CERTIFICATION SPECIFICATIONS
AND
ACCEPTABLE MEANS OF COMPLIANCE
FOR
LARGE AEROPLANES

CS-25 AMENDMENT 27 — CHANGE INFORMATION

The European Union Aviation Safety Agency (EASA) issues amendments to the Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS-25) as consolidated documents. These documents are used for establishing the certification basis for applications submitted after the date of entry into force of the applicable amendment.

Consequently, except for a note, e.g. '[Amdt No: 25/27]', under the amended certification specification (CS) or acceptable means of compliance (AMC), the consolidated CS-25 (the Annex to ED Decision 2021/015/R) does not highlight the amendments introduced. To show these amendments, this change information document was created, using the following format:

— deleted text is ~~struck through~~;

— new or amended text is highlighted in blue;

— an ellipsis '[…]' indicates that the rest of the text is unchanged.

Note to the reader

In amended, and in particular in existing (that is, unchanged) text, 'Agency' *is used interchangeably with* 'EASA'*. The interchangeable use of these two terms is more apparent in the consolidated versions. Therefore, please note that both terms refer to the* 'European Union Aviation Safety Agency (EASA)'.

SUBPART D — DESIGN AND CONSTRUCTION

GENERAL

CS 25.603 Materials

(See AMC 25.603; ~~F~~for ~~C~~composite ~~M~~materials, see AMC 20-29; ~~F~~for use of glass in passenger cabins, see AMC No 2 to CS 25.603(a))

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must: ~~—~~

(a) ~~B~~be established on the basis of experience or tests (see AMC No°1 to CS 25.603(a));

(b) ~~C~~conform to approved specifications~~,~~ that ensure their having the strength and other properties assumed in the design data (~~S~~see AMC 25.603(b)); and

(c) ~~T~~take into account the effects of environmental conditions, ~~such as~~e.g. temperature and humidity, expected in service.

[Amdt No: 25/9]

[Amdt No: 25/18]

[Amdt No: 25/19]

[Amdt No: 25/27]

AMC 25.603 Suitability and durability of materials

The term ‘material’ is differently interpreted, ranging from raw feedstock material to the material state in a final complex part configuration that may have undergone various processes. CS 25.603, CS 25.605, CS 25.613, and AMC 25.613 should therefore be considered together to ensure the coherent and safe design and production of parts and thus maintain occupant and aeroplane safety throughout the aeroplane’s operational life. This is of growing importance as more and more production methods allow the design of complex part configurations for which the characteristics of the materials are defined close to completion of the part production, e.g. castings, composite resin transfer methods, bonding, or additive manufacturing methods. The applicants should therefore discuss with EASA, at an early stage of the certification project, potential details supporting the means of compliance with CS 25.603, CS 25.605, and CS 25.613.

Note: organisations engaged in the design and certification of modifications or repairs should also comply with these CSs and consider the related AMC.

Appropriately defined tests and analysis pyramids (e.g. as outlined in AMC 20-29 for composite materials) should support the certification of materials, processes, and/or fabrication methods, including the development of the associated design values in more complex part configurations and assemblies.

[Amdt No: 25/27]

AMC No 1 to CS 25.603(a) Suitability and durability of materials — Experience or tests

To show compliance with CS 25.603 and CS 25.605, applicants may use previous applicable experience and/or tests together with material specifications and material process specifications. Applicants should therefore carefully consider the controls on materials and material processing that are appropriate to the design data to be used for any part (e.g. controls on additive manufacturing powder material handling processes). However, as material strength and other properties may result from the process limitations that are specific to the configuration of some complex parts, the applicability of previous experience to new part configurations may be limited.

Shared databases: when the material strength and other properties that are used in the design data are not only influenced by the constituent materials and/or material processes, but also by the manufacturing and assembly processes, demonstrating controls on constituent materials and material processes may assist applicants in developing the final design data. For example, if an applicant successfully demonstrates data equivalence with established and accepted databases, this may create confidence in the applicant's production processes, if not providing existing design values.

[Amdt No: 25/27]

AMC No 2 to CS 25.603(a) Suitability and durability of materials — Large glass items

1. General

This AMC defines acceptable minimum performance standards for the specific case of large glass items used as an interior material in passenger cabin installations whereby the glass items carry no other loads than those resulting from the mass of the glass itself, rapid depressurisation, or abuse loading.

[…]

[Amdt No: 25/19]

[Amdt No: 25/27]

AMC 25.603(b) Suitability and durability of materials — Approved material specifications and material process specifications

The approved material specifications and material process specifications should:

— be suitable for the application;

— define material and material process controls;

— include requirements to assist the applicant in managing raw/feedstock/unfinished materials, as appropriate to the technology (e.g. the feedstock powder used in additive manufacturing, or matrix systems used in pre-impregnated composites).

The material strength and other properties that are used in design data (including fatigue and damage tolerance characteristics, when applicable) are governed by, and can be significantly sensitive to, the related variables of the material production process (including raw-material considerations). Furthermore, these properties may also be influenced by other higher-level fabrication processes (manufacturing and assembly), including other post-processing activities (e.g. adhesive material and bonding properties produced in a bonded joint of a complex part may not be the same as those produced in a test coupon).

The material specifications, material process specifications, and/or production drawings should identify key characteristics and parameters to be monitored by in-process quality control, including the acceptable limits to the characteristics of materials and processes (e.g. acceptable anomalies or flaws), and should address anisotropy, when applicable. This information may also help applicants identify other defect types and damage modes than the anomalies and flaws that are accepted under the specifications, including those that may occur in service. Such data may be used to help applicants show compliance with other specifications, e.g. CS 25.571. However, showing compliance with CS 25.571 does not relieve from the requirement for material process controls.

Note: ~~A~~approved material specifications and approved material process specifications can be, for example, industry or military specifications, or European Technical Standard Orders (ETSOs).

[Amdt No: 25/27]

CS 25.605 Fabrication methods

(See AMC 25.605)

(a) The fabrication methods ~~of fabrication~~ used (i.e. the manufacturing and assembly methods, including consideration of the materials and material processes) must produce the strength and other properties necessary to ensure a consistently safe part~~a consistently sound structure~~. If a fabrication method includes processes ~~(such as gluing, spot welding, or heat treating)~~ that require~~s~~ close control to reach this objective, then ~~the~~those processes must be performed under ~~an~~ representative approved fabrication process specifications, supported by appropriately approved material specifications (including considering the raw/feedstock/unfinished material specifications) with appropriate controls for the design data.

(b) Each new ~~aircraft~~ fabrication method must be substantiated by a test programme that is representative of the application.

[Amdt No: 25/27]

AMC 25.605(a) Fabrication methods — Approved process specifications

Examples of fabrication method processes that may require close control to consistently produce safe parts include the following:

— castings,

— composite resin transfer methods,

— bonding,

— welding,

— heat-treating, or

— additive manufacturing methods.

Fabrication method process specifications should include all critical inspection steps and/or process-controlled steps, and should be substantiated (they may require re-evaluation and new substantiation, if modified later). All the inherent part characteristics that result from the fabrication method and affect the material strength and other properties should be closely correlated with non-destructive inspection (NDI) and/or process control variables. Furthermore, the applicant should show that the equipment used to support the process-critical manufacturing steps (particularly those steps that are not directly supported and controlled through inspection) is under appropriate process control, to ensure the consistent production of safe parts.

Note 1: 'safe parts' must comply with CS 25.603 and CS 25.605 to ensure safety by maintaining the appropriate 'material strength and other properties' that are assumed in the design data. Therefore, applicants are reminded that, beyond the consideration of airframe strength, these CSs are also applicable to other applications for which safety relies on strength or stiffness, e.g. system structures. Furthermore, the reference to 'other properties' is intended to ensure that safety is also maintained for applications for which safety relies on 'other properties' (for example, safe interior cabin parts that rely upon suitable flammability properties).

Note 2: approved fabrication process specifications and approved material specifications can be, for example, industry or military specifications, or European Technical Standard Orders (ETSOs).

[Amdt No: 25/27]

AMC 25.605(b) New fabrication methods — Test programme

The test programme should initially consider the material strength and other properties resulting from each new fabrication method ('new' means new to the industry, an applicant, or an application configuration). The scope of the test programme should include considering the potential for anisotropic properties unless the applicant has already established an understanding of these properties.

The test programme that is required for the certification of new fabrication methods should be used to evaluate the critical process variables. Based on that evaluation, the applicant should establish in the fabrication specifications the relevant parameters that govern the final material strength and other properties of the part at the time of its production and throughout its operational life. Furthermore, the applicant should evaluate the sensitivity of the material strength and other properties to the critical process variables to ensure that the established parameters are both robust and practical.

