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Doc 10064

Aeroplane Performance Manual

First Edition, 2020

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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FOREWORD

This manual was developed to combine guidelines on operational requirements regarding aeroplane performance. It supplements the provisions of Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, Chapter 5, *Aeroplane performance operating limitations* and Annex 8 — *Airworthiness of Aircraft*, Part IIIB, as applicable to turbine-powered subsonic transport-type aeroplanes over 5 700 kg maximum certificated take-off mass having two or more engines.

This manual contains guidance material previously presented in Annex 6, Part I, Attachment B, *Aeroplane performance operating limitations*, which has been removed with Amendment 40 C (applicability 2020). This manual also provides new guidance for aeroplane operations on contaminated runways, following the implementation of a new global reporting format for assessing and reporting runway surface conditions. Its content was developed in coordination with the Friction Task Force on the basis of existing and proposed national regulations, the removal of Annex 6, Part I, Attachment B, and guidance on the application of Standards and Recommended Practices (SARPs) concerned with the Runway Condition Report (RCR). In addition, the manual addresses current regulatory shortcomings regarding obstacle clearance.

A single manual for aeroplane performance represents a holistic approach to support the SARPs of multiple Annexes, namely Annex 6, Annex 8, Annex 14 — *Aerodromes*, and Annex 15 — *Aeronautical Information Services* as well as existing associated guidance material. The guidance contained herein describes a possible means for achieving the intended level of safety, however, it is recognized that this may not be the only way of meeting the intent for individual aeroplane manufacturers and operators.

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GLOSSARY

ACRONYMS AND ABBREVIATIONS

AFM	Aeroplane flight manual
AGL	Above ground level
AIREP	Air-report
AIS	Aeronautical information service
AMC	Acceptable means of compliance
ASDA	Accelerate-stop distance available
ATC	Air traffic control
ATIS	Automatic terminal information service
ATM	Air traffic management
CAA	Civil aviation authority
CAS	Calibrated airspeed
CDL	Configuration deviation list
CRM	Collision risk model
EASA	European Union Aviation Safety Agency
EFB	Electronic flight bag
FOD	Foreign object debris
IMC	Instrument meteorological conditions
ISA	International standard atmosphere
JAA	European Joint Aviation Authorities
LDA	Landing distance available
LDF	Landing distance factor
LDR	Landing distance required
MCA	Minimum crossing altitude
MDA	Minimum descent altitude
MEA	Minimum en-route altitude
MEL	Minimum equipment list
METAR	Aerodrome routine meteorological report
MOC	Minimum obstacle clearance
OAT	Outside air temperature
OCA	Obstacle clearance altitude
OCH	Obstacle clearance height
OEI	One engine inoperative
PANS	Procedures for air navigation services
PFC	Porous friction course
RCAM	Runway condition assessment matrix
RCR	Runway condition report
RESA	Runway end safety area
RWYCC	Runway condition code
SARPs	Standards and Recommended Practices
SID	Standard instrument departure
TAS	True air speed
TC	Type certificate
TODA	Take-off distance available
TORA	Take-off run available
VMC	Visual meteorological conditions

DEFINITIONS

When the following terms are used in this manual, they have the following meanings:

Accelerate-stop distance available (ASDA). The length of the take-off run available plus the length of the stopway, if provided.

Note.— Where the minimum recommended length of runway end safety areas is achieved by application of Annex 14 — Aerodromes, *Volume I —* Aerodrome Design and Operations*, Attachment A, Section 9.2, the ASDA may be shorter than the take-off run available.*

Aerodrome. A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

Aeroplane. A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.

Aircraft. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Aircraft operating manual. A manual, acceptable to the State of the Operator, containing normal, abnormal and emergency procedures, checklists, limitations, performance information, details of the aircraft systems and other material relevant to the operation of the aircraft.

Note.— The aircraft operating manual is part of the operations manual.

Airworthy. The status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation.

Alternate aerodrome. An aerodrome to which an aircraft may proceed when it becomes either impossible or inadvisable to proceed to or to land at the aerodrome of intended landing where the necessary services and facilities are available, where aircraft performance requirements can be met and which is operational at the expected time of use. Alternate aerodromes include the following:

Take-off alternate. An alternate aerodrome at which an aircraft would be able to land should this become necessary shortly after take-off and it is not possible to use the aerodrome of departure.

