U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Cowling and Nacelle Skin – Fire Protection

Date: XX/XX/XX
Initiated By: AIR-624

AC No: 25.1193-X

1 PURPOSE.

1.1 This advisory circular (AC) provides guidance for the prevention of hazards caused by a fire, within an engine or auxiliary power unit (APU) fire zone, burning through the fire zone external skin or exiting through a skin opening. Title 14 of the Code of Federal Regulations (14 CFR) 25.1193 requires accessory section cowls subject to flame in the event of a fire in the engine power section and other portions of the cowling subject to exhaust system heat or exhaust gases to be fireproof. It requires engine nacelle skin areas subject to flame in the engine power or accessory sections to be fireproof.

1.2 The guidance provided in this document applies to cowling and nacelle skin on transport category airplanes that are subject to the requirements of § 25.1193. This guidance specifically concerns showing compliance with the requirements of § 25.1193(e), amendment 25-** (** FR **, **).

2 APPLICABILITY.

2.1 The guidance provided in this AC is for airplane manufacturers, modifiers, foreign regulatory authorities, Federal Aviation Administration (FAA) transport airplane type certification engineers, and FAA designees.

2.2 **This is a guidance document. Its content is not legally binding in its own right and will not be relied upon by the Department as a separate basis for affirmative enforcement action or other administrative penalties. Conformity with the guidance document is voluntary only. Nonconformity will not affect rights and obligations under existing statutes and regulations**.

2.3 The FAA will consider other means of demonstrating compliance that an applicant may elect to present. Terms such as "should," "may," and "must" are used only in the sense of ensuring the applicability of this particular method of compliance when the acceptable method of compliance in this document is used. If the FAA becomes aware of circumstances in which following this AC would not result in compliance with the applicable regulations, the FAA may require additional substantiation or design changes as a basis for finding compliance.

2.4 The material contained in this AC does not change, create any additional regulatory requirement, nor does it authorize changes in, or permit deviations from existing regulatory requirements.

3 RELATED MATERIAL.

3.1 Title 14, Code of Federal Regulations.

The following 14 CFR regulations are related to this AC. You can download the full text of these regulations from the Federal Register website at www.ecfr.gov.

- Section 25.901*, Installation.*
- Section 25.1181, *Designated fire zones; regions included.*
- Section 25.1187, *Drainage and ventilation of fire zones.*
- Section 25.1189, *Shutoff means.*
- Section 25.1191, *Firewalls.*
- Section 25.1193, *Cowling and nacelle skin.*
- Section 25.1207, *Compliance.*

3.2 FAA Advisory Circular.

The following AC 20-135, Chg. 1., *Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria*, dated October 11, 2018 is related to the guidance in this AC. The latest version of each AC referenced in this document is available on the FAA website at FAA Advisory Circulars and on the Dynamic Regulatory System.

4 DEFINITIONS OF KEY TERMS.

For the purposes of this AC, the following definitions apply:

4.1 Designated fire zone. According to § 25.1181, areas designated as fire zones are:

- The engine power section.
- The engine accessory section. (Except for reciprocating engines, any complete powerplant compartment in which no isolation is provided between the engine power section and the engine accessory section).
- The auxiliary power unit compartment.

- Any fuel burning heater and other combustion equipment installation described in § 25.859.
- The compressor and accessory sections of turbine engines.
- The combustor, turbine, and tailpipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases.

4.2 Fire zone. A flammable fluid leakage zone that contains a nominal ignition source. While typically any designated fire zone specified in § 25.1181(a) will also qualify as a "fire zone" under this more generic definition, other areas of the airplane may also be considered a "fire zone." The means to protect the airplane from the hazardous effects of a fire within these other "fire zones" may differ from that prescribed for designated fire zones under subpart E of part 25.

4.3 Flammable fluid. Flammable, with respect to fluid (liquid or vapor), means susceptible to igniting or to exploding. This includes any fluid that can burn, e.g., fuels (including hydrogen), hydraulic fluid (including phosphate ester-based fluids such as Skydrol), petroleum and synthetic oils, some ice protection fluids, and some coolants.

4.4 Flight conditions. The airplane operation from airspeed above minimum V_1 until minimum touchdown speed in approved normal or abnormal operations.

