CS-25 AMENDMENT 14 — CHANGE INFORMATION

The Agency publishes amendments to Certification Specifications as consolidated documents. These documents are used for establishing the certification basis for applications made after the date of entry into force of the amendment.

Consequently, except for the note 'Amdt 25/14' under the amended paragraph, the consolidated text of CS-25 does not allow readers to see the detailed changes introduced by the new amendment. To allow readers to also see these detailed changes this document has been created. The same format as for the publication of Notices of Proposed Amendments (NPAs) has been used to show the changes:

The text of the amendment is arranged to show deleted text, new text or new paragraph as shown below:

1. deleted text is shown with a strike through: ~~deleted~~
2. new text is highlighted with grey shading: new
3. an ellipsis (…) indicates that remaining text is unchanged in front of or following the reflected amendment.

BOOK 1

SUBPART D — DESIGN AND CONSTRUCTION

Delete CS 25.729(f) as follows:

CS 25.729 Retracting mechanism

…

~~(f) Protection of equipment on landing gear and in wheel wells. Equipment that is essential to the safe operation of the aeroplane and that is located on the landing gear and in wheel wells must be protected from the damaging effects of –~~

~~(1) A bursting tyre;~~

~~(2) A loose tyre tread unless it is shown that a loose tyre tread cannot cause damage; and~~

~~(3) Possible wheel brake temperatures.~~

Create a new CS 25.734 as follows:

CS 25.734 Protection against wheel and tyre failures

(see AMC 25.734)

The safe operation of the aeroplane must be preserved in case of damaging effects on systems or structures from:

- tyre debris;
- tyre burst pressure;
- flailing tyre strip; and
- wheel flange debris.

Create a new CS 25.735(l) as follows:

CS 25.735 Brakes and braking systems

(See AMC 25.735)

…

(l) *Wheel brake temperature*. Equipment and structure that are essential to the safe operation of the aeroplane and that are located on the landing gear and in wheel wells must be protected from the damaging effects of possible wheel brake temperatures.

Correct CS 25.809 as follows:

CS 25.809 Emergency exit arrangement

…

(g) There must be provisions to minimise the probability of jamming of the emergency exits resulting from fuselage d~~ Het Verloren Symbool~~eformation in a minor crash landing.

…

SUBPART E — POWERPLANT

Amend CS 25.963(e) as follows:

CS 25.963 Fuel tanks: general

(e) Fuel tanks ~~access covers~~ must comply with the following criteria in order to avoid ~~loss of~~ hazardous ~~quantities of~~ fuel leak:

(1) ~~All covers~~ Fuel tanks located in an area where experience or analysis indicates a strike is likely, must be shown by analysis supported by test, or by test, ~~tests~~ to address ~~minimise~~ penetration and deformation by tyre and wheel fragments, ~~low energy~~ small debris from uncontained engine ~~debris~~ failure or APU failure, or other likely debris (such as runway debris).

(2) All fuel tank access covers must have the capacity to withstand the heat associated with fire at least as well as an access cover made from aluminium alloy in dimensions appropriate for the purpose for which they are to be used, except that the access covers need not be more resistant to fire than an access cover made from the base fuel tank structural material.

(See AMC 25.963(e))

BOOK 2

AMC — SUBPART D

Delete paragraph 4.d of AMC 25.729 as follows:

AMC 25.729
Retracting Mechanism
…
4. DISCUSSION.
…
~~d. *Protection of equipment on landing gear and in wheel wells.* (Reference CS 25.729(f) Protection of equipment on landing gear and in wheel wells)~~
~~The use of fusible plugs in the wheels is not a complete safeguard against damage due to tyre explosion.~~
~~Where brake overheating could be damaging to the structure of, or equipment in, the wheel wells, an indication of brake temperature should be provided to warn the pilot.~~
de. *Definitions*. For definitions of V_{SR} and V_C, see CS-Definitions 2, titled Abbreviations and symbols.

Create a new AMC 25.734 as follows:

AMC 25.734
Protection against wheel and tyre failures

1. Purpose

This AMC provides a set of models defining the threats originating from failures of tyres and wheels. Furthermore, protecting the aircraft against the threats defined in these models would also protect against threats originating from foreign objects projected from the runway.

These models should be used for protection of aeroplane structure and systems.

2. Related Certification Specifications and Acceptable Means of Compliance

CS 25.571 Damage tolerance and fatigue evaluation of structure
CS 25.734 Protection against wheel and tyre failures
CS 25.963(e) Fuel tanks: general
AMC 25.963(e) Fuel Tank Protection
CS 25.1309 Equipment, systems and installations
AMC 20-29 Composite Aircraft Structure

3. General

3.1. Threat models

The models provided below encompass the threats applicable to landing gear in the extended, retracting and retracted positions. The threats to be considered are tyre debris, flailing tyre strips, tyre burst pressure effect and wheel flange debris. The models defined below are applicable to brand-new tyres.

With the landing gear in the extended position, the following models are applicable:
Model 1 — Tyre Debris Threat Model
Model 2 — Wheel Flange Debris Threat Model
Model 3E — Flailing Tyre Strip Threat Model

With the landing gear retracting or in the retracted position, the following models are applicable:
Model 3R — Flailing Tyre Strip Threat Model
Model 4 — Tyre Burst Pressure Effect Threat Model

3.2. Structural residual strength and damage tolerance

In-service experience shows that traditional large transport aeroplane configurations, featuring high aspect ratio wings built around a single torsion box manufactured of light metal alloy, have demonstrated inherent structural robustness with regard to wheel and tyre debris threats. This results from the intrinsic properties of the structure, including thick wing skin gauges, as well as the general geometric arrangement (relative position of the landing gear to the wing). Residual strength and damage tolerance evaluations might therefore not be required for aeroplanes featuring such design features. For aeroplanes with novel or unusual design features (configuration, material, fuel tank arrangement, etc.), for principal structural elements and primary structures, the debris models are threats to be considered with respect to the related residual strength and damage tolerance rules and advisory materials, unless otherwise stated in this AMC or addressed by other means.

