammable liquid will produce flammable vapor at sea level ambient pressure. According to the technical publication listed in paragraph 2(d)(4) of this AC, flash point values are obtained by placing a sample of the liquid being tested in a cup and heating at a constant rate. A small flame is directed into the cup at intervals, and the lowest temperature at which the vapor of the sample ignites is taken as the flash point.

The methods used are classified as either closed-cup (closed to the atmosphere and exposed only at the moment of application of the test flame), or open-cup (open to the atmosphere). Usually, flash points obtained by the closed-cup methods are lower and more reliable than those obtained by open-cup methods.

j. Flammable fluid. Any fluid that can burn, such as fuels, hydraulic fluid (including phosphate ester based fluids such as "Skydrol"), and oils. The temperatures shown below are approximate and depend on the test method and conditions; however, generally accepted flammability properties for some common aviation fluids are:

	Flash point	**Auto-ignition temp.**
Jet A, JP-4, Mineral oils	100-140°F	450°F
Aviation gasoline	-40°F	815°F
Synthetic Turbine Engine oils	430°F	700°F
Phosphate ester hydraulic fluid (Skydrol) *****	360°F	750°F

***** *Further information on flammable fluids used in airplanes may be found in the document referenced in paragraph 2(d)(4), above.*

k. Flammability limit. The highest and lowest concentration of fuel vapors in air by percent volume that will sustain combustion. A fuel-to-air mixture below the lower limit is too lean to burn, while a mixture above the upper limit is too rich to burn. The flammability limit varies with altitude and temperature, and is typically presented on a temperature vs. altitude plot. Design precautions, such as ventilation of flammable fluid leakage zones, should be taken where possible to ensure that flammable mixtures do not form following a flammable fluid leak.

4. **BACKGROUND.** A common cause of airplane fires has been the ignition of leaked flammable fluids. The primary means of preventing these fires is to safely drain the fluid away from the airplane, both in flight and on the ground, and to provide ventilation that results in a lean fuel to air mixture. The purpose of this AC is to provide guidance in what factors should be considered in the design of flammable fluid drainage systems and ventilation systems, and to describe a means of showing compliance with the sections of the FAR that address these systems.

a. A variety of methods have been used in the past to show compliance with the sections of the FAR that pertain to compartments containing potential flammable fluid leakage sources. Inconsistency in compliance demonstration methods has led to differences in the effectiveness of sealing and drainage systems on different model airplanes for compartments which contain flammable fluid carrying systems. Some of the methods used in the past are no longer considered adequate to demonstrate that the applicant's design meets the related regulations.

b. Inconsistencies have included:

- demonstration of the drainage system only during static conditions on the ground;
- variations in the drainage rate used to simulate an actual fluid leak; and

- simulation of fluid leakage during demonstration flight tests by spraying dyed water directly into the drain tube inlets, rather than simulating leakage at the fluid source with a spray nozzle or similar device.

Static-only testing of drainage systems may not properly simulate actual drainage system performance because the flow field near the outlet, and pressure differentials between the inlet and the outlet, may be significantly different from those predicted by analysis. The last practice results in an evaluation of drainage paths originating at the intended drain outlet, but does not properly evaluate the design for unintended fluid leaks (such as inadequate seals on compartment openings, etc.) or trapping of flammable fluid within the zone.

5. **DISCUSSION.** Compliance with the sections of the applicable FAR listed above should be shown with a multiple step process involving analysis, ground tests, and flight tests. This three-step process assures that compliance with the regulations has been shown and that significant problems in design or manufacturing are identified early in the certification process.

a. Analysis.

(1) ZONE CLASSIFICATION.

(i) An analysis of each zone in the airplane that contains flammable fluids should be conducted to substantiate the classification of a region as a fire or flammable fluid leakage zone. Examples of flammable fluid leakage zones in some airplane types include:

- the wing leading and trailing edges;
- compartments within the engine strut or pylon;
- areas aft of the pressure bulkhead that contain hydraulic actuators; and
- engine fan cowl compartments that contain flammable fluids, but do not contain ignition sources, such as the accessory gearbox, etc.

(ii) For a zone to be classified as a flammable fluid leakage zone instead of a fire zone, it is necessary to show that no single failure or probable combinations of failures will result in the presence of both an ignition source and a flammable fluid source within the zone. Examples of single or likely combinations of failures that have produced such conditions include; arcing or sparking of an electrical cable to a fuel line, and a pneumatic duct failure that resulted in movement of the duct and impact damage to both an adjacent fuel line and a power cable.

(iii) Analysis should substantiate separation of leakage sources and ignition sources. As stated in AC 43.13-1A (“Acceptable Methods, Techniques, and Practices -- Aircraft Inspection and Repair”), an arc fault between an electrical wire and a metallic flammable fluid line may puncture the line and result in a serious fire. When wiring is run parallel to combustible fluid or oxygen lines, maintain as much separation as possible. Locate wires above or level with the fluid lines and, wherever possible maintain a minimum separation of six inches. In tight spaces (such as the engine strut) where separation is reduced, install clamps or insulative material to assure fuel line contact and arcing are not possible. Based on in service experience, in no case should the minimum clearance between wiring and flammable fluid carrying lines be less than one inch during worst-case failure conditions, taking into consideration relative motion of aircraft structure due to wing deflection or engine movement and manufacturing tolerances.

(2) IGNITION SOURCE ANALYSIS.

(i) For a zone to be classified as a flammable fluid leakage zone instead of a fire zone, components located in the zone must be qualified to meet standards during both normal and failure conditions that ensure that ignition of flammable fluid vapors will not occur.

(ii) Electrical components may be qualified for use within flammable fluid leakage zones by showing the unit meets the appropriate criteria such as the explosion proof requirements as defined in AC 25-16 ("Electrical Fault and Fire Prevention and Protection"), Section 9 of RTCA Document DO-160, and MIL-SPEC-810C. Potting, hermetic sealing, flame quenching drainage provisions, and energies below 0.02 millijoules may also indicate compliance with explosion-proof nature. Components must be shown to be free of potential arcing or friction ignition sources, and have maximum surface temperatures that will not cause auto-ignition of flammable fluids or vapors within the zone.

(3) VENTILATION ANALYSIS. Zones that contain flammable fluid sources should be ventilated in such a way that, should a leak occur, a lean fuel-air mixture would result, thereby reducing the likelihood of ignition. The leak type and the zone configuration affect the amount of ventilation that is required to maintain a lean mixture. For example, an engine compartment may contain obstructions that result in stagnation areas and warm surfaces that result in rapid vaporization of leaked liquid flammable fluids. Other areas of the airplane, such as a wing trailing or leading edge, or an APU compartment, may have fewer obstructions and/or cooler temperatures. Therefore, the applicant should analyze each zone and provide ventilation that will maintain a lean mixture, assuming that liquid flammable fluid is present from leak sources within the zone. Typically, five airflow changes per minute have been found to be acceptable for fire zones. Analytically-determined ventilation rates should be validated by flight test results by measuring pressures within each zone and calculating airflow rates using known areas and the differential pressures.

NOTE: Ventilation of the fire zone should be included in the demonstration of compliance with the fire extinguishing requirements of § 25.1195.

(4) LEAK SOURCE ANALYSIS.

(i) An analysis of the design should be conducted to establish the potential leak sources for each zone of the airplane, including potential leaks due to maintenance errors. The applicant should substantiate that single failures or maintenance errors cannot result in large uncontrolled leaks that will exceed the drainage system design flow rate. Examples of large uncontrolled leaks that have occurred in the past include:

- failures of the strut fuel line coupling due to over-tightening or misassembly of the coupling without the packing (0-ring),
- unsecured fuel filter;

- failure of the high pressure fuel line due to fatigue cracking; and
- failure of the secondary fuel/vapor barrier due to cracking or misapplication.

Typically, drainage systems should provide adequate capacity to handle fluid flow rates that could occur due to failure of a single seal, or cracking of high pressure lines. For example, many current airplanes were certificated based on demonstration of the drainage system flow capacity of one gallon per minute. This rate was established by analysis of the maximum leak possible when one 0-ring seal was omitted from a fuel line coupling. The applicant should establish the proper drainage rate based on analysis of potential leaks sources within the zone.

(ii) Means to ensure that leakage rates will remain within design levels include:

- installation of telltale drains that will provide maintenance awareness of small leaks;
- fail-safe features on connections (such as shrouds around couplings, double attachment of fuel filters, and reduced flow areas around seal retention plates within couplings to restrict flow if seal failure occurs);
- isolation of high-pressure leak source drains from low-pressure leak source drains to preclude back flow into low-pressure systems;
- location of drain lines away from heat sources that are of sufficient temperature to cause clogging due to residual carbon build-up (coking); and
- installation of graduated/increased area drain screens over drain inlets to preclude clogging by debris. One example of a drain screen that has been used for this purpose is a "finger screen," which extends vertically from the drain inlet and allows passage of fluid if debris collects around the base of the screen.

(iii) Airplane drain problems have occurred due to manufacturing discrepancies that resulted in failure of the drainage or sealing systems to perform their intended function. The drainage system analysis also should establish that manufacturing and inspection processes and procedures are in place to ensure that necessary sealing provisions perform their intended function. Examples of production errors that have occurred include:

- improper sealing of firewalls within the engine strut;
- misapplication of secondary fuel barrier coatings (sprayed on external tank surfaces at angles resulting in shadowing of certain areas, such as rivet heads); and
- use of improperly prepared coatings that prematurely cracked with age.

(iv) After the leak source analysis has been performed, the consequences of a maximum foreseeable leak should be evaluated to assure that a hazardous condition is not created. Sealing of compartments should be adequate to allow build-up of fluids without drainage of fluid into areas where ignition could occur. The location of flammable fluid overboard drain outlets is critical in providing a design which precludes ignition of leaked fluids. The following guidelines should be used in locating flammable fluid drain outlets:

(A) Overboard drain outlets should be arranged such that flammable fluids drain clear of the airplane when the airplane is on the ground.

(B) Outlets should be located downstream of areas where drained fluid may reenter the airplane in flight.

(C) Outlets should be designated and/or located to meet the lightning requirements of § 25.954 (see AC 20-53A, “Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning”).

(D) Outlet location and line routing should be evaluated to ensure there are no restrictions because of water traps that result in the accumulation of water or ice.

(E) Drain masts should not be located where they may impact the runway during over-rotation takeoff, wing low landings, or wheels-up landing conditions.

(F) To prevent fluid from running along the outside of the airplane, drain masts should extend beyond the boundary layer; therefore, the location of the drain mast should ideally be where the boundary layer is thin. Installation of a vortex generator on the drain mast upstream of the outlet may facilitate dispersion of the fluid and eliminate hazardous impingement on the airframe.

(5) DEMONSTRATION OF COMPARTMENT SEALING AND DRAINAGE PROVISIONS.

(i) In some cases, it can be shown that leakage from unintended places and impingement on other parts of the airplane are clearly not possible. In these cases it may be permitted to show compliance by analysis. The analysis must show that the drainage system will perform under all allowable flight conditions, and it must be substantiated that unfavorable pressure gradients do not exist under any flight conditions so that the drainage system will function as intended.

(ii) In most cases, however, compliance of compartment sealing and drainage provisions must be substantiated by test. Both ground and flight tests are normally required. As with any FAA certification test program, the applicant must submit a certification plan proposing analysis methods and test conditions, and this plan must be approved before the FAA will conform test articles or witness tests.

b. Ground Test. A static ground test is required to demonstrate that no hazardous quantities of fluid can be trapped within a flammable fluid leakage zone or fire zone by the geometry of the compartment(s) which make up that zone, and to make an assessment of the overall suitability of the drainage paths. The airplane should be in a normal ground attitude. The test is typically performed by introducing a measured amount of fluid (usually 1 to 2 gallons of dyed water) into the test compartment in the vicinity of the potential leakage sources and measuring the amount of water that is recovered from the compartment drains. A guideline that may be helpful in identifying excessive trapped fluid within the zone is to verify recovery of 90 percent of the test fluid, with no indication of excessive puddling (individual puddles must be smaller than 1.5 fluid ounces) and absence of drainage via hazardous paths. This ground test must be completed successfully and the results approved by the FAA before flight test demonstration of the drainage system.

c. Flight Test.

(1) A flight test is necessary to demonstrate that the intended drainage paths and compartment seals are effective under all flight conditions and to show that no fluid migrates to, or impinges on, an area of the airplane where it would create an additional hazard. The following test method has been used successfully by applicants in the past.

(2) A test fluid dispensing system is installed in the airplane with nozzles located to spray into areas where potential leaks would occur. The spray should be dispersed in a manner representative of the potential leakage sources so that any unintended leakage paths will be apparent. Fluid spray bars consisting of a flexible tube with perforations have been used in the past to simulate leakage from flammable fluid lines (such as the engine strut compartments). Selection of test fluid spray rates and dispersion patterns representative of potential leaks is a matter of engineering judgment. The spray nozzle arrangement must be reviewed with the FAA prior to the test flight. Flow rates of one gallon per minute from each spray nozzle are typical, however, higher rates may be required to simulate high pressure leakage patterns and provide coverage of the entire drainage zone. The flowrate should be established based on results of the leak source analysis. The actual flow rate and drainage system function should be validated prior to the test. If pneumatic bleed is used for pressurization of the flight test dye dispersion system, the altitude and flight effects of pressure differentials on the flow rates should be established to assure proper flowrates are achieved. The total amount of dyed fluid sprayed into each zone along with the duration of the test conditions should be used to validate the actual in-flight flow rate.

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(3) The test fluid is normally a mixture of dyed water, and ethylene glycol (to prevent freezing of the dye liquid). A mixture of 50 percent ethylene glycol to water will allow dumping at temperatures down to -32 degrees F. Different colored dye should be sprayed into each compartment if the various compartments are to be tested simultaneously so that the source of the drained fluid can be identified. A dye exposing substance such as powdered soap provides a means to visualize the drainage impingement in critical areas. Internal and external surfaces of the airplane where fluid impingement or re-entry are possible should be coated with the dye sensitive material. The soap coating (Bon Ami has been used in the past) is applied in a water soap mixture using a roller or paint brush and allowed to dry prior to the test. Flight through visible moisture (including clouds) must be avoided to preclude washing away the soap and the dye drainage pattern. (Note: Abrasive soap coating may damage certain surface finishes and any effects should be considered when selecting the coating)

(4) Test fluid should be sprayed for 30 to 120 second test intervals during takeoff, climb, cruise, sideslips, turns, descent, approach with gear extended and during the flap transition to the extended position during the dye dump condition, landing with and without reverse engine thrust and during the flap transition to the extended position, taxi, and static ground idle operation. Due to the difficulty in predicting complex airflow patterns and the number of

different flight test conditions required, numerous flight test conditions are usually required. Test results may necessitate redesign of fluid drainage systems and therefore testing should be scheduled accordingly. Relocation of drain masts, extension of drain masts, installation of vortex generators on the end of the drain mast, installation of drip fences to deflect flammable fluids away from critical areas, and implementation of revised sealing procedures or modification of seal designs have been required on some airplanes in order to obtain a satisfactory result.

d. Test Results. The ground and flight tests are normally witnessed by a FAA representative. Photos of the airplane prior to the flight test should be taken to show the dye sensitive coating application. Post-test photos should be taken to document the drainage patterns and to substantiate compliance. Evaluation of drainage test result is often subjective in nature, but drainage of fluid into the following areas is always considered unacceptable.

(1) Passenger compartment, cargo compartment.

(2) Any area where a potential ignition source exists.

(3) APU compartment.

(4) APU exhaust - special design precautions may be required such as a drip fence to guide fuel leakage away from the exhaust nozzle.

(5) APU inlet - uncontrolled drainage into the inlet may result in inability of the APU fuel control to maintain control of the APU resulting in overspeed.

(6) Engine inlets or exhaust systems.

(7) Accessory compartments or areas that contain potential ignition sources such as the battery compartment, electronics bays, or logo lights.

(8) Wheel well.

(9) Another compartment of the same engine or APU.

e. Some examples of hazardous impingement which have been seen in the past are:

(1) Leakage from engine pylon/strut compartments runs along the top of the nacelle or forward along the bottom edge of the pylon/strut aft fairing or heat shield and drips onto the primary nozzle.

(2) Leakage from the wing trailing edge compartment aft of the rear spar has run inboard to the wheel well.

(3) Leakage from fuselage drains has run aft to the fuselage outflow valves where it could be ingested during unpressurized flight.

(4) Leakage from fuselage mounted drain masts has run along the fuselage and impinged upon the APU exhaust duct or entered the APU compartment.

■■

End of Advisory Circular 25.1187-1

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Advisory Circular 25-1187-1, “Minimization of Flammable Fluid Fire Hazards (Flammable Fluid Fire Protection)”[Incorporated in total in this Propulsion Mega AC].

Section 25.1189 Shutoff means.

a. **Rule Text.**

(a) Each engine installation and each fire zone specified in § 25.1181(a)(4) and (5) must have a means to shut off or otherwise prevent hazardous quantities of fuel, oil, deicer, and other flammable fluids, from flowing into, within, or through any designated fire zone, except that shutoff means are not required for --

(1) Lines, fittings, and components forming an integral part of an engine; and

(2) Oil systems for turbine engine installations in which all components of the system in a designated fire zone, including oil tanks, are fireproof or located in areas not subject to engine fire conditions.

(b) The closing of any fuel shutoff valve for any engine may not make fuel unavailable to the remaining engines.

(c) Operation of any shutoff may not interfere with the later emergency operation of other equipment, such as the means for feathering the propeller.