Note: the test programme may also be used to help applicants understand the defect types and damage modes to be considered when showing compliance with other specifications, e.g. CS 25.571. Understanding the potential defects and damage modes is particularly important for sensitive fabrication processes, e.g. those used for structural bonding.

[Amdt No: 25/27]

AMC 25.613 Material ~~S~~strength ~~P~~properties and ~~M~~material ~~D~~design ~~V~~values

[…]

3. *General*. CS 25.613 contains the requirements for material strength properties and material design values. Material properties used for fatigue and damage tolerance analysis are addressed by CS 25.571 and AMC 25.571(a).

When developing the material strength properties and material design values, the applicant should also consider potential anisotropies and establish all properties and design values relevant to the application of the material.

[…]

4.2. *Statistically Based Design Values*. […]

[…]

The ~~"~~'A'~~"~~ and ~~"~~'B'~~"~~ properties published in ~~"T~~the SAE 'Metallic Materials Properties Development and Standardization (MMPDS) ~~h~~Handbook~~"~~' or ESDU 00932 are acceptable, as are the statistical methods specified in the applicable chapters/sections of these handbooks. Other methods of developing material design values may be acceptable to the EASA~~Agency~~.

The test specimens used for material property certification testing should be made from material produced using production processes. Test specimen design, test methods, and testing should:

[…]

(ii) conform to those detailed in the applicable chapters/sections of ~~"T~~the SAE ~~Metallic Materials Properties Development and Standardization (~~MMPDS ~~h~~Handbook~~"~~, ~~MIL-HDBK-17~~Composite Materials Handbook 17 (CMH-17), ESDU 00932 or other accepted equivalent material data handbooks, or:

[…]

~~The Agency~~EASA may approve the use of other material test data after review of test specimen design, test methods, and test procedures that were used to generate the data.

The use of some materials and processes may allow the applicant to design parts for which the material strength and other properties are produced during production or repair. Consequently, the use of simple material test coupons (as typically produced, independent of the part) at the base of a typical test pyramid (e.g. as defined in AMC 20-29 for 'composite structures') may not be representative of the material strength and other properties of the final part. When a higher test pyramid is required, then the applicant may need to reduce (for practical reasons) the number of specimens below what is normally expected for generating statistically significant values, e.g. as those associated with A and B basis data (as defined in the MMPDS Handbook). Therefore, other mitigating measures are likely necessary (e.g. coupon testing of prolongations, testing of coupons from sections of production parts, other sampling strategies, more intensive non-destructive inspection (NDIs), etc.). Until industry establishes standards for such situations, the applicant should agree with EASA whether and how to use test articles of a higher test pyramid, as well as associated small datasets, to generate material and design data. In that agreement, EASA may give credit to the applicant for applicable established practices.

[…]

4.4. *Use of Higher Design Values Based on Premium Selection*. […]

~~If the material is known to be anisotropic then testing should account for this condition.~~The applicant should have data available to understand if a material is anisotropic and should account for this condition during testing.

[…]

[Amdt No: 25/1]

[Amdt No: 25/27]

CONTROL SYSTEMS

AMC 25.671 Control Systems — General

[…]

4. *DEFINITIONS*

[…]

~~p~~q. *Take-off* is the time period from the brake release up to the time when the aeroplane reaches 10 m (35 ft) AAL.

[…]

6. ***EVALUATION OF FLIGHT CONTROL SYSTEM ASSEMBLY — CS 25.671(b)***

The intent of CS 25.671(b) is to minimise the risk by design that the elements of the flight control system are incorrectly assembled, such ~~that~~ that this leads to significant safety effects. The intent is not to address configuration control (refer to CS 25.1301(a)(2)).

[…]

[Amdt No: 25/24]

[Amdt No: 25/27]

PERSONNEL AND CARGO ACCOMMODATIONS

AMC 25.775(d) Windshields and ~~W~~windows

[…]

8. OTHER FAILURE CONDITIONS THAT MAY HAVE STRUCTURAL EFFECTS

AMC 25.1309, point 10(c) 'Considerations When Assessing Failure Condition Effects', states that the applicant should evaluate the severity of failure conditions, considering the effects that potential or consequential effects on structural integrity may have on the aeroplane.

Therefore, the applicant should carefully consider the potential effects on the windshield structural integrity when assessing any failure condition in windshield-related systems (e.g. windshield heating systems).

Unless otherwise shown, the applicant should classify as at least hazardous a system failure condition that leads to a structural failure that could result in partial or complete loss of a windshield.

In addition, it is reminded that CS 25.365(e)(3) requires the applicant to consider the maximum compartment opening, caused by aeroplane or equipment failures (e.g. windshield failures), that is not shown to be extremely improbable.

Service experience has shown that failure or deterioration of windshield installation components (e.g. a degraded seal), combined with environmental conditions (e.g. water accumulation or moisture ingress) or with manufacturing/installation issues, may lead to failure of other components of windshield-related systems (e.g. degradation of, or damage to, the insulation of a heating-system wire). The combination of such failures may lead to a malfunction or failure of the related system, which may cause a structural failure that could result in the partial or complete loss of the windshield or the loss of transparency of the windshield.

Therefore, the applicant should pay attention to common causes of failures when installing windshields and related systems or components, and to the contribution of such common causes to cascading failures. The applicant should identify through common cause analysis appropriate design, manufacturing, installation, and maintenance precautions to mitigate the risk of any failure condition adversely affecting systems or components, which may directly or indirectly lead to a structural failure that could result in the partial or complete loss of the windshield or the loss of transparency of the windshield (refer to AMC 25.1309, Appendix 1).

[Amdt No: 25/27]

EMERGENCY PROVISIONS

AMC 25.801 Ditching

EASA accepts the relevant parts of Federal Aviation Administration (FAA) AC 25-17A 'Transport Airplane Cabin Interiors Crashworthiness Handbook', of 24 May 2016, as an acceptable means of compliance with CS 25.801(d).

Note: 'relevant parts' means the AC 25-17A parts that address the applicable Federal Aviation Regulation (FAR)/CS-25 paragraph(s).

[Amdt No: 25/27]

SUBPART E — POWERPLANT

GENERAL

AMC 25.907 Propeller vibration

EASA accepts Federal Aviation Administration (FAA) Advisory Circular (AC) 20-66B 'Propeller Vibration and Fatigue', of 24 March 2011, as an acceptable means of compliance with CS 25.907 regarding the evaluation of vibratory stresses on propellers. The applicant should use in that evaluation fatigue and structural data that is obtained in accordance with the Certification Specifications and Acceptable Means of Compliance for Propellers (CS-P).

When investigating the actual vibration behaviour of each propeller, the applicant should include the operating conditions that correspond to descent with the power levers at flight idle position and with speeds around maximum operating limit speed (V_{MO}). Experience has shown that such conditions may cause cyclic loads and vibrations that may exert excessive stress on some parts of the propeller. As aerodynamic loads differ depending on the position of the engine-propeller assembly on the aeroplane, the applicant should investigate the propellers' vibration behaviour at all engine-propeller assembly positions.

[Amdt No: 25/27]

SUBPART F — EQUIPMENT

GENERAL

CS 25.1305 Powerplant instruments

(See AMC 25.1305)

The following are required powerplant instruments:

[…]

(c) *For turbine engine-powered aeroplanes.*

[…]

(9) A vibration indication system that indicates unbalances in engine rotor systems and, when applicable, in propeller rotating assemblies.

(d) *For turbo-jet engine-powered aeroplanes*.

[…]

~~(3) An indicator to indicate rotor system unbalance.~~

[…]

[Amdt No: 25/12]

[Amdt No: 25/18]

[Amdt No: 25/27]

AMC 25.1309 System ~~D~~design and ~~A~~analysis

[…]

APPENDIX 3. CALCULATION OF THE AVERAGE PROBABILITY PER FLIGHT HOUR.

[…]

b. *Calculation of the Probability of a Failure Condition for a certain 'Average Flight'*.

[…]

(2) If the failure is only relevant during certain flight phases, the calculation should be based on the probability of failure during the relevant ~~"~~'at risk'~~"~~ time for the ~~"~~'Average Flight'~~"~~.
[…]

APPENDIX 5. EXAMPLE OF LIMIT LATENCY AND RESIDUAL PROBABILITY ANALYSIS.

[...]