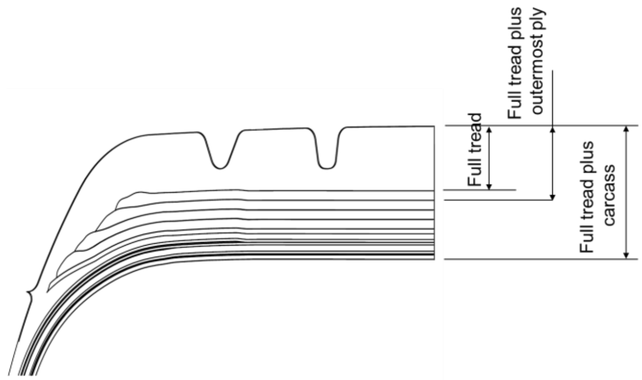
3.3. Fuel tank penetration

In-service experience shows a good safety record for the fuel tanks located within the torsion box of high aspect ratio wings manufactured of light metal alloy, owing to the intrinsic characteristics of the structure, including the wing skin gauge and typical arrangement of the stringers and ribs. Therefore, for tanks located within similar structures, in the absence of any unusual design feature(s), fuel tank penetration evaluation needs only to consider small tyre debris.

3.4. Definitions

Carcass of a tyre: This comprises the entire main body of a tyre (also named the casing) including the materials under the tread, the sidewall, and steel belts if any.

Full tread: The thickness of the tread rubber measured from the outer tread surface to the top of the outermost fabric or steel layer, including the rubber thickness above and below the tread groove bottom. Refer to the figure below (section of a tyre):



Hazardous fuel leak: a definition is provided in AMC 25.963(e).

Maximum unloaded operational pressure: Unloaded rated tyre pressure (available from the TRA Year Book) divided by the 1.07 factor from CS 25.733(c)(1).

Minimum tyre speed rating: The lowest tyre speed rating certified for the aeroplane in compliance with CS 25.733(a) or (c). The aeroplane manufacturer may decide to certify several tyre speed ratings; in this case, the lowest certified speed rating value should be taken as the 'minimum tyre speed rating' used in the models of this AMC.

Total tread area: $\Pi . D_G . W_{SG}$

Terms used in accordance with the Tire and Rim Association (TRA) Aircraft Year Book[1]:

- D = TRA Rim Diameter
- D_G = TRA Grown Tyre Diameter
- W_{SG} = TRA Maximum Grown Shoulder Width

Tyre speed rating: The maximum ground speed at which the tyre has been tested in accordance with (E)TSO C62e.

4. Threat models

Model 1 — Tyre Debris Threat Model

Applicability: landing gear extended

(1) Threats occurring when the tyre is in contact with the ground release tyre debris.

[1] The Tire and Rim Association, Inc. (TRA) is the standardizing body for the tire, rim, valve and allied parts industry for the United States. TRA was founded in 1903 and its primary purpose is to establish and promulgate interchangeability standards for tires, rims, valves and allied parts. TRA standards are published in the Tire and Rim Year Book, Aircraft Year Book and supplemental publications. More information available at: http://www.us-tra.org/index.html.

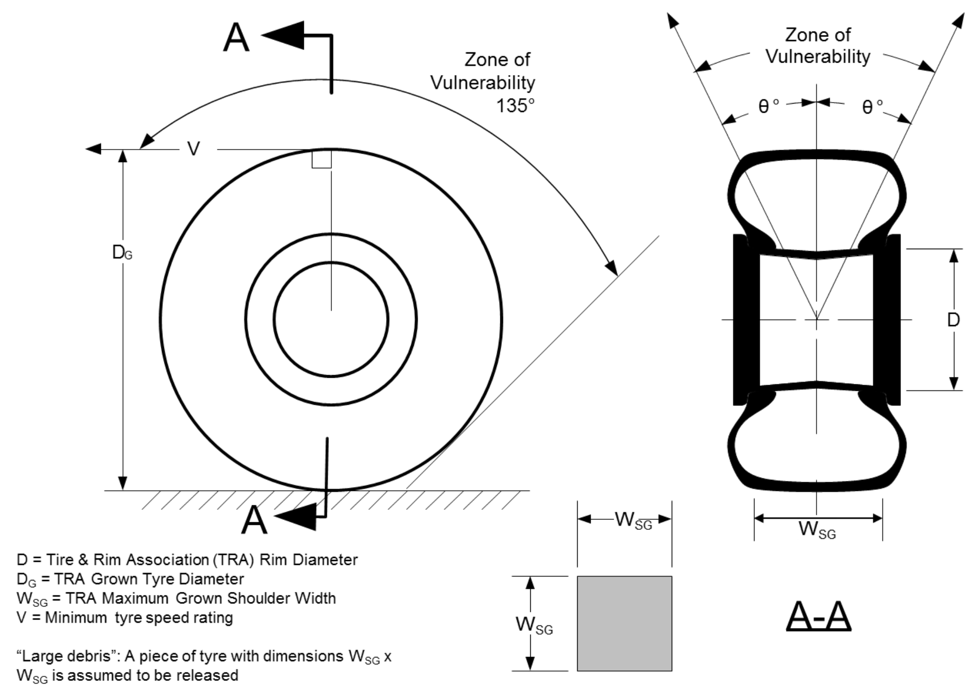
Two tyre debris sizes are considered.
These debris are assumed to be released from the tread area of the tyre and projected towards the aircraft within the zones of vulnerability identified in Figure 1:

(i) a 'large debris' with dimensions $W_{SG} \times W_{SG}$ at D_G and a thickness of the full tread plus outermost ply (i.e. the reinforcement or protector ply). The angle of vulnerability θ is 15°.

(ii) a 'small debris' consisting of 1 per cent of the total tyre mass, with an impact load distributed over an area equal to 1.5 per cent of the total tread area. The angle of vulnerability θ is 30°.

The debris have a speed equivalent to the minimum tyre speed rating certified for the aircraft (the additional velocity component due to the release of carcass pressure need not be taken into account).

Figure 1 – Tyre Debris Threats



<u>(2) Protection of the fuel tank structure and pass-fail criteria on effects of penetration</u>

(2.1) The large tyre debris size as defined in (i) above is assumed to penetrate and open the fuel tank or fuel system structure located in the zone of vulnerability defined in (i). It is used to define the opening size of the structural damage. A fuel leakage is assumed to occur whenever either the fuel tank structure or any structural element of fuel system components is struck by this large debris. It need not be used as a sizing case for structural design.