(d) Each flammable fluid shutoff means and control must be fireproof or must be located and protected so that any fire in a fire zone will not affect its operation.

(e) No hazardous quantity of flammable fluid may drain into any designated fire zone after shutoff.

(f) There must be means to guard against inadvertent operation of the shutoff means and to make it possible for the crew to reopen the shutoff means in flight after it has been closed.

(g) Each tank-to-engine shutoff valve must be located so that the operation of the valve will not be affected by powerplant or engine mount structural failure.

(h) Each shutoff valve must have a means to relieve excessive pressure accumulation unless a means for pressure relief is otherwise provided in the system.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-23, 35 FR 5677, April 8, 1970; Amendment 25-57, 49 FR 6849, Feb. 23, 1984)

b. **Intent of Rule.** The intent of this rule is to ensure that a safe and effective means is provided to shutoff the supply of hazardous quantities of flammable fluids that flow through designated fire zones of the engine or APU.

c. **Background.**

(1) The flammable fluid requirements of § 25.1189(a),(b),(c), (d), (e), and (f) originated from section 4b.445 of the Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) This section was amended by Amendment 25-23 (35 FR 5665, April 8, 1970), which followed Notice of Proposed Rulemaking 68-18. Notice 68-18 proposed to revise § 25.1189 to remove the requirements for shutoff valves in engine oil systems, and to add new paragraphs (g),(h), and (i). The preamble of the Notice included the following discussion:

> Section 25.1189(a) requires flammable fluid shutoff means. However, the majority of the large turbine-powered transport airplanes have been certificated without a shutoff means for their oil systems. The deviations from the oil shutoff means requirement were permitted on the basis that equivalent safety was otherwise achieved since the oil tanks were close to the engine, the quantities of oil were relatively small, and all components materials were fireproof. The service experience of these airplanes has shown that oil shutoff means are not essential, and the proposal would relax the requirement for oil shutoff means on turbine engine installations.

The preamble to Amendment 25-23 discussed the proposal as follows:

> Proposed § 25.1189(a)(2) has been changed to make it clear that a shutoff means is not required for oil systems for turbine engine installations in which all external components of the oil system, including the oil tanks, are fireproof. The Notice proposed to add a new § 25.1189(g) to require each flammable fluid shutoff valve control to be fireproof or to be located so that exposure to fire will not affect its operation. In response to comments received, and consistent with the intent of the Notice, the proposal has been changed to make it clear that it applies only to flammable fluid shutoff means and controls located in a fire zone or that would be affected by a fire in a fire zone. The proposal, as revised, is adopted as an amendment to current paragraph (d).

(3) This regulation was also amended by Amendment 25-57 (49 FR 6832, February 23, 1984). The preamble to the Amendment contained the following discussion:

> Section 25.1198 is revised to clarify the requirement for shutoff means in terms of the vulnerability of oil system components to engine fire sources, and to ensure that fittings and components are considered along with lines that form an integral part of an engine when determining the need for shutoff means, since they are in the same category when installed.
>
> . . . One commenter recommends that this rule be cross referenced to Part 33 for clarity sake. The FAA does not consider a cross reference necessary, since the emphasis of this section is upon the aircraft manufacturers' responsibility to ensure a fireproof engine installation. Adding the word "installation," however, will provide additional clarification. The proposed regulation is adopted with this change.

d. **<u>Policy/Compliance Method</u>**<u>s.</u>

(1) Guidance has been provided on the various components covered by paragraph (a) of this rule as follows:

(a) <u>Installation of a flammable fluid shutoff means</u> (or a means that will otherwise prevent hazardous quantities of flammable fluids from flowing into, within, or through any fire zone): Historically, flammable fluid shutoff valves or flow prevention means located outside the engine fire zone have been required on all fuel supply lines, hydraulic lines, external oil supply lines, and deicer lines.

(b) <u>Engine fuel/oil supply and hydraulic supply/return lines:</u> If a shutoff valve were located within a fire zone, the valve would be required to be fireproof. Components of the actuation means, such as wiring or cables, would also be required to meet fire proof requirements.

(c) <u>Engine fuel heat return line</u>: Airplanes have been equipped with fuel heat rejection lines that are routed from the engine back to the airplane fuel tank. Failure of the line could result in uncontrolled fuel leakage into the engine fire zone. Manufacturers have been required to incorporate reverse flow check valves to prevent the flow of fuel from the fuel tank back into the engine fire zone. Maintenance checks of the “non return valves” are required to be incorporated into the maintenance program to address possible latent failure of the valves.

(d) <u>External engine oil supply:</u> If installed, this should be equipped with a shutoff valve to limit the supply of oil to a fire.

(e) <u>Engine hydraulic line:</u> Hydraulic lines running within the engine fire zone must contain shutoff features to stop the flow of hazardous quantities of fluid to the engine in the event of a fire.

(2) **Hydraulic Shutoff Provisions:** The term “hazardous quantity of flammable fluids” used within § 25.1189 is not defined as a specific value. The quantity that is considered hazardous is dependent upon the particular engine installation design. The discussion below was extracted from an FAA Issue Paper that was generated during a certification project. In that project, the applicant maintained that it met this requirement without installing a shutoff valve because the quantity of fluid was claimed to not be hazardous.

> **Statement of Issue:** The engine installation does not have a hydraulic shut-off valve to isolate the flammable (hydraulic) fluid leakage in the engine fire zone. Section 25.1435(c) requires each hydraulic system using flammable hydraulic fluid must meet the applicable requirements of §§ 25.863, 25.1183, 25.1185, and 25.1189. Section 25.1189 requires each engine installation and fire zone to have a means to shut-off or prevent hazardous quantities of flammable fluids from flowing into, within, or through the fire zone. In addition, § 25.863 requires that in an area where flammable fluids or vapors may escape by leakage, there must be

means to minimize the probability of ignition of these fluids and vapors, and the resultant hazards if ignition does occur. Furthermore, § 25.863(b)(4) states that the applicant must consider means available for controlling or extinguishing a fire, such as stopping the flow of flammable fluids, shutting down the equipment, fire proof containment, or use of extinguishing agents.

Background: Section 25.1435(c) requires each hydraulic system using flammable hydraulic fluid meet the applicable requirements of §§ 25.863, 25.1183, 25.1185, and 25.1189. Section 25.1189 requires each engine installation and fire zone to have a means to shut off or prevent hazardous quantities of flammable fluids from flowing into, within, or through the fire zone. While the definition of "hazardous quantities of flammable fluids" has been interpreted differently by the regulatory authorities over the years, the FAA has historically required shutoff means on all flammable fluid sources (fuel, hydraulic fluid, and in some cases, even oil) located outside of a fire zone. FAA review of the design has concluded that 10 liters of hydraulic fluid should be considered as a hazardous quantity. The FAA position is based on previous incidents which have shown that hydraulic system leaks have fueled fires, especially when mist fluid is produced at high pressure due to small (pinhole) leaks.

The applicant stated in certification documents that hydraulic systems would be emptied in 21 seconds if a major leak (e.g. hydraulic line severed) occurred. However, a more likely and critical condition would be a minor leak (pinhole) due to a small hydraulic line crack or improperly maintained fitting. This latter condition is of greater concern to the FAA as the time exposure would be longer and in addition, hydraulic fluid is more flammable when mixed or misted with the surrounding air to form a flammable gas. Once the hydraulic fluid/gas is ignited, it would likely continue burning independent of residual pressure in the hydraulic system.

Section 25.863 requires that in an area where flammable fluids or vapors may escape by leakage, there must be means to minimize the probability of ignition of these fluids and vapors, and the resultant hazards if ignition does occur. In addition, § 25.863(b)(4) states that the applicant must consider means available for controlling or extinguishing a fire, such as stopping the flow of flammable fluids, shutting down the equipment, fire proof containment, or use of extinguishing agents. Of these identified means for controlling or extinguishing a fire, other FAR requirements overlap the § 25.863 requirement when addressing the engine fire zone. Section 25.1191 requires the engine fire zone be isolated from the rest of the airframe by a firewall constructed of fireproof material and § 25.1189 requires each engine and fire zone have a means to shut off or prevent hazardous quantities of flammable fluids from flowing into, within, or through the fire zone.

The provisions of § 25.863 require the applicant to "minimize the resultant hazards if ignition does occur". Depending on the failure mode inducing the engine fire, a hydraulic shut-off valve could limit the flow of flammable fluid into the fire zone and thus be considered as a means to minimize the resultant hazard. The FAA has recognized hydraulic shut off valves on large and small (business jets) Part 25 category aircraft as an acceptable means to minimize the resultant hazards if ignition occurs.

Ignition Source Evaluation: The following discussion provides guidance regarding acceptable methods for establishing autoignition temperatures for flammable fluids. Determination of whether a quantity of flammable fluid would be considered hazardous (compliance to § 25.1189) can be directly related to the ignition source and flammable fluid analysis.

In one instance an applicant attempted to establish autoignition temperatures significantly above published values to show that hydraulic fluid leakage would not be hazardous. The FAA responded that “Due to the difficulties in determining flammable fluid ignition temperatures, manufacturers have historically utilized the industry standard for the auto ignition temperatures of all potential flammable fluids (fuels, lubricants, and hydraulic fluids). To date no manufacturer has taken exception to the published data regarding the fluid’s flammability characteristics (auto ignition temperature, flash point, and fire point). Furthermore, the FAA is not aware of any manufacturer’s attempts to establish revised fluid flammability characteristics or establish that an ignition source is not present in a fire zone when surface temperatures well in excess of the fluid’s published auto ignition temperature are present.

When properly conducted, the FAA considers an ignition test demonstration to be one viable method for substantiating that no ignition sources exist in a fire zone. However, based on ASTM (American Society for Testing and Materials) test methods, the FAA believes it would be impractical in most cases for an applicant to substantiate local conditions within a fire zone throughout the airplane operating envelope. The FAA’s understanding of ignition tests has been that the results are extremely sensitive to the measurement and control of the simulated conditions. Elaborate test instrumentation is required to measure all parameters that influence ignition, including duct surface temperatures, compartment air/vapor temperatures, local air velocities near the ducting, and air/vapor ratios. Local air velocities near the duct would be heavily influenced by installation effects. As stated in our previous correspondence, localized stagnation areas are likely to exist in the actual installation.

For the applicant to be successful, they would be required to show that the conditions noted above will never be present in the subject fire zone. In addition, to properly test the configuration, a full scale test that accounts for installation effects and utilizes elaborate test instrumentation would be required. The FAA would also suggest that any test, relative to this issue, be coordinated with the FAA so that time and resources are not wasted on testing that will not be accepted for certification.

(3) The following discussion is from an Issue Paper, developed for a certification project, that provides additional guidance on compliance methods for § 25.1189.

While the definition of "hazardous quantities of flammable fluids" has been interpreted differently by the regulatory authorities over the years, the FAA has historically required shutoff means on all flammable fluid sources (fuel, hydraulic fluid, and in some cases, even oil) located outside of a fire zone. FAA review of the generic model design has concluded that 10 liters of hydraulic fluid should be considered as a hazardous quantity. The FAA position is based on previous incidents which have shown that hydraulic system leaks have fueled fires, especially when mist fluid is produced at high pressure due to small (pinhole) leaks. This condition is of great concern to the FAA as the time exposure would be longer and in addition, hydraulic fluid is typically more flammable when mixed or misted with the surrounding air to form a flammable gas or vapor. Once the hydraulic fluid/gas is ignited and the engine was shutdown per airplane flight manual (AFM) procedures, the fire would likely continue burning independent of residual pressure in the hydraulic system until the flammable fluid supply was depleted.

Types of hydraulic fluid range from MIL-H-5606 hydraulic fluid which is classified as a "red" or "mineral oil" and has flammability characteristics (auto ignition temperature, flash point, and fire point) which are similar to those of most jet fuels. MIL-H-5606 fluid has a minimum auto ignition temperature (heated vessel test method) of 437ºF. In comparison, "phosphate ester" based hydraulic fluids (Skydrol), which are used in many current transport airplane applications, have minimum auto ignition temperatures in excess of 800ºF.

Compliance with this section has required installation of shutoff valves for fuel, oil, and hydraulic system sources located outside the fire zone. In some cases shutoff provisions have not been required however extensive analysis and/or test would be required to show that the quantity of fluid was not hazardous.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-23 (35 FR 5665, April 8, 1970).

(3) Amendment 25-57 (49 FR 6832, February 23, 1984).

Section 25.1191 Firewalls.

a. **Rule Text.**

(a) Each engine, auxiliary power unit, fuel-burning heater, other combustion equipment intended for operation in flight, and the combustion, turbine, and tailpipe sections of turbine engines, must be isolated from the rest of the airplane by firewalls, shrouds, or equivalent means.

(b) Each firewall and shroud must be --

(1) Fireproof;

(2) Constructed so that no hazardous quantity of air, fluid, or flame can pass from the compartment to other parts of the airplane;

(3) Constructed so that each opening is sealed with close fitting fireproof grommets, bushings, or firewall fittings; and

(4) Protected against corrosion.

b. **Intent of Rule.** The intent of this rule is to ensure that a fire originating in any fire zone will not be a hazard to the airplane.

c. **Background.** The regulatory history shows that this requirement originated from section 4b.486 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.486 without any substantive changes.

d. **Policy/Compliance Methods.**

(1) ***Fireproof protective devices.*** The following guidance is extracted from the material contained in Advisory Circular (AC) 29-2B, July 30, 1997. (Although that AC provides guidance for transport rotorcraft, it may provide insight into acceptable compliance methodology useful for other category aircraft.) Fireproof protective devices are typically certified by a combination of test and/or analysis, including flight tests or simulated flight tests, as follows:

(a) Fireproof protective devices should be provided to isolate a fire within a defined fire zone from any portion of the airplane where a fire could create a hazard, including, personnel compartment areas containing critical components (such as structural elements, controls, rotor mechanisms, and system components) that are necessary for a controlled landing. A thorough hazard analysis should be conducted during certification to identify, define and quantify in order of severity (i.e., maximum temperature, hot exposed area, etc.) all thermal hazards or zones that require fireproof protection in a given design. Engines (including the combustor, turbine, and tailpipe sections of turbine engines), APU's, combustion heaters, and combustion devices are required by regulation to be isolated. Other high temperature devices may also require isolation because of local hot spots (which occur during normal operations or from failure modes) that can thermally injure occupants or cause spontaneous combustion of surroundings. A hazard analysis should identify these potential problems and provide proper certification solutions.

(b) Fireproof protective devices should be able to withstand at least 2000°F flame (±150°F) for 15 minutes minimum (per reference AC 20-135). The fireproof protective device should allow the protected parts, subsystems or systems to perform their intended function for the duration of a severe fire (see definition). For firewalls, examples of flat, geometry materials undergoing uniform heat fluxes with material gauges that automatically meet the certification requirements are given in Table 589-1.

If firewalls are utilized that involve other materials, significant geometric changes, or significantly non-uniform heat fluxes, then automatic compliance may not be assured. In such cases the fireproof protective devices should be analyzed and, in some cases, tested in accordance with AC 23-2 to insure proper certification. For example, a curved protective surface may absorb a uniform incident heat flux unevenly and create a local hot spot that exceeds 2050 degrees Fahrenheit that burns through in less than 15 minutes; whereas, a flat surface of equal thickness would not exceed 2050 degrees Fahrenheit and would not burn through in less than 15 minutes. It should be noted that composite materials are not generally used for protective devices because of their inability to withstand high temperatures (i.e., exceedance of the glass transition temperature); however, some specially formulated composites have been previously certified as engine cowlings. Titanium is an acceptable material for fireproof protective devices such as firewalls. However, use of titanium should always be carefully considered and reviewed, because it can lose structural load carrying ability and burn severely (self combust) above 1,050 degrees Fahrenheit, under certain thermodynamic environments, and contribute to the fire instead of providing the intended fire protection. AC 33-4, "Design Considerations Concerning the Use of Titanium in Aircraft Turbine Engines" and MIL-HDBK-5D contain more detailed information on the unique thermal properties of titanium.

(2) ***Test Criteria and Philosophy.*** The following excerpt is from the guidance material contained in Advisory Circular 20-135, February 6, 1990.

Acceptable Test Criteria and Philosophy.

(1) The test for demonstrating compliance with the criteria for “fireproof” and “fire resistant” materials, components, and fittings is to expose the specimen to the required flame temperature and heat flux density for the required time (15 minutes for “fireproof” and 5 minutes for “fire resistant”). The specimen shall withstand flame required test time. Sheet materials and panels shall be tested by exposing a sample size approximately 10 inches on a side (10” x 10”, or a size appropriate for the intended application) to a flame from an acceptable burner at the test operating conditions outlined in paragraph 7. The flame size and temperatures shall be sufficient to maintain the required test temperature and heat flux density over an area of approximately 5” x 5” for sheet materials and panels.

(2) Fittings used in firewalls and in fire zones shall be completely enveloped in the flame on the side that would normally be exposed to fire in the fire zone. The fittings shall be mounted in a manner simulating the actual installation, and fluid lines or tubing may be connected to both ends of the fitting to simulate the installation that would be present during a typical fire event. However, for the testing of fluid-fittings, there should be no fluid in the line on the engine side of the fitting in the fire zone, since the fire may have been caused by a failure of the line to the fitting under evaluation. Likewise, if failure of the line on the engine side of the line upstream of the firewall, up to the fluid shutoff valve, then the lines connected to both sides of the fitting should not contain fluid for this testing. If the fitting is part of the shutoff valve, then the line behind or upstream of the valve should contain fluid.