En-route alternate. An *alternate* aerodrome at which an aircraft would be able to land in the event that a diversion becomes necessary while en-route.

Destination alternate. An alternate aerodrome at which an aircraft would be able to land should it become either impossible or inadvisable to land at the aerodrome of intended landing.

Note.— The aerodrome from which a flight departs may also be an en-route or a destination alternate aerodrome for that flight.

Anticipated operating conditions. Those conditions which are known from experience or which can be reasonably envisaged to occur during the operational life of the aircraft, taking into account the operations for which the aircraft is made eligible, the conditions so considered being relative to the meteorological state of the atmosphere, to the configuration of terrain, to the functioning of the aircraft, to the efficiency of personnel and to all the factors affecting safety in flight. Anticipated operating conditions do not include:

a) those extremes which can be effectively avoided by means of operating procedures; and

b) those extremes which occur so infrequently that to require the Standards to be met in such extremes would give a higher level of airworthiness than experience has shown to be necessary and practical.

Calibrated airspeed (CAS). The calibrated airspeed is equal to the airspeed indicator reading corrected for position and instrument error. (As a result of the sea level adiabatic compressible flow correction to the airspeed instrument dial, CAS is equal to the true airspeed (TAS) in International Standard Atmosphere at sea level.)

Configuration *(as applied to the aeroplane)*. A particular combination of the positions of the movable elements such as wing flaps, landing gear, etc., that affect the aerodynamic characteristics of the aeroplane.

Configuration deviation list (CDL). A list established by the organization responsible for the type design with the approval of the State of Design which identifies any external parts of an aircraft type which may be missing at the commencement of a flight, and which contains, where necessary, any information on associated operating limitations and performance correction.

Commercial air transport operation. An aircraft operation involving the transport of passengers, cargo or mail for remuneration or hire.

Contaminated runway.[1] A runway is contaminated when 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 substances listed in the runway surface condition descriptors.

Note.— Further information on runway surface condition descriptors can be found in the Annex 14, Volume I *Definitions.*

Crew member. A person assigned by an operator to duty on an aircraft during a flight duty period.

Critical engine(s). Any engines(s) whose failure gives the most adverse effect on the aircraft characteristics relative to the case under consideration.

Declared temperature. A temperature selected in such a way that when used for performance purposes, over a series of operations, the average level of safety is not less than would be obtained by using official forecast temperatures.

Design landing mass. The maximum mass of the aircraft at which, for structural design purposes, it is assumed that it will be planned to land.

Design take-off mass. The maximum mass at which the aircraft, for structural design purposes, is assumed to be planned to be at the start of the take-off run.

Elevation. The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Engine. A unit used or intended to be used for aircraft propulsion. It consists of at least those components and equipment necessary for functioning and control, but excludes the propeller/rotors (if applicable).

Expected. Used in relation to various aspects of performance (e.g. rate or gradient of climb), this term means the standard performance for the type, in the relevant conditions (e.g. mass, altitude and temperature).

Flight crew member. A licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.

1. Applicable as of 5 November 2020

Flight manual. A manual, associated with the certificate of airworthiness, containing limitations within which the aircraft is to be considered airworthy, and instructions and information necessary to the flight crew members for the safe operation of the aircraft.

Flight operations officer/flight dispatcher. A person designated by the operator to engage in the control and supervision of flight operations, whether licensed or not, suitably qualified in accordance with Annex 1, who supports, briefs and/or assists the pilot-in-command in the safe conduct of the flight.

Grooved or porous friction course runway. A paved runway that has been prepared with lateral grooving or a porous friction course (PFC) surface to improve braking characteristics when.

Height. The vertical distance of a level, a point, or an object considered as a point, measured from a specified datum.

Note.— For the purposes of this manual, the point referred to above is the lowest part of the aeroplane and the specified datum is the take-off or landing surface, whichever is applicable.

Human Factors principles. Principles which apply to aeronautical design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

Human performance. Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Landing distance available (LDA). The length of runway which is declared available and suitable for an aeroplane landing.

Note.— This definition differs slightly from the definition in Annex 6, specifically for the purposes of this manual.

Landing surface. That part of the surface of an aerodrome which the aerodrome authority has declared available for the normal ground or water run of aircraft landing in a particular direction.