#	Probability (per flight hour)	Event name	Event description	Failure rate (constant, unless noted)	Exposure time	Event probability (per flight)	CS 25.1309(b)(5) Applicability/ compliance
1	3.992E-10	A001	ACT 1	1.000E-07	2.5 h	2.500E-07	Not compliant with the limit latency criterion [L001 probability is more frequent than 1.000E-03].
		L001	LAT 1	4.000E-06	1 000.0 h	3.992E-03	
2	2.000E-10	A002	ACT 2	2.000E-05	2.5 h	5.000E-05	Not compliant with the residual probability criterion [A002 probability per flight hour (2.000E-05/FH) is more frequent than 1.000E-05/FH].
		L003	LAT 3	1.000E-06	10.0 h	1.000E-05	
3	1.000E-10	A004	ACT 4	1.000E-05	2.5 h	2.500E-05	Not compliant with the residual probability criterion [while A004 probability per flight hour is equal to 1.000E-05/FH, the combined probability per flight hour of A004 and A002 (1.000E-05/FH + 2.000E-05/FH) is more frequent than 1.000E-05/FH. *Note: Dual-order minimal cut sets #2 and #3 are grouped due to same event L003 appearing under G002 and G004.*
		L003	LAT 3	1.000E-06	10.0 h	1.000E-05	
4	1.000E-10	A004	ACT 4	1.000E-05	2.5 h	2.500E-05	Compliant with both limit latency and residual probability criteria [A004 probability per flight hour is equal to 1.000E-05/FH and combined probability of L005 and L003 (1.000E-05 + 1.000E-05) is less frequent than 1.000E-03].
		L005	LAT 5	1.000E-06	10.0 h	1.000E-05	
5	~~2~~5.000E-11	A002	ACT 2	2.000E-05	2.5 h	5.000E-05	This dual-order minimal cut set does not contain any basic event being latent for more than one flight. Therefore, CS 25.1309(b)(5) is not applicable to this minimal cut set.
		A005	ACT 5	1.000E-06	2.5 h	2.500E-06	
6	6.500E-13	A003	ACT 3	6.500E-07	2.5 h	1.625E-06	Compliant with both limit latency and residual probability criteria [A003 probability per flight hour (6.500E-07/FH) is less frequent than 1.000E-05/FH and L004 probability is less frequent than 1.000E-03]
		L004	LAT 4	1.000E-07	10.0 h	1.000E-06	
7	3.991E-11	A002	ACT 2	2.000E-05	2.5 h	5.000E-05	

		L001	LAT 1	4.000E-06	1 000.0 h	3.992E-03	This minimal cut set is more than a dual failure combination. Therefore, CS 25.1309(b)(5) is not applicable to this minimal cut set.
		L002	LAT 2	5.000E-06	100.0 h	4.999E-04	
Flight time = 2.5 hours P[LAT i] ~ FR * T							

Table A5-1: Minimal Cut Sets

[…]

[Amdt No: 25/2]

[Amdt No: 25/12]

[Amdt No: 25/14]

[Amdt No: 25/24]

[Amdt No: 25/27]

SUBPART G — OPERATING LIMITATIONS AND INFORMATION

MARKINGS AND PLACARDS

AMC 25.1541 Markings and ~~P~~placards —~~-~~ General

Markings or placards should be placed close to or on (as appropriate) the instrument or control with which they are associated. The terminology and units used should be consistent with those used in the Flight Manual. The units used for markings and placards should be those that are read on the relevant associated instrument.

Publications which are considered to provide appropriate standards for the design substantiation and certification of symbolic placards may include, but are not limited to, 'General Aviation Manufacturers Association (GAMA) Publication No. 15 — Symbolic Messages', Initial Issue, 1 March 2014.

EASA accepts the relevant parts of Federal Aviation Administration (FAA) AC 25-17A 'Transport Airplane Cabin Interiors Crashworthiness Handbook', of 24 May 2016, as an acceptable means of compliance with CS 25.1541.

Note: 'relevant parts' means the AC 25-17A parts that address the applicable Federal Aviation Regulation (FAR)/CS-25 paragraph(s).

[Amdt No: 25/19]
[Amdt No: 25/27]

AEROPLANE FLIGHT MANUAL

AMC 25.1581 Aeroplane ~~F~~flight ~~M~~manual

[…]

6 *AEROPLANE FLIGHT MANUAL CONTENTS*

[…]

d. *Performance Section.* […]

[…]

(18) Landing Distance. The landing distance from a height of 50 ft must be presented either directly or with the factors required by the operating regulations, together with associated conditions and weights up to the maximum take-off weight. For all landplanes, landing distance data must be presented for smooth, dry, hard-surfaced runways for standard day temperatures. With concurrence by the Agency, additional data may be presented for other temperatures and runway slopes within the

operational limits of the aeroplane, or for operations on other than smooth, hard-surfaced runways. For all weather operations, additional landing performance data may be required.

The unfactored landing distances for dry and wet runways are minimum normalised values based on certification test procedures. For those distances, a runway surface with no slope at standard day temperature as well as standard landing speeds are assumed.

The AFM should state the following conditions for which the landing distances are valid:

— runway slope,

— temperature,

— landing configuration, and

— thrust or power setting.

The landing distances at the time of arrival (LDTA) reflect the performance that is expected in operational conditions. The AFM should present LDTA as follows:

— for all runway condition codes from 1 to 6,

— for certified landing configurations,

— for final-approach speeds (V_{APP}) including recommended speed increments,

— with and without reverse thrust credit, and

— within the certified flight envelope for:

  — runway slope, and

  — outside air temperature.

The AFM should state that a safety margin should be applied to the landing distances to account for operating practices and expected operational variability.

The performance information that is provided in the AFM to comply with CS 25.1592 and the LDTA concept in the applicable air operations regulations produce a large variety of landing distance data being provided in the AFM. Therefore, the intended use of each piece of the landing-distance information should be properly explained in the AFM.

The AFM should emphasise the need to apply a safety margin, particularly to such landing distances whose method of derivation is the least conservative. Such landing distances are, for example, those determined by a maximum-performance manoeuvre based on data (e.g. flight path angle and touchdown sink rate) that are normalised to specified conditions so that the landing distances achieved in operational conditions may be greater.

[…]

[Amdt No: 25/2]

[Amdt No: 25/21]

[Amdt No: 25/22]

[Amdt No: 25/26]
[Amdt No: 25/27]

SUPPLEMENTARY INFORMATION

CS 25.1591 Take-off Pperformance Iinformation for Ooperations withon slippery wet and Ccontaminated Rrunways Surface Conditions

(See AMC 25.1591)

(a) Supplementary take-off performance information applicable to aeroplanes operated on slippery wet runways and on runways contaminated with standing water, slush, snow, or ice may be furnished at the discretion of the applicant. If supplied, this information must include the expected performance of the aeroplane during take-off and landing on hard-surfaced runways covered by these contaminants. If information on any one or more of the above contaminated surfaces conditions is not supplied, the AFM must contain a statement prohibiting take-offoperation(s) on the surfaces that do not meet the minimum friction criteria, or contaminated surface(s) for which information is not supplied. Additional information covering operation on contaminated surfaces other than the above may be provided at the discretion of the applicant.

(b) Performance information furnished by the applicant must be contained in the AFM. The information may be used to assist operators in producing operational data and instructions for use by their flight crews when operating with contaminated runway surface conditions. The information may be established by calculation or by testing.

(c) The AFM must clearly indicate the conditions and the extent of applicability for each contaminant used in establishing the contaminated runway performance information. It must also state that actual conditions that are different from those used for establishing the contaminated runway performance information may lead to different performance.

[Amdt No: 25/2]

[Amdt No: 25/27]

AMC 25.1591 The derivation and methodology of performance information for use when taking-off and landing withfrom slippery wet and contaminated runways surface conditions.

1.0 Purpose

This AMC provides information, guidelines, recommendations, and acceptable means of compliance for use by applicants in the production of performance information for aeroplanes when operated ontaking off from runways that are slippery wet or contaminated by standing water, slush, snow, and ice or other contaminants.

2.0 Technical Limitations of Data

[…]

It has been recently determined that the assumption to use wet runway surface field length performance data for operations on runway surfaces contaminated with dry snow (depths below 10 mm) and wet snow (depths below 5 mm) may be inappropriate. Flight test evidence together with estimations have indicated some measure of relatively low gear displacement drag and a measurable reduction in surface friction in comparison to the assumptions associated with wet runway field performance data. As a consequence it has been agreed that additional work is required to further develop the associated methodology. As an interim measure it has been concluded that it is reasonable to consider these surfaces by recommending that they be addressed by using the data for the lowest depth of the contaminant provided.EASA acknowledges that the observing of and reporting on the type and depth of runway surface contaminants (water, slush, dry snow, wet snow) is limited. This information may not be accurately and timely relayed to the flight crew. Furthermore, shallow depths of contaminants do not generally reduce wheel braking friction below that of a wet runway, except in unfavourable circumstances where lower than expected runway condition codes (RWYCCs) are reported (see AMC 25.1592). In line with International Civil Aviation Organization (ICAO) and Federal Aviation Administration (FAA) standards, EASA considers a depth of more than 3 mm for loose contaminant accountability in take-off performance assessments a reasonable lower threshold. If the depth of such loose contaminant is lower than 3 mm, or if there is a thin layer of frost, the runway is considered wet, for which this AMC 25.1591 does not apply.