(3) ***Nacelle Skin Fireproof Requirements.*** The FAA has provided the following guidance concerning requirements for fireproof nacelle skin:

Fire protection of the airframe requires isolation of potential sources of fire within the engine from critical airframe systems, a means to isolate sources of flammable fluids from the fire, a means to alert the flight crew of the fire, and a means to extinguish the fire. For typical turboprop engine installations, § 25.1193 requires that the nacelle skin meet the fireproof requirements since the engine is mounted forward of the wing where the propeller downwash results in airflow patterns that direct the fire toward the wing. If a fire passed through the nacelle skin it could result in severe wing damage. Large turbofan engine installations which are mounted below the wing have been approved where the entire nacelle skin has not been fireproof. Only the upper 90 degrees of the nacelle skin has been fireproof. The applicant has demonstrated through test that the airflow pattern is such that a fire which burned through the lower fire resistant skin would not be a hazard to the aircraft.

Section 25.1103 addresses both turbine and reciprocating engine inlet ducts and specifically requires the engine inlet duct to be fire resistant when it is located in a fire zone which has fire extinguishing. The intent of the rule is that if a fire were to start in the fire zone surrounding the inlet duct, the fire protection features within the fire zone (detection, isolation of combustibles, fire extinguishing) would allow control of the fire before the fire could escape the zone through the inlet duct. Compliance of an engine installation to these regulations would also require consideration of the design specific fire protection features. For example, if the engine inlet were to (1) form part of a firewall or (`2) be part of the nacelle skin where escape of flame from the fire zone could result in a hazard to the airframe, the inlet duct would be required to be fireproof.

(4) ***Aft Fuselage Mounted Engine Cowl Fire Protection.*** The following guidance is based on an Issue Paper concerning aft fuselage mounted engine cowl fire protection, used during certification of an airplane with aft fuselage mounted engines.

Statement of Issue: The engine nacelles are fireproof for only ± 22.5 degrees (total of 45 degrees) from the centerline of the engine pylon. Section 25.1193(c)(1) requires that the entire engines cowling or nacelle skin be fireproof. Furthermore, § 25.1193(e)(1) states that the airplane must be designed and constructed so that a fire originating in any fire zone cannot enter any other airplane zone or region where it could create additional hazards. In a recent certification review, the applicant requested further FAA guidance/policy on these requirements. Furthermore, the FAA maintains that a fire originating within the engine fire zone which could potentially burn through the non-fireproof portion of the nacelle, should not impinge upon the horizontal stabilizer or any other zone or control surface which could create an additional hazard for the airplane.

In addition, the FAA reviewed § 25.1193(e)(1) compliance for the APU installation. The applicant stated that only the upper 45 degree segment of APU fire zone(directly above the APU) should be fireproof per the same conditions as the engine nacelles. The FAA requires that an APU fire not be allowed to penetrate into the airplane's vertical/horizontal stabilizer zone, unless it can be shown that fire penetration of that zone is not a hazard.

The applicant's position relative to the size and location of engine and APU firewalls was agreed to and documented in an equivalent safety finding.

Discussion: In a recent certification review meeting, the applicant stated that the engine nacelles (outer cowls) are made of composite material and are fireproof for only ± 22.5 degrees from the pylon centerline. Fire testing accomplished on similar composite material during earlier certification projects, determined that the material is fireproof when ventilated (cooled on the backside). Based on design analysis and similarity to this design composite material fire tests, an equivalent safety finding was granted by the foreign authority.

The FAA requested compliance information on how ± 22.5 degrees was substantiated (vs. full fireproof nacelle enclosure -- 360 degrees) with respect to § 25.1193(e)(1). FAR section 25.1193(c)(1) requires that the entire engine cowling or nacelle skin be fireproof. Furthermore, § 25.1193(e)(1) requires that the airplane must be designed and constructed so that a fire originating in any fire zone cannot enter any other airplane zone or region where it could create additional hazards. During the subject certification meeting, the applicant was unable to address this issue and requested clarification of the FAA policy on this requirement.

Historically, the FAA has allowed some wing mounted turbofan engine nacelles to be fireproof only on the upper 90 degrees (± 45 degrees from centerline) of the nacelle surface. Substantiation of these designs originates from airflow characteristics data generated by an airframe manufacturer during an actual flight test. The airflow data verified that for typical airplane angles of attack, speeds, and configurations, an engine fire penetrating the lower 270 degrees of the nacelle would not impinge upon the wing or other critical structure. For wing mounted turboprop installations, the FAA has required that entire engine nacelle be fireproof due the potential of the propwash blowing an engine fire directly into the wing.

Although the airplane has two turbofan engines mounted on the aft fuselage body, the horizontal stabilizer is mounted relatively low on the vertical fin rather than the traditional “T” tail configuration used on most airplanes with aft-mounted engines. The partially fireproof nacelle in combination with the tail configuration may increase the potential for a fire escaping the engine nacelle to impinge upon the horizontal stabilizer and elevator.

Concerning the APU installation, the applicant stated that the APU fire zone is not totally surrounded by fireproof material. The applicant proposed that fireproof material be used only on the bulkhead forward of the APU and the upper 45 degrees of the APU zone. The FAA maintains that for ground and flight conditions, an APU fire should not be allowed to penetrate into the airplane’s vertical/horizontal stabilizer zone or externally impinge upon the control surfaces of the horizontal and vertical stabilizer.

FAA Position: The applicant must show that for the engine and APU installation, a fire originating in either fire zone cannot impinge upon or enter, either through openings or by burning through external skin (i.e. non-fireproof section), any other zone or region where it could create additional hazards for the airplane.

For the engine installation, special emphasis should be given to an engine fire penetrating the non-fireproof section of nacelle, and impinging upon the horizontal stabilizer and elevator. The applicant’s test/analysis of this proposed scenario should include typical airplane pitch attitudes, speeds, and configurations (flap and horizontal stabilizer trim) for one-engine inoperative airplane operation.

For the APU installation, special emphasis should be given to an APU fire burning through the non-fireproof section of the APU enclosure and penetrating into the airplane’s vertical/horizontal stabilizer zone or externally impinging upon the control surfaces of the horizontal and vertical stabilizer. The test/analysis of this scenario should include all ground and flight conditions for which the APU operational approval is sought.

Applicant Position:

In summary, these documents provide test substantiation for the following claims:

For the engine nacelles:

1) during flight conditions, the nacelle is fireproof (360 degrees).

2) during ground conditions, the outer nacelle (fire zone 1) is fireproof. However, the inner or core firewall (fire zone 2) is only fire resistant. The applicant claims that a core fire on the ground poses no hazard to the airframe (cannot penetrate the fuselage because of the outer nacelle and pylon firewalls).

> The APU firewall and tailcone are fireproof for all ground and flight conditions.

Conclusion: The FAA has reviewed documents and have found that the proposed engine and APU firewall compliance methodology to be consistent with the intent of this Issue Paper. Prior certification meeting discussions which led the FAA to believe that the engine nacelles were fireproof only for ± 22.5 degrees proved to be inaccurate when these compliance documents were reviewed. Certification documents substantiated that the entire engine outer nacelle (360 degrees) is fireproof in flight. This Issue Paper is therefore closed.

(5) ***APU Fireproof Enclosures/Auxiliary Power Unit Standardization:*** The following guidance was generated following a review of APU enclosures.

APU Isolation: Installation of a partially shrouded APU, in a compartment containing other aircraft components, does not comply with § 25.1191, which requires the entire APU to be isolated from the rest of the airplane by firewalls, shrouds, or equivalent means. Section 25.1181(a)(4) designates the APU compartment as a fire zone. Therefore, in accordance with § 25.1181(b), the APU compartment (fire zone) must meet the requirements of § 25.1185 through 25.1205.

In addition, compliance with APU inlet requirements §§ 25.1091 through 25.1105 must be accomplished together with § 25.901(c) and § 25.903(d). Thus, only partial shrouding to isolate the APU becomes a very difficult design to accomplish in order to meet the intent of Part 25 standards. Therefore, partially shrouded APU installations require a complete enclosure, unless an equivalent means is offered for evaluation and an equivalent safety finding under the provisions of § 2l.21(b)(1).

(6) ***Localized Firewall Shrouding of an APU.*** The following excerpt from an internal FAA memorandum yields additional policy information on guidance for rotorcraft, and may provide insight into Part 25 compliance methodology. This memorandum is to document the position of the FAA Rotorcraft Directorate regarding an applicants plan for localized firewall shrouding of an APU in a particular aircraft model.

The installation of the Model APU has stainless steel localized shrouds around the combustion section, the fuel control, and the DC starter-generator. The APU compressor, accessory section, the oil tank, and all fuel and bleed air lines are not isolated from the pylon and transmission area. The regulations [reference § 29.1181(a)(4)] require that the entire APU compartment be designated as a fire zone, and § 29.1191(b) requires that each APU be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

You stated that there have been many similar approvals of localized fire shrouds in Part 25 airplanes. Although Part 25 rules are almost identical to FAR 29, this is not an adequate basis for acceptance of this design. Each installation must be evaluated individually and a finding made as to either direct or equivalent means of compliance with the applicable certification requirements. As a result of our review of the applicant's installation, we cannot agree that the localized shrouding installed for this APU provides the fire protection required by

§ 29.1181 and § 29.1191. We recommend that the APU compartment be completely isolated from the rotorcraft by a suitable firewall, shroud, or equivalent means.

An applicant under the cognizance of ANE-170 [*the FAA's New York Aircraft Certification Office*] currently holds STC SA1196EA pertaining to the subject installation. Because the APU is only partially shrouded, the STC is limited to ground use only. The applicant claims that it is suffering from an unfair marketing disadvantage because an STC holder in your Region . . . has approval for a similar installation that is not limited to ground use only.

Actually, neither installation complies literally with § 25.1191, which requires the entire APU to be isolated -- from the rest of the airplane by firewalls, shrouds, or equivalent means. In your memorandum of March 12, 1984, you advised ANE-170 that Part 29 contains a similar requirement for transport category rotorcraft. Because neither installation complies literally with § 25.1191, we assume that each must have been approved on an equivalent safety basis under the provisions of § 21.21(b)(1).

In order for us to determine whether ANE-170 could remove the limitation to ground use only from their STC, please advise the considerations taken into account concerning equivalent safety at the time your STC was-issued. We are requesting similar information from ANE-170 concerning their approval.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Advisory Circular 20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria," February 6, 1990.

(4) Advisory Circular 29-2B, "Certification of Transport Category Rotorcraft," July 30, 1997.

Section 25.1192 Engine Accessory Section Diaphragm

a. **Rule Text.**

For reciprocating engines, the engine power section and all portions of the exhaust system must be isolated from the engine accessory compartment by a diaphragm that complies with the firewall requirements of § 25.1191.

(Amendment 25-23, 35 FR 5678, April 8, 1970)

b. **Intent of Rule.** The intent of this rule is self-explanatory.

c. **Background.**

(1) Notice of Proposed Rulemaking 68-18 (33 FR 11913, August 22, 1968) proposed to add a new § 25.1192 to require an engine accessory section diaphragm for reciprocating engines. The preamble to Notice 68-18 discussed the proposal as follows:

> Diaphragms were formally required under Part 4b.488 and served to isolate the most probable ignition sources (the power section and exhaust system on reciprocating engines) from the most probable sources of flammable material. The discussion in the preamble of Amendment 4b-12, which deleted the requirement, implied that, so long as a fire extinguisher system is provided to extinguish a fire in the engine compartment, additional protection is not necessary, However, fire extinguishing systems are not equivalent to diaphragms. The purpose of a diaphragm is to confine a power section fire to that section where the shutoff would be most effective. A fire extinguishing system is useful only after a fire has stared. Section 25.1187 recognizes the need for ventilation and drainage in the event of failure or malfunction of flammable fluid components to prevent fires. If means for preventing a fire are reasonably effective, safety is better served by making use of such means rather than eliminating such means and permitting a fire to start on the assumption that it can be extinguished. Deletion of the diaphragm requirements eliminated one of the basic ways for separating flammable sources from probable ignition sources, and the proposal would reinstate the requirements for reciprocation engines.

(2) Amendment 25-23 (35 FR 5665, April 8, 1970) followed Notice 68-18. The proposal was adopted without substantive change. The preamble of the amendment contained the following:

> [This amendment] adds a new § 25.1192 to require an engine accessory section diaphragm for reciprocating engines. As a result of this amendment, § 25.1181 is amended to except reciprocating engines from the requirements of § 25.1181(a)(3).

d. **Policy/Compliance Methods.** No dedicated policy material on transport category airplanes is currently available.

e. **References.**

(1) Notice of Proposed Rulemaking 68-18 (33 FR 11913, August 22, 1968).

(2) Amendment 25-23 (35 FR 5665, April 8, 1970).

Section 25.1193 Cowling and nacelle skin.

a. **Rule Text.**

(a) Each cowling must be constructed and supported so that it can resist any vibration, inertia, and air load to which it may be subjected in operation.

(b) Cowling must meet the drainage and ventilation requirements of § 25.1187.

(c) On airplanes with a diaphragm isolating the engine power section from the engine accessory section, each part of the accessory section cowling subject to flame in case of fire in the engine power section of the powerplant must --

(1) Be fireproof; and

(2) Meet the requirements of § 25.1191.

(d) Each part of the cowling subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

(e) Each airplane must --

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet paragraph (e)(1) of this section with the landing gear retracted (if applicable); and

(3) Have fireproof skin in areas subject to flame if a fire starts in the engine power or accessory sections.

b. **Intent of Rule.** Section 25.1193(a) requires the cowling and nacelle skin to structurally withstand the loads experienced in flight. Section (b) requires ventilation and complete drainage from the cowling and nacelle to prevent pooling of flammable fluids. Sections (c), (d) and (e) provide clarification of fireproof requirements.

c. **Background.**

(1) The regulatory history shows that this requirement originated from section 4b.487 of the Civil Air Regulations (CAR) 4b, per amendment 4b-12 (27 FR 2986, March 30, 1962). Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a

Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.487 without any substantive changes.

(2) Notice of Proposed Rulemaking 89-25 (54 FR 38610; September 19, 1990) proposed an amendment to the airworthiness standards for transport category airplanes to require improved engine cowling retention devices and provided current FAA policy on this subject. The Notice proposed to amend § 25.1193 by adding new paragraphs (e)(4) and (f) to read as follows:

(e) Each airplane must--

. . .

(4) Be designed and constructed to--

(i) Preclude any inflight opening or loss of any cowling or nacelle skin which would, under any foreseeable conditions, prevent continued safe flight and landing; and

(ii) Minimize the occurrence and hazardous effects of inflight opening or loss of any other cowling or nacelle skin.

(f) The retention system for each removable or openable cowling must--

(1) Keep the cowling closed and secured following any single failure or malfunction or probable combinations of failures;

(2) Have readily accessible means of closing and securing the cowling that do not require excessive force or manual dexterity; and

(3) Have reliable provisions for effectively verifying that the cowling is secured prior to each takeoff. The provisions must address --

(i) Any affects of wear or improper adjustment; and

(ii) Any failure to properly close, latch, or lock the cowling. If direct visual inspection means are used, the provisions must be clearly evident during a preflight check using a flashlight or equivalent lighting source.

This proposed new language was predicated on a review of a number of in-flight incidents where engine cowlings were lost, which revealed that the largest single cause of such losses was improper latching of the cowlings. The Notice proposed to provide additional design standards to detect improperly latched cowlings and ensure integrity of the latching system. The preamble to the Notice included the following discussion:

There have been a number of recent inflight incidents of engine cowling separations which have resulted in damage to the airplane or damage to property on the ground. Although none of the incidents resulted in injury to persons, they represent a potential hazard. The airplane damage caused by cowling separations has ranged from minor damage of airplane skin to rapid depressurization and loss of critical hydraulic systems. Damage to property on the ground has included cowling penetration of buildings and damage to automobiles. These occurrences indicate a need to reevaluate the airworthiness design requirements applicable to engine cowlings and the maintenance practices employed on those components. Further, the potential hazards due to engine cowling separations will be even greater with the advent of proposed “pusher” type powerplant installations.

Data from the FAA Service Difficulty System, as well as the service information provided by the major airplane manufacturers, have been reviewed relative to the loss of engine cowlings. This review has disclosed that improperly closed latches or fasteners, latch deterioration, and improper adjustment of the retention mechanisms were the primary causes of the cowling separations. Many latch designs operate with an overcenter device and positive lock that engages with the final latching motion. The latches can get out of adjustment or deteriorate as a result of wear and corrosion so that they appear locked when they are not. Latches have been found in which the positive locking device was deteriorated to the point that it no longer functioned.

Section 25.1193 of the Federal Aviation Regulations (FAR) (“Cowling and nacelle skin”) is the primary regulation addressing the structural design of engine cowlings. Paragraph (a) of this section states: *“Each cowling must be constructed and supported so that it can resist any vibration, inertia, and air load to which it may be subjected in operation.”* This design standard does not contain a requirement that specifically addresses the single failure of a latch or hinge nor does it consider an improperly fastened latch. Although the current regulations lack specific fail-safe or damage tolerant design requirements for engine cowling retention systems, most manufacturers have generally applied their own fail-safe criteria so that most cowlings are designed with multiple latches so that any one latch can fail without affecting cowling retention. Some designs are, however, inadequate in that they do not account for the flexibility of the structure and redistribution of the loading after a single latch failure occurs. As a result, designs purported to have been fail-safe have failed after a single latch failure or improper latching of one latch.

