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

Advisory Circular

Subject: Fuel Tank Strength in Emergency Landing Conditions

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AC No: 25-30

This advisory circular describes an acceptable means for showing compliance with the fuel tank structural integrity requirements of §§ 25.561, 25.721, and 25.963 of Title 14, Code of Federal Regulations. Section 25.963(d) addresses fuel tank safety in emergency landing conditions. Section 25.963(d) references §§ 25.561 and 25.721, which also address emergency landing conditions.

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/s/

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1 PURPOSE.

This advisory circular (AC) describes an acceptable means for showing compliance with the fuel tank structural integrity requirements of §§ 25.561, 25.721, and 25.963 of Title 14, Code of Federal Regulations (14 CFR). Section 25.963(d) addresses fuel tank safety in emergency landing conditions. Section 25.963(d) references §§ 25.561 and 25.721, which also address emergency landing conditions.

2 APPLICABILITY.

2.1 The guidance provided in this document is directed to airplane and engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers and their designees.

2.2 The material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. These means are issued, in the interest of standardization, for guidance purposes and to outline a method that has been found acceptable in showing compliance with the standards set forth in the rule. If, however, we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

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

2.4 Except in the explanations of what the regulations require, the term "must" is used in this AC only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this AC is used.

3 RELATED DOCUMENTS.

3.1 Regulations.

The following 14 CFR regulations are referenced in this AC. The full text of these regulations can be downloaded at the U.S. Government Printing Office e-CFR. You can order a paper copy by sending a request to the U.S. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-0001; or by calling telephone number (202) 512-1800; or by sending a request by facsimile to (202) 512-2250.

- Section 25.561, *Emergency Landing Conditions—General*.
- Section 25.721, *Landing Gear—General*.

- Section 25.963, *Fuel tanks: general*.
- Section 25.994, *Fuel system components*.

3.2 **Advisory Circulars.**

The following ACs are related to the guidance in this AC. If any AC is revised after publication of this AC, you should refer to the latest version at the FAA website.

- AC 20-128A, *Design Considerations for Minimizing Hazards caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure*, dated March 25, 1997.
- AC 25-8, *Auxiliary Fuel System Installations*, dated May 2, 1986.
- AC 25.994-1, *Design Considerations to Protect Fuel Systems during a Wheels-Up Landing*, dated July 24, 1986.

4 BACKGROUND.

4.1 For many years, the FAA has required that fuel tanks within the fuselage contour be designed to withstand the inertial load factors prescribed for the emergency landing conditions specified in § 25.561. These load factors have been developed through many years of experience and are generally considered conservative design criteria applicable to objects of mass that could injure occupants if they came loose in a minor crash landing.

4.2 A minor crash landing is a complex dynamic condition with combined loading. However, to have simple and conservative design criteria, the emergency landing forces were established as conservative static ultimate load factors acting in each direction independently.

4.3 Recognizing that the emergency landing load factors were applicable to objects of mass that could injure occupants, and that the rupture of fuel tanks in the fuselage could also be a serious hazard to the occupants, § 4b.420 of the Civil Air Regulations (CAR) part 4b (the predecessor of 14 CFR part 25) extended the emergency landing load conditions to fuel tanks located within the fuselage contour. Even though the emergency landing load factors were originally intended for solid items of mass, they were applied to the liquid fuel mass in order to develop hydrostatic pressure loads on the fuel tank structure. The application of the inertial forces as a static load criterion (using the full static head pressure) has been considered a conservative criterion for the typical fuel tank configuration within the fuselage contour. This conservatism has been warranted considering the hazard associated with fuel spillage.

4.4 The European Aviation Safety Agency (EASA) Certification Specification (CS) for Large Aeroplanes CS 25.963, and the corresponding European Joint Aviation Requirement (JAR) that preceded it, required that fuel tanks, both in and near the fuselage, resist rupture under survivable crash conditions. The advisory material previously associated with CS 25.963 specified design requirements for all fuel tanks that, if ruptured, could release fuel in or near the fuselage or near the engines in quantities sufficient to start a serious fire.