[…]

4.0 Definitions

These definitions may be different to those used by other sources but are considered appropriate for producing acceptable performance data, suitable for use in aeroplane operations.The following definitions are a subset of the runway surface condition descriptors for which a representative take-off performance model may be derived using the methods contained in this AMC.

4.1 Frost

Ice crystals formed from airborne moisture on a surface whose temperature is below freezing. Frost differs from ice in that frost crystals grow independently and, therefore, have a more granular texture.

Note 1: 'below freezing' refers to air temperature equal to or lower than the freezing point of water (0 C/32°F).

Note 2: under certain conditions, frost can render the runway surface very slippery, which should then be appropriately reported as 'reduced braking action'.

4.1.a Standing Wwater

Water of a depth greater than 3mm. A surface condition where there is a layer of water of 3mm or less is considered wet for which AMC 25.1591 is not applicable.

Note: a surface condition where there is a layer of water of 3 mm or less is considered wet, for which this AMC 25.1591 is not applicable.

4.2 Slush

Partly melted snow or ice with a high water content, from which water can readily flow, with an assumed specific gravity of 0.85. Slush is normally a transient condition found only at temperatures close to 0°C.Snow that is so water-saturated that water will drain from it when a handful is picked up or will splatter if stepped on forcefully.

4.3 Wet Ssnow

Snow that will stick together when compressed, but will not readily allow water to flow from it when squeezed, with an assumed specific gravity of 0.5.Snow that contains enough water to be able to make a well-compacted, solid snowball, without squeezing out water.

4.4 Dry Ssnow

Fresh snow that can be blown, or, if compacted by hand, will fall apart upon release (also commonly referred to as loose snow), with an assumed specific gravity of 0.2. The assumption with respect to specific gravity is not applicable to snow which has been subjected to the natural ageing process.Snow from which a snowball cannot readily be made.

4.5 Compacted Ssnow

Snow which has been compressed into a solid mass such that the aeroplane wheels, at representative operating pressures and loadings, will run on the surface without causing significant rutting.Snow that has been compacted into a solid mass such that aeroplane tyres, at operating pressures and loadings, will run on the runway surface without significant further compaction or rutting of the runway surface.

4.6 Ice

Water whichthat has frozen or compacted snow that has transitioned into iceon the runway surface, including the condition where compacted snow transitions to a polished ice surface, in cold and dry conditions.

Note: this definition excludes wet ice that has a film of water on top of it or contains melting ice, which provides minimal braking friction and uncertain lateral control.

4.7 Slippery wet runway

A wet runway where the surface friction characteristics on a significant portion of the runway have been determined to be degraded.

4.87 Specially Pprepared Wwinter Rrunway

A runway, with a dry frozen surface of compacted snow and/or ice which has been treated with sand or grit or has been mechanically or chemically treated to improve runway friction. The runway friction is measuredmonitored and reported on a regular basis in accordance with national procedures.

4.98 Specific Ggravity

The density of the contaminant divided by the density of the water.

5.0 Contaminant Properties to be Considered

5.1 Range of Contaminants

[…]

Contaminant Type	***Range of Depths to be Considered - — mm***	***Specific Gravity Assumed for Calculation***	***Is Drag Increased?***	***Is Braking Friction Reduced Bbelow Dry Runway Value?***	***Analysis Paragraphs Relevant***
Standing Wwater, Flooded runway	More than 3 up to 15 (see Note 1)	1.0	Yes	Yes	7.1, 7.3, 7.4
Slush	More than 3 up to 15 (see Note 1)	0.85	Yes	Yes	7.1, 7.3, 7.4
Wet Ssnow (see Note 2)	BelowMore than 3 up to 5 (see Note 1)		No	Yes	7.3, 7.4
Wet Ssnow (see Note 3)	More than 5 up to 30	0.5	Yes	Yes	7.1, 7.3, 7.4

Dry ~~S~~snow (see Note 2)	~~Below~~More than 3 up to 10 (see Note 1)		No	Yes	7.3, 7.4
Dry ~~S~~snow	More than 10 up to 130	0.2	Yes	Yes	7.2, 7.3, 7.4
Compacted ~~S~~snow at or below outside air temperature (OAT) of -15 °C/5 °F	0 (see Note 4)		No	Yes	7.3, 7.4
Compacted snow above OAT of -15 °C/5 °F	0 (see Note 4)		No	Yes	7.3, 7.4
Dry snow over compacted snow	More than 10 up to 130	0.2	Yes	Yes	7.2, 7.3, 7.4
Wet snow over compacted snow (see Note 3)	More than 5 up to 30	0.5	Yes	Yes	7.1, 7.3, 7.4
Ice (cold & dry)	0 (see Note 4)		No	Yes	7.3, 7.4
Slippery wet	0 (see Note 4)		No	Yes	7.3, 7.4
Specially ~~P~~prepared ~~W~~winter ~~R~~runway (see Note 5)	0 (see Note 4)		No	Yes	7.3.4, 7.4

Table 1

Note 1: Runways with water depths or slush depths or snow depths of 3 mm or less are considered wet, for which this AMC 25.1591 is not applicable.

Note 2: Contaminant drag may be ignored.

Note 3: For conservatism, the same landing gear displacement and impingement drag methodology is used for wet snow as for slush.

Note 4: Where depths are given as zero, it is assumed that the aeroplane is rolling on the surface of the contaminant.

Note 5: No default model is provided for specially prepared winter runways in this AMC. Such runway surfaces are specific, and their treatment may be of variable effectiveness. The competent authority of the State of operator should approve the related procedures and methods.

[…]

6.0 Derivation of Performance Information

6.1 General Conditions

Take-off ~~and landing~~ performance information for contaminated runways should be determined in accordance with the assumptions given in paragraph 7.0.

[…]

[…]

~~6.3 Landing on a Contaminated Runway~~

~~6.3.1 Airborne distance~~

~~Assumptions regarding the airborne distance for landing on a contaminated runway are addressed in paragraph 7.4.2.~~

~~6.3.2 Ground Distance~~

~~Except as modified by the effects of contaminant as derived below, performance assumptions for ground distance determination remain unchanged from those used for a dry runway. These assumptions include:~~

~~- Touchdown time delays.~~

~~- Stopping means other than wheel brakes (but see paragraph 7.4.3).~~

7.0 Effects of Contaminant

7.1 Contaminant Drag ~~-~~— Standing Water, Slush, Wet Snow

General advice and acceptable calculation methods are given for estimating the drag force due to fluid contaminants on runways:

Total drag due to fluid contaminant	=	Drag due to fluid displacement by tyres	+	Drag due to airframe impingement of fluid spray from tyres

The essence of these simple calculation methods is the provision of appropriate values of drag coefficients below, at, and above tyre aquaplaning speed, V_P (see paragraph 7.1.1):

- — Paragraphs 7.1.2.a and 7.1.2.b give tyre displacement drag coefficient values for speeds below V_P.
- — Paragraph 7.1.3.b.2 gives tyre equivalent displacement drag coefficient values to represent the skin friction component of impingement drag for speeds below V_P.
- — Paragraph 7.1.4 gives the variation with speed, at and above V_P, of drag coefficients representing both fluid displacement and impingement.

The applicant may account for the contaminant drag for computing the deceleration segment of the accelerate-stop distance. However, if the actual contaminant depth is less than the reported value, then, using the reported value to determine the contaminant drag will result in a higher drag level than the actual one. This will lead to a conservative take-off distance and take-off run, but also to a potentially optimistic accelerate-stop distance. It is assumed that these effects will offset each other; however, the applicant may consider:

— either using 100 % of the reported contaminant depth when determining the acceleration portion, and 50 % when considering the deceleration portion; or

— using 50 % of the reported contaminant depth when determining both the acceleration portion and the stop portion of the accelerate-stop distance; this should result in a conservative computation without being unduly penalising; the applicant should ensure that using drag for 50 % of the reported contaminant depth for computing the accelerate-stop distance is conservative for the applicant's aeroplane configuration.

7.1.1 Aquaplaning Speed

An aeroplane will aquaplane at high speed on a surface that is contaminated by standing water, slush or wet snow. For the purposes of estimating the effect of aquaplaning on contaminant drag, the aquaplaning speed, V_P, is given by -

$$V_P = 9\sqrt{P}$$

where V_P is the ground speed in knots and P is the tyre pressure in lb/in^2.

To estimate the effect of aquaplaning on wheel-to-ground friction, the aquaplaning speed (V_P) that is provided above should be factored by a coefficient of 0.85.