The fuel leakage should not result in hazardous quantities of fuel entering areas of the aeroplane that could present a hazard such as, but not limited to:

1. an engine air intake,

2. an APU air intake, or
3. a cabin air intake.

All practical measures should be taken to avoid fuel coming into contact with an ignition source (which may also result from the tyre failure event, e.g. electrical wire damage).
This should be shown by test or analysis, or a combination of both, for each engine forward thrust condition and each approved reverse thrust condition.

Alternatively, it is acceptable to demonstrate that the large tyre debris as defined in (i) above will not cause damage sufficient to allow a hazardous fuel leak whenever fuel tank deformation or rupture has been induced (including through propagation of pressure waves or cracking sufficient to allow a hazardous fuel leak).

(2.2) The small tyre debris as defined in (ii) should not create damage sufficient to allow a hazardous fuel leak in the zone of vulnerability defined in (ii).

(3) Protection of systems and pass-fail criteria
The two tyre debris sizes (defined in (i) and (ii) above) are considered. The sizes of debris are to be considered for the separation of systems.

When shielding is required (to protect a component or system), or when an energy analysis is required (for instance, for the validation of the structural parts of systems), the small debris defined in (ii) should be used.

An initial tyre failure can also result in failure of, and debris from, the companion tyre. This can occur even when the tyres have been designed to have double dynamic overload capability.

The analysis for the segregation of systems installation and routing should take this companion tyre failure into account inside the vulnerability zone defined by $\theta = 15°$ (either side of the tyre centre line) and only considering both tyres releasing large debris. Inside zones defined by $15° < \theta \leq 30°$, where only the small debris size is applicable, only debris (defined in (ii)) from a single tyre needs to be considered.

A ‘companion’ tyre is a tyre on the same axle.

To demonstrate compliance with the applicable Certification Specifications, the following approach should be used:

(a) Identify all hazards associated with the possible impact areas defined by Figure 1, including simultaneous/cascade failure of companion tyres.

(b) All practicable design precautions should be taken to eliminate all Catastrophic failure situations by means of system separation and/or impact resistant shielding and/or redesign. Impact resistance should be assessed for small debris (type (ii)) impacts only. Consideration should also be given to Hazardous failure situations when showing compliance in accordance with CS 25.1309.

(c) Any Catastrophic failure situation that remains after accomplishment of step (b) above will be submitted to the Agency for consideration in accordance with step (d) below.

(d) If the Agency concludes that the applicant has taken all practicable precautions to prevent a Catastrophic failure situation and the probability of the occurrence is consistent with the hazard classification (assuming a probability of companion tyre failure, if applicable, equal to 10 per cent), the design would be considered as compliant with the intent of CS 25.734.

Model 2 — Wheel Flange Debris Threat Model

Applicability: gear extended

(1) It is considered that a 60° arc segment of the wheel flange can be released laterally, in the zones identified in Figure 2. The speed of release is 100 m/s (328 ft/s).

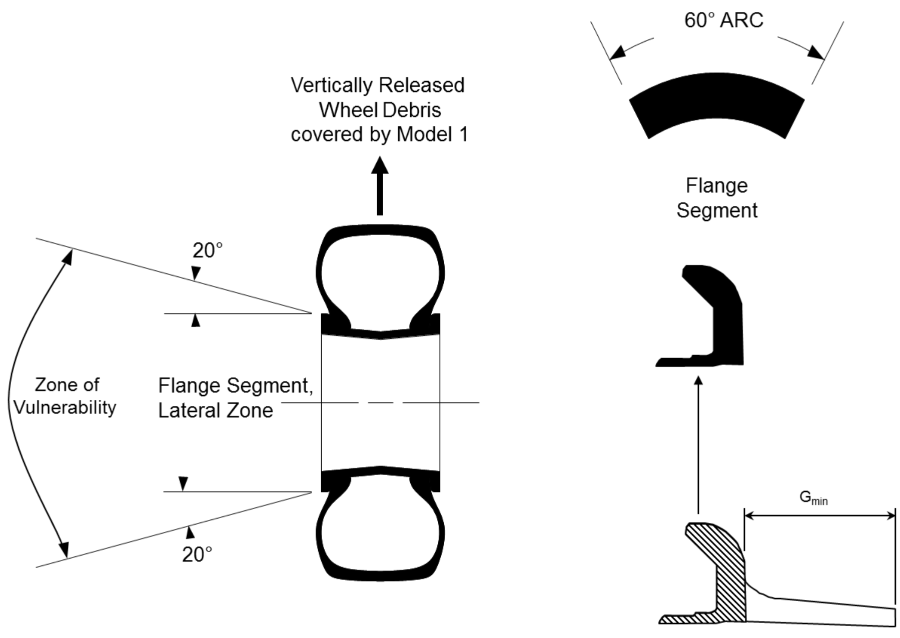
Where multiple wheels are installed on a landing gear leg, the lateral release of only the flange on the outer wheel halves needs to be considered.

If only a single wheel is installed on a landing gear leg, then the lateral release of either flange shall be considered.

(2) Vertically released debris are covered by Model 1 tyre debris.

(3) The debris should be considered to impact in the most critical condition.

Figure 2 - Wheel Flange Release Threat



Model 3 — Flailing Tyre Strip Threat Model

(1) Model 3E: Landing Gear Extended

A flailing tyre strip with a length of 2.5 W_{SG} and a width of $W_{SG}/2$ will remain attached to the outside diameter of the rotating tyre at take-off speeds.
The thickness (t) of the loose strip of tyre is the full tread plus the carcass of the tyre. If the applicant demonstrates that the carcass will not fail, then the thickness may be reduced to full tread plus outermost ply (i.e. the reinforcement or protector ply).
The strip has a speed equivalent to the minimum tyre speed rating certified for the aircraft. For this threat the zone of vulnerability is 30°, as shown in Figure 3.

(2) Model 3R: Landing Gear Retracting or Retracted

The loose tyre strip and the conditions remain unchanged from that considered for the Gear Extended case. However, due to the wheel spin down after take-off, the rotational speed of the wheel may be lower or even zero as it enters the wheel bay.