4.5 In complying with the CS 25.963 requirement, and the preceding JAR, for wing tanks, several different techniques have been used by manufacturers to develop the fuel tank pressure loads due to emergency landing inertial forces. A real emergency landing is a dynamic transient condition, during which the fuel must flow in a very short period of time to re-establish a new level surface normal to the inertial force. For many tanks, such as large swept wing tanks, the effect is that the actual pressure forces are likely to be much less than what would be calculated from a static pressure based on a steady state condition using the full geometric pressure head. Because the use of the full pressure head results in unrealistically high pressures and creates a severe design penalty for wing tanks in swept wings, some manufacturers have used the local streamwise head rather than the full head. Other manufacturers have used the full pressure head, but with less than a full tank of fuel. These methods of deriving the pressures for wing tanks have been accepted as producing design pressures for wing tanks that would more closely represent actual emergency landing conditions. Service history shows no deficiency in strength for wing fuel tanks designed using these methods.

4.6 Part 25 did not contain a requirement to apply fuel inertial pressure requirements to fuel tanks located outside the fuselage contour. However, the FAA has issued special conditions, in accordance with 14 CFR 21.16, for fuel tanks located in the tail surfaces. The need for special conditions was justified by the fact that these tanks are located in a rearward position from which fuel spillage could directly affect a large portion of the fuselage, possibly on both sides at the same time, a situation not contemplated by the regulations.

5 GENERAL.

Section 25.963(d), as revised by Amendment 25-139, requires that “Fuel tanks must, so far as it is practicable, be designed, located, and installed so that no fuel is released in or near the fuselage, or near the engines, in quantities that would constitute a fire hazard in otherwise survivable emergency landing conditions….” In addition to this primary requirement, § 25.963(d)(1) through (d)(5) provide minimum quantitative criteria, which are discussed in paragraphs 5.1 through 5.6 of this AC. Survivable landing conditions may occur that exceed, or are not captured by, the conditions specified in § 25.963(d)(1) through (d)(5). Therefore, to meet the introductory requirement in § 25.963(d), every practicable consideration should be made to ensure protection of fuel tanks in more severe crash conditions. For example, as much clearance as possible should be provided between fuel tanks and structure that can be crushed, or the tanks should be protected by primary structure not likely to be crushed. The tank design should isolate the tank from airframe-induced structural loads and from deformations induced by the wing and fuselage during a crash landing. Lastly, fuel tanks and supports should not be located at fuselage break points, where the fuselage is most likely to fail in a minor crash landing. For tanks located in the fuselage below the main cabin floor, the capability to withstand a survivable, off-runway takeoff or landing accident should be comparable to that of an equivalent integral aluminum wing fuel tank. Equivalent structural integrity, as well as tear and penetration resistance, should be provided.

5.1 **Fuel Tank Pressure Loads.**

Section 25.963(d)(1) provides a conservative method for establishing the fuel tank ultimate emergency landing pressures. The specified pressure loads vary depending on whether the fuel tank is within or outside the fuselage pressure boundary. The phrase "fuel tanks outside the fuselage pressure boundary," as used in this section, includes all fuel tanks where fuel spillage through any tank boundary would remain physically and environmentally isolated from occupied compartments by the fuselage pressure boundary. In this regard, cargo compartments that share the same environment with occupied compartments would be treated the same as if they were occupied. Figure 1 and figure 2 of this AC show examples of a fuel tank for an underslung wing configured airplane and a fuel tank within a movable tailplane, respectively, both of which would be considered as being entirely outside of the fuselage pressure boundary.