Predictions (Reference 5) indicate that the effect of running a wheel over a low-density liquid contaminant containing air, ~~such as~~e.g. slush, is to compress it such that it essentially acts as high-density contaminant. This means that there is essentially no increase in aquaplaning speed to be expected with such a lower density contaminant.

For this reason, the aquaplaning speed given here is not a function of the density of the contaminant.

(See References 1, 5 and 10)

[…]

7.1.4 Effect of Speed on Displacement and Impingement Drag Coefficients at and above Aquaplaning Speed (V_P)

The drag above V_P reduces to zero at lift off and one acceptable method is to reduce C_D as shown in the curve in Figure 1. This relationship applies to both displacement and spray impingement drag coefficients.

[…]

[…]

7.3.1 Default Values

To enable aeroplane performance to be calculated conservatively in the absence of any direct test evidence, default wheel-braking coefficient values~~friction~~ as defined in Table 2 may be used. These ~~friction~~ values represent the maximum effective wheel-braking coefficient of a~~n~~ fully modulating anti-skid controlled braked wheel/tyre. For quasi-modulating systems, the applicant should multiply the listed wheel-braking coefficient by 0.625, and for on-off systems, multiply the listed wheel-braking coefficient by 0.375. For the classification of anti-skid systems, the applicant should refer to AMC 25.109(c)(2). Aeroplanes without anti-skid systems should be addressed separately on a case-by-case basis.

Contaminant	***Default Wheel-Braking Coefficient~~Friction Value~~ μ***
Standing ~~W~~water and ~~S~~slush	$= -0.0632\left(\frac{V}{100}\right)^3 + 0.2683\left(\frac{V}{100}\right)^2 - 0.4321\left(\frac{V}{100}\right) + 0.3485$ where V is ground speed in knots Note: For V greater than 85 % of the aquaplaning speed (V_P), use the μ = 0.05 constant. At the discretion of the applicant, the wheel-braking coefficient as defined for runway condition codes (RWYCC) 2 in AMC 25.1592 may be applied.
Wet ~~S~~snow ~~below 5mm~~above 3 mm depth	0.16~~7~~
~~Wet Snow~~	~~0.17~~
Dry ~~S~~snow ~~below 10mm~~above 3 mm depth	0.16~~7~~
~~Dry Snow~~	~~0.17~~
Wet snow over compacted snow	0.16
Dry snow over compacted snow	0.16
Compacted ~~S~~snow below outside air temperature (OAT) of -15 °C	0.20
Compacted ~~S~~snow above OAT of -15 °C	0.16
Ice ~~(Cold & Dry)~~	0.07~~5~~
Slippery wet	0.16

Note: Braking Force = load on braked wheel x Default Friction Value μ

Table 2

Note: For a specially prepared winter runway surface no default friction value can be given due to the diversity of conditions that will apply.

(See reference 10)

[…]

7.3.3 Use of Ground Friction Measurement Devices

~~Ideally it would be preferable to relate aeroplane braking performance to a friction index measured by a ground friction device that would be reported as part of a Surface Condition Report. However, t~~There is not, at present, a correlation between aircraft stopping capability and~~common friction index for all~~ ground friction measuring devices. Hence, it is not practicable at ~~the~~ present ~~time~~ to determine aeroplane performance on the basis of a~~n internationally accepted~~ friction index measured by ground friction devices. Notwithstanding this lack of correlation~~a common index~~, the applicant may optionally choose to present take-off ~~and landing~~ performance data as a function of an aeroplane braking coefficient or wheel braking coefficient constant with ground speed for runways contaminated with ~~wet snow, dry snow,~~ compacted snow or ice. The responsibility for relating this data to a friction index measured by a ground friction device will fall on the operator and the ~~operating~~competent authority of the State of operator.

7.3.4 Specially prepared winter runway surfaces

At the discretion of the applicant, take-off performance data may be provided for specially prepared winter runway surfaces. This may include icy surfaces that have been treated with sand or gravel in such a way that a significant improvement of friction may be demonstrated. The applicant should apply a reasonable margin to the observed braking action in performance computations for such surfaces, and assume wheel-braking coefficients no greater than 0.20 for fully modulating anti-skid systems. For other anti-skid system types, this coefficient must be factored as described in Section 7.3.1. The competent authority of the State of aerodrome should approve appropriate procedures and methods in compliance with point ADR.OPS.B.036 of Annex IV (Part-ADR.OPS) of Regulation (EU) No 139/2014 ('Aerodromes Regulation').

7.4 Additional Considerations

[…]

~~7.4.2 Landing Air Distance~~

~~For contaminated surfaces, the airborne distance should be calculated by assuming that 7 seconds elapse between passing through the 50 ft screen height and touching~~

down on the runway. In the absence of flight test data to substantiate a lower value, the touchdown speed should be assumed to be 93% of the threshold speed.

7.4.23 Reverse Thrust

Performance information may include credit for reverse thrust where available and controllable, as described in AMC 25.109.

8.0 Presentation of Supplementary Performance Information

[…]

8.3 Take-off and Landing Data

This should be presented either as separate data appropriate to a defined runway contaminant or as incremental data based on the AFM normal dry or wet runway information. Information relating to the use of speeds higher than VREF on landing, that is speeds up to the maximum recommended approach speed additive to VREF, and the associated distances should also be included.

The landing distance must be presented either directly or with the factors required by the operating regulations, with clear explanation where appropriate.

Where data is provided for a range of contaminant depths, for example greater than 3, 6, 9, 12, 15 mm, then the AFM should clearly indicate how to define data for contaminant depths within the range of contaminant depths provided.

The AFM should provide:

— the performance data for operations on contaminated runways; and

— definitions of runway surface conditions.

The AFM should state that operations are prohibited on runways with contaminant depths greater than those for which data is provided. Instructions for the use of that data should be provided in the appropriate documentation.

Where the AFM presents data using V_{STOP} and V_{GO}, it must be stated in the AFM that use of this concept is acceptable only where operation under this standard is permitted.

9 References

Reference sources containing worked methods for the processes outlined in 7.1 to 7.3.3 are identified below:

1. ESDU Data Item 83042, December 1983, with Amendment A, May 1998., “‘Estimation of Spray Patterns Generated from the Side of Aircraft Tyres Running in Water or Slush’”.

2. ESDU Data Item 98001, May 1998., “‘Estimation of Airframe Skin-Friction Drag due to Impingement of Tyre Spray’”.

3. ESDU Data Item 90035*, November 1990, with Amendment A, October 1992., "'Frictional and Retarding Forces on Aircraft Tyres., Part V: Estimation of Fluid Drag Forces'".

4. ESDU Memorandum No.97*, July 1998., "'The Order of Magnitude of Drag due to Forward Spray from Aircraft Tyres'".

5. ESDU Memorandum No. 96, February 1998reissue May 2011, "'Operations on Surfaces Covered with Slush'".

6. ESDU Memorandum No. 95, March 1997reissue October 2013, "'Impact Forces Resulting From Wheel Generated Spray: Re-Assessment Of Existing Data'".

7. NASA Report TP-2718 "'Measurement of Flow Rate and Trajectory of Aircraft Tire-Generated Water Spray'".

8. Van Es, G.W.H., "'Method for Predicting the Rolling Resistance of Aircraft Tires in Dry Snow'". AIAA Journal of Aircraft, Volume 36, No.5, September-October 1999.

9. Van Es, G.W.H., "'Rolling Resistance of Aircraft Tires in Dry Snow'", National Aerospace Laboratory NLR, Technical Report TR-98165, Amsterdam, 1998.

10. ESDU Data Item 72008*, May 1972., ''Frictional and retarding forces on aircraft tyres',. Part III: planning.

11. FAA AC 25-31, 'Takeoff Performance Data for Operations on Contaminated Runways', dated 22 December 2015.

12. ICAO Document 10064, 'Aeroplane Performance Manual', First Edition 2020.

* *This document has been withdrawn by ESDU and is no longer available.*

[Amdt No: 25/2]

[Amdt No: 25/27]

CS 25.1592 Performance information for assessing the landing distance

(See AMC 25.1592)

(a) At the discretion of the applicant, supplementary landing performance information may be furnished for aeroplanes landing on slippery wet runways and on runways contaminated with standing water, slush, snow, or ice to be used by operators to support the dispatch of a flight. If information on any one or more of the above surface conditions is not supplied, the AFM must contain a statement that prohibits landing on surfaces that do not meet the minimum friction criteria, or contaminated surface(s) for which information is not supplied. Additional information covering operation on surface conditions other than the above may be provided at the discretion of the applicant.

(b) Landing-distance information must be furnished for assessing the landing performance at the time of arrival on dry, wet, slippery wet runways, and runways contaminated with standing water, slush, snow, or ice.

(c) Performance information that is furnished by the applicant must be contained in the AFM. The information may be established through calculation or testing.