Maximum mass. Maximum certificated mass.

Note.— This definition differs slightly from the definition in Annex 6, specifically for the purposes of this manual.

Net gradient. The net gradient of climb throughout these requirements is the expected gradient of climb diminished by the manoeuvre performance (i.e. that gradient of climb necessary to provide power to manoeuvre) and by the margin (i.e. that gradient of climb necessary to provide for those variations in performance which are not expected to be taken explicit account of operationally).

NOTAM. A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

Obstacle clearance altitude (OCA) or ***obstacle clearance height (OCH).*** The lowest altitude or the lowest height above the elevation of the relevant runway threshold or the aerodrome elevation as applicable, used in establishing compliance with appropriate obstacle clearance criteria.

Note 1.— Obstacle clearance altitude is referenced to mean sea level and obstacle clearance height is referenced to the threshold elevation or in the case of non-precision approach procedures to the aerodrome elevation or the threshold elevation if that is more than 2 m (7 ft) below the aerodrome elevation. An obstacle clearance height for a circling approach is referenced to the aerodrome elevation.

Note 2.— For convenience when both expressions are used they may be written in the form "obstacle clearance altitude/height" and abbreviated "OCA/H".

Operations manual. A manual containing procedures, instructions and guidance for use by operational personnel in the execution of their duties.

Operations specifications. The authorizations, including specific approvals, conditions and limitations associated with the air operator certificate and subject to the conditions in the operations manual.

Operator. The person, organization or enterprise engaged in or offering to engage in an aircraft operation.

Pressure-altitude. An atmospheric pressure expressed in terms of altitude which corresponds to that pressure in the Standard Atmosphere.

Reference humidity. The relationship between temperature and reference humidity is defined as follows:

— at temperatures at and below ISA, 80 per cent relative humidity;

— at temperatures at and above ISA + 28°C, 34 per cent relative humidity; and

— at temperatures between ISA and ISA + 28°C, the relative humidity varies linearly between the humidity specified for those temperatures.

Runway condition assessment matrix (RCAM).[2] A matrix allowing the assessment of the runway condition code, using associated procedures, from a set of observed runway surface condition(s) and pilot report of braking action.

Runway condition code (RWYCC). A number describing the runway surface condition to be used in the runway condition report.

Note.— The purpose of the runway condition code is to permit an operational aeroplane performance calculation by the flight crew. Procedures for the determination of the runway condition code are described in the PANS-Aerodromes (Doc 9981).

Runway condition report (RCR).* A comprehensive standardized report relating to runway surface condition(s) and its effect on the aeroplane landing and take-off performance.

Runway surface condition(s).* A description of the condition(s) of the runway surface used in the runway condition report which establishes the basis for the determination of the runway condition code for aeroplane performance purposes.

Note 1.— The runway surface conditions used in the runway condition report establish the performance requirements between the aerodrome operator, aeroplane manufacturer and aeroplane operator.

Note 2.— Aircraft de-icing chemicals and other contaminants are also reported but are not included in the list of runway surface condition descriptors because their effect on runway surface friction characteristics and the runway condition code cannot be evaluated in a standardized manner.

Note 3.— Procedures on determining runway surface conditions are available in the PANS-Aerodromes (Doc 9981).

a) *Dry runway*. A runway is considered dry if its surface is free of visible moisture and not contaminated within the area intended to be used.

2. Applicable as of 5 November 2020

b) *Wet runway.* The runway surface is covered by any visible dampness or water up to and including 3 mm deep within the intended area of use.

c) *Slippery wet runway.* A wet runway where the surface friction characteristics of a significant portion of the runway has been determined to be degraded.

d) *Contaminated runway*. A runway is contaminated when 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 substances listed in the runway surface condition descriptors.

Note.— Procedures on determination of contaminant coverage on runway are available in the PANS-Aerodromes (Doc 9981).

e) *Runway surface condition* descriptors*.* One of the following elements on the surface of the runway:

Note.— The descriptions for e)i) to e)viii) are used solely in the context of the runway condition report and are not intended to supersede or replace any existing WMO definitions.

i) *Compacted snow.* Snow that has been compacted into a solid mass such that aeroplane tires, at operating pressures and loadings, will run on the surface without significant further compaction or rutting of the surface.

ii) *Dry snow.* Snow from which a snowball cannot readily be made.

iii) *Frost.* Frost consists of ice crystals formed from airborne moisture on a surface whose temperature is below freezing. Frost differs from ice in that the frost crystals grow independently and therefore have a more granular texture.