If the aeroplane is equipped with a system braking the wheel during landing gear retraction ('retraction brake'), then the applicant may take credit for this system provided:

(i) the retraction braking system is reliable and its failure is not latent;

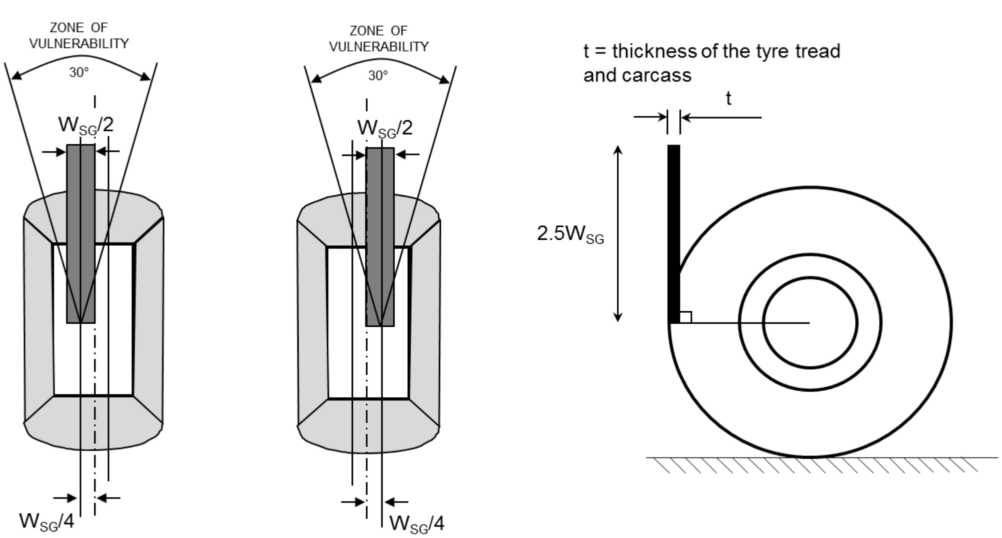
(ii) the failure of the retraction brake is independent from a flailing tyre strip event;

(iii) the retraction braking stops the rotation of the tyre before the trajectory of the flailing tyre strip can cause a hazard to the aircraft; and

(iv) the effect of a zero velocity retraction with the loose strip of tyre is assessed.

The strip has an initial speed equivalent to the minimum tyre speed rating certified for the aircraft. Allowance for rotation speed reduction during retraction may be substantiated by the applicant. For this threat the zone of vulnerability is 30°, as shown in Figure 3.

Figure 3 – Flailing Tyre Strip Threat



Model 4 — Tyre Burst Pressure Effect Threat Model

Applicability: landing gear retracting or landing gear retracted

1) In-flight tyre bursts with the landing gear retracted are considered to result from previous damage to the tyre, which could occur at any point on the exposed surface. A review of the known incidents shows that all cases of retracted tyre burst have occurred to main gear with braked wheels. This hazard is therefore considered to be applicable only to tyres mounted on braked wheels.

2) It is assumed that tyres do not release debris and consequential damage is considered to be caused only from the pressure effects of resulting gas jet (‘blast effect’). The blast effect has been shown to differ between radial and bias tyres.

3) The tyre burst pressure is assumed to be 130 % of the maximum unloaded operational pressure, which is the unloaded tyre rated pressure reduced by a factor of 1.07 (safety factor required by CS 25.733(c)(1)).

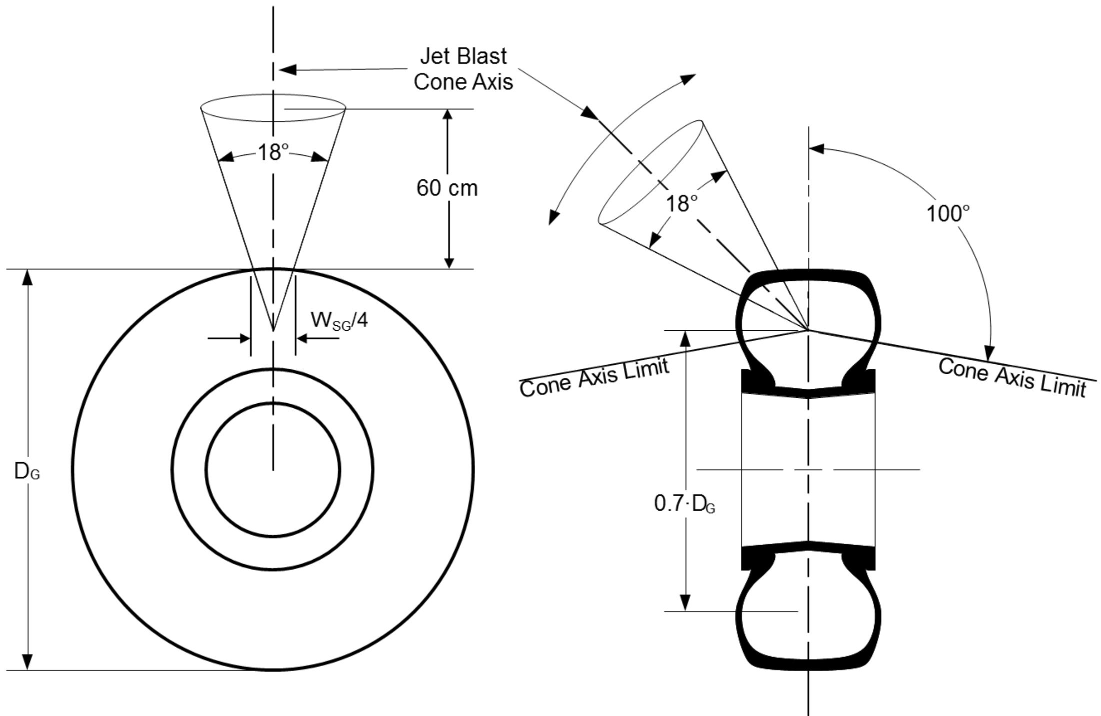
Example: For an H44.5 × 16.5 – 21 26PR Tyre — The unloaded tyre rated pressure is 1 365 kPa (198 psig), so the maximum unloaded operational pressure is 1 365 / 1.07 = 1 276 kPa (185 psig), i.e. 1 377 kPa absolute pressure (199.7 psia); therefore the tyre burst pressure is 1 377 × 1.3 = 1 790 kPa absolute pressure (259.7 psia).

4) For bias tyres, the burst plume model shown in Figures 4a and 4b should be used, with the blast cone axis rotated over the tread surface of the tyre (± 100° as shown in Figure 4a). The pressure distribution is provided in Figures 4b and 4c.