(d) The data to be used for assessing the landing performance at the time of arrival consists of the horizontal distance from the point at which the main gear of the aeroplane is 15 m (50 ft) above the landing surface to the point where the aeroplane comes to a complete stop. This data must allow to compute the landing distance based on the following elements:

— runway condition (see AMC 25.1592),

— wind,

— ambient air temperature,

— average runway slope,

— pressure altitude,

— icing conditions,

— planned final-approach speed,

— aeroplane mass and configuration, and

— deceleration devices.

The applicant may optionally provide information on runway surface conditions and braking actions.

[Amdt No: 25/27]

AMC 25.1592 The derivation and methodology of performance information for use when landing on slippery wet and contaminated runways to support the dispatch of a flight, and landing assessment performance at the time of arrival in all runway surface conditions

1.0 Purpose

This AMC provides information, guidelines, recommendations, and acceptable means of compliance for use by applicants in the production of landing performance information. Operators should use that landing performance information to:

— support the dispatch of a flight when planning to land on runways that are slippery wet or contaminated by standing water, slush, snow, ice, or other contaminants; and

— assess the landing performance at the time of arrival in all runway surface conditions.

2.0 Applicability of data

Appropriate landing performance data are required for dispatch and for the time-of-arrival landing performance assessments. As the variables to be considered as well as the ways in which that data is to be used vary, the landing performance data for assessing the landing performance at the time of arrival may be different from the landing performance data that are developed in accordance with CS 25.125 and provided in the aeroplane flight manual (AFM) in accordance with CS 25.1587(b).

DRY AND WET RUNWAYS: this AMC 25.1592 includes the methods for deriving the landing distance on dry and wet runways, which is intended to be used for assessing the landing performance at the time of arrival only. For assessing the preflight landing performance when planning to land on a dry or wet runway, the landing distance established in compliance with CS 25.125 should be used.

SLIPPERY WET AND CONTAMINATED RUNWAYS: the data that is derived in accordance with the method(s) included in this AMC is appropriate for assessing the landing performance at the time of arrival and for dispatch, when planning to land on a slippery wet or contaminated runway surface, provided that CS 25.125(c)(3) and CS 25.125(g) are also complied with.

Aeroplane performance data for contaminated runway conditions, which are produced in accordance with CS 25.1592, should include recommendations for their operational use. Where possible, this operational guidance should be provided by the applicant or its production should be co-ordinated with the applicant to ensure that the information is valid for use.

Operators should carefully and conservatively select the appropriate performance data to use in operations on slippery wet and contaminated runways. They should pay special attention to any contaminant being present in the critical high-speed portion of the runway.

When determining the maximum depth of runway contaminants, the applicant should also consider the maximum depth for which the engine air intakes are shown to be free of hazardous ingestion of water in accordance with CS 25.1091(d)(2).

3.0 Standard assumptions

The data for assessing the landing performance at the time of arrival should assume the expected landing performance of a trained flight crew of average skill following normal flight procedures. It should take into account the following:

— runway surface conditions/runway condition codes,

— winds,

— temperatures,

— average runway slopes,

— pressure altitudes,

— icing conditions,

- final-approach speeds,
- aeroplane weight and configuration, and
- deceleration devices used.

As the landing distances defined in CS 25.125, the landing distances to be used for time-of-arrival landing performance assessments are defined as the horizontal distance from the point at which the main gear of the aeroplane is 50 ft above the landing surface to the position where the aeroplane comes to a stop (see Figure 1 below).

4.0 Definitions

In addition to the terms that are defined in AMC 25.1591, the applicant should consider the following:

Runway condition code (RWYCC)

RWYCC is a number that is used in the runway condition report and describes the effect of the runway surface condition(s) on the deceleration performance and lateral control of the aeroplane (see Section 6.2 of this AMC for the classification of runway conditions).

Note: the objective of the RWYCC is to enable the flight crew to calculate the operational performance of the aeroplane. ICAO Doc 9981 'PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) — Aerodromes', 3rd Edition, 2020, describes procedures for determining the RWYCC.

5.0 Assumptions for landing distances

The applicant should provide landing performance data as RWYCCs for codes six through one within the approved operational envelope for landing. The applicant may decide to provide additional data for fluid contaminants (dry snow, wet snow, slush, and standing water) for the range of depths that are given in Table 2 of Section 7.0 of this AMC.

The applicant does not provide landing performance data for code zero (0) as this code does not represent a performance category. Code 0 is a condition in which flight operations should cease on the runway until the aerodrome improves the braking action.

The applicant should provide the impact of each of the parameters affecting landing distance, taking into account the following:

- approved landing configurations, including Category-III landing guidance, where approved;
- approved deceleration devices (e.g. wheel brakes, speed brakes/spoilers, and thrust reversers);
- pressure altitudes within the approved operational envelope for landing;
- weights up to the maximum take-off weight (MTOW);

— expected airspeeds at the runway threshold, including speeds up to the maximum recommended final-approach speed, considering possible speed additives for winds and icing conditions;

— temperatures within the approved operational envelope for landing;

— operational correction factors for winds within the established operational limits of the aeroplane for:

  — no more than 50 % of the nominal wind components along the take-off path opposite to the direction of landing; and

  — no less than 150 % of nominal wind components along the take-off path in the direction of landing;

— runway slopes within the approved operational envelope for landing; and

— icing conditions if CS 25.125(a)(2) applies.

6.0 Derivation of landing distance

The landing distance consists of three segments:

— an airborne segment,

— a transition segment, and

— a final stopping-configuration (full-braking) segment,

as shown in Figure 1.

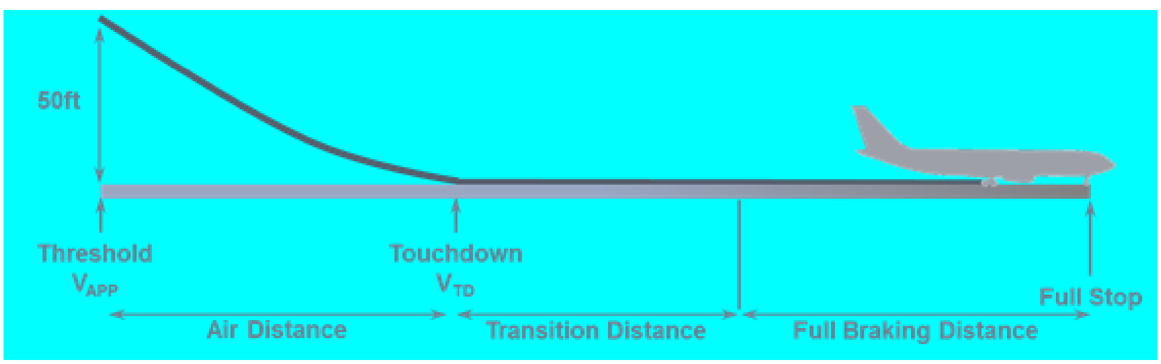

Figure 1 — Landing-distance segments

The applicant should derive the landing distance for assessing the landing performance at dispatch, when planning to land on a dry or wet runway surface, in accordance with CS 25.125.

The applicant should derive the landing distance for assessing the landing performance at dispatch, when planning to land on a contaminated or slippery wet runway surface, in accordance with the method(s) contained in Sections 6 and 7 of this AMC.

The applicant may analytically derive the landing distance for assessing the landing performance at the time of arrival from the landing performance model that the applicant developed to show compliance with CS 25.125, modified as described in the following sections.

The applicant should make changes in the aeroplane's configuration, speed, power, and thrust that are used to determine the landing distance for assessing the landing performance at the time of arrival using procedures that are established for operation in service. These procedures should:

— be able to be consistently executed in service by flight crews of average skill;

— include safe and reliable methods or devices; and

— allow for any time delays that may reasonably be expected in service (see Section 6.2 below).

6.1 Air distance

6.1.1 Default distance allowance

Based on this section, the applicant should establish a distance allowance for the airborne phase, which is appropriate to most aeroplanes and types of approaches.

As shown in Figure 1, 'air distance' is defined as the distance from an aeroplane height of 15 m (50 ft) above the landing surface to the point of the main-gear touchdown. This 'air distance' definition is the same as the one used for compliance with CS 25.125. However, an air distance that is determined under CS 25.125 may not be appropriate for making operational assessments of the landing performance, as it may be shorter than the distance that an average pilot is likely to achieve in normal operation.

The air distance that is used for any landing at any runway is a function of the following variables:

— runway approach guidance;

— runway slope;

— use of any aeroplane features or equipment (e.g. heads-up guidance, auto-flight systems, etc.);

— pilot technique; and

— the inherent flare characteristics of the aeroplane.