4.5 Ground conditions. The airplane operation not covered by the flight conditions in paragraph 4.4 of this AC. It includes static, taxi, takeoff roll, and landing roll.

5 BACKGROUND.

5.1 The original requirement in Civil Air Regulations (CAR) 4b.487 for fireproof cowling was developed for piston-powered airplanes where the engines were typically mounted directly forward of the wing. The intent of the regulation was to prevent fire from escaping from the cowling and impinging on the wing. CAR 4b.487 was recodified in 14 CFR, including in § 25.1193(e), which explicitly stated:

> Each airplane must be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, into any other zone of the nacelle where such fire would create additional hazards… Have fireproof skin in areas subject to flame if a fire starts in the engine power or accessory sections.

5.2 Though identical language to that of CAR 4b.487 was proposed in the notice of proposed rulemaking for the original § 25.1193, the wording was changed for the final version of part 25 at amendment 25-0. The preamble of the final rule clearly stated that the intention of the rewording was to improve consistency in the language style used throughout part 25, and that it was not intended to alter the requirements of any regulations.

5.3 With the advent of turbojet and turbofan engines, engines began to be mounted on pylons well below the wing, changing when and where fire hazards might apply to sections of the nacelle or cowl. On wing strut-mounted or fuselage tail-mounted nacelles, a fire hazard might affect a portion of the nacelle or cowling during ground operation but not flight operation, flight operation but not ground operation, or during both operations. This resulted in applicants requesting equivalent level of safety (ELOS) findings in lieu of direct compliance with the regulation. These ELOS findings historically allow fireproofness for some wing strut-mounted and fuselage tail-mounted turbofan engine nacelles to be shown by defined section of the nacelle or cowl consistent with the combination of the locally applicable fire hazard and operational conditions. For such ELOS findings to be approved, hazard applicability and appropriate fireproofness need to be included in the showing of compliance at all operational conditions for each designated portion of the nacelle or cowl. During review of engine fire protection regulations by the Aviation Rulemaking Advisory Committee (ARAC), the subject of cowl fire resistance and compliance to § 25.1193 was addressed. The inconsistency in methods of compliance and previous approval of certification designs not meeting the literal requirements of § 25.1193 were recognized and engine cowl fire protection was part of an ARAC task intended to harmonize the requirements between the FAA and other regulatory authorities.

5.4 Section 25.1193(e)(3) applies to the cowling and nacelle skin, and it is the fire protection standard for cowls surrounding engine fire zones and any other airplane skin areas subject to flame during engine fire conditions. Both § 25.1193(e)(3) and § 25.1193(e)(1) prescriptively require that those parts of the airplane be fireproof, regardless of the level of hazard created by re-entry or burning through those areas. Section 25.1193(e)(1) applies to all fire zones (engine fire zones, APU compartments, and combustion heater or other combustion equipment compartments), and it requires the airplane to be designed so that fire originating in any fire zone will not re-enter, or be introduced into, another zone where it could create a hazard. Section 25.1193(e)(3) was intended to apply in addition to the requirements of § 25.1193(e)(1), and it is the applicable fire protection standard for cowls surrounding engine fire zones and any other airplane skin areas subject to flame during engine fire conditions.

5.5 One intent of § 25.1193(e)(3) is to prevent a fire from exiting the engine or APU fire zones except through intended ventilation openings designed for this purpose. This allows the behavior of the fire control features (including fire containment, fire detection, and fire extinguishing) to be reliably predicted based on the assumption that the engine cowls will remain intact and will not burn through when exposed to fire. This serves to protect other parts of the airplane from unanticipated impingement of flames and hot gases, and ensures that the fire detection and extinguishing systems will function as designed so that fire can be detected and controlled.

5.6 Another intent of § 25.1193(e)(3) is to prevent fire, that escapes the nacelle via a ventilation opening or through damaged cowling, from re-entering another cowling area and continuing to spread.

5.7 The ground condition is the most critical for showing fire resistance properties due to the lack of back-side airflow to remove heat loads. Some manufacturers used back-side airflow to show the remainder of the nacelle surfaces are fireproof for flight. Substantiation of equivalent safety of the design originates from airflow characteristics data generated by the airframe manufacturer during actual flight tests. The airflow data verified that for anticipated 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. It was therefore determined by the FAA that the level of safety intended by § 25.1193 was achieved in the proposed designs. While these approvals did not find compliance with the prescriptive requirements of §§ 25.1193(c) and (e) for all flight conditions, at least several of the approvals have been mistakenly recorded as findings of direct compliance rather than findings of equivalent safety.

