*Apostila da Masterclass*

Engenharia Aeronáutica

# CERTIFICAÇÃO DE AERONAVES

## Evolução dos Requisitos

YVAN MURTA
RAFAELA CAILLAUX
FÁBIO SOUZA
CLARISA FEDEL

# CONTEÚDO

- *Certificação de Aeronaves*
- *Evolução dos Requisitos de Certificação*
- *Acidente do Boeing 727, voo 227 – Salt Lake City*
- *Requisitos que mudaram após o acidente*
- *Como são definidos os requisitos aplicáveis?*
- *Como aprofundar os conhecimentos sobre Regulamentos e Certificação Aeronáutica?*
- *Qual o papel do Engenheiro de Certificação?*
- *Como serão os requisitos para os eVTOLs?*


## CERTIFICATION

**the process of giving official approval to a person, company or product that has reached a particular standard**


# Types of Product Approval

## Part 21

**Type Certificate**
**Suppemental Type Certificate**
**Technical Standard Order**
**Parts Approval**
**Repairs**

https://engenhariaaeronautica.com.br/

Engenharia Aeronáutica


## Applicable Requirements

Depends on the Aircraft Category

- Higher the risk
- Heavier the requirement

## Aircraft Category

https://engenhariaaeronautica.com.br/

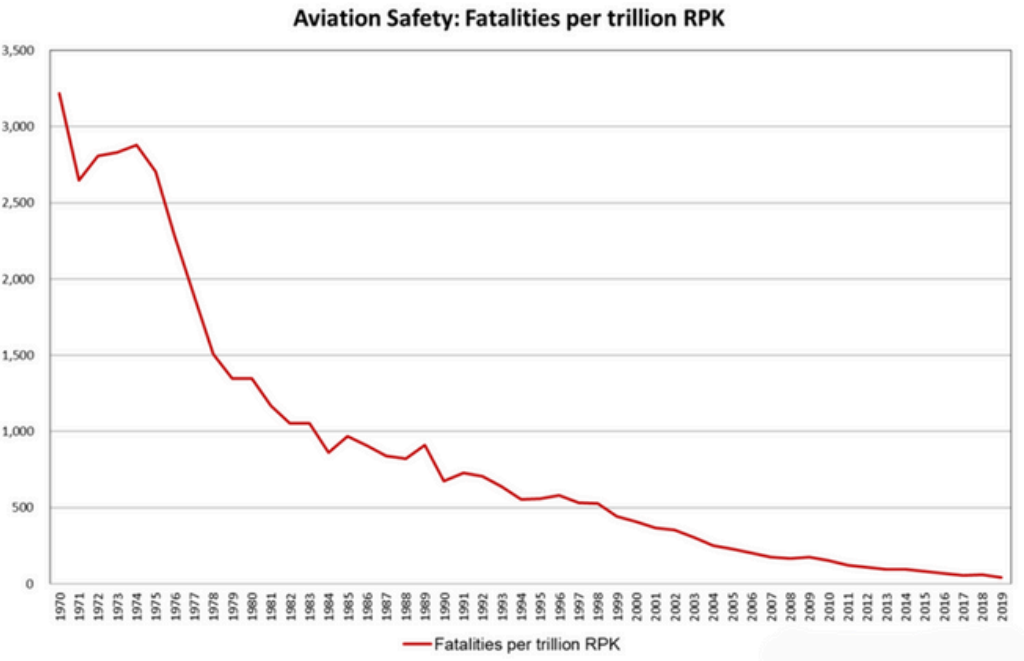
Engenharia Aeronáutica

## Applicable Requirements

Improves over time

- The newer the aircraft
- The heavier the requirement

## Aviation Safety Improvement




Fatalities per trillion revenue passenger kilometers since 1970
(five-year moving average for fatalities)


**Requirements Evolution**

# The Boeing 727 – Flight 227 Accident

**Flight** UA 227 November 11, 1965
**Model:** Boeing 727-22
**Operator:** United Airlines
**Registration:** N7030U

**Departure airport:** New-York-La Guardia (LGA)

**Destination airport:** San Francisco (SFO) via Cleveland (CLE), Chicago (MDW), Denver (DEN) and **Salt Lake City (SLC).**