5) For radial tyres, the burst plume model (‘wedge’ shape) is shown in Figures 4d and 4e. The pressure decay formula provided in Figure 4e below should be used. It provides the level of pressure as a function of the distance from the tyre burst surface.

6) The effect of the burst should be evaluated on structure and system items located inside the defined burst plume. In addition, there should be no effect detrimental to continued safe flight and landing due to the increase in pressure of the wheel well as a result of a retracted tyre burst.

Figure 4a – Tyre Burst Pressure Effect – Bias Tyre



Note: 'Grown dimensions' should be calculated for bias tyres using TRA formulas.

Figure 4b – Tyre Burst Pressure Effect – Bias Tyre

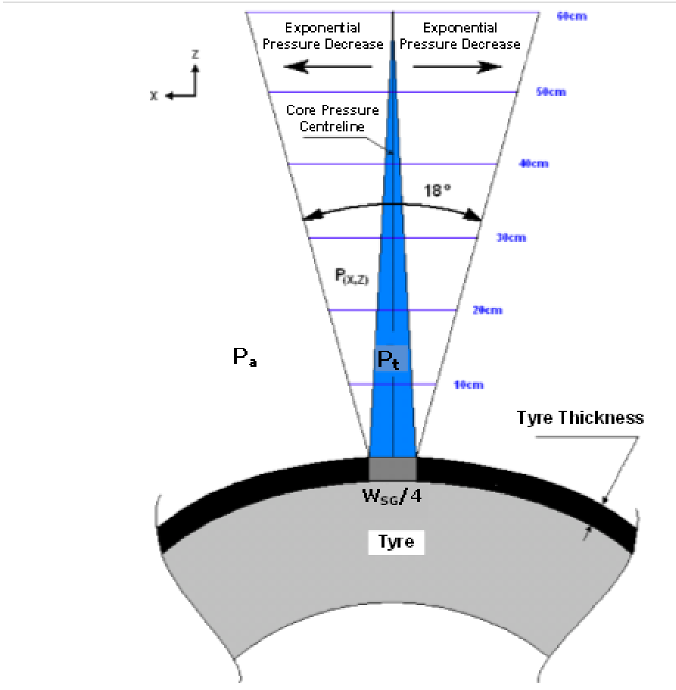
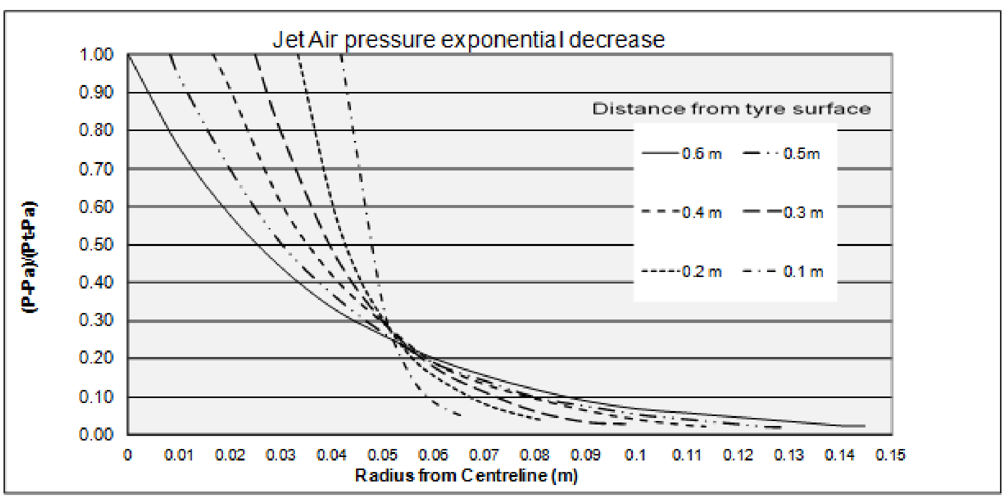


Figure 4c – Tyre Burst Pressure Effect – Bias Tyre
Air jet pressure distribution



Pa= Ambient pressure
P= P(x,z)= Pressure inside the cone as shown on Figure 2b
Pt= Tyre Burst pressure

Figure 4d – Tyre Burst Pressure Effect – Radial Tyre

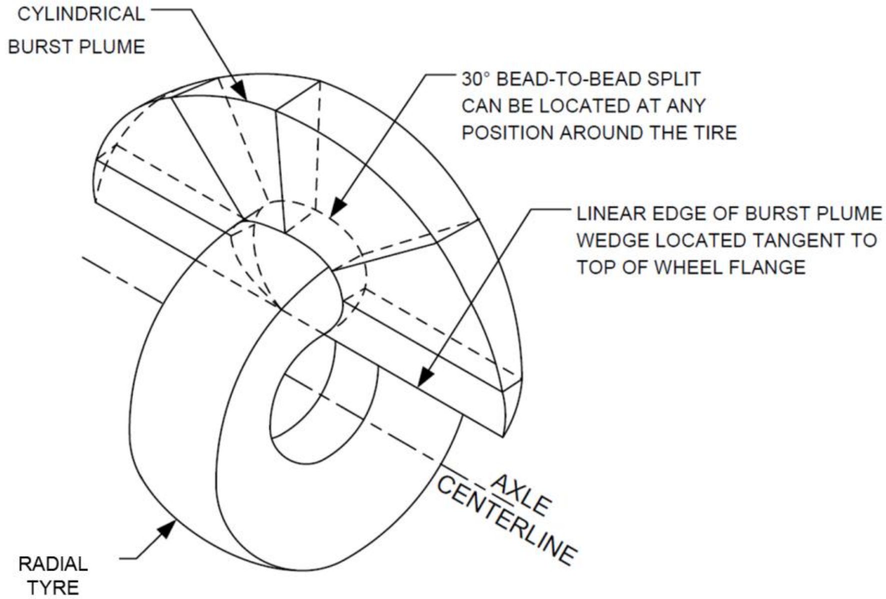
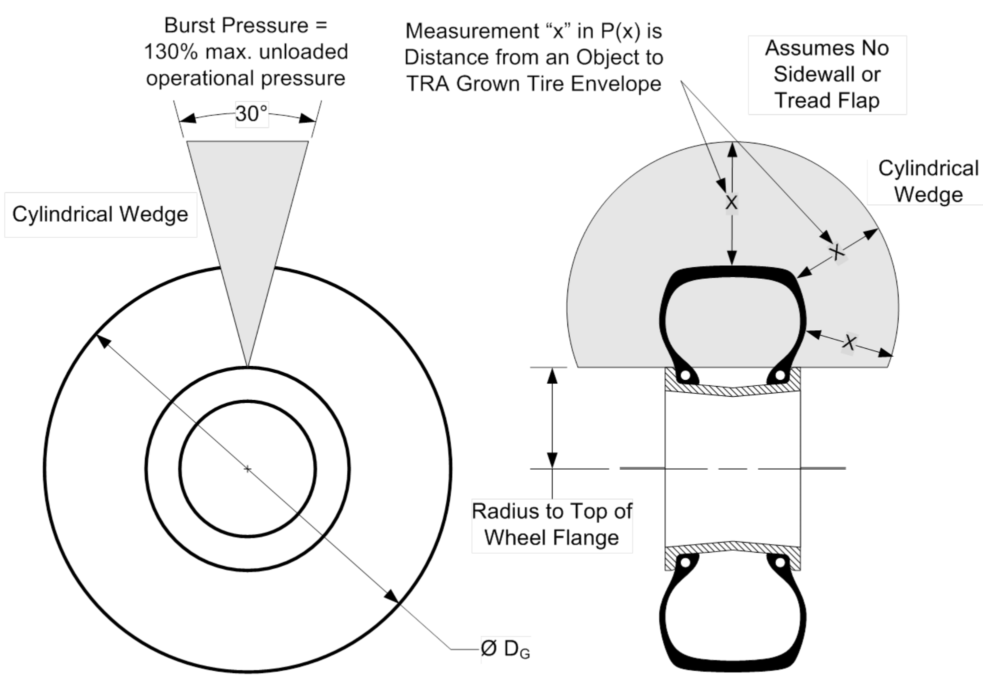