5.8 The guidance in AC 20-135 allows an applicant to consider scrubbing airflow when demonstrating fireproof or fire-resistant compliance with § 25.1193(e). Cowlings are subject to airflow over one or both sides, which greatly improves the fire protection capability and has been found to be acceptable.

5.9 In making these ELOS findings, the FAA required the applicant to show that any fire that burned through the non-fireproof portion of the engine cowls will not cause hazardous flame or hot gases to impinge on the outer surface of the fireproof portion of the cowls, the strut, the wing (in any flap position), or any other part of the airplane that is not fireproof. In addition, the applicant should show that performance of the non-fireproof portion of the cowls will not affect the fire detection and extinguishing systems ability to function as designed so that an under-cowl fire can be properly detected and controlled. The FAA determines the required size of the fireproof sector based on airflow-characteristic data generated by the airframe manufacturer during actual flight test and/or ground test of the proposed design.

5.10 The airflow data should validate that for the anticipated airplane angles of attack, speeds, and configurations that an engine fire penetrating the other areas of the nacelle would not impinge upon the wing, tail, or other critical systems and structure. 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.

5.11 In addition, to ensure that adequate time is provided for safe evacuation of the airplane in the event of an engine fire on the ground, an applicant should show that the remainder, non-critical sections, of the engine cowl materials are constructed of materials that are at least fire resistant under static conditions with the engine shut down. Fire resistance should be demonstrated by testing the applicable requirements within AC 20-135.

5.12 To reduce the likelihood of engine cowl burn-through in the event of an engine fire in flight, these same non-critical sections should be shown to meet the test standards for fireproof materials under conditions representative of in-flight conditions. The backside airflow conditions should be representative of the engine running for 5 minutes followed by the engine windmilling for 10 minutes unless other conditions are agreed to by the FAA. The FAA considers static fire tests to represent the most critical cases including providing confidence that under conditions involving airflow, that the cowlings will retain sufficient structural integrity for the completion of a flight with likely structural damage resulting from an in-flight engine fire (reference § 25.571(e)). FAA Advisory Circular AC 20135, paragraph 7.b., *Design and Application Factors*, does provide for testing with airflow but not without including the other factors that could coexist with scrubbing airflow. Paragraph 7.a. of AC 20-135 states that structural static and dynamic loading should be addressed in the test plan. In some applications, materials can experience pressure differentials across the panels and be subject to vibrations. If an applicant intends to use airflow to establish that a nacelle is fireproof, they should address appropriate companion effects. The applicant should accomplish all testing per the applicable sections of AC 20-135 in consideration of the critical cases of the in-flight environment for differential pressure, airflow, and vibration. The FAA will retain approval of test plans for fire testing of any cowl features that will involve backside airflow to ensure that we agree with the proposed airflow conditions and companion pressure differential and vibration conditions.

5.13 Applicants have shown that having non-fireproof engine cowling and nacelle skin in some locations under some operating conditions does not adversely affect safety. Consequently, not all cowling and nacelle skin, subject to flame if a fire starts in the engine power or accessory sections, have been required to be fireproof under all operating conditions. For instance, portions of the cowling and nacelle skin have been allowed to only be fire resistant for ground operating conditions under an ELOS finding, in lieu of direct compliance with § 25.1193(e)(3).

5.14 The ELOS allowance for only the upper part of certain cowls to be fireproof led to an unsafe condition and AD action on at least two broadly used powerplant installations. A similar safety concern was seen on a subsequent fire that had the AD-required change, which only made the forwardmost hoop frame fireproof, and further AD action may be necessary. It is critical that, even if the skin of lower cowl areas is allowed to not be fireproof, the structure of the overall cowl that retains the upper fireproof portion of the cowl in position must be fireproof to comply with § 25.1193(e). From a practical standpoint, this often means that the entire cowl frame and latch system should be fireproof.