The FAA has determined that standards for fail-safe criteria should be included in Part 25 to ensure that an adequate level of safety is achieved by all manufacturers. These proposed criteria generally require that the retention systems be designed to withstand the loss of a single latch and that unlocked or improperly closed latches be easily detected. Continued retention of the cowling in flight during engine compartment fires and after uncontained rotor failures must be a design objective, because the fire protection features required by § 25.1193 would be rendered ineffective if engine cowling retention failed under fire conditions.

The configuration and size of some cowlings could be such that the opening of a cowling could preclude continued safe flight and landing. (Note that the completion of safe flight and landing may include the use of any approved emergency procedures.) For example, a cowling that opens in such a manner as to create an excessively high asymmetric drag situation or severe buffeting, or a cowling whose separation could cause extensive damage to critical empennage or fuselage pressure vessel structure, could severely affect airplane flight characteristics. Furthermore, the cowlings of airplanes with pusher-propellers may have even greater potential for catastrophe. The loss of cowlings on those airplanes could damage the propeller blades, which could result in further catastrophic damage to the airplane. It is therefore proposed that inflight opening of any cowling which could preclude continued safe flight and landing be an extremely improbable event. As shown by service history, improper maintenance or operations actions, such as failure to properly close and lock a cowling or failure to identify an improperly closed and locked cowling, are not extremely improbable events. Therefore, for any cowling whose opening could preclude continued safe flight and landing, it is proposed that a cockpit warning means be provided to indicate to the flightcrew before takeoff that the cowling is not properly closed and locked.

Over the past 10 years, the FAA has examined a number of aviation incidents which involved engine cowling losses on transport category airplanes. Two examples of such incidents are given below:

1. In 1981, shortly after takeoff of a Boeing 747, the tower reported that parts of cowling were found on the runway. The cowling for the left side of the number one engine was missing. The number five leading edge flap was damaged, requiring replacement, and there was a dent in the horizontal stabilizer. The right hand cowling was jammed rearward. The precooler inlet duct was ruptured. An investigation concluded that the separation was an isolated incident that was due to improperly latched cowling.

2. On March 12, 1987, the FAA issued an airworthiness directive (AD) which requires the installation of a secondary retention system for the engine core cowl doors of certain McDonnell Douglas Model DC-10 and KC-10A series airplanes within 18 months after the effective date of the AD. Since the time the AD was issued, however, engine core cowl doors have separated from two DC-10 airplanes. In one case, the door separated from the airplane during takeoff, landed on the runway, and was struck by another airplane. The crew of the other airplane aborted the takeoff because they heard a loud, external noise. An investigation revealed that the impact of the engine core cowl door on the other airplane had caused two main landing gear tires to blow and one other tire to go flat because of slices in the casings. The aborted takeoff caused the brakes to overheat, melting the fuse plugs for fourteen additional tires. In another case, an engine core cowl door separated from the airplane during takeoff and struck the fuselage, creating a hole approximately 25 inches by 3 inches in the pressure shell. The door also hit the center engine inlet, creating two holes and additional damage in that structure.

These and other incidents clearly indicate that a safety problem associated with engine cowling losses does exist. This proposed rule is intended to significantly mitigate this safety problem.

This action is still on-going. In light of the comments submitted to the Notice and additional new issues raised, the FAA is considering additional rulemaking on this subject.

d. **Policy/Compliance Methods.** *[Note that guidance for nacelle fireproof requirements can be found in Section 25.1191.]* Although the following excerpt is from a proposed change to § 25.1193 [see Background section above, paragraph c.(2)], it does provide current transport airplane policy.

Engine Cowling Retention Requirements For Transport Category Airplanes

Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) No. 89-25 (54 FR 38610; September 19, 1990), which proposed a requirement for improved engine cowling retention devices. As discussed in Notice 89-25, there have been in-flight incidents of engine cowling separations that have resulted in hazards such as rapid aircraft depressurization, loss of critical hydraulic systems, and damage to property on the ground. There is no record of personal injury as a result of these incidents; however, the risk of future incidents involving damage and personal injury is considered sufficient to warrant this amendment. Furthermore, the advent of "pusher" type propeller installations being proposed for some new transport category aircraft will make the risks associated with future cowling separations even greater. Although the current regulations contain general requirements for aircraft design integrity and fault tolerance, service history indicates that specific standards for cowling retention systems are required to assure the intended levels of design integrity and fault tolerance are consistently achieved.

Notice 89-25 proposed changes to § 25.1193 to require that:

(1) each retention system for a removable or openable cowling have a means to lock each cowling to prevent in-flight opening which results from mechanical failure or failure of a single structural element either during or after closure;

(2) each retention system for a removable or openable cowling be designed and constructed to withstand the effects of vibration, inertial loads, overpressure and normal air loads, and thermal conditions due to an engine compartment fire after failure or improper fastening of any single latching device;

(3) each retention system for a removable or openable cowling have a provision for direct visual inspection of the retention mechanism to verify the cowling is fully closed and locked. The provisions must be discernible under operational lighting conditions by appropriate crewmembers using a flashlight or equivalent lighting source; and

(4) for any cowling, the opening of which could preclude continued safe flight and landing, there be a visual warning means in the cockpit to alert the crew before takeoff that the cowling is not properly closed and locked. The cowling must be designed so that opening in flight is extremely improbable.

As a result of comments, the rule has been revised to more clearly state the general objectives of the notice without unnecessarily restricting the methods of compliance. Additional emphasis has been placed on the inspectability, maintainability, and failsafe design requirements.

Discussion of Comments

Twelve commenters, representing the views of industry, a foreign airworthiness authority, and a private citizen, responded to the request for comments on Notice 89-25. Most commenters endorse the general intent of the proposals while offering suggested changes.

Several commenters state that the proposed requirement for cockpit indication would cause more problems than it would solve. Their concerns include the fact that false indications could cause unnecessary delays, aborts, in-flight shutdowns, air turn backs, diversions, and unscheduled landings; in-flight warning would not preclude separation and might initiate inappropriate crew action; such systems would add complexity, cost and weight; and cockpit indication should not be necessary if the design meets all of the other proposed requirements.

The FAA agrees that cockpit indication should not be mandated and this requirement is not included in the final rule. However, if properly designed, constructed, and maintained, such an indication system could serve as part of the means "for effectively verifying that the cowling is secured prior to each takeoff," as is now required by the final rule.

Several commenters indicate that requiring cowling retention after certain combinations of failures, as proposed in the notice, would be unreasonable due to:

(1) the very low risk of these combinations occurring;

(2) the historically low risk that loss of the cowling will result in a major safety problem; and

(3) the additional cost, weight, and complexity required to comply.

The FAA agrees that the rule should not protect the aircraft beyond a logical and traditionally acceptable inverse relationship between the probability and the severity of each conceivable failure condition. However, the conceivable failure conditions which diminish aircraft safety should be "minimized" by qualitatively eliminating, wherever practical, any failure modes which lead to such failure conditions. Only where the elimination of such failure modes is not feasible is it then reasonable to consider failure rates as providing the warranted level of safety, and then only when these failure rates have also been "minimized." Based on these comments, the specific failures and malfunctions addressed in the notice have been removed from the final rule, but are still events that must be considered in showing compliance with the more general final rule objectives of:

(1) minimizing the occurrence and hazardous effects of in-flight opening or loss of any cowling or nacelle skin;

(2) precluding any in-flight opening or loss of any cowling or nacelle skin which would, under any foreseeable conditions, prevent continued safe flight and landing; and

(3) keeping the cowling closed and secured following any single failure or malfunction or probable combinations of failures.

The single failure or malfunction events to be considered in showing compliance with this final rule must include at least:

(1) failure of any single structural element;

(2) improper fastening of any single latching, locking, or other retention device;

(3) engine compartment fire;

(4) engine case burn through;

(5) failure of any engine rotor or blade (except where the fragment trajectory would cause the failure of several structural elements required for retention); and

(6) rupture of any pressurized components.

The need to consider combinations of these and other failures and malfunctions should be assessed based on the understanding that an event is considered "probable" if it is anticipated to occur during the entire operational life of a single airplane (i.e. approximately 100,000 hours).

Further, "preclude" is intended to mean that there is no conceivable way for the event to occur. However, when this clear assurance cannot reasonably be provided or readily demonstrated, then "preclude" can be interpreted to mean that the event is not anticipated to occur during the entire operational life of all aircraft of a given type design (i.e. approximately 1 billion hours). The later definition allows the event to be "conceivable" but not "anticipated to occur" due to the probability of the event.

When demonstrating the hazards have been "minimized" or an event is not "anticipated to occur," all assumptions must be documented, validated to the greatest extent possible, and then a degree of confidence established in the conservatism and applicability of the assumption. This "confidence assessment" should address at least:

(1) methods used for determining possible failure modes;

(2) practical reasons why failure modes cannot be eliminated;

(3) methods used for establishing predicted failure rates (applies to assumed qualitative as well as quantitative rates);

(4) practical reasons why failure rates cannot be further reduced;

(5) methods used for assessing exposure times;

(6) methods used to determine acceptability of target event rates;

(7) justification for any assumptions of fault independence, fault detection, fault accommodation or fault elimination; and

(8) methods used for selecting validation test conditions.

Several commenters state that the "over-pressure" condition referred to in the proposed rule should be clarified as to the scope of the intent. Potential definitions provided by the commenters included overpressure loads due to ruptured pressure lines, cowling flexibility in combination with inertial and normal air loads, and the pressure rise (potentially explosive) which may result following the ignition of flammable vapors.

The FAA agrees that all of these sources could produce an over-pressure condition within the nacelle and each is intended to be addressed by § 25.1193 of the FAR, as modified by this final rule. Over-pressure of the nacelle due to "engine compartment fire" or "rupture of any pressurized components" are effects that must, as discussed above, be addressed when showing compliance with § 25.1193(f)(1) of this rule. Over-pressure of the nacelle due to cowling flexibility, in combination with inertial and normal air loads, is an effect that must be considered when showing compliance with the existing requirements of § 25.1193(a). Also, the new § 25.1193(e)(4)(ii) would require that the pressure relief function be implemented in a manner which "minimizes" the hazardous effects of the overpressure. For example, no pressure relief doors should depart or damage the aircraft after opening, etc.

Several commenters state that the rule should include increased emphasis on the need for improved maintenance of nacelles. These commenters express concerns such as inadequate inspection procedures; inadequate inspection frequencies; lack of mechanism wear minima; inadequate training to assure proper adjustment and operation; and inadequate designs features including ineffective indicators, inadequate access to the retention systems, and designs which are difficult to properly adjust or operate. One other commenter contends that the present design requirements are more than adequate and that the problem is inadequate pre-flight inspections.

The FAA disagrees that inadequate pre-flight inspections are solely responsible for this risk. However, the FAA agrees that inspectability, maintainability, and other human factor issues are important aspects of effective nacelle retention. Although design requirements cannot assure proper maintenance and operation, they can reduce the potential for human error. For this reason, the final rule contains design requirements to:

(1) have readily accessible means of closing and securing the cowling which do not require excessive force or manual dexterity; and

(2) have reliable provisions for effectively verifying that the cowling is secured prior to each takeoff.

The provisions must address the affects of wear; improper adjustment; and failure to properly close, latch, or lock the cowling. If direct visual inspection means are used, the provisions must be clearly evident during a preflight check using a flashlight or equivalent lighting source.

Several commenters ask if the FAA intends to require retrofit of existing aircraft with cowling which meets these requirements. Current service experience does not justify requiring recertification of all transport category airplanes to these new standards. However, the FAA will continue to monitor service experience and require any notable unsafe conditions be rectified in a timely manner.

One commenter recommends a latching and locking system be required whereby a second closing action (locking) is necessary.

The FAA agrees that any mechanism carrying loads required to secure the cowling or nacelle skin must be suitably restricted from any inadvertent action which could release those loads. However, due to the diversity of potential retention systems for removable or openable cowling, including the more specific requirement in the rule as proposed by the commenter, would be inappropriate. The FAA contends that the final rule, as written, would require an independent lock if that was necessary to "keep the cowling closed and secured following any single failure or malfunction or probable combinations of failures".

One commenter states that the proposed rule on retention systems should be limited to openable, and not removable, cowling.

The FAA does not agree. The airworthiness impact of not complying with these amendments is potentially equivalent for both removable and openable cowling. However, demonstrating compliance should be easier for traditional removable cowling.

One commenter states that the notice suggests that there are cowlings the opening of which would not preclude continued safe flight and landing. The commenter asks for guidance to specify where a design will or will not affect safety.

The FAA contends that there cannot be an all encompassing advisory on how a design can affect safety. Applicants are required to propose a structured safety assessment method acceptable to the FAA and use good engineering judgment in performing that assessment. This is no different than many other certification demonstrations requiring a structured safety assessment.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, per amendment 4b-12 (27 FR 2986, March 30, 1952).

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Notice of Proposed Rulemaking 89-25 (54 FR 38610; September 19, 1990).

(4) Notice of New Task Assignments for the Aviation Rulemaking Advisory Committee (ARAC) (63 FR 50954, September 23, 1998).

Section 25.1195 Fire extinguishing systems.

a. **Rule Text.**

(a) Except for combustor, turbine, and tail pipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases for which it is shown that a fire originating in these sections can be controlled, there must be a fire extinguisher system serving each designated fire zone.

(b) The fire extinguishing system, the quantity of the extinguishing agent, the rate of discharge, and the discharge distribution must be adequate to extinguish fires. It must be shown by either actual or simulated flights tests that under critical airflow conditions in flight the discharge of the extinguishing agent in each designated fire zone specified in paragraph (a) of this section will provide an agent concentration capable of extinguishing fires in that zone and of minimizing the probability of reignition. An individual ''one-shot'' system may be used for auxiliary power units, fuel burning heaters, and other combustion equipment. For each other designated fire zone, two discharges must be provided each of which produces adequate agent concentration.

(c) The fire extinguishing system for a nacelle must be able to simultaneously protect each zone of the nacelle for which protection is provided.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-46, 43 FR 50598, Oct. 30, 1978)

b. **Intent of Rule.** The intent of this rule is to define the requirements for fire extinguishing systems for engine and APU's.

c. **Background.**

(1) The regulatory history shows that this regulations originated in section 4b.484 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.484 without any substantive changes.

(2) This section was amended by Amendment 25-46 (43 FR 50578, October 30, 1978), which followed Notice of Proposed Rulemaking 75-19. The amendment contained the following discussion in its preamble:

Proposals 8-49 and 3-41. (Disposition of Proposal 3-41 to amend § 25.1195(b) (Notice 75-19) was deferred so that it could be considered in connection with Proposal 8-49.) One commenter objects to Proposal 3-41 and suggests that it be revised to read " . . . all extinguishers are not required to crossfeed all engines, but two shots to each engine are required." [*FAA's response:*] The proposal deletes the last sentence of current § 25.1195(b) to avoid the possible interpretation that a particular discharge must be directable to every fire zone. Such an arrangement would be acceptable, but individual systems that have a dual discharge capability may be confined to serve a particular fire zone. The proposal is considered equivalent to the wording preferred by this commenter.

Another commenter states that the proposal does not meet the intent of the explanation unless the last sentence of present § 25.1195(b) is deleted. [*FAA's response:*] The proposal includes this deletion.

This commenter further states that the proposed wording contradicts the exemptions allowed by § 25.1195(a). The FAA does not agree. Section 25.1195(b) applies only to non-excepted fire zones. Proposal 3-41 to amend § 25.1195(b) is adopted without substantive change.

One commenter objects to the requirement in Proposal 8-49 for § 25.1195(b) that the test fully simulate actual critical airflow conditions, stating that there should be provisions in the regulations to allow the use of test results and analysis to show compliance. Another commenter objects to the proposal because it does not allow demonstration of compliance by a combination of analysis and analogy with similar engine installations that have been subjected to full scale fire tests. The FAA does not agree with these comments. Distribution of the extinguishing agent within a fire zone is a controlling factor in extinguishing a fire within that fire zone. No acceptable procedure has been found to demonstrate extinguishing agent concentration by analysis, or by reference to tests or service experience on similar powerplant installations, or by reference to tests conducted under conditions other than those encountered in service. Compliance with proposal § 25.1195(b) must be based on actual or simulated flight tests which fully provide the critical airflow conditions to be encountered in flight.

One commenter objects to the words "under critical airflow conditions," "any fire," and "preventing reignition," as meaningless when engine breakup or cowling damage occurs. A second commenter objects to the proposal because no hole size is specified. [*FAA's response:*] The proposal is based on the assumption that the fire zones under consideration remain intact, with no engine breakup or cowling damage and with only those holes that are present during normal operation. Therefore, no damage factors are specified.

Several commenters object to the words ". . . and preventing reignition" for the reason that there is no practical way to determine compliance unless the fire and potential reignition sources are defined. These commenters suggest that this requirement should be changed to ". . . and minimize the probability of reignition." The FAA agrees that the phrase "and preventing reignition" may imply that extinguishing agent concentration must be maintained indefinitely. The FAA believes that this is beyond the present state-of-the-art, and the proposal is revised in the manner suggested by these commenters.

Three of these commenters further object to the proposed requirement for an extinguishing agent concentration capable of "extinguishing any fire" in a fire zone, because there is no practical way to determine compliance unless the fire is defined. The FAA agrees, and the proposal is revised to incorporate the words "extinguishing fires" to be consistent with the provisions of current § 25.1195(b).