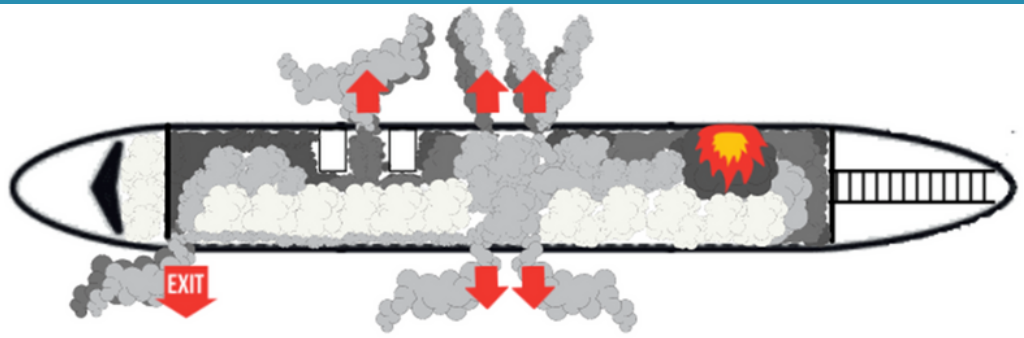
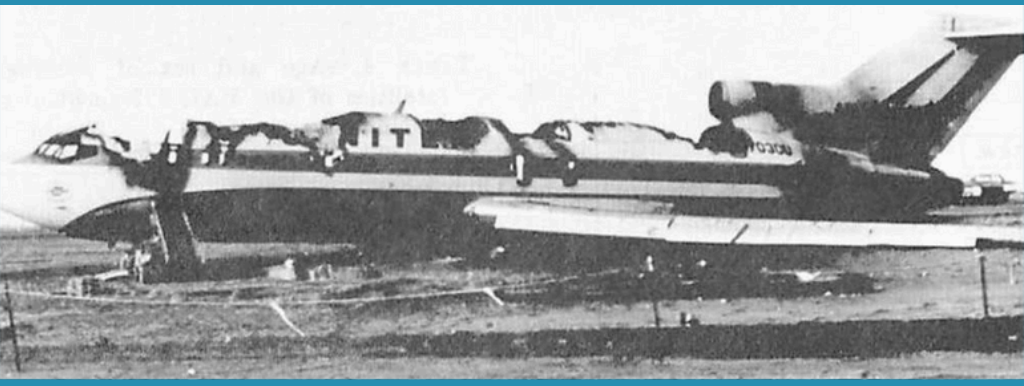




Diagram based on information from CAMI Report
(https://lessonslearned.faa.gov/United227/CAMI.pdf) detailing smoke and fire dispersion in cabin

FAA - https://aviation-safety.net/photo/8272/Boeing-727-22-N7030U



**Crew:**
Fatalities: 0 / Occupants: 6
**Passengers:**
Fatalities: 43 / Occupants: 85
**Total:**
Fatalities: 43 / Occupants: 91

Causes of deaths:

- **FIRE** caused by **fuel leak**
- **Difficulty** in **evacuating the cabin**
- Indoor items **FIRE spread**
- **Dense**, and possibly **toxic**, black **SMOKE**
- **Lack of lighting** for emergency evacuation

Key Safety Issues

•Rigid metal fuel lines within the fuselage with no provision for deformation during a survivable accident.

•Inadequate design, procedures, and training to maximize passenger survivability after a survivable accident.

•Inadequate training for piston airplane pilots to transition into jet airplanes, which are less forgiving during approach and landing.

•The seating of the crew's three flight attendants away from emergency exits, which would preclude them from reaching those exits in time to assist in passenger evacuation.


Prevailing Cultural / Organizational Factors

•Airplane Take off and Landing Characteristics were different from the predecessor Boeing 707. Boeing 727 was relatively new in-service and crew were still being trained.

•Crew Resource Management was not an industry standard for aircrew interaction.