Unless the air distance that is used for compliance with CS 25.125 is representative of an average pilot flying in normal operation (see flight test demonstration below), the applicant should analytically determine the air distance that is used for operational assessments of the landing performance as 'the distance that is traversed over a period of 7 sec at a speed of 98 % of the recommended speed above the landing threshold'. The recommended 'speed above the landing threshold' may also be referred to as the 'final-approach speed (V_{APP})'. The above air distance represents a flare time of 7 sec and a touchdown speed (V_{TD}) of 96 % of the V_{APP}. The V_{APP} should be consistent with the procedures recommended by the applicant, including any speed additives, e.g. those that may be used due to winds or icing conditions. The applicant should also provide the effects of higher speeds, to account for variations that occur in operations or are caused by the operating procedures of individual operators.

If the applicant derives the air distance directly from flight test data instead of using the analytical method described above, the flight test data should meet the following criteria:

— procedures consistent with the applicant's recommended procedures for operation in service should be used; these procedures should address the recommended V_{APP}, flare initiation height, thrust/power reduction height and technique, and target pitch attitudes;

— at a height of 15 m (50 ft) above the runway surface, the aeroplane should have an airspeed not lower than the recommended V_{APP}; and

— the rate of descent at touchdown should be in the range of 0.3-1.2°m/sec (1-4 ft/sec).

If the air distance is based on a time of 7 seconds at a speed of 98 % of the recommended speed above the runway threshold, this air distance is considered valid for downhill runway slopes of up to 2 % in magnitude (no credit should be taken for uphill runway slopes).

6.1.2 Steep-approach landing

The distance allowance described in Section 6.1.1 may not be appropriate for steep approaches. Therefore, this paragraph provides information for determining the air distance at a steep approach using a glide path greater than or equal to 4.5 °.

The applicant determines air distances that are achieved at steep approaches directly from flight tests performed in accordance with CS-25 Appendix Q. The applicant may use those demonstrated air distances for assessing the landing distance at dispatch and at the time of arrival, in lieu of complying with the air distances provided for in Section 6.1.1.

6.2 Transition distance

As shown in Figure 1, 'transition distance' is defined as 'the distance from the point of the main-gear touchdown to the point where all deceleration devices that are used for determining the landing distance are operating. If the air distance is based on a time of 7 sec at a speed of 98 % of the recommended speed above the runway threshold, the speed at the start of the transition segment should be 96 % of the recommended speed above the runway threshold.

The applicant should determine the transition distance based on the recommended procedures for use of the approved means of deceleration, both in terms of sequencing and of cues for initiation. The applicant should also consider reasonably expected time delays.

For procedures that call for the initiation of deceleration devices at nose gear touchdown, the minimum time for each pilot action to deploy or activate a deceleration means should be the demonstrated time but no less than 1 second.

For procedures that call for the initiation of deceleration devices prior to nose gear touchdown, the minimum time for each pilot action to deploy or activate a deceleration means should be the demonstrated time plus 1 second.

For automatically deployed or activated deceleration means (e.g. auto-speedbrakes or auto-brakes), the demonstrated time may be used with no added delay.

When determining the distance of the transition segment, as well the speed at the start of the final stopping-configuration segment, the applicant should consider the expected evolution of the braking force that is achieved over the transition distance. The evolution of the braking force should include any differences that may occur for different RWYCCs, e.g. regarding the aeroplane transition to the full-braking configuration (see Table 1 for the wheel-braking coefficient of the full-braking configuration for each runway surface condition and reported RWYCC).

RWYCC	**Runway surface condition description**	**Wheel-braking coefficient**
6	**DRY**	90 % of the certified value that is used to comply with CS 25.125[1]
5	**FROST** **WET** (the runway surface is covered by any visible dampness or water up to, and including, 3 mm deep **SLUSH** (up to, and including, 3 mm deep) **DRY SNOW** (up to, and including, 3 mm deep) **WET SNOW** (up to, and including, 3 mm deep)	As per the method that is defined in CS 25.109(c)
4	**COMPACTED SNOW** (outside air temperature of less than or equal to -15 °C/5 °F)	0.20[2]
3	**WET** ('Slippery wet' runway) **DRY SNOW** (more than 3 mm deep) **WET SNOW** (more than 3 mm deep) **DRY SNOW ON TOP OF COMPACTED SNOW** (of any depth) **WET SNOW ON TOP OF COMPACTED SNOW** (of any depth) **COMPACTED SNOW** (outside air temperature of more than -15° C/5 °F)	0.16[2]

2	**STANDING WATER** (more than 3 mm deep) **SLUSH** (more than 3 mm deep)	(a) For speeds below 85 % of the aquaplaning speed[3], 50 % of the wheel-braking coefficient that is determined in accordance with CS 25.109(c), but no greater than 0.16[2] (b) For speeds equal to or higher than 85 % of the aquaplaning speed[3], 0.05[2]
1	**ICE**	0.07[2]
0	**WET ICE** **WATER ON TOP OF COMPACTED SNOW** **DRY SNOW OR WET SNOW ON TOP OF ICE**	Not applicable (no operations in 'RWYCC = 0' conditions)

Table 1 — Correlation between wheel-braking coefficient and RWYCC

[1] The applicant may use 100 % of the wheel-braking coefficient that is used to comply with CS 25.125 if the testing from which that braking coefficient was derived was conducted on portions of runways with operationally representative amounts of rubber contamination and paint stripes.

[2] For these wheel-braking coefficients, the applicant should assume a fully modulating anti-skid system. For quasi-modulating systems, the applicant should multiply the listed wheel-braking coefficient by 0.625. For on-off systems, the applicant should multiply the listed wheel-braking coefficient by 0.375. For the classification of anti-skid systems, refer to AMC 25.109(c)(2). The applicant should address aeroplanes without anti-skid systems separately, on a case-by-case basis.

[3] The aquaplaning speed 'V_P' may be estimated by solving the equation '$V_P = 9\sqrt{P}$', where 'V_P' is the ground speed in kt and 'P' is the tyre pressure in lb/in^2. To estimate the effect of aquaplaning on wheel-to-ground friction, the aquaplaning speed (V_P) given above should be factored by a coefficient of 0.85.

6.3 Final stopping-configuration distance (Full-braking distance)

As shown in Figure 1, the final stopping-configuration (full-braking) segment begins at the end of the transition segment, where all deceleration devices that are used for determining the landing distance are operating. The full-braking segment ends at the nose gear position where the aeroplane comes to a stop.

The applicant should calculate the final stopping-configuration distance based on the wheel-braking coefficient that is appropriate for the runway surface condition or RWYCC, including the effect of aquaplaning, if applicable. The applicant may use a means other than wheel brakes to determine the landing distances if that means complies with CS 25.109(e) and CS 25.109(f), except for time-of-arrival dry runway landing distances, where the applicant may consider the effects of the available reverse thrust. The applicant may take credit for using a thrust reverser if the design of that reverser fulfils the criteria of AMC 25.109(f), except for the demonstration requirements of Section 6 of this AMC. Using a thrust reverser may reduce directional controllability in combinations of crosswinds and low-friction conditions. The applicant should provide to operators recommendations or guidelines for crosswind landings, including the maximum recommended crosswinds, for the RWYCCs for which landing-distance data is provided. The applicant may carry out a suitable simulation to develop these guidelines for operation on contaminated runways (see Section 7 on considering contaminant drag from loose contaminants).

6.4 Landing-distance data for dispatch

For dispatch computation, performance data for landing on a contaminated runway surface may include credit for reverse thrust in compliance with CS 25.125(c)(3) and CS 25.125(g); CS 25.125(g) requires to consider the one-engine-inoperative configuration. The applicant should assume that the engine fails during the landing flare. If this adversely affects the availability of a deceleration device, then the applicant, in compliance with CS 25.125(g), must compare:

(a) the normal landing distance without engine failure, using the available deceleration means factored by 1.15; and

(b) the unfactored landing distance, assuming an engine failure in the landing flare and loss of availability of any related deceleration means.

The scheduled landing distance is the longer between (a) and (b) above. Such distance is the minimum landing distance that already includes an operational factor of 1.15.

6.5 Time-of-arrival landing distance

For time-of-arrival landing distances, CS 25.125(g) does not need to be applied.

7.0 Contaminant drag — standing water, slush, wet snow

Loose contaminants result in additional contaminant drag due to the combination of the following:

— the aeroplane tyres displace the contaminant; and

— the contaminant spray is impinged upon the airframe.