One commenter states that the use of full-scale fire tests, evidence of similar powerplant configurations, and analysis were proposed as part of Airworthiness Review Notice No. 3 (Notice 75-19; 40 FR 21866; May 19, 1975) to show compliance with the requirements of §§ 25.1181 through 5.1203, and that this proposal is in conflict with Notice 75-19. The proposal in Notice 75-19 to which the commenter refers has been adopted as § 25.1207 (Airworthiness Review Amendment No. 4, effective May 2, 1977). Section 25.1207, as adopted, provides for those cases when tests are specifically required. However, in light of the adoption of proposed § 25.1195(b), the FAA believes that § 25.1207 could be confusing and it is revised for clarity.

Additionally, this commenter states that the method of demonstrating satisfactory fire extinguishing capability should be by agreement between the manufacturer and the certificating authority. The FAA does not agree. Objective rules are needed to ensure that a consistent level of safety is maintained.

One commenter states that the proposal refers to critical airflow conditions while the explanation refers to flight conditions, which are not necessarily the same thing. The FAA agrees that clarification is necessary. The proposal is revised to specify critical airflow conditions in flight.

d. **Policy/Compliance Methods.**

(1) ***Historical Compliance Methods.*** Historically, a high rate freon extinguishing system has been used on turbine engines for compliance with this regulation. The nozzles in the compartment(s) are placed and sized to provide acceptable distribution throughout the fire zone. From 1959 to 1968, the FAA was actively engaged in the evaluation of aircraft powerplant fire-extinguishing systems. During this period, testing was conducted and data was obtained for short takeoff and landing (STOL) aircraft, vertical takeoff and landing (VTOL) aircraft, helicopters, large transport category aircraft, military aircraft, executive aircraft, turbo jets, turbopropellers, and reciprocating engine-powered aircraft. This evaluation program provided information helpful in establishing criteria for the installation and utilization of the fire-extinguishing agent concentration recorder.

The extensive testing conducted by the FAA [e.g., FAA Final Report No. NA-69-26, (DS-68-26), "An Investigation of In-flight Fire Protection with a Turbofan Powerplant Installation," dated April, 1969; and FAA Final Report No. FAA-DS-70-3, (AD-712-191), "Criteria for Aircraft Installation and Utilization of an Extinguishing Agent Concentration Recorder", March, 1970] established the concentration and duration levels that were required to effectively extinguish an engine fire. The FAA has historically required that when using Halon 1301, the concentration required is 6 % by volume simultaneously in all portions of the fire zone. Typically this has been demonstrated by placing twelve probes within the fire zone at critical locations and assuring that the 6% concentration level is maintained for a minimum of 1/2 second. The discharge rate for the High Rate System is usually less than one second duration. The requirement to have the

6% concentration simultaneous throughout the fire zone is to extinguish the fire and prevent relight from one portion of the zone to another.

Currently, there are two analyzers that have been accepted by the FAA for certification of airplane fire extinguishing systems:

- **Statham Model GA-2A** (which has been approved for HALON 1301, CO_2 and other agents) and

- **HTL Model H-1 Halonizer** (which has been approved for use with HALON 1301 only).

The eligibility and approval criteria for an analyzer is contained in Report ST 7864, dated May 4,1987, and was initiated by the FAA's Los Angeles Aircraft Certification Office (LAACO). The guidelines for operation of the Statham Analyzer are contained in Advisory Circular 20-100, "General Guidelines for Measuring Fire Extinguishing Agent Concentrations in Powerplant Compartments," dated September 21, 1977.

With curtailment of production of Halon due to environmental concerns, the aviation industry is currently using existing stockpiles of Halon to fulfill needs. The industry is working with the military and regulatory authorities to develop replacement fire extinguishing agents and to develop standards for certification of these new agents. Applicants wishing to use a replacement agent prior to establishing of new standards should work with the FAA to establish agreed-upon methods of demonstrating compliance with this rule for the replacement agent.

(2) ***APU Compartments:*** The following excerpts represent compliance guidelines as reflected in FAA Order 8110.16, "Fire Extinguishing Requirements for APU Compartments," dated 8/12/76,

(a) Section 25.1195(a) requires a fire extinguisher system for each designated fire zone. Further, Section 25.1195(b) states an individual one-shot system may be used for auxiliary power units, fuel burning heaters and other combustion equipment. For other designated fire zones, two discharges must be provided each of which produce adequate concentrations. It must be possible to direct each of these discharges to any main engine installation.

(b) The question has arisen as to whether or not one of the two shots required for other zones could be used for an APU compartment. The rule permits an individual one-shot system solely for the APU but does not imply that it must be isolated from the two-shot system for main powerplant fire zones. The purpose in requiring a two-shot system for a main fire zone is not to provide a surplus of extinguishing agent, but rather to provide a backup shot in the event of failure of the first shot or to deal with a reignition of a fire.

(c) This question may have come about because in many installations a separate one-shot system for the APU is provided in addition to the two or more system units for the other fire zones. This was not because such a configuration was mandatory but rather because it was a more convenient and feasible arrangement created by distance and sizing factors.

(d) The one-shot extinguishment system required for the APU may either be independent of the system for other fire zones or utilize one of the two shots intended for main engine fire zones. The same concept applies to § 29.1195(b).

Review of Part 25's requirements and policy regarding fire extinguishing systems indicates that two shots of fire extinguishing agent are required for each engine; one shot is required for the APU; and a knock-down and continuous concentration level is required for Class C cargo compartments. In practice, shared engine and auxiliary power unit (APU) fire extinguishing systems have been implemented on aircraft where overall weight savings and reduced system complexity have promoted application for FAA approval. Examples of these types of installations included:

- McDonnell Douglas DC-9/MD-80 airplanes, which are certified with shared engine and APU fire extinguishing system supply;

- McDonnell Douglas DC-10/MD-11 with shared rear engine and APU; and

- Boeing 757/767 with shared right and left engine fire extinguishing supply.

Certification of these installations was based on a determination that the installation provided equivalent fire extinguishing capability to that required by Part 25.1195. The applicant was required to demonstrate that there was no interrelationship between the need for fire extinguishing capability in more than one location, (i.e. a fire in the APU could not cause a fire in the engine), and that the likelihood of having unrelated fire in more than one location was very low due to the short overall exposure time.

Historically engine fire extinguishing bottle discharge incident rates (including false fire warnings) far exceed those for the APU and cargo compartment. For this reason a shared engine/cargo compartment system would result in exposure to operation without cargo compartment fire extinguishing capability. An engine fire in either engine could result in loss of cargo compartment fire extinguishing capability. Loss of cargo compartment fire extinguishing capability has a much more significant impact on overall safety than the loss of APU or engine capabilities due to the nature of fire protection features required within the regulations. The engines and APU are required to have fire extinguishing provisions; as well as 1) fuel shutoff provisions located outside the fire zone to shutoff the supply of flammable fluids to a fire, and 2) fire walls to isolate the fire from the airframe. The cargo compartment is required to have a liner that can contain the fire until the fire extinguishing agent extinguishes the fire. Loss of cargo compartment fire extinguishing capability could allow a fire to burn uncontrolled until the potentially large supply of combustibles was consumed .

Comparison of these previously certificated systems with the proposed system architecture found the proposed system was unique due to sharing of propulsion (engine/APU) fire extinguishing supply with the cargo compartment system. Our office has determined that sharing of the engine and cargo compartment fire extinguishing systems does not provide equivalent fire extinguishing capability as that required by separate engine (§ 25.1195) and cargo compartment (§ 25.857) requirements, and therefore should not be approved. Approval of sharing of fire extinguishing sources for other types fire extinguishing system installations (i.e. engine/APU, cargo compartment/APU, engine/engine) should be evaluated based on the previous criteria that assured no interrelationship existed between possible fire sources (e.g., engine rotor non containment causing cargo compartment fire).

(3) ***Fire Extinguishing Agent Concentrations:*** The following excerpt from Advisory Circular 20-100, "General Guidelines for Measuring Fire Extinguishing Agent Concentrations in Powerplant Compartments," dated September 21, 1977, provides guidance for measuring fire extinguishing agent concentrations.

Ventilation: The conditions under which the testing defined within the AC are conducted has been the topic of discussion with several applicants. Simulation of the airflow within the fire zone for the ground test should be based on airflow determined from flight testing of the engine. Calculation of airflow within the zone utilizing differential pressures and known ventilation inlet and exhaust areas is acceptable. The effects of ventilation air from sources such as precoolers, bleed valves or other intermittent ventilation sources within the fire zone should also be considered. Simulation of the critical airflow conditions has required introduction of air into the fire zone via ventilation openings (e.g., NACA scoops) from an external air source and firing of the fire extinguishing bottles at engine rotor speeds (during engine deceleration) that produce critical ventilation conditions.

Bottle Temperature: The temperature of the fire extinguishing bottles during the test has also been the topic of discussion. Typically lower temperatures have been critical for the test, therefore, cooling of the fire extinguishing bottle to -65°F with dry ice, has been required. To facilitate conducting of the test, warming of the bottle up to 50 °F has been allowed.

Paragraph (c): In one instance the number of fire extinguishing agent concentration measurement probes needed to provide adequate coverage of the engine nacelle fire zones exceeded the twelve available in the currently approved analyzers. This made it impractical to measure the concentration of agent within all the fire zones simultaneously. In this case the FAA accepted conducting separate tests for each of the fire zones. .

(4) ***Measuring Extinguishing Agent Concentration.*** The following excerpt provides additional guidance and has been extracted from, Report No. ST7864, "Eligibility and Approval Criteria for a Halon Measuring Device for Conducting FAA Fire Protection Evaluations of Agent Concentration":

Section I

A. **Eligibility:** In order that the Halon concentration measurement device can be approved by the FAA, it must first be found to be eligible for approval and must be shown to be equal to or to exceed the characteristics of the approved FAA standard (the Statham Halon concentration measuring instrument, Model GA-2A). Sufficient descriptive data and specifications should be submitted to show that it will meet the FAA standard. For example, the applicant must show that his instrument will provide the minimum required number of simultaneous sensing channels, the response rate, the rate of sampling, the accuracy of measurement, etc. That is, equal to or better than the standard. When the applicant has shown from his descriptive data and specifications that he intends to satisfy the standards the FAA will participate in a program for approval of the instrument.

B. **Applicability**: The data required in this document is for approval of a single instrument bearing a specific serial number. For multiple unit approvals, additional tests and Quality Assurance provisions would be required. For approval of multiple “agents”, the defined requirements will need to be repeated for each agent.

C. **Submittal of Reports and Dat**a: After the applicant has fixed the design and evaluated his instrument and the drawings have been released, the top drawing and supporting drawings and specifications should be submitted so that an FAA conformity inspection can be accomplished before starting the assembly or demonstrations of the first article. Section 11 and III of this document outlines the criteria that must be addressed and demonstrated during the FAA approval program. These demonstrations should be witnessed by the FAA. Demonstration proposals should be submitted to the FAA for comment and approval. After completion of the demonstrations the following reports and data should be submitted:

1) *Certification Reports*. This data should be completed to cover each of the items in Sections II and III of this document.

2) *Operating Manual.* This report should cover the description, operating envelope, all limitations on the instrument, procedures for conducting laboratory and on-site primary calibrations (calibrations against known certified concentrations of Halon) and secondary calibrations (adjustments to the instrument based upon calibration numbers, zero tares, scale factors, or slope), procedures for correcting raw data, trouble shooting, guidelines for observing contamination or leakage limits procedures for performing a test, etc.

3) *Training Requirements.* This document should define the procedures and. requirements for controlling the personnel permitted to operate the instrument.

4) *Acceptance Test Document.* This document should consider the criteria necessary for acceptance of the concentration analyzer assembly and the critical measurement element(s). For example, acceptance criteria should be based on an examination of the product, leakage, flow, calibration, functional test, final test, etc.

<u>Section II</u>

A. **Demonstration of “Single Channel” Measurement Performance (Relative Concentration Verification)**

1) Halon 1301 measurements of four certified known concentrations for baseline relative concentrations (e.g., 6.0%, 10.0%, 25.0%, 100%).

   Note: All known Halon vessels must be certified as to concentration and be traceable to the NBS standard.

2) Halon 1301 measurements of four certified known concentrations with gas samples at two extreme temperatures, (e.g., 0^0 F and 165^0F).

3) Halon 1301 measurements of four certified known concentrations at various altitudes, from sea level to 10,000 ft. (10 altitude points minimum).

4) Halon 1301 measurements at high relative humidity (90%) and ambient relative humidity (35%).

B. **Demonstration of 12 Measurement Channel Performance (Relative Concentration).** Demonstrate that all channels read the same relative concentration when exposed to the unknown concentrations of Halon gas.

C. **Operating Temperature Limits.** Demonstrate that the instrument can maintain accuracy when both the measurement device and the gas samples are at temperature extremes (e.g., 45^OF to 100^OF) defined as the temperature operating limits for four known certified Halon concentrations.

D. Demonstrate that vibration effects do not change the performance of the instrument over a defined vibration envelope.

Section III

A. **Evaluation of Physical Effects:** The evaluation of physical effects depends upon the instrument operating principles used for measuring Halon concentration. The principle may depend upon the pressure drop across a laminar flow device in series with a nozzle. If this is the case, one objective is to maintain temperatures relatively constant while recordingsΔ P. However, if the principle is based upon infrared measurement to define Halon concentration, the ability of the device to control infra-red output and the frequency may be of importance. The following is a partial listing of certification test demonstrations of these special factors.

1) The effect of nozzle clogging, contamination, filter clogging, aging and/or sooting of the infra-red source or target, or other special considerations on the instrument gain linearity and accuracy.

2) The effect of voltage, frequency, power factor on accuracy measurement. In addition, a test evaluation using the worst power source (highest ripple factor) available from the aircraft or the aircraft power ground supply.

3) Evaluation of the length of sensing lines on transient concentration measurement to establish line size and length limits. (If sensors and transmitters are mounted directly on the engine to yield an electrical signal in lieu of gas flow, the proposal should consider special factors for the sensor-transmitter).

4) A demonstration of a change in critical instrument spare components to show that spares to be used in the field do not alter performance.

5) Evaluation and analysis of the internal parameter control tolerance band (e.g., internal temperature control) on the performance of the instrument.

B. **System Accuracy Single Channel Evaluation for Environmental and other Effects at certified known Constant Agent Concentration** Upon completion of the testing, the system accuracy should be documented and analyzed as follows:

1) Measurement accuracy over the approved ambient temperature band for acceptable usage.

2) Measurement accuracy over the approved ambient pressure band for acceptable usage.

3) Measurement accuracy over the approved humidity band for acceptable usage.

4) Analysis of combined accuracy from environmental, physical effects, and including all other factors affecting accuracy.

C. **Demonstration of 12 Channel Calibrations and Verify Channel Operation Under Variable Concentrations:** Derive calibration curves of relative concentration vs. actual concentration for the specific instrument system under evaluation.

D. Repeatability of the system shall be defined from the above evaluations.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-46 (43 FR 50578, October 30, 1978).

(3) Amendment 25-AD (29 FR 18289, December 24, 1964).

(4) Advisory Circular 20-100, “General Guidelines for Measuring Fire Extinguishing Agent Concentrations in Powerplant Compartments,’ September 21, 1977.

(5) FAA Order 8110.16, “Fire Extinguishing Requirements for APU Compartments,” August 12, 1976.

(6) FAA Final Report No. NA-69-26, (DS-68-26), “An Investigation of In-flight Fire Protection with a Turbofan Powerplant Installation,” April, 1969.

(7) FAA Final Report No. FAA-DS-70-3, (AD-712-191), “Criteria for Aircraft Installation and Utilization of an Extinguishing Agent Concentration Recorder”, March, 1970.

(8) Society of Automotive Engineers (SAE), Inc., Aerospace Information Report (AIR) 1076.

(0) Report No. ST7864, “Eligibility and Approval Criteria for a Halon Measuring Device for Conducting FAA Fire Protection Evaluations of Agent Concentration.”

CHARACTERISTICS OF EXTINGUISHING AGENTS

AGENT	Halon Number	FreonNumber	Symbol	Chemical Formula	Relative Toxicity	Statham Concen	Molecular Weight	Specific Gravity	Specific Weight 3 lb./in.	Boiling Point, °F	Freezing Point °F	Heat of Vaporiza-tion (BTU/lb)	Approx. Lethal Conc. ppm *	Vapor Press. (psia) 70°F.	Vapor Press. (psia) 160°F.
Bromochlor omethane	1011		CB	CH 2BrC1	3	25	129.4	1.94	.069/. 070	149	-110	99.8	29000 4000	2.7	17.0
Bromotrifluor omethane	1301	13b1	BT	CBrF3	6	15	148.9	1.57	0.057	-72	-270.4	47.7	800000 14000	212	550
Carbon Dioxide			CO_2	CO2	5	40	44	1.02 (0°F)	0.0368	-110		112.5	6580006 58000	750	
Carbon Tetrachloride	104			CC14	3		153.8	1.63	0.059	170		83.5	2800030 0	1.9	12.5
Dibromochlor otri- Fluoroethane		113b2		C2Br2C1F 3			276.5	2.25	0.081	200					
Dibromodiflu oromethane	1202	12B2	DB	CBr2F2	4	15	209.8	2.28	0.0822	76	-223	52.4	54000 1850	13	58
Methyl Bromide			MB	CH3Br	2	15	95.0	1.73	0.0625	39	-139	108.2	5900 9600	27	120
Monobromom onochloro- Difluorometh ane	1211	12B1		CBrC1F2			165.4	1.83	0.0663	25	-257	57.6	324000 7650	35	135
Dibromotetraf luoro- Ethane		114B2		CBrF2-CBrF2			259.9	2.16	0.078	117.5	-166.8	45.0	126000 1600	5.6	31
Earth -— Mineral- Salt Solutions															
10% Lithium Chloride 20% Calcium				LiC1+CaC 12					0.044	221	-80				

24% Lithium Chloride				LiC1					0.057	237	-87				
47% Zinc Chloride				ZnC12					0.041	230	-69				

*<u>**NOTE:**</u> 15 minute exposure to rats - 1st number, unheated agent --- 2nd number, agent heated to 800° C.