•There was no requirement for Cabin Crew Seating Arrangement.

Following this accident, the requirements incorporated in the amdt. 15 of the CFR 15 Part 25 were aimed at increasing substantially the probability of occupant survival in an aircraft accident by requesting:

•More effective self-extinguishing characteristics for aircraft interior materials;

•Cabin fire suppressant systems;

•Protection from smoke and fumes;

•Improved emergency lighting and exit visibility;

•Improved evacuation facilities and techniques;

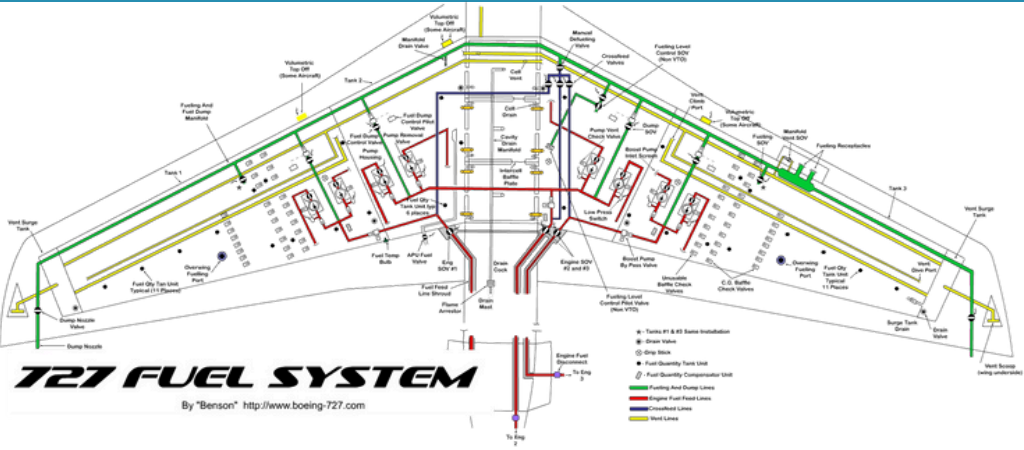
•Flexibility for fuel lines and wiring harnesses;

•Isolation of power cables from flammable fluids;

•Landing gear safe disengagement.

The FAA considered additional revisions of the regulations, as advances in the state-of-the-art allow, in order to further increase that probability of survival.

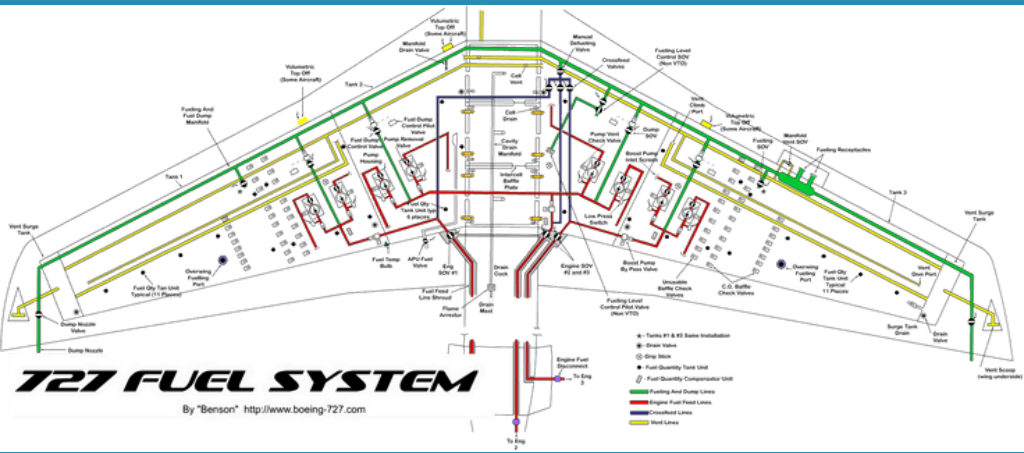
https://i.ytimg.com/vi/E9QE6LNdP4Y/maxresdefault.jpg




The Boeing Model 727-200 was certified using Part 4b of the Civil Air Regulations (CAR 4b). However, the accident resulted in changes to 14 CFR 25.