Note 1.— Below freezing refers to air temperature equal to or less than the freezing point of water (0 degree Celsius).

Note 2.— Under certain conditions frost can cause the surface to become very slippery and it is then reported appropriately as reduced braking action.

iv) *Ice.* Water that has frozen or compacted snow that has transitioned into ice, in cold and dry conditions.

v) *Slush.* 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.

vi) *Standing water.* Water of depth greater than 3 mm.

Note.— Running water of depth greater than 3 mm is reported as standing water by convention.

vii) *Wet ice.* Ice with water on top of it or ice that is melting.

Note.— Freezing precipitation can lead to runway conditions associated with wet ice from an aeroplane performance point of view. Wet ice can cause the surface to become very slippery. It is then reported appropriately as reduced braking action in line with procedures in the PANS-Aerodromes (Doc 9981).

viii) *Wet snow.* Snow that contains enough water content to be able to make a well-compacted, solid snowball, but water will not squeeze out.

SNOWTAM.† A special series NOTAM notifying the presence or removal of hazardous conditions due to snow, ice, slush or standing water associated with snow, slush and ice on the movement area, by means of a specific format.

SNOWTAM.‡ A special series NOTAM given in a standard format providing a surface condition report notifying the presence or cessation of hazardous conditions due to snow, ice, slush, frost, standing water or water associated with snow, slush, ice, or frost on the movement area.

State of Design. The State having jurisdiction over the organization responsible for the type design.

State of Registry. The State on whose register the aircraft is entered.

Note.— In the case of the registration of aircraft of an international operating agency on other than a national basis, the States constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a State of Registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies which can be found in Policy and Guidance Material on the Economic Regulation of International Air Transport *(Doc 9587).*

State of the Operator. The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

Take-off distance available (TODA). The length of the take-off run available plus the length of the clearway, if provided.

Take-off run available (TORA). The length of runway declared available and suitable for the ground run of an aeroplane taking off.

Take-off surface. That part of the surface of an aerodrome which the aerodrome authority has declared available for the normal ground or water run of aircraft taking off in a particular direction.

TAS (True airspeed).The speed of the aeroplane relative to undisturbed air.

V_{APP}. Final approach speed.

V_{FTO}. Final take-off speed.

V_{MCG}. Minimum control speed on ground.

V_{REF}. Referenced speed.

V_{S_0}. A stalling speed or minimum steady flight speed in the landing configuration.

V_{S_t}. A stalling speed or minimum steady flight speed.

V_{TD}. Touchdown speed.

V_{FTO}. Final take-off speed.

V_1. Decision speed.

Note 1.— See Chapter 1 and Annexes 8 and 14, Volume I, for other definitions.

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†. Applicable until 4 November 2020.
‡. Applicable as of 5 November 2020.

Note 2.— The terms "accelerate-stop distance", "take-off distance", "V_1", "take-off run", "net take-off flight path", "one engine inoperative en-route net flight path", and "two engines inoperative en-route net flight path", as relating to the aeroplane, have their meanings defined in the airworthiness requirements under which the aeroplane was certificated. If any of these definitions are found inadequate, then a definition specified by the State of the Operator should be used.

REFERENCES

Annex 6 — *Operation of Aircraft,* Part I — *International commercial air transport — Aeroplanes* mandates the check of performance at time of landing and the reporting of worse than expected runway surfaces conditions by flight crew (AIREPs).

Annex 8 — *Airworthiness of Aircraft* requires the publication of landing distances to be used for the performance assessment at time of landing for all aeroplanes for which the application for the type certificate is made on or after 2 March 2019.

Annex 14 — *Aerodromes*, Volume I — *Aerodrome Design and Operations* defines the reporting needs in terms of runway surface conditions.

Annex 15 — *Aeronautical Information Services* and the *Procedures for Air Navigation Services — Aeronautical Information Management* (PANS-AIM, Doc 10066) describe the new SNOWTAM format.

Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444) defines the phraseology to be used in runway surface reports and AIREPs.

*Procedures for Air Navigation Services — Aerodromes (*PANS-Aerodromes, Doc 9981) describes the content and format of the runway condition report (RCR).