<u>Information Sources</u>:

- Kinetic Technical Bulletin. b-4, E. J. DuPont Nemours Co.
- Technical Memorandum, M-108, U. D. Naval Civil Engineering Research & Evaluation

Section 25.1197 Fire extinguishing agents.

a. **Rule Text.**

(a) Fire extinguishing agents must-

(1) Be capable of extinguishing flames emanating from any burning of fluids or other combustible materials in the area protected by the fire extinguishing system; and

(2) Have thermal stability over the temperature range likely to be experienced in the compartment in which they are stored.

(b) If any toxic extinguishing agent is used, provisions must be made to prevent harmful concentrations of fluid or fluid vapors (from leakage during normal operation of the airplane or as a result of discharging the fire extinguisher on the ground or in flight) from entering any personnel compartment, even though a defect may exist in the extinguishing system. This must be shown by test except for built-in carbon dioxide fuselage compartment fire extinguishing systems for which --

(1) Five pounds or less of carbon dioxide will be discharged, under established fire control procedures, into any fuselage compartment; or

(2) There is protective breathing equipment for each flight crewmember on flight deck duty.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-38, 41 FR 55467, Dec. 20, 1976; Amendment 25-40, 42 FR 15044, Mar. 17, 1977)

b. **Intent of Rule.** The agents used to meet this regulation must be approved and demonstrated to extinguish fires, provide thermal stability over the aircraft environmental envelope, and address any toxicity aspects.

c. **Background.**

(1) The regulatory history shows that this section originated section 4b.484 of the Civil Air Regulations (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.484 without any substantive changes.

(2) Notice of Proposed Rulemaking 75-10 (40 FR 10802, March 7, 1975) proposed amending § 25.1197(a) by introducing objective fire extinguishing requirements in lieu of the restrictive language of the original language. The original language of this section read as follows:

> *§ 25.1197 (original)*
>
> *(a) Extinguishing agents must be methyl bromide, carbon dioxide, or any other agent with equal extinguishing action.*
> *. . .*

The explanation for the changes proposed in Notice 75-10 was as follows:

> Current rules prescribe that extinguishing agents must be methyl bromide (Chemical Formula CH3Br, Symbol MB), carbon dioxide (Chemical Formula CO2, Symbol CO_2), or an agent with equal extinguishing action. While there are airplanes in service having extinguishing systems that use the prescribed agents, new installations use newer agents. One agent that is widely used is bromotrifluoromethane (Chemical Formula CBrF3, Symbol BT, Halon Number 1301, Freon Number 13b1). The FAA considers it appropriate to recognize the fact that new agents are being used and to change the rules to prescribe the objective rather than specific agents.

Amendment 25-38 (41 FR 55454, December 20, 1976) followed Notice 75-10. Since no unfavorable comments were received on the proposal to amend § 25.1197, it was adopted as Amendment 25-38 without substantive change. The new text of § 25.1197(a) read as follows:

> *§ 25.1197 (Amdt. 25-38)*
>
> *(a) Fire extinguishing agents must--*
>
> *(1) Be capable of extinguishing flames emanating from any burning of fluids or other combustible materials in the area protected by the fire extinguishing system; and*
>
> *(2) Have thermal stability over the temperature range likely to be experience in the compartment in which they are stored.]*

(3) Notice of Proposed Rulemaking 75-19 (40 FR 21866, May 19, 1975), proposed further clarification of § 25.1197 to remove specific references to obsolete extinguishing agents. Amendment 25-40 (42 FR 15044, Mar. 17, 1977) followed Notice 75-19, and adopted the rule text that is currently in use.

d. **<u>Policy/Compliance Methods.</u>**

(1) ***Use of Simulants:*** For basically the entire jet fleet, Halon 1301 has been the agent of use for aircraft fire extinguishing systems. However, there are increasing restrictions on the use of Halon worldwide. Halon production has been stopped in the U.S. and much of the world since January 1,1994 under the terms of the

Montreal Protocol on Substances that Deplete the Ozone Layer, a treaty under the auspices of the United Nations Environment Program (UNEP).

Due to the need to reduce the impact of Halon on the environment, an applicant proposed use of sulfur hexafluoride (SF_6) in place of Halon as a simulant for certification testing of an engine nacelle and auxiliary power unit (APU) fire extinguishment system. SF_6 is meant only to simulate the behavior of Halon (i.e., flow characteristics and species concentration) under test conditions and is not to be used as a substitute in service. The ultimate goal was to use the simulant to demonstrate Halon concentrations during certification testing and thereby eliminate the release of Halon during testing.

The FAA has not previously accepted a simulant for fire extinguishment concentration testing. Before a simulant can be used as a substitute for Halon, the applicant must substantiate that its behavior is indeed comparable to that of Halon for the purpose of determining agent concentrations.

Simulants presently under consideration include sulfur hexafloride and HFC-125. FAA acceptance of HFC-125 as a simulant is under review. Testing procedures for simulants in place of HALON 1301 will need to be developed and can be incorporated as an appendix to AC 20-100.

(2) ***Certification of Replacement Agents*:** Industry, the FAA, and foreign airworthiness authorities have been conducting research and development to find a replacement agent for in service aircraft use. The International Halon Replacement Working Group (IHRWG) is the body that has been formed to study these potential alternate agents and their application to engine, cabin / cargo hand held and cargo fire extinguishing systems. A task group of the IHRWG is the Minimum Performance Standards for Engine & APU Fire Extinguishing Systems (MPSE). The MPSE was formed to evaluate engine compartment and APU compartment Halon replacement agents and extinguishing systems. The MPSE has delivered its first draft defining the fire threat, minimum requirements for alternative agents / systems, test methods & procedures necessary for evaluating agents / systems and prioritizing the sequence of testing that will be used to evaluate the presently identified alternate agents. The work of the MPSE does not include methods for achieving certification. The findings and requirements to date are as follows:

(a) Through October 1996, the search for alternative agents has resulted in evaluation of numerous compressed liquid agent alternatives at Wright-Patterson Laboratory located at the Wright-Patterson USAir Force Base. With more extensive evaluation to be conducted at the engine fire simulator at the FAA's Technical center. Most penalize the aircraft by increased volume and weight to ensure necessary volume concentration sufficient to extinguish the fire. The leading alternative agent at the time that the MPSE was developed, based upon a "minimum change in volume, weight, and cost", was trifluoroiodomethane, (CF_3I), which is also known by the trade-names "Triodide" and "Iodoguard". The use of CF_3I, compared to Halon 1301, reportedly:

- requires no change in volume, but approximately a 20% increase in weight;
- is environmentally safe (atmospheric lifetime less than 0.005 year; Ozone Depletion Potential index =0.0001; Global Warming Potential index less than 1); and
- has a comparable cost to Halon 1301.

However, there remains concern over potential toxicity.

Future testing may evaluate other alternate compressed liquid agents, as well as water spray and/or solid propellant gas generator extinguishing systems. Either of these may require additional consideration by the MPSE group.

(b) Use of CF_3I, with its increase in weight of 20% in existing aircraft fire extinguisher installations, is thought to be compatible. However, other alternatives would require increases in container size and agent weight which, for cargo systems, may be prohibitive.

(c) All analyzers will require a complete calibration and certification in accordance with Report FAA-DS-70-3.

(d) As previously mentioned, the IHRWG and specifically the MPSE group do not propose specific methodology to achieve certification. Their purpose is to evaluate alternate engine compartment and APU compartment Halon replacement agents and extinguishing systems. One continuing issue is the use of full-scale fire tests. It is the current interpretation that the FAA will require that such a test be accomplished for each candidate agent to evaluate concentration levels required.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-38 (41 FR 55467, Dec. 20, 1976).

(3) Amendment 25-40 (42 FR 15044, Mar. 17, 1977).

(4) Advisory Circular 20-100, “General Guidelines for Measuring Fire Extinguishing Agent Concentrations in Powerplant Compartments,’ September 21, 1977.

(5) FAA Report FAA-DS-70-3, “Criteria for Aircraft Installation and Utilization of an Extinguishing Agent Concentration Recorder,” March 1970.

Section 25.1199 Extinguishing agent containers.

a. **Rule Text.**

(a) Each extinguishing agent container must have a pressure relief to prevent bursting of the container by excessive internal pressures.

(b) The discharge end of each discharge line from a pressure relief connection must be located so that discharge of the fire extinguishing agent would not damage the airplane. The line must also be located or protected to prevent clogging caused by ice or other foreign matter.

(c) There must be a means for each fire extinguishing agent container to indicate that the container has discharged or that the charging pressure is below the established minimum necessary for proper functioning.

(d) The temperature of each container must be maintained, under intended operating conditions, to prevent the pressure in the container from --

(1) Falling below that necessary to provide an adequate rate of discharge; or

(2) Rising high enough to cause premature discharge.

(e) If a pyrotechnic capsule is used to discharge the extinguishing agent, each container must be installed so that temperature conditions will not cause hazardous deterioration of the pyrotechnic capsule.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-23, 35 FR 5678, April 8, 1970; Amendment 25-40, 42 FR 15044, March 17, 1977)

b. **Intent of Rule.** The intent of this rule is to provide a safe installation for the high pressure fire extinguishing container (600/800 psi) over the environmental envelope of the aircraft, and to provide cockpit indication when the container has discharged due to overpressure, leakage, or on pilot command.

c. **Background.** The earlier version of the container design allowed for a thermal container relief. Instances in service revealed that with pneumatic leaks impinging on the opposite side of the container from the thermal relief, the pressure rise was very rapid and resulted in the container exploding before the thermal relief would melt. The requirement was revised for pressure relief. The earlier design of the containers incorporated a pressure gage that was visible during the walkaround. However, the gages were prone to leakage, so the improved design used all-welded fittings (hermetically sealed) with a sealed/welded pressure switch to monitor container pressure and to give cockpit indication if below minimum pressure.

(1) Notice of Proposed Rulemaking 75-19 (40 FR 21866, May 19, 1975) proposed to modify the requirements of paragraphs (b) and (c) of this section. The original text of those paragraphs read as follows:

> *§ 25.1199 (original)*
> *. . .*
> *(b) Each discharge line from a relief connection must terminate outside the airplane in a location convenient for inspection on the ground.*
>
> *(c) There must be a visual discharge indicator at the discharge end of each discharge line.*

The explanation for the proposal was as follows:

> The pressure relief of newer, non corrosive fire extinguishing agents need not discharge outside the airplane; the proposal would revise the present requirement in this regard. In addition, the increasing size of newer transport category airplanes makes compliance with § 25.1199(c) impractical. The proposal would make optional the location of the means to indicate a discharge. Additional requirements would be added relating to low pressure indications and the location of discharge lines with respect to clogging.

(2) Amendment 25-40 (42 FR 15034, March 17, 1977) followed Notice 75-19. The preamble to the amendment contained a discussion of the only comment received to this proposal, as follows:

> The commenter recommends a revision of the first sentence of proposed § 25.1199(b) concerning the location of pressure relief discharges of fire extinguishing agents. The commenter suggested that the discharge end be required to be located to avoid *hazard* to the airplane rather than *damage*. The FAA disagrees. The proposal is intended to provide for the consideration of damage, such as corrosion, that may be caused by the discharge of fire extinguishing agents. The commenter's suggestion would not clearly provide for such necessary considerations.

d. **Policy/Compliance Methods.** The fill ratio (N_2/Agent) will affect the pressure/temperature relationship in the container. Verification should be made that at -65°F the container pressure is above the pressure switch setting and is a minimum of 200 psi. At the high temperature end, there should be sufficient margin from the pressure relief setting. A majority of the hermetically sealed containers use the discharge port as the overpressure relief, and there have been instances in service where the fire extinguisher discharge line has disengaged during an overpressure relief. This has resulted in a failure of the container mount system and the container, causing considerable damage in the aircraft compartment. Mounting system structural loads with a discharge line disconnected need to be addressed. Squib/cartridge(s) do have a life limit that can be affected by the installation temperature envelope. The squib drawing identifies the acceptable temperature range and should be addressed for certification.

e. **References.**

(1) Notice of Proposed Rulemaking 75-19 (40 FR 21866, May 19, 1975).

(2) Amendment 25-23 (35 FR 5678, April 8, 1970).

(3) Amendment 25-40 (42 FR 15044, March 17, 1977).

Section 25.1201 Fire extinguishing system materials.

a. **Rule Text.**

(a) No material in any fire extinguishing system may react chemically with any extinguishing agent so as to create a hazard.

(b) Each system component in an engine compartment must be fireproof.

b. **Intent of Rule.** The intent of this rule is to ensure that the integrity of the system will be maintained and not be affected by corrosion, chemical reaction, or a fire within the fire zone.

c. **Background.**

(1) The regulatory history shows that this requirement originated from section 4b.484(e) of the Civil Air Regulations (CAR) 4b, December 31, 1953. It received a minor correction via Amendment 4b-12 (27 FR 2986, March 30, 1962). Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.484(e) without any substantive changes.

(2) Some of the early agents used in fire extinguishing systems were corrosive and required cleanup after use. With the advent of Halon 1301, this has not been a problem. Amendment 25-15 (32 FR 13255, September 20, 1967) listed the following areas under development:

- more effective self-extinguishing characteristics for aircraft interior materials;
- cabin fire suppressant systems;
- protection from smoke and fumes;
- gelled fuels;
- improved emergency lighting; and
- improved evacuation facilities and techniques.

d. **Policy/Compliance Methods.** Because of the planned phase-out of Halon 1301 as the extinguishing agent for propulsion installation use, any new agent will require a full evaluation of its chemical composition corrosive properties and toxic effects. The following excerpt is based on guidance from Advisory Circular 29-2B, July 30, 1997. (Although that AC provides guidance for transport rotorcraft, it may provide insight into acceptable compliance methodology useful for other category aircraft.)

Many different fire extinguishing agents are available for use in fire extinguishing systems. The choice of extinguishing agent should take into account the chemical reaction (if any) between the extinguishing agent and the materials utilized in the extinguishing system. If there are any incompatibilities, they should not create a hazard by creating volatile or toxic vapors or fumes which could feed a fire or cause injury to passengers, crew or other personnel.

The fire extinguishing components in an engine compartment must be fireproof to ensure operation in the event of a compartment fire.

Procedure.

(a) Compliance with the requirements of § 29.1201(a) can be demonstrated by analysis, test, or a combination of both.

(b) Certification data submitted by the applicant should contain a listing of the chemical ingredients of the extinguishing agent and the other materials in the extinguishing system. These data should also show that the chemical reaction (if any) of these materials, when combined, does not create a hazard.

(c) Where chemical compounds exist and the chemical reaction is not predictable when two different compounds are combined, actual tests may be necessary to determine the hazard potential.

(d) Analysis, test, or a combination of both may be used to demonstrate compliance with the fireproof requirement for all fire extinguishing components located within the engine compartment.

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 4-b (27 FR 2986, March 30, 1962).

(3) Amendment 25-AD (29 FR 18289, December 24, 1964).

(4) Amendment 25-15 (32 FR 13255, September 20, 1967).

(5) Advisory Circular 29-2B, “Certification of Transport Category Rotorcraft,” July 30, 1997.

Section 25.1203 Fire detector system.

a. **Rule Text.**

(a) There must be approved, quick acting fire or overheat detectors in each designated fire zone, and in the combustion, turbine, and tailpipe sections of turbine engine installations, in numbers and locations ensuring prompt detection of fire in those zones.

(b) Each fire detector system must be constructed and installed so that --

(1) It will withstand the vibration, inertia, and other loads to which it may be subjected in operation;

(2) There is a means to warn the crew in the event that the sensor or associated wiring within a designated fire zone is severed at one point, unless the system continues to function as a satisfactory detection system after the severing; and

(3) There is a means to warn the crew in the event of a short circuit in the sensor or associated wiring within a designated fire zone, unless the system continues to function as a satisfactory detection system after the short circuit.

(c) No fire or overheat detector may be affected by any oil, water, other fluids or fumes that might be present.

(d) There must be means to allow the crew to check, in flight, the functioning of each fire or overheat detector electric circuit.

(e) Wiring and other components of each fire or overheat detector system in a fire zone must be at least fire-resistant.

(f) No fire or overheat detector system component for any fire zone may pass through another fire zone, unless --

(1) It is protected against the possibility of false warnings resulting from fires in zones through which it passes; or

(2) Each zone involved is simultaneously protected by the same detector and extinguishing system.

(g) Each fire detector system must be constructed so that when it is in the configuration for installation it will not exceed the alarm activation time approved for the detectors using the response time criteria specified in the appropriate Technical Standard Order for the detector.

(Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amendment 25-23, 35 FR 5678, April 8, 1970; Amendment 25-26, 36 FR 5493, March 24, 1971)

b. **Intent of Rule.** The intent of this rule is to provide an accurate and quick-acting fire detection system that will withstand the operational and environmental loads, provide system checks, ensure that the system will remain active, and provide indication during the initial phases of a nacelle fire.

c. **Background.**

(1) The regulatory history shows that this section originated from section 4b.485 of the Civil Aviation Regulation (CAR) 4b, December 31, 1953. Amendment 25-AD was published in the Federal Register on December 24, 1964 (29 FR 18289), which added Part 25 [New] to the Federal Aviation Regulations and replaced Part 4b of the Civil Air Regulations. It was part of the Agency recodification program announced in Draft Release 61-25, published in the Federal Register on November 15, 1961 (26 FR 10698). Part 25 [New] was published as a Notice of Proposed Rulemaking in the Federal Register on June 2, 1964 (29 FR 7169), and given further distribution as Notice No. 64-28. It was recodified from CAR 4b.485 without any substantive changes.

(2) Amendment 25-23, which was published in the Federal Register on April 8, 1970 (35 FR 5665), revised this section by incorporating a change of the words “fire detector” to “fire or overheat detector”.

(3) Notice of Proposed Rulemaking 69-7 (34 FR 5020, March 8, 1969) proposed to expand the design and installation requirements for fire detectors in transport aircraft. The items addressed by this proposal included an indication to the crew for a short requirements when the detector has been severed at one point; and clarification of the language “unless the system continues to function as a satisfactory detection system”. This Notice also proposed to require that the installation configuration meet the activation time identified in the appropriate TSO (5 sec.).

Amendment 25-26 (36 FR 5490, March 24, 1971) followed Notice 69-7. The preamble to the Amendment included a discussion of the following comments submitted to the proposal, which serve to show the evolution of the FAA’s current interpretation:

> One of the commenters states that fire detectors should be capable of monitoring the worst fire foreseeable, and suggests that this language be incorporated into § 25.1203. The FAA does not consider that such a change is necessary. The regulations now require that fire detectors be installed in each designated fire zone and in the combustion, turbine, and tailpipe sections in sufficient numbers and locations to ensure prompt detection of a fire. This regulation is not limited to any particular type of fire, but applies to all fires in the designated areas. It would, therefore, include the worst fire foreseeable.
>
> The commenter also requests that the regulation be changed to prevent the fire detectors from being rendered inoperative by a type of fire, such as blowtorching. The FAA is aware that there have been instances in which detectors were rendered inoperable due to blowtorching. However, this has occurred infrequently. Under this regulation, the detector system must still function in the event the sensor or wiring is severed at one point, unless there is a means to warn the crew of the severing, whether or not the severing results from “blowtorching.” Moreover, if the system does

become inoperative due to a short circuit in the system, a means is required to alert the crew to this condition. The FAA, therefore, believes that the matters raised by the commenter are already adequately covered and that the suggested changes to the proposal are unnecessary.

One commenter suggests that fire detector systems should provide both visual and aural fire warning, contending that visual lights are ineffective in sunlight and that taller pilots are unable to see some warning lights from the normal sitting position. The commenter also urges that all transport category aircraft be required to have installed the newer and more reliable types of fire detection equipment as they become available. The commenter also observes that some aircraft currently in service do not provide fire extinguishing for certain combustion heaters that burn JP-1 fuel and are located in the tail compartment, inaccessible to the crew during flight.

With respect to the commenter's first comment, the FAA does not believe it is necessary to require both visual and aural fire warning indicators. So long as the type of warning means selected by the manufacturer provides prompt and effective warning of fire to the crew, either visual or aural means may be used. If both visual and aural means are needed to provide effective fire warning, then both means would have to be used. Further evaluation of the proposal has revealed that the term "alert" as used in the proposed § 25.1203(b)(3) may cause some confusion. The intent of the requirement was to provide a warning for the crew and this term is consistently used throughout the regulations. Therefore, the regulation has been revised to require a means to warn the crew in the event that a short circuit occurs.

With regard to the second comment, the FAA does not believe it is either necessary or feasible to require that the newer fire detection equipment be installed in the older transport category airplanes. In many instances the installation of the newer detection systems in the older airplanes would be extremely burdensome, if not impossible. Moreover, the FAA is not aware that fire detection systems on older aircraft are inadequate or that they need to be replaced with the newer equipment. In any event, if an unsafe condition were found involving the fire detector system of any airplane now in operation, appropriate action, including airworthiness directives, would be taken to correct that condition.

Regarding the commenter's observation concerning JP-1 combustion heaters, it should be noted that the current airworthiness regulations (§ 25.859) do not require fire protection for all combustion heaters. Section 25.859 requires that combustion heater fire protection must be provided for the region surrounding the heater only if this region contains any flammable fluid system components (excluding the heater fuel system) that could be damaged by heater malfunctioning or could allow flammable fluids or vapors to reach the heater in case of leakage, or if the heater fuel system has fittings that, if they leaked, would allow fuel or vapors to enter this region. Thus, in any region surrounding a heater where the conditions covered in the regulation do not exist, fire protection would not be required. This rule would apply to the situation referred to by the commenter. A change in the current requirements is not considered necessary in the interest of safety.

After further evaluation in light of various comments received, the FAA has determined that the proposed requirement that a fire detector remain in an operable condition in the event it is severed at one point is unnecessarily restrictive. The FAA has determined that it is not necessary in the interest of safety to require that a fire detector system remain operable after it has been severed at one point or, for that matter, after a short circuit, if there is a means to warn the crew that the system has been severed or that there has been a short circuit. The proposal has, therefore, been changed to require that there be a means to warn the crew in the event that the fire detector system does not continue to function as a satisfactory detection system after the sensor or the associated wiring has been severed at one point or after there has been a short circuit in the sensor or associated wiring.

Another commenter observes that single spot detectors would not meet the proposed requirements since they do not remain operable if severed at any one point, and states further that the regulation would dictate the use of dual loop detector systems. The FAA responds by noting that, in view of the change to the proposal discussed in the preceding paragraph, single spot detectors could be used if the fire detection system provided the required warning to the crew.

One commenter suggests that the term “fire detector system” be defined to include the sensors, control means, indicating panel, and associated wiring. The commenter also suggests that § 25.1203(b)(1) be changed to refer to the severing of sensors and associated interconnecting means. The FAA’s recent evaluation of fire detector system failures has shown that only the fire detector sensors and associated wiring located in designated fire zones need to be protected from severing and that failures due to shorts are most likely to occur in designated fire zones. The proposal has, therefore, been revised to refer only to the “sensor or associated wiring within a designated fire zone.”

The FAA has also determined, on the basis of comments received, that the phrase “remain in an operable condition” does not accurately convey the intent of the proposal. Safety requires that the crew must be warned in the event that the fire detecting sensor or associated wiring in any designated fire zone is severed unless the system “continues to function as a satisfactory detection system.” The text of the amendment has been changed accordingly.

The Notice proposed to require a means to alert the pilot in the event of a short circuit in the detector system. However, after further consideration, the FAA believes that it is not appropriate in the interest of safety to restrict the warning to the pilot, and the text of the amendment now provides for a means to warn the crew in the event of a short circuit.

Two commenters point out that the proposal would require an alert in the event of a short circuit even though, in a given case, the short circuit might not impair the performance of the fire detector system. The FAA agrees that the proposal is not clear in that respect, and that it is not necessary in the interest of safety to require that the system provide an alert to the crew of any short circuit which does not render the detector system incapable of detecting a fire. The text of the amendment has been changed accordingly.

Several commenters object to the proposed requirement that the fire detector be constructed or protected so that, when it is in the configuration for installation, it would withstand mechanical damage that might occur as a result of routine maintenance performed on the powerplant. The commenters indicate difficulty with the scope of routine maintenance and with the requirement that the detector withstand mechanical damage. The FAA notes that, in view of the changes being made to the proposal permitting a warning to the crew in the event that a fire detector sensor or associated wiring is severed at one point, the subject requirement is no longer necessary. Section 25.1203(g), as proposed in Notice 69-7, has been revised accordingly.

Some commenters contend that the current fire detector TSO (TSO-C11d) should be changed so that the required response time test will allow more than the currently prescribed 5 seconds for high alarm temperature sensors. One of the commenters also suggests that TSO-C11d allow for the effect of airframe structure on response time, and that a pre-flight check be required in order to verify the performance of the detector system if the system is not demonstrated to be unaffected by damage or age.

With respect to the first comment, the FAA believes that the 5-second response time now permitted by TSO-C11d is the maximum that can be allowed consistent with safety. However, the TSO does provide for a higher initial temperature for high alarm temperature sensor tests, provided those sensors are used only in the corresponding high alarm temperature installation.

Regarding the comment concerning the effect of airframe structure on detector response time, the TSO requirements pertain to the performance of the detectors separate from the many types of aircraft in which they may be installed. However, with respect to the commenter's suggestion, the FAA does not agree that the detector response time in the TSO should be increased to take into consideration the effect of airframe structure. Safety dictates that the TSO detector response time must be met with the detectors in the installed configuration and the proposal is unchanged in this respect.

With regard to the last comment, while § 25.1203(d) currently requires that there must be a means to check the functioning of each fire detector circuit in flight, service experience has not indicated that there is a need to require a preflight check to verify performance of the detector system.

One commenter recommends that the system remain in an operable condition or, in the alternative, that there be a means to warn the crew in the event of a break or short in a fire detector element. As previously pointed out, the amendment has been changed to provide for a crew warning, unless the system continues to function as a satisfactory detection system after the severing or short circuit.

d. **Policy/Compliance Methods.**

(1) FAA Notice N8100.1, "Standardization of Emergency Procedures," addresses emergency flight manual procedures for engine fire, severe

damage, etc., and the sequence required. The accepted procedure with respect to the fire detector indication is as follows:

> Upon engine fire indication --
>
> - Throttle to IDLE
> - IF fire indication remains on --
>   - ➔ Fuel Handle- OFF
>   - ➔ Fire Handle- DOWN and DISCHARGE

To define the acceptable trip setting margin for the installed fire detector system, a comparison of the maximum hot day (120°F) fire detector average temperature obtained during the installation inflight cooling test is compared to the defined average fire detector ALARM setting. Although not an absolute requirement, the policy that has been applied is that the margin should be between 150°F (minimum) and 250°F (maximum). Maintaining this margin should ensure that excessive false warnings will not occur and that fires will be detected. Fire detectors that are routed near the pylon to provide indication of a combustion burnthrough occurrence, do not usually meet, nor need to meet, the 150°F - 250°F margin of the detector installed in the nacelle to detect fires.

The routing of the fire detector in the engine nacelle of a given installation is initially defined by the applicant. The FAA review of the nacelle mock up or the installation on the aircraft does need to address and verify the location of the detector routing is acceptable with respect to component location, clearances, adequate support and wire clipping, location with respect to pneumatic duct flanges & clamps, and especially that the compartment ventilation path and direction passes across the fire detector location(s).

(2) The following excerpt from FAA Order 8110.20, "In-Flight Monitoring of Fire Detector Systems," addresses the issue of in-flight monitoring of fire detection systems.

> Amendment 25-26 added new requirements for fire detector installations. These new rules covered, among other things, a requirement for crew warnings in the event of a short circuit or severing of the detector wiring or sensor. The new words require "a means to warn the crew in the event of a short circuit in the sensor or associated wiring" and "a means to warn the crew in the event that the sensor or associated wiring within a designated fire zone is severed at one point."
>
> A manufacturer suggested that a push-to-test circuit for in-flight monitoring of the detector system might satisfy the new requirements. In such a case the crew would be required to check the detector system manually to determine the condition of the system. Sections 25.1203(b)(2) and (b)(3) require that there be a means to alert the crew when a fault or short circuit occurs in the fire detector system. This implies that an automatic continuous warning system is needed. The manual push-to-test periodic system proposed by the manufacturer does not fulfill this requirement.

> The FAA's position was that a push-to-test circuit will not satisfy the requirements of § 25.1203(b)(2) and (3). These rules require continuous in-flight monitoring of the integrity of the fire detector system, and § 25.1203(d) requires a means to allow the crew to check in flight the functioning of each fire or overheat detector system.

(3) The following excerpts from FAA Notice N8100.1, "Standardization of Emergency Procedures," provides guidance on the standardization of emergency procedures for engine fire:

> As a result of an accident at San Francisco, California, on June 28, 1965, some airframe manufacturers have revised the emergency procedures in some airplane flight manuals to require actuation of the fire shutoff valve early in the checkoff list for engine-fire, severe engine damage, or engine separation. The major difference between two of these manuals is that in one case, the manufacturer proposes to actuate the fire handle as the *third* item in the checklist, while another proposes to actuate the fire handle as the *first* item.
>
> Information from the investigation of an accident at London, England, on April 8, 1968, served to indicate the necessity for updating the emergency procedures for the older aircraft. A standardized emergency procedure for all aircraft is also considered an important factor in assuring that the fire shutoff handle is actuated as soon as engine fire, severe engine damage, or engine separation occurs.
>
> This FAA Order requested that FAA regions reexamine the airplane flight manuals of all certificated turbine-powered aircraft to require that the firewall shutoff valve be actuated early in the emergency procedures in case of engine fire, severe engine damage, or engine separation; and report to FS-100. The regions were also requested to study the feasibility of developing one standardized procedure for all turbine-powered aircraft in the above described emergency and send their comments to FS-100.
>
> The engine fire fighting procedures and training practices on turbine-powered aircraft are based upon a sequence designed to permit the crew, in response to a fire warning signal to take selected actions prior to actuating the firewall shutoff valves for complete shutdown of the engine. These procedures have yielded satisfactory results for the occurrence of fire or overheat conditions such as are caused by fuel leaks or bleed pipe ruptures.
>
> For the more severe type of fire conditions which result from drastic mechanical failure in the engine or other severe damage within the engine compartment, experience has shown that the normal fire fighting procedures may not be adequate because they result in either the shutoff being actuated too late or the shutoff not being actuated at all. When damage occurs to the powerplant installation, either from external or internal sources, causing loss, or puncturing of the cowling, normal fire fighting procedures are ineffective because the compartment no longer will contain the fire or the extinguishing agent concentration required to extinguish a fire. In these instances, catastrophic structural damage is likely to result unless shutoffs are actuated quickly.
>
> Some current airplane flight manuals contain procedures for emergencies involving the need for engine shutdown and engine fire control. Experience has shown these procedures to be generally adequate for the purpose intended. Recent experience with other kinds of propulsion emergencies such as damage resulting from rotor disc failure, combustion chamber burnthrough, fire and

explosion in which the cowling is disrupted or lost, damage to the engine nacelle from external causes such as ground contact, or contact with an obstruction, constitutes a type of emergency which is not always covered either by the engine shutdown procedures or by the engine fire control procedures.

Turbine engine installations are required to incorporate steel barriers to isolate the engine compartment from the remainder of the aircraft (either wing or fuselage). These barriers, together with the installation of firewall shutoff valves serve to confine and isolate a fire which can then be extinguished with the installed fire extinguisher system. When an engine fire occurs, the fire will not be extinguished if either the firewall shutoff valves are not actuated or if the cowling fails to the extent that the extinguishing agent is lost overboard without actually suppressing the fire. In any event, the most important function in the fire fighting procedure is to close the flammable fluid firewall shutoff valves.

It is concluded that emergency procedures to cover severe engine damage or engine separation should be in the aircraft flight manual. These may be characterized as engine breakup" as distinguished from the fire case. This type of occurrence could be identified as a failure which produces an explosion, a bump, severe vibrations or shake or shudder of the aircraft, or failure or *loss* of cowling, or the penetration of an engine cowl.

Procedures for coping with this category of emergency should require immediate closure of the firewall shutoff valves.

(4) The following excerpt from an FAA letter, dated January 20, 1983, to a fire detector manufacturer provides additional insight into compliance policy and methodology:

Your letter of June 3, 1982, has been forwarded to the Aircraft Certification Division, Regulations and Policy Office for response to your petition for a ruling and issuance of a statement from the FAA on the subject fire detector circuit compliance.

An analysis has been made of the fire detection circuit submitted by your company with the reference letter wherein you proposed the circuit design meets the requirements of Section 25.1203(b)(2) and (3) as amended by Amendment 25-26. Our conclusion is that the circuit only partially complies. We find that the unique detector wiring circuit, if shorted or severed, does not warn the crew. Depending on the action of the circuit breaker/relay, the circuit will continue to detect a fire as long as the spot fire detectors are capable of performing their intended function and the c/b functions as stated. This feature does make the wiring portion of the fire circuit acceptable in meeting the intent of the regulations. However, we further find that the other components in the total fire circuit, such as the spot detectors (thermoswitch units) and the combination circuit breaker/relay are not automatically and continuously monitored in flight for shorts, severances or other modes of failure; nor is there any warning given the crew when these components become inoperative or malfunction, as is the intent of the later regulation. Although the spot fire detector units are stated to have a high reliability, a circuit preflight or inflight test does not announce a spot detector unit failure if the bi-metallic switch is failed open, for instance.

The other aspect of this unique circuit is the use of and function of the circuit breaker/relay device. In our judgment, the use of such a device in this fire circuit becomes an integral part of the fire detection capability of this circuit design.

> This feature must be considered in the context of the intent and requirements promulgated by Amendment 25-26. Therefore, this component, if it becomes inoperative or malfunctions (discounting loss of 28 VDC) must not prevent the fire detector circuit from performing its intended function; or if it does malfunction then a warning to the crew is, required.
>
> In conclusion, based on our interpretation of the intent of the later rule, we do not consider the fire detector circuit design submitted by the manufacturer to fully meet the requirements of § 25.1203(b)(2) and (3) as amended by Amendment 25-26.