Figure 4e – Tyre Burst Pressure Effect – Radial Tyre



Radial Tyre Burst Pressure Decay Formula

$$P(x) = 0.5283 \cdot (P_t - P_0)\left[1.4 \cdot e^{-\left(\frac{\psi}{3}\right)\cdot x} + e^{-\psi \cdot x}\right] + P_0$$

Where:

$$\psi.x = \left(\frac{C_1}{\left(\frac{W_G}{in.}\right)^{C_2}} + C_3\right).\frac{x}{in.}$$

Or:

$$\psi.x = \left(\frac{C_1}{\left(\frac{W_G}{25.4mm}\right)^{C_2}} + C_3\right).\frac{x}{25.4mm}$$

and:

C_1 = 12.478,

C_2 = 1.222,

C_3 = 0.024

W_G = the Maximum Grown Section Width of the tyre [in or mm] as specified in the Tyre & Rim Association (TRA) designation for the tyre

P_t = Total or burst pressure [psia or bar]

P_0 = Ambient pressure [psia or bar]

x = Distance from object to grown tyre surface [in or mm]

If $P(x) > P_t$ then $P(x) = P_t$; otherwise $P(x) = P(x)$.

Create a new paragraph 4.l. in AMC 25.735 as follows:

AMC 25.735
Brakes and Braking Systems Certification Tests and Analysis
…
4. DISCUSSION
…
l. Ref. CS 25.735(l) Wheel brake temperature.
The use of fusible plugs in the wheels is not a complete safeguard against damage due to tyre burst. Where brake overheating could be damaging to the structure of, or equipment in, the wheel wells, an indication of brake temperature should be provided to warn the pilot.

AMC — SUBPART E

Amend AMC 25.963(e) as follows:

AMC 25.963(e)
Fuel Tank Protection ~~Access Covers~~

1. PURPOSE.
This AMC sets forth a means of compliance with the provisions of CS-25 dealing with the certification requirements for fuel tanks (including skin and fuel tank access covers) ~~access covers~~ on large aeroplanes. Guidance information is provided for showing compliance with the impact and fire resistance requirements of CS 25.963(e).
2. BACKGROUND.
Fuel tanks ~~access covers~~ have failed in service due to impact with high speed objects such as failed tyre tread material and engine debris following engine failures. Failure of ~~an access cover on~~ a fuel tank may result in ~~loss of~~ hazardous ~~quantities of~~ fuel ~~which could subsequently ignite~~ leak.

3. IMPACT RESISTANCE.
a. All fuel tanks ~~access covers~~ must be designed to ~~minimise~~ address penetration and deformation by tyre fragments, wheel fragments, ~~low energy~~ small ~~engine~~ debris from uncontained engine failure or APU failure, or other likely debris (such as runway debris), unless the ~~covers~~ fuel tanks are located in an area where service experience or analysis indicates a strike is not likely. The rule does not specify rigid standards for impact resistance because of the wide range of likely debris which could impact the ~~covers~~ fuel tanks. The applicant should, however, choose to minimise penetration and deformation by analysis supported by test, or test, of ~~covers~~ fuel tanks using debris of a type, size, trajectory and velocity that represents conditions anticipated in actual service for the aeroplane model involved. There should be no hazardous ~~quantity of~~ fuel leak~~age~~ after impact. ~~It may not be practical or even necessary to provide access covers with properties which are identical to those of the adjacent skin panels since the panels usually vary in thickness from station to station and may, at certain stations, have impact resistance in excess of that needed for any likely impact. The access covers, however, need not be more impact resistant than the average thickness of the adjacent tank structure at the same location, had it been designed without access covers. In the case of resistance to tyre debris, this comparison should be shown by tests or analysis supported by test.~~

A hazardous fuel leak results if debris impact to a fuel tank surface (or resulting pressure wave) causes:

a) a running leak,

b) a dripping leak, or

c) a leak that, 15 minutes after wiping dry, results in a wetted aeroplane surface exceeding 15.2 cm (6 in) in length or diameter.

The leak should be evaluated under maximum fuel pressure (1g on ground with full fuel volume, and also considering any applicable fuel tank pressurisation).

b. ~~In the absence of a more rational method, t~~The following may be used for evaluating ~~access covers~~ fuel tanks for impact resistance to tyre, wheel, ~~and~~ engine and APU debris. Furthermore, protecting the fuel tank against the threats defined in the models below would also protect against threats originating from foreign objects projected from the runway.