5.14.1 The FAA has required special consideration in showing compliance with § 25.1193(e) for airplane installation of engines with composite fan case structure. The composite fan case is the inner firewall of the fan compartment fire zone and provides structural support for the engine inlet and the fan cowls that act as the outer fire zone boundary. Composite material may lose load-bearing capabilities at temperatures above 400° F. Failure of the composite fan case structure could lead to separation of the engine inlet and loss of fire containment, which could have catastrophic consequences.

6 COMPLIANCE WITH § 25.1193.

6.1 Compliance Approach to § 25.1193(e).

6.1.1 Compliance with § 25.1193(e) needs to address both in-flight operations and ground operations. This includes maintaining the functionality of the fire detection and control features during a fire event as well as safety during ground operations and emergency evacuation.

6.1.2 The required ability to withstand the effects of fire varies with the potential hazards associated with different flight and ground operating conditions.

6.2 Flight Conditions.

6.2.1 For approved normal and abnormal flight operations from airspeed above minimum V_1 until minimum touchdown speed, the cowling and nacelle skin, in areas subject to flame if a fire starts in an engine or APU fire zone, must be shown to be fireproof (§ 25.1193(e)(3)(i)).

6.2.2 For demonstrating the fireproof capabilities of the cowling and nacelle skin, the following apply:

- Credit from the external airflow on the cowling and nacelle skin can be considered.
- The conditions for demonstrating the fireproof capabilities of the cowling should be consistent with the most critical anticipated operating conditions. The engine and APU operating conditions that can affect the fire resistance of the cowling and nacelle skin (including engine power, bleed extraction, ventilation, etc.) should be examined and the most critical ones should be determined. A probabilistic approach showing low likelihood by combining the probability of a critical operating condition and the probability of a fire is not acceptable.
- The engine and APU should be assumed operative for the first 5 minutes and during the remaining 10 minutes under windmilling conditions for the engine and stopped conditions for the APU.

6.3 Ground Conditions.

6.3.1 For ground operations, the portion of the cowling and nacelle skin, in areas subject to flame if a fire starts in an engine or APU fire zone must be fireproof when a skin burnthrough would affect critical areas of the airplane (§ 25.1193(e)(3)(ii)(A)). Critical areas would be those areas where not containing the effects of the fire could result in serious hazards to the aircraft, and injuries to crew, passengers or ground personnel. Serious hazards of concern include, but are not limited to, events such as fuel tank explosion, hazardous spread of fire to flammable fluid sources outside the fire zone, overheating of critical elements outside the fire zone, hazardous conditions in evacuation paths, and fuselage penetration.

6.3.2 The fire resistance capabilities (i.e., shown to be fireproof or fire resistant) should be demonstrated with the engine either operating or not operating, whichever is shown to be more critical.

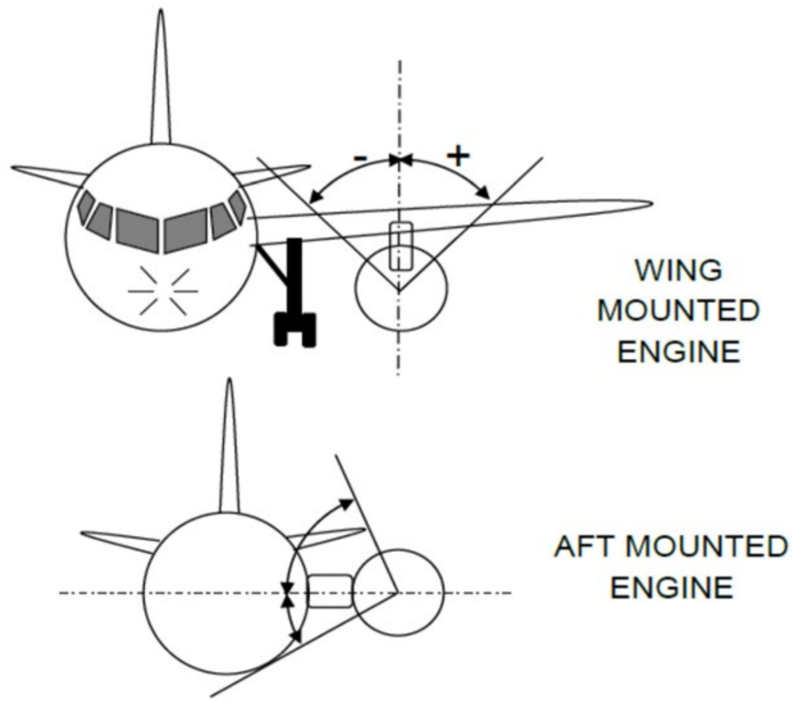
6.3.3 Pod-mounted engines.