4b.432 which addressed fuel lines and requirements for flexibility. It requires that for sections of fuel lines where relative motion may exist, that flexibility between the sections (i.e. flexible connections) and/or flexible hose was required to prevent fuel leakage.

Relative to this accident, the ruptured fuel lines were in areas where the flexibility was not required. As a result, the fuel lines ruptured, releasing fuel under pressure.




"It has been established with reasonable certainty that the fire following impact resulted from fuel lines being broken by the failed right main landing gear."

"Fuel lines through the fuselage should be rerouted that they pass through the floor beams near the centerline of the aircraft."

"The fuel lines and their shrouds should be made of stainless steel and should have a wall thickness of sufficient dimension to withstand rather severe impacts. We suggest that the wall thickness be not less than 0.040 inch."

ANTES:
No regulation for landing gear failure.

DEPOIS:
25.721 (Amendment 25-15).
(d) The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads are in the vertical plane parallel to the longitudinal axis of the airplane), the failure mode is not likely to puncture any part of the fuel system in the fuselage.

Sec. 25.721

General.

(a) The landing gear system must be designed so that when it fails due to overloads during takeoff and landing, the failure mode is not likely to cause spillage of enough fuel to constitute a fire hazard. The overloads must be assumed to act in the upward and aft directions in combination with side loads acting 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.

(b) The airplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway, under the following minor crash landing conditions:

(1) Impact at 5 feet-per-second vertical velocity, with the airplane under control, at Maximum Design Landing Weight—

(i) With the landing gear fully retracted; and (ii) With any one or more landing gear legs not extended.

(2) Sliding on the ground, with—

(i) The landing gear fully retracted and with up to a 20° yaw angle; and (ii) Any one or more landing gear legs not extended and with 0° yaw angle.

(c) For configurations where the engine nacelle is likely to come into contact with the ground, the engine pylon or engine mounting must be designed so that when it fails due to overloads (assuming the overloads to act predominantly in the upward direction and separately, predominantly in the aft direction), the failure mode is not likely to cause the spillage of enough fuel to constitute a fire hazard.

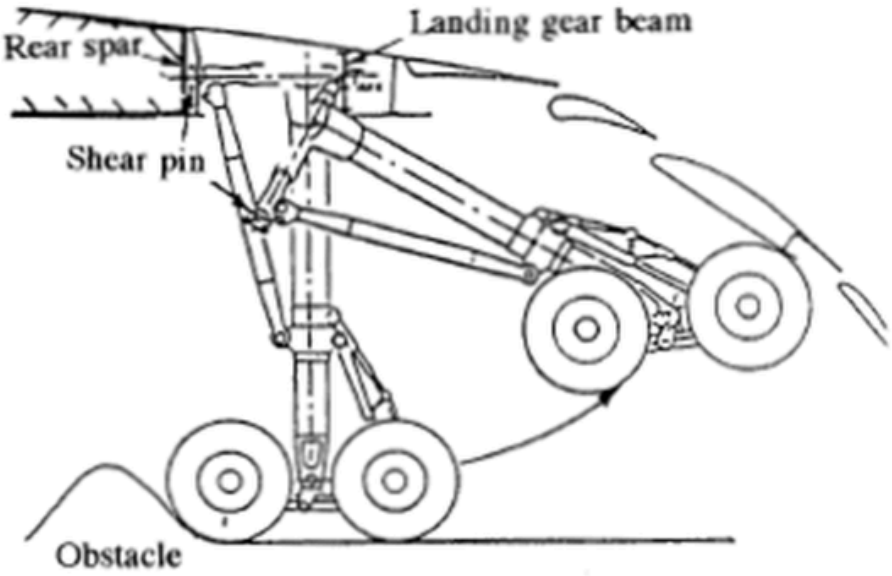
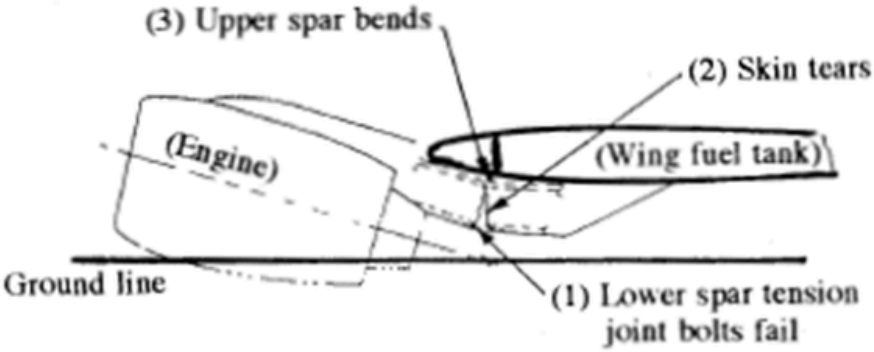