(i) Wheel and Tyre Debris ~~– Covers located within 30 degrees inboard and outboard of the tyre plane of rotation, measured from centre of tyre rotation with the gear in the down and locked position and the oleo strut in the nominal position, should be evaluated. The evaluation should be based on the results of impact tests using tyre tread segments equal to 1 percent of the tyre mass distributed over an impact area equal to 1.5 percent of the total tread area. The velocities used in the assessment should be based on the highest speed that the aircraft is likely to use on the ground under normal operation.~~
Fuel tanks must be protected against threats from wheel and tyre failures. Refer to AMC 25.734, which provides wheel and tyre failure threat models.

(ii) Engine Debris ~~– Covers located within 15 degrees forward of the front engine compressor or fan plane measured from the centre of rotation to 15 degrees aft of the rearmost engine turbine plane measured from the centre of rotation, should be evaluated for impact from small fragments. The evaluation should be made with energies referred to in AMC 20128A "Design Considerations for Minimising Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure". The covers need not be designed to withstand impact from high energy engine fragments such as engine rotor segments or propeller fragments. In the absence of relevant data, an energy level corresponding to the impact of a 9·5 mm (3/8 inch) cube steel debris at 213·4 m/s (700 fps), 90 degrees to the impacted surface or area should be used. For clarification, engines as used in this advisory material is intended to include engines used for thrust and engines used for auxiliary power (APU's).~~
The following provides the definition of a debris model to be used for protection of the fuel tanks against the threat of small engine debris (propulsion engines). It also describes how the debris model impacts a surface and a pass-fail criteria is provided.
This debris model is considered to be representative of the threat created by engine small non-rotating and rotating parts debris, including ricochets, occurring after an uncontained engine failure event. It is considered to address High Bypass Ratio and Low Bypass Ratio turbine engines.

Note: AMC 20-128A remains applicable to engine debris, other than small engine fragments, threatening fuel tanks as described here, and also remains applicable to all engine debris to other areas of the aircraft structures and systems.

A. Definition of the debris
A solid steel cube with a 9.5 mm (3/8 in) edge length.

B. Velocity of the debris

The velocity of the cube at the impact is 213.4 m/s (700 ft/s).

C. Impact areas and pass-fail criteria

Two areas are to be considered. See also Figure 1 below.

(1) ± 15-degree area

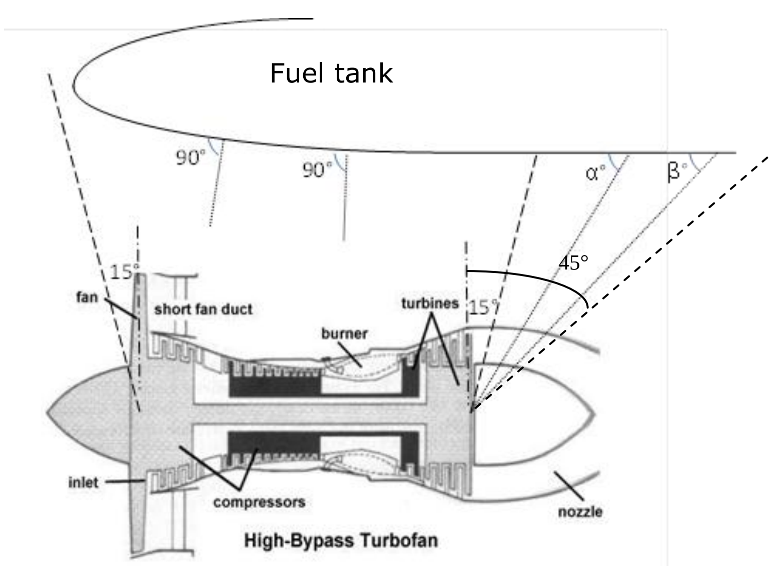
Within 15 degrees forward of the fan plane (or front engine compressor if no fan) measured from the centre of rotation to 15 degrees aft of the rearmost engine turbine plane measured from the centre of rotation, a normal impact is used (i.e. the angle between the trajectory of the debris and the surface is 90 degrees).
The impact should not create a hazardous fuel leak (see definition in paragraph 3.a of this AMC).
The leak should be evaluated under maximum fuel pressure (1g on ground with full fuel volume, and also considering any applicable fuel tank pressurisation).

(2) Area between – 15 and – 45 degrees (aft of the rearmost engine turbine plane)

Within this area, the angle of impact (see Figure 1, α and β angles) is defined by the trajectory of the debris originating from the centre of rotation of the rearmost engine turbine plane.
Similarly, as within the ± 15-degree area, the impact should not create a hazardous fuel leak.

D. Guidance material

— When showing compliance with oblique impacts, it is acceptable to consider a normal impact using a debris velocity at impact equal to the normal component of the oblique velocity vector.
— Orientation of the cube at the impact: testing and analysis should ensure that all orientations (side-on, edge-on, and corner-on) are represented.
— Impact tests should be completed in adequate number to show repeatable stable localised damage modes and damage extents for all impactor orientations (side-on, edge-on, and corner-on).



Note: α and β angles are examples of possible angles between the fuel tank skin and the debris trajectory at the impact.

Figure 1 — Cube impact angles

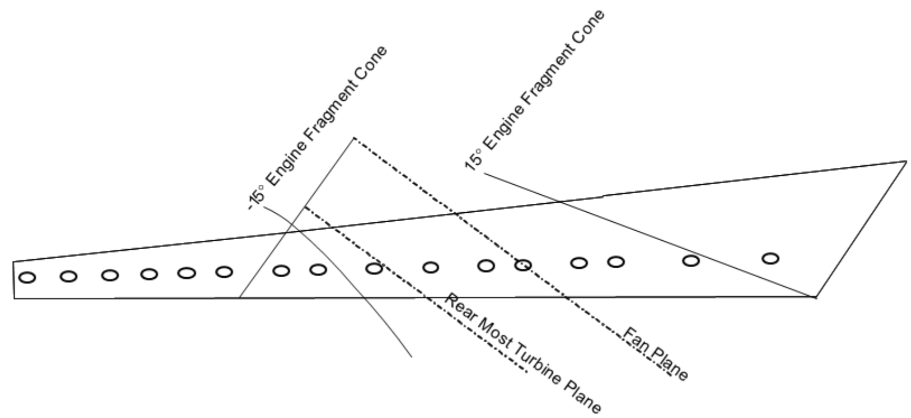


Figure 2 — Example of the ± 15-degree threat area representation
Note: The threat area between – 15 and – 45 degrees is not represented.