Figure 1. Diagram of Fuel Tank in the Underslung Wing Outside the Pressure Boundary

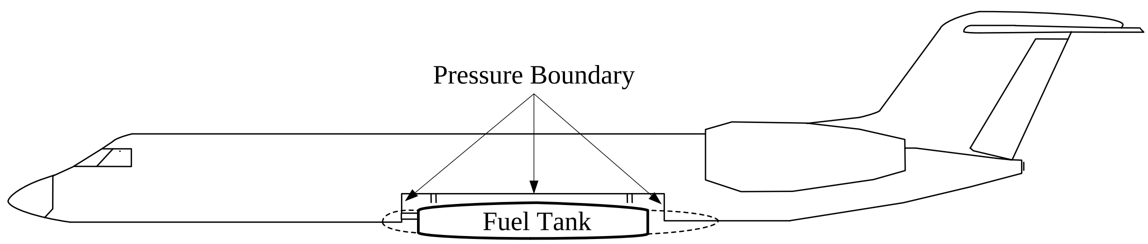
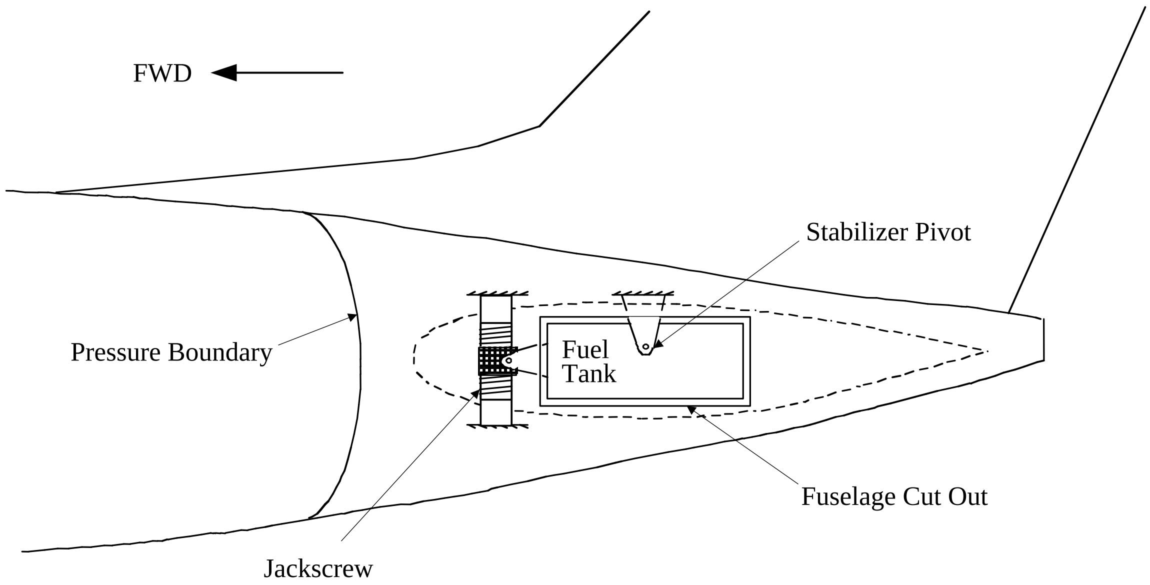


Figure 2. Diagram of Fuel Tank within the Movable Tailplane



5.1.1 Section 25.963(d) prescribes the fuel tank pressures according to the formula $P = K\rho gL$, where P is fuel tank pressure, ρ is fuel density, g is acceleration due to gravity, L is a reference distance between the point of pressure and the tank farthest boundary in the direction of loading, and K is load factor. Figure 3 of this AC shows examples of the way L is calculated for fuel pressures arising in the forward loading condition. Figure 4 of this AC shows examples for fuel pressures arising in the outboard (lateral) loading condition.