(5) The following is an excerpt from an FAA Grant of Exemption (Exemption No. 2072) published in the Federal Register as Regulatory Docket No. 13665, on January 14, 1975, which was directed to an airplane manufacturer who had requested exemption from the requirements for fire detectors within the tailpipe section of the airplane. It provides additional guidance regarding this section:

> By letter dated March 6, 1974, supplemented by letter dated May 13, 1974, [a commercial airplane company] petitioned for an exemption from Section 25.1203(a) of the Federal Aviation Regulations to permit the amended type certification of [one of its model airplanes] equipped with turbine engines without a fire detector system in the extended nacelle tailpipe sections of the engines.
>
> Section 25.1203(a), insofar as here pertinent, requires fire or overheat detectors in the tailpipe sections of turbine engine installations.
>
> In support of its request for exemption, the petitioner submitted information and data which, it asserts, show that with the fire detectors removed, the airplane has a level of safety equivalent to that required by Section 25.1203(a). According to the petitioner, the extensive trouble-free operational experience of the [model airplane] installation demonstrates the equivalent level of safety. In addition, the petitioner states that granting the exemption would reduce system complexity and associated maintenance work, spares requirements, and cost, thereby assuring the lowest fares to the public. The petitioner also maintains that an exemption would eliminate airplane dispatch delays due to malfunctions or false indications of the system and the associated inconvenience caused to the traveling public by such delays.
>
> Finally, the petitioner asserts that an exemption would be in the public interest because deletion of the detector in the engine tailpipes of this airplane would give a potential improvement in airplane safety by precluding the need for flight crew actions as a result of a false indication, which might pose a safety hazard to passengers, crews, and airplanes.
>
> A review of the data and information submitted indicates that the design of the [model airplane] provides for a relatively cool tailpipe environment, low temperatures in the engine case, and small amounts of flammable fluid that could possibly leak. The probability of a fire in the tailpipe compartment of this airplane is accordingly considered to be extremely remote. The FAA has therefore determined that deletion of the fire detector in the tailpipe sections will not adversely affect the fire protection presently provided for this engine installation in the [model airplane]. Under these conditions, the FAA agrees that it would be in the public interest to reduce system complexity and eliminate a possible source of false indications which could pose some degree of hazard to

the passengers, crew, and airplane due to overreaction by the crew to a situation erroneously indicated to be emergency in nature.

The reasons submitted by petitioner in support of a grant of exemption, in conjunction with a technical determination that safety will not be adversely affected under certain design conditions, indicate that the rule requiring a fire or overheating detector in the tailpipe section may not be appropriate in every case. Accordingly, the FAA is considering rulemaking to determine whether and to what extent the relief afforded petitioners in this case could be extended to others similarly situated by an amendment to the regulations.

(6) The following excerpt is taken from the FAA Generic Issue Paper on “Fire Detector in Tailpipes,” and provides additional compliance policy/methodology:

Statement of Issue: Section 25.1203(a) requires fire detection within turbine engine tailpipe sections. The *generic model airplane* includes the installation of thrust reversers which are hydraulically operated and electrically controlled. The thrust reversers being proposed for installation on the *generic model* are built by *the reverser manufacturer*. The *generic* thrust reverser assembly also acts as a tailpipe for the *generic* engines. The proposed engine installation does not incorporate fire detection within the tailpipe section.

Discussion: Section 25.1203(a), “Fire detector system,” requires that there must be approved, quick acting fire or overheat detectors in each tailpipe section of turbine engine installations in numbers and locations ensuring prompt detection of fire in those zones. Section 25.1181(a)(7), “Designated fire zones,” identifies tailpipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases as fire zones.

FAA Position: The engine tailpipe configuration must either comply to § 25.1203(a) by incorporating fire detection within the tailpipe zone, or compensating design features should be presented and analyzed to support a finding of equivalent safety under the provisions of § 21.21(b)(1). In general, the applicant should list and analyze the generic model compensating design features which would minimize the number of potential ignition sources and limit the amount of flammable fluid (hydraulic) which could leak into the tailpipe section. *Generic aircraft company’s* certification documentation should address the following issues:

1. <u>Hydraulic Fluid Flammability and Exhaust Pipe Temperatures</u>. The minimum flash point, fire point, and auto ignition temperature of the hydraulic fluid should be specified. The auto ignition temperature of the hydraulic fluid should be compared to maximum exhaust pipe temperature which were measured during thrust reverser testing and then extrapolated to the worst case “hot day” maximum temperature. The exhaust pipe surface (within this tailpipe zone) should not be an ignition source for the hydraulic fluid.

2. <u>Electrical Wires and Components</u>. The heat rating for the thrust reverser wiring should be given and credit should be given for any additional wire sleeving which would further minimize the probability of contact between wiring and combustible fluids. In addition, when the thrust reverser is not operating (normal inflight configuration), electrical current should not be running through the wires and switches within this zone. If an electrical short should occur, maximum current flow should be limited by a low amperage breaker (i.e. three amps) for this micro switch circuit(s).

3. Thrust Reverser Hydraulic Fluid Leakage. Any applicant should identify the maximum amount of hydraulic fluid which can leak into the tailpipe zone inflight. Credit should be given for thrust reverser hydraulic isolation valves which would limit the hydraulic fluid leakage into the tailpipe zone.

4. Flammable Fluid Drainage. The tailpipe sections should be in compliance with the drainage and ventilation provisions of § 25.1187 (*and if applicable, the flammable fluid fire protection Generic Issue Paper).*

5. Firewall Containment and Isolation. Firewalls should be provided in the aft cowl and pylon sections (not around the tailpipe/thrust reverser zone) in order to isolate a fire within the tailpipe fire zone from the fuselage, pylon, and remainder of the engine nacelle. These firewalls are required for compliance with § 25.1193(e)(1).

6. Service Experience of Similar Designs. If available, a brief summary of service experience number (hours/cycles and the number of incidents or Airworthiness Directives) with similar/identical thrust reverser designs can also be used as substantiating data.

The applicant must address the issues outlined above to demonstrate that compensating design features provide an equivalent level of safety to the provisions of § 25.1203(a).

e. **References.**

(1) Civil Air Regulations (CAR) 4b, December 31, 1953.

(2) Amendment 25-AD (29 FR 18289, December 24, 1964).

(3) Amendment 25-23 (35 FR 5665, April 8, 1970).

(4) Amendment 25-26 (36 FR 5490, March 24, 1971).

(5) FAA Order 8110.20, "In-Flight Monitoring of Fire Detector Systems," August 27, 1976.

(6) FAA Notice N8100.1, "Standardization of Emergency Procedures," May 28, 1968.

(7) Technical Standard Order (TSO)-C11d, Powerplant Fire Detection Instruments (Thermal Sensing/Ionization and Sensing Types).

(8) Technical Standard Order (TSO)-C11e, Powerplant Fire Detection Instruments (Thermal and Flame Contact Types), October 17, 1991.

Section 25.1207 Compliance.

a. **Rule Text.**

Unless otherwise specified, compliance with the requirements of § 25.1181 through § 25.1203 must be shown by a full scale fire test or by one or more of the following methods:

(a) Tests of similar powerplant configurations;

(b) Tests of components;

(c) Service experience of aircraft with similar powerplant configurations;

(d) Analysis.

(Amendment 25-40 42 FR 15044, March 17, 197; Amendment 25-46, 43 FR 50598, Oct. 30, 1978)

b. **Intent of Rule.** This rule identifies the methods that can be used to show compliance with § 25.1181 through § 25.1203.

c. **Background.**

(1) Section 25.1207 originated in Amendment 25-40, published in the Federal Register on March 17, 1977 (42 FR 15034). The following excerpt is from the preamble of the amendment and provides insight into the intent of the rule:

> One commenter questions proposed § 25.1207. The commenter states that analysis should not be permitted as the sole method of showing compliance with the fire protection requirements. The FAA agrees that some of the requirements of §§ 25.1181 through 25.1203 may be complied with by analysis alone, while others may require other methods of substantiation. Section 25.1207(d) is therefore revised to make clear that, unless tests are specifically required in §§ 25.1181 through 25.1203, analysis is an acceptable method of showing compliance.
>
> Another commenter points out that proposed § 25.1207(b) as written would preclude the use of the Statham test to determine extinguisher agent concentrations in an actual fire zone, contrary to the commenter's understanding that the Statham test method is acceptable. The FAA agrees ,and proposed paragraph (b) is revised to specify "tests of components," instead of "bench fire tests of components."

(2) Amendment 25-46 (43 FR 50578, October 30, 1978) revised this section again. Its preamble contains the following discussion:

> One commenter states that the use of full-scale fire tests, evidence of similar powerplant configurations, and analysis were proposed as part of Airworthiness Review Notice No. 3 (Notice 75-19; 40 FR 21866; May 19, 1975) to show compliance with the requirements of §§ 25.1181 through 25.1203, and that this

proposal is in conflict with Notice 75-19. The proposal in Notice 75-19 to which the commenter refers has been adopted as § 25.1207 (Airworthiness Review Amendment No. 4, effective May 2, 1977). Section 25.1207, as adopted, provides for those cases when tests are specifically required. However, in light of the adoption of proposed § 25.1195(b), the FAA believes that § 25.1207 could be confusing and it is revised for clarity.

Additionally, this commenter states that the method of demonstrating satisfactory fire extinguishing capability should be by agreement between the manufacturer and the certificating authority. The FAA does not agree. Objective rules are needed to ensure that a consistent level of safety is maintained."

One commenter states that the proposal refers to critical airflow conditions while the explanation refers to flight conditions, which are not necessarily the same thing. The FAA agrees that clarification is necessary. The proposal is revised to specify critical airflow conditions in flight."

d. **Policy/Compliance Methods.**

(1) Usually the method used to show compliance has not included full-scale nacelle fire tests. Advisory Circular (AC) 20-135, "Powerplant Installation and Propulsion System component Fire Protection Test Methods, Standards, and Criteria," dated February 6, 1990, defines the acceptable methods and criteria for acceptance of the component or assembly fire testing. Testing of engine oil tanks are usually accomplished as part of the FAR 33 engine certification, but should be verified for the installation per FAR 25 requirements (i.e., § 25.1183). The criteria and methods to be used for oil tank testing are contained in a FAA policy memorandum, "Policy on Turbine Engine Oil Tank Fire Test", dated November 10, 1992:

The drainage and ventilation for the fuselage and nacelle are accomplished during flight test on the aircraft. For example, for APU inlet ingestion, drainage tests are done in both the clean (gear up) and dirty (gear down) configuration.

The fire extinguishing and fire detection compliance are always accomplished on the test aircraft. There have been exceptions with respect to demonstration of the fire extinguishing agent concentration where a full Class 3 mock-up of the engine and nacelle have been used, provided the entire fire extinguishing system (bottles, line routing, etc.) of the installation have been duplicated and conformed. The ventilation of the nacelle is also duplicated.

(2) The following excerpt from AC 20-135 provides additional guidance:

Acceptable Test Criteria and Philosophy.

a) The test for demonstrating compliance with the criteria for “fireproof” and “fire resistant” materials, components, and fittings is to expose the specimen to the required flame temperature and heat flux density for the required time (15 minutes for “fireproof” and 5 minutes for “fire resistant”). The specimen shall withstand flame penetration and not exhibit backside ignition for the required test time. Sheet materials and panels shall be tested by exposing a sample size approximately 10 inches on a side (10” x 10”, or a size appropriate for the intended application) to a flame from an acceptable burner at the test operating conditions outlined in paragraph 7. The flame size and temperatures shall be sufficient to maintain the required test temperature and heat flux density over an area of approximately 5” x 5” for sheet materials and panels.

b) Fittings used in firewalls and in fire zones shall be completely enveloped in the flame on the side that would normally be exposed to fire in the fire zone. The fittings shall be mounted in a manner simulating the installation, and fluid lines or tubing may be connected to both ends of the fitting to simulate the installation that would be present during a typical fire event. However, for the testing of fluid-fittings, there should be no fluid in the line on the engine side of the fitting in the fire zone, since the fire may have been caused by a failure of the line to the fitting under evaluation. Likewise, if failure of the line on the engine side of the firewall could drain the fluid from that portion of the line upstream of the firewall, up to the fluid shutoff valve, then the lines connected to both sides of the fitting should not contain fluid for this testing. If the fitting is part of the shutoff valve, then the line behind or upstream of the valve should contain fluid. For operational components, such as check valves, lines, etc., the flame should completely envelop the unit.

c) Technical Standard Order TSO-C53a (“Fuel and Engine Oil System Hose Assemblies”) and TSO-C75 (“Hydraulic Hose Assemblies”) specify hose assembly fire resistance requirements. These hose assemblies should be exposed to a 2000°F flame for 5 minutes while maintaining the fuel or oil at critical (minimum or maximum) operating flow rates and pressures without evidence of any leakage. The 5-minute exposure provides a reasonable time for the flightcrew to recognize a fire condition, shut down the appropriate engine, and close the appropriate shutoff valve(s), thus shutting off a liquid flow to the engine compartment. It is important to evaluate the particular installation and obtain the minimum flow rate over the entire operating envelope. Although the TSO specifies a flow rate in gallons per minute of 3 to 5 times the (ID)”, ID measured in inches, experience has shown, for example, that a hydraulic system drain or return line not under system demand can have no flow or a flow quite a bit less than that specified by 3 times (ID)”. The lower flow rate should then be used for the fire resistant or fireproof testing. The fire test procedure for hoses is outlined in FM Powerplant Engineering Report No. 3A, (see Appendix 2, Nos. 1, 5, and 6).

d) The operational criteria required for various components depends on the kind of component to be tested. For example, if the unit is an oil line routed through a fire zone with the shutoff valve located outside and downstream of the fire zone, the line should withstand the test flame, without leakage or failure, for 15 minutes. If the unit under test is a shutoff valve located in the engine compartment fire zone, the valve should be exposed to the burner or flame for 5 minutes. The valve should not leak and should be able to be closed by normal application means at the end of the 5-minute exposure.

After the valve has been closed, it is to be exposed to the flame for an additional 10 minutes, and the valve should not leak. Operational components should be subjected to the fire tests in every installation, unless similarity to previously approved configurations can be shown, or they are made of steel or copper based alloys, or they are of such construction that their capability to operate satisfactorily under fire conditions is obvious.

e) Electrical and mechanical controls (cables, electrical wires, drive links, etc.) for components such as shutoff valves located in the engine compartment or other designated fire zones are required to be “fire resistant.” These shall be tested at a 2000^{o}F temperature for 5 minutes. At the end of 5 minutes, the control shall perform its intended function without failure or malfunction. The flame should completely envelop the control and the end fittings and connections from one direction, all as a unit. Where control rods or cables are to be tested, a typical section is all that is required to be evaluated. About 8 inches of the typical section will suffice in most tests, including the end connections and fittings. For testing cable controls, the normal rigging load should be simulated. Control rods which act in compression to operate their component should have the flame applied over the center portion of the rod length where the column compression action will most likely cause failure of the material. Flammable fluid shutoff valve controls should be tested for fire resistance in each installation, except where the cables or rods are purely tension controls and constructed of steel or other materials shown to be “fire resistant” or are designed such that their operation in fire conditions is obvious.

f) The following minimum thickness materials are considered acceptable for use in firewalls or shrouds for non structural/non load-carrying applications, without being subjected to additional fire tests:

i) Stainless steel sheet, .015 inch thick.

ii) Mild steel sheet protected against corrosion, .018 inch thick.

iii) Titanium sheet, .016 inch thick.

iv) Monel metal sheet, .018 inch thick.

v) Steel or copper base alloy firewall fittings/fasteners.

g) In every application the applicant should coordinate and obtain approval for the fire test verification plan and other certification testing for the fireproof and fire resistant aspects of the proposed installation with the FAA office responsible for the project.

h) At the conclusion of the testing, a report, including photographs, which describes the fire test results and addresses the pertinent items identified in this advisory circular should be submitted for FAA approval.

Unique Design Testing Considerations.

a) The applicant should evaluate firewall designs, putting special emphasis on fuel and oil lines, cowling and/or bleed duct, and other firewall penetration points to determine the need for a specific fire test setup and incorporation of the penetrations in the firewall test specimen. As noted in paragraph 6d(2), flammable fluid-carrying lines and fittings need careful consideration. The use of previously approved corrosion-resistant steel or equivalent material is considered satisfactory without further tests. Use of aluminum alloy for any size line/fitting on either side of a firewall should be avoided. An evaluation of the specific installation configuration and actual minimum flow rates should be accomplished to determine fire resistant or fireproof capability. Previous tests (Appendix 2, No. 3) have shown aluminum couplings (3/4 inch or larger) have leaked after exposure to the test flame for 5 minutes with nominal 30 psi pressure and a fluid flow rate in gallons per minute equal to 5 times the (ID)", ID measured in inches. All sizes of aluminum fittings up to 2 inches-failed the "no flow" conditions. Five minutes is acceptable for fire resistant tubing; however, all firewall fittings/penetrations are required to maintain the integrity of the firewall without flame penetration or leakage for 15 minutes. Other designs which require special considerations are butt-joint seals between firewall diaphragms, cowl doors and where a cowl door is part of the firewall, seals between the doors, and drain/vent masts interfacing with the doors. Special fire tests of these "kiss" seals will be necessary to ensure the capability of the overall firewall.

e. **References.**

(1) Amendment 25-40 (42 FR 15034, March 17, 1977).

(2) Amendment 25-46 (43 FR 50578, October 30, 1978).

(3) Advisory Circular 20-135, "Powerplant Installation and Propulsion System component Fire Protection Test Methods, Standards, and Criteria." February 6, 1990.

(4) FAA Memorandum, "Policy on Turbine Engine Oil Tank Fire Test", November 10, 1992.