*Fig. 3.10.2 Main Landing Gear Breakaway Case (Break Shear Pins)*

Niu, M. C. Y. *Airframe Stress Analysis and Sizing*.




(c) Break tension bolt

*Fig. 3.10.1 Wing-mounted Engine Breakaway Cases*

## Relevant Regulations / Policy / Background

• 4b.432 which addressed fuel lines and requirements for flexibility. This regulation was particularly important in its relation to this accident. The regulation requires that for sections of fuel lines where relative motion may exist, that flexibility between the sections (i.e. flexible connections) and/or flexible hose was required to prevent fuel leakage.

• Relative to this accident, the ruptured fuel lines were in areas where the flexibility was not required. As a result, the fuel lines ruptured, releasing fuel under pressure (the fuel boost pumps continued operating for a period during the initiation of the fire), which was ignited by either sparking generator leads, sparks from the fuselage on the runway, or both.

## Resulting Safety Initiatives

Sec. 25.993 (Fuel system lines and fittings):
(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure and accelerated flight conditions.
(b) Each fuel line connected to components of the airplane between which relative motion could exist must have provisions for flexibility.
(c) Each flexible connection in fuel lines that may be under pressure and subjected to axial loading must use flexible hose assemblies.
(d) Flexible hose must be approved or must be shown to be suitable for the particular application.
(e) No flexible hose that might be adversely affected by exposure to high temperatures may be used where excessive temperatures will exist during operation or after engine shut-down.
[(f) Each fuel line within the fuselage must be designed and installed to allow a reasonable degree of deformation and stretching withoutleakage.]

## Key safety issues

The following key safety aspect contributed to this accident:

Fuel feed lines made of rigid material and with no provision for deformation or stretching during a "survivable accident".

## Lessons learned

- Post crash survivability can be greatly compromised by uncontrolled fuel leaks. (Threat Category: Cabin Safety/Hazardous Cargo);

- The Civil Aeronautics Board determined that this accident was survivable, and that no passengers suffered crash-related injuries that would have prevented their safe evacuation from the airplane. However, broken fuel lines, feeding fuel under pressure, combined with sparks from runway contact, or broken and shorted generator leads, or both, led to a fire. This fire prevented the evacuation of nearly half the passengers. Subsequent rule changes required flexible fuel lines that could withstand the forces associated with this kind of accident, and provide an additional safeguard against post-crash fires.

## Requirement intent

The intent of 993(f) requirement is to prevent fire post survivable crash and provide a reasonable time to the passengers to evacuate the aircraft in safety.

## Preliminary design precautions

- Pressurized area (Best design practice)
- Avoid routing or contact with electrical cables and hydraulic lines (System Segregation);
- Landing gear bay installation (Tire burst test);
- Minimize or avoid "guillotine effect";
- Material definition: “...reasonable degree of deformation and stretching ..."

Sec. **25.994**

Fuel system components.

Amdt. 25-23, Eff. 5/8/70 (post accident)

Fuel system components in an engine nacelle or in the fuselage must be protected from damagewhich could cause the release of fuel as a result of a wheels-up landing.