Figure 3. Example of Distances for Fuel Forward Acting Design Pressure Calculations

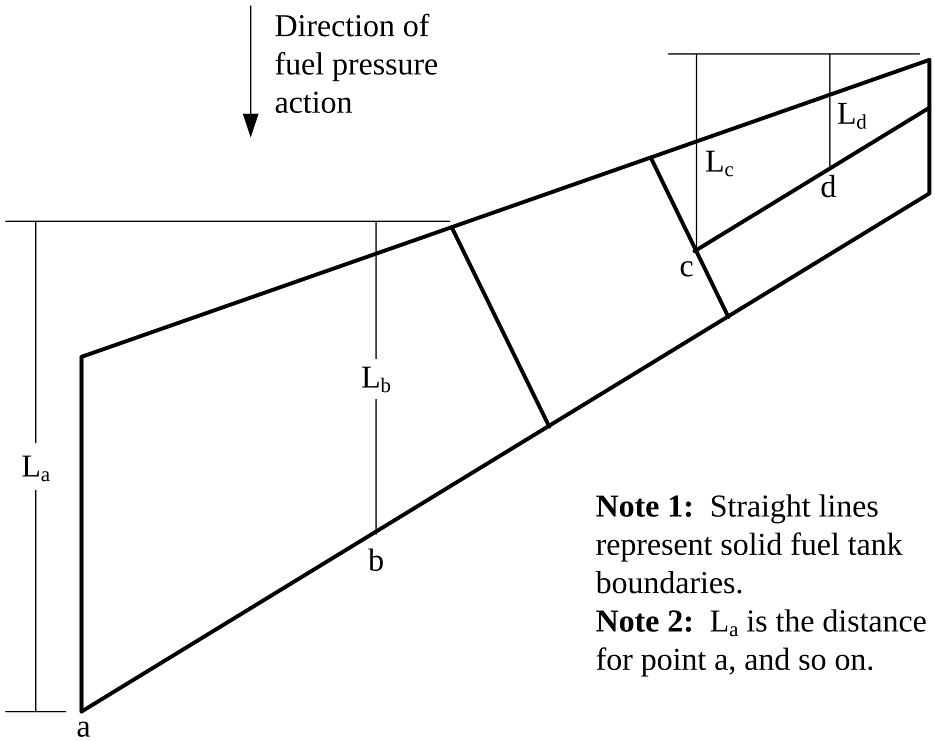
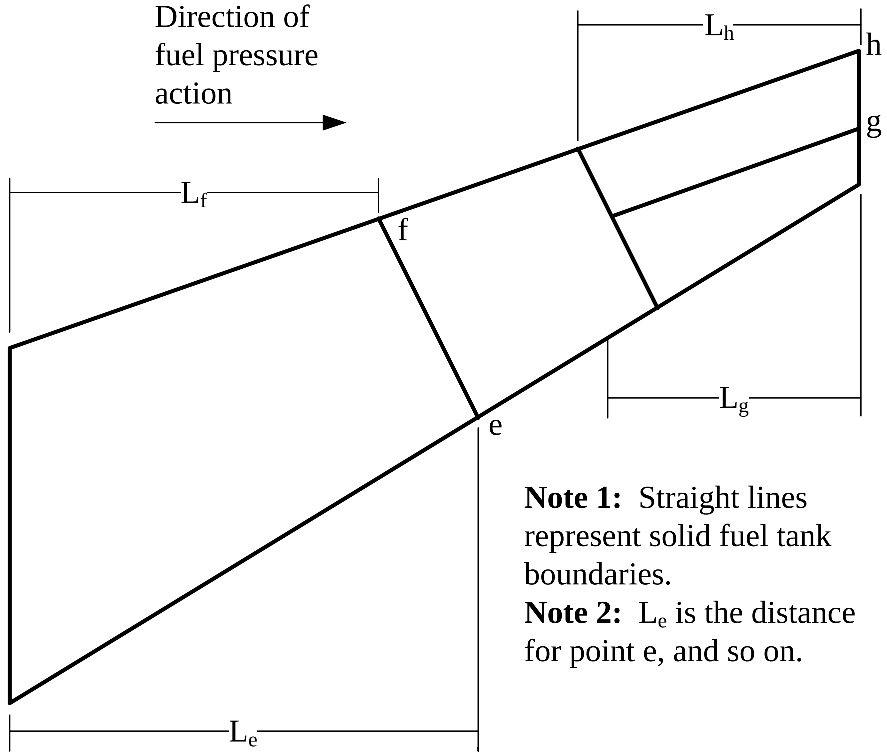