(iii) APU Debris — For small APU debris, the small fragment model as defined in AMC 20-128A applies. The impact should not create a hazardous fuel leak (as defined in paragraph 3.a above).
Note: AMC 20-128A remains applicable to APU debris, other than small APU fragments, threatening fuel tanks as described here, and also remains applicable to all APU debris to other areas of the aircraft structures and systems.

…

AMC — SUBPART F

Amend AMC 25.1309 as follows:

AMC 25.1309
System Design and Analysis
…
9b(3) *Availability of Industry Standards and Guidance Materials*. There are a variety of acceptable techniques currently being used in industry, which may or may not be reflected in Documents referenced in paragraphs 3b(2~~3~~) and 3b(3~~4~~). This AMC is not intended to compel the use of these documents during the definition of the particular method of satisfying the objectives of this AMC. However, these documents do contain material and methods of performing the System Safety Assessment. These methods, when correctly applied, are recognised by the Agency as valid for showing compliance with CS 25.1309(b). In addition, Document referenced in paragraph 3b(3~~4~~) contains tutorial information on applying specific engineering methods (e.g. Mar kov Analysis, Fault Tree Analysis) that may

be utilised in whole or in part.

9b(4) *Acceptable Application of Development Assurance Methods*. Paragraph 9b(1)(iii) above requires that […]. The level of Development Assurance should be determined by the severity of potential effects on the aeroplane in case of system malfunctions or loss of functions. Guidelines, which may be used for providing Development Assurance, are described for aircraft and systems in Document referenced in paragraph 3b(2~~3~~), and for software in Documents referenced in paragraph~~s~~ 3a(3) ~~and 3b(2)~~. (There is currently no agreed Development Assurance standard for hardware.) Because these documents were not developed simultaneously, there are differences in the guidelines and terminology that they contain. A significant difference is the guidance provided on the use of system architecture for determination of the appropriate development assurance level for hardware and software. EASA recognises that consideration of system architecture for this purpose is appropriate. If the criteria of Document referenced in paragraph 3b(2~~3~~) are not satisfied by a particular development assurance process the development assurance levels may have to be increased using the guidance of Document referenced in paragraph 3a(3) ~~3b(2)~~.

…

11b. *Single Failure Considerations*.

(1) According to the requirements of CS 25.1309b(1)(ii), […]A single failure includes any set of failures, which cannot be shown to be independent from each other. Appendix 1 and Document referenced in paragraph 3b(3~~4~~) describe types of common cause analyses, which may be conducted, to assure that independence is maintained. Failure containment techniques available to establish independence may include partitioning, separation, and isolation.

…

11c *Common Cause Failure Considerations*.

[…]loss of power supply or return (e.g. mechanical damage or deterioration of connections), excessive voltage, physical or environmental interactions among parts, errors, or events external to the system or to the aeroplane (see Document referenced in paragraph 3b(3~~4~~)).

…

11f *Integrated Systems*. Interconnections between systems[…]

In addition, rigorous and well-structured design and development procedures play an essential role in facilitating a methodical safety assessment process and providing visibility to the means of compliance. Document referenced in paragraph 3b(2~~3~~) may be helpful in the certification of highly integrated or complex aircraft systems.

…

13 ASSESSMENT OF MODIFICATIONS TO PREVIOUSLY CERTIFICATED AEROPLANES.

The means to assure continuing compliance with CS 25.1309 […]. The result of this assessment may range from a simple statement that the existing system safety assessment still applies to the modified system in accordance with the original means of compliance, to the need for new means of compliance encompassing the plan referred to in paragraph 9b. (STC applicants, if the TC holder is unwilling to release or transfer proprietary data in this regard, the STC applicant may have to create the System Safety Assessment. Further guidance may be found in paragraph 6 of Document referenced in paragraph 3b(2~~3~~).)

…

APPENDIX 1. ASSESSMENT METHODS.

Various methods for assessing the causes, severity, and probability of Failure Conditions are available to support experienced engineering and operational judgement. Some of these methods are structured. The various types of analysis are based on either inductive or deductive approaches. Probability assessments may be qualitative or quantitative.

Descriptions of some types of analysis are provided below and in Document referenced in paragraph 3b(3~~4~~).
…

c. *Failure Modes and Effects Analysis*. This is a structured, inductive, bottom-up analysis, which is used to evaluate the effects on the system and the aeroplane of each possible element or component failure. When properly formatted, it will aid in identifying latent failures and the possible causes of each failure mode. Document referenced in paragraph 3b(3~~4~~) provides methodology and detailed guidelines, which may be used to perform this type of analysis.
…

APPENDIX 2. SAFETY ASSESSMENT PROCESS OVERVIEW.
In showing compliance with 25.1309(b)[…]. Their sole purposes are to assist, by illustrating a systematic approach to safety assessments, to enhance understanding and communication by summarising some of the information provided in this AMC, and to provide some suggestions on documentation. More detailed guidance can be found in Document referenced in paragraph 3b(3~~4~~). Document referenced in paragraph 3b(2~~3~~) includes additional guidance on how the safety assessment process relates to the system development process.
…

APPENDIX 3. CALCULATION OF THE AVERAGE PROBABILITY PER FLIGHT HOUR.
…
b. *Calculation of the Probability of a Failure Condition for a certain "Average Flight"*. The probability of a Failure Condition occurring on an "Average Flight" P_{Flight}(Failure Condition) should be determined by structured methods (see Document referenced in paragraph 3b(3~~4~~) for example methods) and should consider all significant elements (e.g. combinations of failures and events) that contribute to the Failure Condition. The following should be considered:[…]

c. Calculation of the Average Probability per Flight of a Failure Condition. The next step is to calculate the "Average Probability per Flight" for the Failure Condition. I.e. the probability of the Failure Condition for each flight (which might be different although all flights are "Average Flights") during the relevant time (e.g. the least common multiple of the exposure times or the aeroplane life) should be calculated, summed up and divided by the number of flights during that period. The principles of calculating are described below and also in more detail in Document referenced in paragraph 3b(3~~4~~).
…