Amdt. 25-139, 79 FR 59430, Oct. 2, 2014 (actual)

Fuel system components in an engine nacelle or in the fuselage must be protected from damage that could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in §25.721(b).

## Design Precautions

- Fuel system components should be located and routed as far as practicable fromlikely impact areas and from areas where structural deformation may cause crushing, severing, punctures or high tensile loads in the lines.
- Fuel shutoff valves should not be located within:
  - the engine nacelles,
  - pylon areas or
  - adjacent to engine air intakes and exhausts
  - where they may be subjected to damage from impact and scraping action during a wheels-up landing.

- Fuel Shutoff valves and fuel pumps operation capability should be protected as much as possible.

Sec. **25.1359**

Electrical system fire and smoke protection.

Amdt. 25-15, Eff. 5/8/70 (post accident)

(a) Components of the electrical system must meet the applicable fire and smoke protection requirements of Secs. 25.831(c), 25.863, and 25.1205.

(b) Electrical cables, terminals, and equipment in designated fire zones, that are used during emergency procedures, must be at least fire-resistant.

[(c) Main power cables (including generator cables) must--

(1) Be isolated from flammable fluid lines in the fuselage;
(2) Be shrouded by means of electrically insulated flexible conduit, or equivalent, which is in addition to the normal cable insulation; and
(3) Be designed to allow a reasonable degree of deformation and stretching without failure.]


25.1359(c)(1)

25-72 - Eff. 08/20/1990

25.869(a)(3)(i)

25-123 - Eff. 12/10/2007

**25.1707 System separation: EWIS.**

(e) **Except to the extent necessary** to provide electrical connection to the fuel systems components, the EWIS must be designed and installed with adequate physical separation from fuel lines and other fuel system components, so that:

(1) An EWIS component failure will not create a hazardous condition.

(2) Any **fuel leakage onto EWIS** components **will not create a hazardous** condition.


25.1359(c)(3) → 25.1359(c) 25-17 - Eff. 06/20/1968

↓

25.869(a)(3)

↓

**25.1703 Function and installation: EWIS.**

(c) The design and installation of the main power cables (including generator cables) in the fuselage must allow for a reasonable degree of deformation and stretching without failure


## Design Precautions

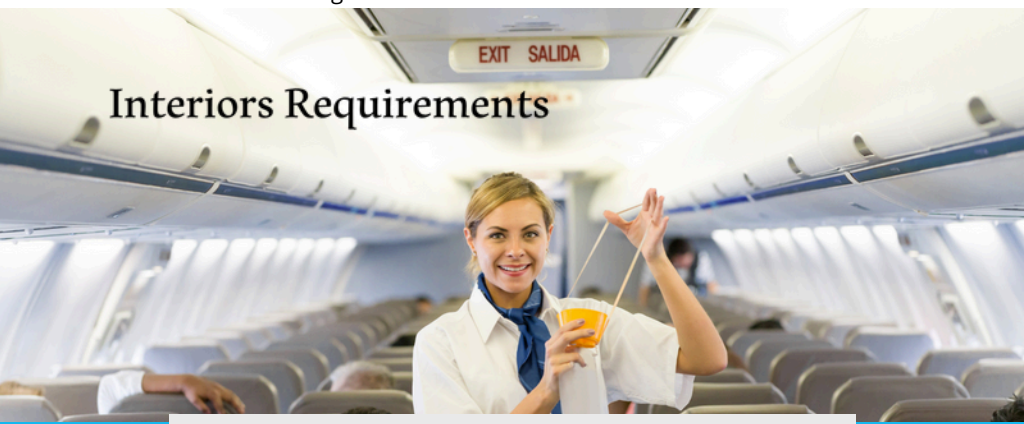
•Wiring shall be installed, whenever is possible, above or level with the fluid lines and not in the same vertical plane.

•Consider the failure conditions when evaluating the separation with fluid lines.

•In tight spaces, consider installing clamps or insulating material to assure fluid line contact and arcing are not possible.

•Take into consideration, relative motion of aircraft structure due to wing deflection or engine movement and manufacturing tolerances.