Figure 4. Example of Distances for Fuel Outboard Acting Design Pressure Calculations



5.1.2 Any internal barriers to the free flow of fuel may be considered as a solid pressure barrier, if—

5.1.2.1 It can withstand the loads due to the expected fuel pressures arising in the conditions under consideration; and

5.1.2.2 The time *T* for fuel to flow from the upstream side of the barrier to fill the cell downstream of the barrier is greater than 0.5 seconds. *T* may be conservatively estimated as:

$$T = \frac{V}{\sum_{i=1}^{j} C_{di} a_i \sqrt{2 g h_i K}}$$

Where:

V is the volume of air in the fuel cell downstream of the barrier assuming a full tank at 1 g flight conditions. For this purpose, a fuel cell should be considered as the volume enclosed by solid barriers. In lieu of a more rational analysis, 2 percent of the downstream fuel volume should be assumed to be trapped air.

j is the total number of orifices in the baffle rib.

C_{di} is the discharge coefficient for orifice *i*. The discharge coefficient may be conservatively assumed to be equal to 1.0 or it may be rationally based upon the orifice size and shape.

a_i is the area for orifice *i*.

g is the acceleration due to gravity.

h_i is the hydrostatic head of fuel upstream of orifice *i*, including all fuel volume enclosed by solid barriers.

K is the pressure design factor for the condition under consideration.

5.2 **Near Fuselage/Near Engines.**

Compliance with § 25.963(d)(2):

5.2.1 For Aircraft with Wing-Mounted Engines.

5.2.1.1 The phrase “near the fuselage” addresses those (parts of) wing fuel tanks located between the fuselage and the most inboard engine; and

5.2.1.2 The phrase “near the engine” addresses those (parts of) wing fuel tanks as defined in AC 20-128A, figure 2, as a minimum distance of 10 inches laterally from potential ignition sources of the engine nacelle.

5.2.2 For Aircraft with Fuselage-Mounted Engines.

The phrase “near the fuselage” is addressing those (parts of) wing fuel tanks located within one maximum fuselage width outside the fuselage boundaries.

5.3 **Protection from Crushing and Scraping Action.**

Compliance with § 25.963(d)(4) and § 25.721(b) and (c): Each fuel tank should be protected against the effects of crushing and scraping action (including thermal effects) of the fuel tank and surrounding airframe structure with the ground under the following minor crash landing conditions:

5.3.1 An impact at 5-feet-per-second vertical velocity on a paved runway at maximum landing weight, with all landing gears retracted and in any other possible combination of gear legs not extended. The unbalanced pitching and rolling moments due to the ground reactions are assumed to be reacted by inertia and by immediate pilot control action consistent with the airplane under control until other structure strikes the ground. It should be shown that the loads generated by the primary and subsequent impacts are not of a sufficient level to rupture the tank. A reasonable attitude should be selected within the speed range from V_{L1} to 1.25 V_{L2} based upon the fuel tank arrangement. The attitude or attitudes selected for evaluation should be shown to be the most critical attitude(s) in terms of the effect on the structural integrity of the fuel tanks. V_{L1} equals V_{S0} (TAS) at the appropriate landing weight and in standard sea-level conditions, and V_{L2} equals V_{S0} (TAS) at the appropriate landing weight and altitudes in a hot day temperature of 41 °F above standard.