6.3.4 The portion of the cowling and nacelle skin, which is required to be fireproof on the ground, varies by installation. A design is considered acceptable when it is demonstrated that the fireproof area protects the pylon strut and other portions of the aircraft considered to be put at a serious risk if a burnthrough occurs. Factors to consider within the analysis and to use when substantiating the design are—

- The engine location – wing or aft mounted.
- The coupling (distance) of the nacelle to the wing or fuselage.
- The airflow characteristics.
- The fluid migration scheme and the fire plume patterns.
- The symmetry of the protection may also vary. Wing-mounted engines usually have symmetrical protection while aft-mounted engines may have non-symmetrical protection to cover more of the inboard area as shown in Figure 1.

6.3.5 After the initial analysis, similarity demonstration and in-service experience may be used, as appropriate, if sufficient similarity between the designs (or obvious conservative differences) is shown to exist. Analyses have demonstrated that the typical area of concern ranges from 90° (± 45°) to 180° (± 90°) and centered on the pylon centerline. This area may increase or decrease depending on the analysis results. For example, most wing-mounted engines, not closely coupled to the wing, have been found acceptable with a ± 45° protection while more closely coupled installations, aft mounted engines, and those with other unique design features, have required ± 90° protection.

Figure 1. Pod-mounted Engine Symmetrical Protection.



6.3.6 Turbopropellers, APUs, and other non-pod-mounted engines.

6.3.7 Due to the wide variations in installation configurations, each turbopropeller, APU, and other non-pivod-mounted engine installation should be evaluated to determine if failure to contain the effects of a fire would result in a serious hazard as described in paragraph 6.3.1 of this AC. If so, the affected area of the fire zone must be fireproof.

6.3.8 For demonstrations of fireproof capabilities, the following apply:

- No credit for external airflow on the cowling and nacelle skin should be considered in conjunction with the assumption that the aircraft may be static.
- The engine/APU should be assumed to be operative for the first 5 minutes and stopped for the remaining 10 minutes.

6.3.9 For engine/APU operation, the requirements for the ability of the cowling and nacelle skin, in areas subject to a flame if a fire starts in an engine or APU fire zone, to withstand the effects of fire during ground operating conditions apply with either the engine operating or not operating, whichever is the more critical. The applicant shall substantiate the engine/APU operating conditions.

6.3.10 **Other areas.**

6.3.11 For the remaining portions of the cowling and nacelle skin in areas subject to a flame if a fire starts in an engine or APU fire zone, the degree of fire resistance can be lower than "fireproof" due to less serious or less probable hazards to the aircraft, crew, passengers, and ground personnel under the critical operating conditions. Any burnthrough of the APU compartment external skin should consider the hazards associated with the combustion product and possible outgassing and reingestion of toxic air into the cabin air system.

6.3.12 Fire-resistant cowling and nacelle skin provide adequate fire protection for those areas as they provide sufficient time to stop the airplane and evacuate it.

6.3.13 A lower than 'fire-resistant' degree of fire protection may be considered. Applicants must comply with § 25.1193(e)(1) by substantiating that this lower level of fire protection will not lead to additional hazards including, but not limited to, the following:

- Reduced fire-withstanding capability of both the fire-resistant and fireproof areas. There should be no effect on the fire-withstanding capability of these areas upon burnthrough of the lower than 'fire-resistant' area.
- Liberation of parts that would affect the airplane evacuation procedure or reduce the efficiency of fire protection means.
- Reduction in flammable fluid drainage capability such that fire severity would be increased (magnitude, residual presence, propagation to surrounding area).
- Reduction in airplane evacuation capability due to the proximity to evacuation paths or due to the visibility of the fire hindering the ability of the passengers to evacuate the airplane in a rapid and orderly manner.
- Hazards involving airplane evacuation, even in the absence of burnthrough, due to such concerns such as smoke and flaming liquids exiting from openings. Burnthrough of nacelle skin should not significantly increase these hazards.
- Reduction in fire detection capability such that the flight crew would not be aware of the fire, especially in a situation involving taxiing prior to takeoff.
- Reduction in fire-extinguishing capability, which could cause or aggravate one of the potential hazards listed above.
- Flammable fluid and/or fire spreading on the airplane evacuation path.