•Consider the scenarios fuselage can be damaged with partial separation or other structural damages after a survivable accident.




## Interiors Requirements

https://engenhariaaeronautica.com.br/

Engenharia Aeronáutica


## Interiors Requirements

14 requirements changed in Amdt 15 – 1967

Intent of the Rule

- Improve cabin evacuation
- Prevent fire propagation

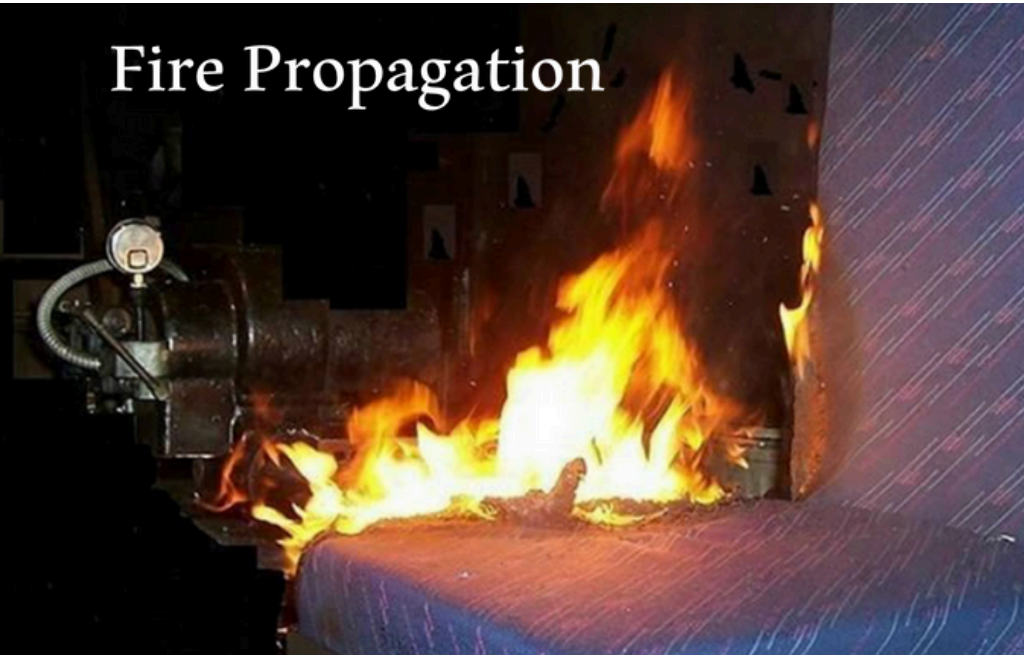
| | |
|---|---|
| 25.783 | Doors |
| 25.785 | Seats, berths, safety belts, and harnesses |
| **25.803** | **Emergency evacuation** |
| 25.807 | Passenger emergency exits |
| 25.809 | Emergency exit arrangement |
| 25.811 | Emergency exit marking |
| 25.812 | Emergency lighting |
| 25.813 | Emergency exit access |
| 25.815 | Width of aisle |
| 25.817 | Maximum number of seats abreast |
| 25.853 | Compartment interiors |
| 25.855 | Cargo and baggage compartments |
| **F25.1** | **Appendix F-An Acceptable Test Procedure for Showing Compliance with Sec. 25.853** |



https://engenhariaaeronautica.com.br/

Engenharia Aeronáutica


United ★★★★
United ★★★★


Fire Propagation


United ★★★★
United ★★★★


The **Aircraft Certification** is essential to the aviation safety and the **accidents investigation** continuously **increase** the aviation **level of safety**


**Como são definidos os requisitos aplicáveis?**

**Como aprofundar os conhecimentos sobre Regulamentos e Certificação Aeronáutica?**

**Qual o papel do Engenheiro de Certificação?**

**Como serão os requisitos para os eVTOLs?**

Engenharia
Aeronáutica

**Acesse o no nosso site e aproveitar nossos outros conteúdos para se tornar um profissional de elite da indústria aeronáutica!**

**https://engenhariaaeronautica.com.br/**