Assessment, Measurement and Reporting of Runway Surface Conditions (Cir 355) provides additional guidance for aerodrome operators.

FAA Advisory Circular AC 25-7D, *Flight Test Guide for Certification of Transport Category Airplanes*

Chapter 1

INTRODUCTION AND OVERVIEW

1.1 PURPOSE AND SCOPE

1.1.1 This manual was developed to provide guidance material to support the Standards and Recommended Practices of Annex 6 — *Operation of Aircraft*, Part I, Chapter 5, Aeroplane Performance Operating Limitations, and the complimentary Standards of Annex 8 — *Airworthiness of Aircraft*, Part IIIB, as applicable to large transport type aeroplanes. It also presents the guidance material previously contained in Annex 6, Attachment B, which was removed from Annex 6 as of Amendment 40C, applicable 2020. This manual therefore serves as the new location for that guidance.

1.1.2 This manual contains guidance material following the introduction of a global reporting format for assessing and reporting runway surface conditions (applicability 5 November 2020). The global reporting format defines the information regarding runway surface condition that is communicated to flight crew, as it is directly relevant to aeroplane performance. Manufacturers should provide performance information that can be used by the flight crew in their assessment of take-off and landing performance, in particular on winter-contaminated runways. This manual presents the parameters to be used by manufacturers in developing their performance models in order to make available information that fulfils the intent. However, performance data and a limited number of contaminant types or braking action categories covered in the global reporting format will never reflect the complexity of the situations that can develop in active winter events. This manual includes information that flight crew should be made aware of when assessing performance and explains how to use the available data to build their awareness of the situation and its potential development.

1.1.3 This manual introduces the global reporting format for runway conditions, as it may impact take-off and landing performance. The content is then organized by flight phases; each phase has a separate chapter. Appendices A and B contain examples for the continued operation of piston-engine aeroplanes with two, three or four engines which cannot comply with the level of performance intended by the provisions of Annex 6, Chapter 5. These examples have been reproduced in their original composition in two separate appendices, having previously formed a large part of the content of Attachment B in Annex 6.

1.2 AEROPLANE PERFORMANCE STANDARDS

1.2.1 Aeroplane performance can be divided into three general categories. The first is airworthiness standards, for which compliance demonstration is under the responsibility of the aeroplane manufacturer or type certificate (TC) holder. The second is operating standards which must be complied with by the aeroplane operator. Third, and in order to assist operators with this compliance, manufacturers may provide supplemental performance standards, which may be of an advisory nature.

1.2.2 Current airworthiness Standards, as applied to turbojet aeroplane performance, have evolved such that they are harmonized to a very large extent, and fulfil the broad Standards promulgated in Annex 8 — *Airworthiness of Aircraft*. Aeroplane manufacturers agree with their States of Design on the method of compliance demonstration with the applicable airworthiness Standards for certification of their aeroplane. The information provided in this manual with regards to certification standards is applicable to large aeroplanes that have been certificated under Annex 8, Part III.

1.2.3 Each State is responsible for the operating standards of the aircraft on its registry and those for which the transfer of functions and duties has been agreed with the State of Registry under Article 83 bis of the Chicago Convention. As with airworthiness, these standards address the majority of the operating issues and in general, aeroplane manufacturers offer operational performance data for their aeroplane that allow operators to meet the applicable standards. It may be necessary (or desired) for a State to have specific operating standards addressing specific issues affecting their jurisdiction. Operators must comply with the regulations of their State of Registry, which must fulfil the broad Standards in Annex 6, Chapter 5 regarding performance limitations. Only in very rare and specific cases is compliance required with differing local regulations of the States an operator may fly to.

1.2.4 Airworthiness and operating Standards may not cover all the information necessary to operate the aeroplane with regard to take-off and landing performance. Therefore, this document discusses specific aeroplane performance issues that operators should consider to ensure a safe operation. The operation of aeroplanes on runways that are not dry, i.e. wet or contaminated, crosses multiple boundaries in the regulatory framework such as airworthiness standards, aircraft operating standards, aerodrome runway construction and maintenance standards and the determination and dissemination of the description of the runway surface condition. The runway condition report (RCR) creates a common language on runway surface conditions for all stakeholders. It allows aerodrome personnel to report the relevant elements that characterize a contaminated runway surface in terms of their effect on performance.