Such contaminant drag is an additional force that helps decelerate the aeroplane, thus reducing the distance needed to stop the aeroplane. As the contaminant drag increases with the contaminant depth, the deeper the contaminant is, the shorter the stopping distance will be. However, the actual contaminant depth may be less than the reported depth for the following reasons:

— contaminant depths are reported in runway surface condition reports using specific depth increments;

— the procedure for reporting contaminant depths is to report the highest depth of the contaminant along the reported portion of the runway surface; contaminant depths, however, may not be uniform over the whole runway surface (or reported portion of the runway surface), therefore, areas of lower contaminant depth are likely;

— in a stable weather environment (the contaminant is not replenished on the runway), the contaminant depth is likely to decrease as successive aeroplanes use the runway displacing the contaminant; and

— contaminated conditions are reported starting from 25 % coverage in each runway third; the total coverage of the runway with significant depths of contaminant may thus be less than 10 % of the entire runway surface.

If the actual contaminant depth is lower than the reported value, using the reported value to determine the contaminant drag will result in a higher drag level than the actual one, leading to an optimistic prediction of the stopping distance. Therefore, it is recommended not to include the effect of contaminant drag when calculating the landing distances for assessing the landing performance at the time of arrival. However, if the effect of contaminant drag is included, the applicant should limit it to no more than the drag resulting from 50 % of the reported depth.

If the effect of contaminant depth is included in the landing-distance data, the applicant should provide data for up to the maximum depth of each runway contaminant, for which landing operations are permitted. When determining the maximum depth of runway contaminants, the applicant may need to consider the maximum depth for which the engine air intakes are shown to be free of hazardous ingestion of water in accordance with CS 25.1091(d)(2).

If the effect of contaminant depth is included in the landing distance data, then the applicant should provide data for the specific gravities as shown in Table 2:

Loose contaminant	***Specific gravity***
Standing water	1.0
Slush	0.85
Dry snow	0.2
Wet snow	0.5

Table 2 — Specific gravity of loose contaminants

For the method of determining the contaminant drag, refer to AMC 25.1591.

8.0 Presentation of supplementary performance information

8.1 General

The applicant should include in the performance information for dry, wet, slippery wet, and contaminated runways, derived in accordance with Sections 5.0-7.0 of this AMC, the following statements or equivalent ones:

— operation on runways that are contaminated with water, slush, snow, ice, or other contaminants implies uncertainties regarding runway friction and contaminant drag; therefore, the achievable performance and control of the aeroplane during landing are also uncertain as the actual conditions may not completely match the assumptions on which the performance information was based; where possible, every effort should be made to ensure that the runway surface is cleared of significant contamination;

— the performance information has been established with the assumption that any runway contaminant is of uniform depth and density; and

— ground handling characteristics on contaminated runways should not be considered equivalent to those that may be achieved on dry or wet runways, in particular following an engine failure, in presence of crosswinds, or when using reverse thrust.

8.2 Procedures

In addition to performance information for operating on contaminated runways, the applicant should include in the AFM recommended procedures associated with this performance information if such procedures are specific to the aeroplane. The applicant should also include in the AFM changes in other procedures, e.g. reference to crosswinds, to adapt them to the operation of the aeroplane on a contaminated runway.

8.3 Landing data

The applicant should present landing data:

— either as separate data appropriate to a defined runway contaminant; or

— as incremental data based on the dry or wet runway information in the AFM.

The applicant should also include information on the use of speeds higher than the reference landing speed (V_{REF}) on landing, i.e. speeds up to the maximum recommended approach speed in addition to the V_{REF}, as well as on the related distances. The applicant should present the landing distance either directly or along with the factors that are required by the applicable air operations regulations, including a clear explanation, where appropriate.

Where the applicant provides data for a range of contaminant depths, e.g. greater than 3, 6, 9, 12, or 15 mm, then the AFM should clearly indicate how to define data for contaminant depths within the range of the contaminant depths provided.

When for at least one runway condition, the landing distances to be used at the time of dispatch are defined by the unfactored distance that is determined with one engine assumed to be failing in the flare, the applicant should present all landing distances at the time of dispatch as factored distances in the AFM. The AFM should clearly state this to avoid double application of operational factors.

The AFM should provide:

(a) definitions of runway surface conditions;

(b) the performance data for operations on contaminated runways;

(c) landing distances on contaminated runways;

(d) data with no reverse thrust credit to:

(1) cover operational restrictions on the use of reversers; and

(2) make flight crew aware of the importance of reverser selection on contaminated runways;

(e) the procedures and assumptions that are used to develop the performance data; and

(f) the appropriate statements as per Section 8.1 of this AMC.

The applicant should provide instructions on the use of the data in the appropriate operational documentation.

9.0 References

Federal Aviation Administration (FAA) Advisory Circular (AC) 25-32, 'Landing Performance Data for Time-of-Arrival Landing Performance Assessments', 22 December 2015.

[Amdt No: 25/27]

SUBPART H — ELECTRICAL WIRING INTERCONNECTION SYSTEMS

AMC 25 Subpart H Correlation with previous amendment of CS-25

[…]

Subpart H paragraph	Subparagraph	Based on previous CS-25 paragraph
[…]	[…]	[…]
CS 25.1705 Systems and functions; EWIS	[…] (b)(3) (b)(4) (b)(5) (b)(6) (b)(7) (b)(8) (b)(9) (b)(10) (b)(11) (b)(12) (b)(13) (b)(14) (b)(15) (b)(16) ~~(b)(17)~~ ~~(b)(18)~~	[…] CS 25.885~~5~~ CS 25.981~~857~~ CS 25.1165~~858~~ CS 25.1203~~981~~ CS 25.1303(b)~~1165~~ CS 25.1310~~1203~~ CS 25.1316~~1303(b)~~ CS 25.1331(a)(2)~~1310~~ CS 25.1351~~1316~~ CS 25.1355~~1331(a)(2)~~ CS 25.1360~~1351~~ CS 25.1362~~1355~~ CS 25.1365~~1360~~ CS 25.1431(c) & (d)~~1362~~ ~~CS 25.1365~~ ~~CS 25.1431(c) & (d)~~
[…]	[…]	[…]
CS 25.1709 System safety; EWIS	(a)(1)~~(1)(i)~~ (a)(2)~~(1)(ii)~~ (b)~~(2)~~	CS 25.1309(b)(1) CS 25.1309(b)(1) CS 25.1309(b)(2)
[…]	[…]	[…]
CS 25.1715 Electrical bonding and protection against static electricity; EWIS	[…] (b) ~~(b)(12)~~ ~~(b)(13)~~ ~~(b)(14)~~ ~~(b)(15)~~ ~~(b)(16)~~ ~~(b)(17)~~ ~~(b)(18)~~	[…] CS 25.1353(e)~~none~~ ~~CS 25.1331(a)(2)~~ ~~CS 25. 1351~~ ~~CS 25. 1355~~ ~~CS 25.1360~~ ~~CS 25.1362~~ ~~CS 25.1365~~ ~~CS 25.1431(c)~~ ~~CS 25.1431(d)~~
[…]	[…]	[…]

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[Amdt No: 25/5]

[Amdt No: 25/27]

GENERAL ACCEPTABLE MEANS OF COMPLIANCE (AMC)

[…]

AMC 25-13 Reduced aAnd dDerated tTake-oOff tThrust (pPower) pProcedures

[…]

4 *Definitions*

[…]

d. A 'wet runway' is one ~~that is neither dry nor contaminated~~whose surface is covered by any visible dampness or water up to, and including, 3 mm deep within the intended area of use.

e. A 'contaminated runway' is ~~a runway where more than 25% of the required field length, within the width being used, is covered by standing water or slush more than 3·2 mm (0·125 inch) deep, or that has an accumulation of snow or ice. However, in certain other situations it may be appropriate to consider the runway contaminated. For example, if the section of the runway surface that is covered with standing water or slush is located where rotation and lift-off will occur, or during the high speed part of the take-off roll, the retardation effect will be far more significant than if it were encountered early in the take-off while at low speed. In this situation, the runway might better be considered 'contaminated' rather than 'wet'.~~a runway where a significant portion of the runway surface area (whether in isolated areas or not) within the length and width being used is covered by one or more of the following substances:

— compacted snow,

— dry snow more than 3 mm deep,

— heavy frost,

— ice,

— slush more than 3 mm deep,

— standing water more than 3 mm deep, and

— wet snow more than 3 mm deep.

For the definitions of the contaminants, refer to Section 4 of AMC 25.1591.

f. A 'slippery wet runway' is a wet runway where the surface friction characteristics on a significant portion of the runway have been determined to be degraded.

5 *Reduced Thrust*: (Acceptable Means ~~O~~of Compliance)

[…]

f. The AFM states, as a limitation, that take-offs utilising reduced take-off thrust settings: ~~–~~

(1) Are not authorised on runways contaminated with standing water, snow, slush, or ice, and are not authorised on wet runways, including slippery wet runways, unless suitable performance accountability is made for the increased stopping distance on the wet surface.

[…]

[Amdt No: 25/2]
[Amdt No: 25/27]