6.4 Compliance Demonstration.

6.4.1 Multiple skin layers.

For some specific fire zones, a fire originating in that zone will have to pass through several layers of cowling or nacelle skin before burning through the external skin. This may be the case, for example, for the core zone of some turbofan installations. In such cases, credit may be taken for multiple layers, having regard to the location of the fire source and the likely direction of propagation from that location, providing burnthrough of the inner layer does not produce other hazardous effects and it does not invalidate other certification requirements such as fire extinguishing capability. The corresponding compliance substantiation should take into account particular geometrical configuration with respect to the risk of flame propagation, as well as critical systems or structures.

6.4.2 Inlet skin.

For external inlet skin, which enclose fire zones, the guidance provided above for multiple skin layers applies. Inlet ducts should meet § 25.1103 requirements.

6.4.3 Openings.

The following considerations are applicable to openings in a fire zone skin; whether the openings are of fixed size, variable or controllable size, or normally closed, such as access or inspection doors, or pressure relief doors.

6.4.3.1 Openings should be located such that flame exiting the opening would not enter any other region where it could cause a hazard in flight or a serious hazard on the ground, as per Section 6.3. Exception is made for covered openings which meet the same criteria for ability to withstand the effects of fire as the surrounding cowl skin, and which are not expected to become open under fire conditions. Since pressure relief doors may open during some fire conditions, they should be located such that flames exiting the door will not cause a hazard. However, doors that will remain closed during most fire conditions, or will tend to re-close following initial opening, have traditionally been assumed closed for the purposes of evaluating fire detection and extinguishing.

6.4.3.2 Openings should have the same ability to withstand the effects of fire as the adjacent skin with respect to becoming enlarged under fire conditions. Some enlargement, such as burning away of louvers or doublers surrounding the opening or gapping of covered openings, is acceptable provided that the hazard is not significantly increased by a reduction in fire extinguishing or detection capability, increased airflow causing increase in fire size or intensity, or increase in the probability of a hazardous spread of fire to other regions.

6.4.4 Hinges, Fittings, and Latches.

The means to maintain the attachment mechanisms between the nacelle and cowlings, and the nacelle and cowlings to the aircraft/engine/APU structure may need to have a greater ability to withstand the effects of fire than the surrounding skin. Loss of attaching means may create more severe hazards, such as cowling liberation, in comparison to a skin burnthrough. Such hazards should be considered when determining the fire requirements for hardware supporting nacelle skins and cowls consistent with § 25.901. The applicant should justify the required level of fire-withstanding capability by test and/or analysis. This should include developing and verifying the air loads on damaged cowls if portions of the cowl are required to be fireproof, including consideration of cowl flutter.

6.4.5 Seals. Where seals are used as part of the external engine nacelle/cowling or APU compartment boundaries, they should at least comply with the same fire integrity standard as the surrounding cowling and nacelle skin.

6.5 Compliance must be shown per § 25.1207. Analytical results should be validated. Probabilistic analysis showing low likelihood of a hazardous situation by combining the probability of a condition and the probability of a fire is generally not acceptable. Substantiation involving airflow patterns may include analytical methods such as computational fluid dynamics (CFD), test methods, other flow visualization methods, or a combination of these methods. Fire testing should be performed in accordance with the guidance in AC 20-135, Change 1 or later revisions, or another method acceptable to the FAA. In accordance with AC 20-135, Change 1, representative conditions (i.e., airflow, loads, vibrations) and establishment of appropriate pass/fail criteria (burnthrough, elongation, dislocation) should be considered.

7 AC FEEDBACK FORM.

For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.

Daniel J. Elgas
Director, Policy and Standards Division
Aircraft Certification Service

OMB Control Number: 2120-0746
Expiration Date:12/31/2027

Advisory Circular Feedback Form

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Subject:____________________ Date: _______________

Please mark all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _________on page __.

☐ Recommend paragraph ______ on page be changed as follows:

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

☐ Other comments:

☐ I would like to discuss the above. Please contact me using the information below.

Submitted by:___________________________________ Date: ______________________

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