5.3.2 Sliding on the ground starting from a speed equal to V_{L1} to a complete stop, all gears retracted, with up to a 20° yaw angle, and as a separate condition, sliding with any other possible combination of gear legs not extended with a 0° yaw angle. The effects of runway profile need not be considered.

5.3.3 The impact and subsequent sliding phases may be treated as separate analyses or as one continuous analysis. Rational analyses that take into account the pitch response of the airplane may be used. However, care must be taken to assure that abrasion and heat transfer effects are not inappropriately reduced at critical ground contact locations.

5.3.4 For airplanes with wing-mounted engines, if failure of engine mounts or failure of the pylon or its attachments to the wing occurs during the impact or sliding phase, the subsequent effect on the integrity of the fuel tanks should be assessed. Trajectory analysis of the engine/pylon subsequent to the separation is not required.

5.3.5 The above emergency landing conditions are specified at maximum landing weight where the amount of fuel contained within the tanks may be sufficient to absorb the frictional energy (when the airplane is sliding on the ground) without causing fuel ignition. When lower fuel states exist in the affected fuel tanks, these conditions should also be considered in order to prevent fuel-vapor ignition.

5.4 Engine/Pylon Separation.

Compliance with § 25.721(c) and § 25.963(d)(5): For configurations where the nacelle is likely to come in contact with the ground, failure due to overload should be considered. Consideration should be given to the separation of an engine nacelle (or nacelle + pylon) under predominantly upward loads and under predominantly aft loads. The predominantly upward load and the predominantly aft load conditions should be analyzed separately. Applicants should show that, with an engine/pylon failure, the fuel tank itself is not ruptured at or near the engine/pylon attachments.

5.5 Landing Gear Separation.

Compliance with § 25.721(a) and § 25.963(d)(5): Failure of the landing gear due to overload should be considered, assuming the overloads act in any reasonable combination of vertical and drag loads, in combination with side loads acting both inboard and outboard. In the absence of a more rational analysis, the side loads must be assumed to be up to 20 percent of the vertical load or 20 percent of the drag load, whichever is greater. It should be shown that, at the time of separation, no fuel tank will be ruptured at or near the landing gear attachments. In addition, it should be shown that a failed landing gear will not impact an adjacent fuel tank, considering the kinematic motion of the landing gear throughout the breakaway sequence. The assessment of secondary impacts of the airframe with the ground following landing gear separation is not required.

5.6 Compliance.

Compliance with the provisions of the referenced regulations may be shown by analysis or tests, or both.

6 OTHER CONSIDERATIONS.

6.1 Supporting Structure.

In accordance with § 25.561(c), all large mass items that could break loose and cause direct injury to occupants must be restrained under all loads specified in § 25.561(b). To meet this requirement, the supporting structure for fuel tanks should be able to withstand each of the emergency landing load conditions, as far as they act in the "cabin occupant sensitive directions," acting statically and independently at the tank center of gravity as if it were a rigid body. Where an empennage includes a fuel tank, the empennage structure supporting the fuel tank should meet the restraint conditions applicable to large mass items in the forward direction.

6.2 Auxiliary Fuel Tanks.

AC 25-8, *Auxiliary Fuel System Installations*, provides additional information applicable to auxiliary fuel tanks carried within the fuselage. That AC provides guidance on crashworthiness and other design issues that may also be applied to fuel tanks other than those considered auxiliary fuel tanks.

Advisory Circular Feedback

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) emailing this form to 9-AWA-AVS-AIR500-Coord@faa.gov or (2) faxing it to the attention of the Aircraft Certification Service Directives Management Officer at (202) 267-3983.

Subject: (insert AC title/number here) Date: Click here to enter text.

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph Click here to enter text. on page Click here to enter text..

☐ Recommend paragraph Click here to enter text. on page Click here to enter text. be changed as follows:

Click here to enter text.

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

Click here to enter text.

☐ Other comments:

Click here to enter text.

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

Submitted by: ________________________________ Date: _________________________