1.3 PERFORMANCE OPERATING LIMITATIONS

1.3.1 This manual contains provisions for aeroplane operating performance limitations that have been relocated from Annex 6 — *Operation of Aircraft*. Although what previously constituted a Standard is now represented as guidance material, these former provisions should still be complied with, unless deviations are specifically authorized by the State of Design or by the State of the Operator on the grounds that the special circumstances of a particular case make a literal observance unnecessary for safety.

1.3.2 Compliance should be established using performance data in the flight manual and in accordance with other applicable operating requirements. In no case should the limitations in the flight manual be exceeded. However, additional limitations may be applied when operational conditions not included in the flight manual are encountered. The performance data contained in the flight manual may be supplemented with other data acceptable to the State of the Operator, if necessary, to show compliance. When applying the factors prescribed, any operational factors already incorporated in the flight manual data should be considered to avoid double application of factors.

1.3.3 The procedures scheduled in the flight manual should be followed, except where operational circumstances require the use of modified procedures in order to maintain the intended level of safety.

Chapter 2

RUNWAY SURFACE CONDITION ASSESSMENT AND REPORTING

2.1 GENERAL

2.1.1 Runway accidents and incidents are aviation's number one safety-related risk category. A primary factor contributing to this risk includes runway excursions during take-off or landing in adverse weather conditions; the runway surface may be contaminated by snow, ice, slush or water, with a potentially negative impact on an aircraft's braking, acceleration or controllability. ICAO therefore introduced a methodology to harmonize the assessment and reporting of runway surface conditions. This methodology will improve the flight crew's assessment of the take-off and landing performance of aeroplanes. The report is intended to cover conditions found in all climates and provides a means for aerodrome operators to rapidly and correctly assess the conditions, whether they be a wet runway, snow, slush, ice or frost, including rapidly changing conditions such as those experienced during winter or in tropical climates. The information can be provided to the flight crew via various channels, such as the revised SNOWTAM or air traffic control. This is a conceptual change for the airport as it no longer just reports a series of observations and measurements, but it also turns this information into an overall assessment of the effect that the surface condition has on the aeroplane performance.

2.1.2 The reporting process begins with the evaluation of a runway by human observation, normally performed by airport operations staff. A description of the surface contaminant based on its type, depth and coverage for each third of the runway, is then used to obtain a runway condition code (RWYCC) specific to the conditions observed. The evaluation and associated RWYCC are used to complete a standard report called the runway condition report (RCR) which is then forwarded to air traffic control (ATC) and the aeronautical information service (AIS) for onward dissemination to pilots.

2.1.3 Pilots use the RCR provided to determine the expected performance of their aircraft by correlating the RWYCC or the reported runway condition description with performance data provided by the aircraft manufacturer. This helps pilots to correctly carry out their landing and take-off performance calculations for wet or contaminated runways. Pilots should also report their own observations of runway conditions once a landing has been completed, thereby confirming the RWYCC or providing an alert to changing conditions. This relatively simple and globally applicable reporting methodology is an important means by which the risk of runway excursion can be mitigated and the safety of runway operations improved. This chapter describes the reporting method in more detail and provides guidance for flight crew on how to interpret and use the information.

2.1.4 Further guidance on runway surface condition assessment and reporting that is specific to airport operations staff is presented in the PANS-Aerodromes (Doc 9981) and the *Assessment, Measurement and Reporting of Runway Surface Conditions* (Cir 355).

2.2 THE RUNWAY CONDITION REPORT (RCR)

2.2.1 The RCR is the basis for all runway surface condition reporting. It is a comprehensive, standardized report relating to the runway surface condition and its effect on the landing and take-off performance of an aeroplane. In accordance with Annex 14 — *Aerodromes*, Volume 1 — *Aerodrome Design and Operations*, the runway condition should be reported with an RCR whenever a runway is contaminated by water, snow, slush, ice or frost, to the extent where its state has an impact on the performance of an aircraft operating on it. Whatever the means of communicating the report (SNOWTAM, automatic terminal information service (ATIS[1]), ATC), it should contain the elements that are comprehensively described in the PANS-Aerodromes (Doc 9981), Part II, Chapter 1, 1.1.3. These elements, including details on how they are relevant to the operation of an aeroplane and its performance, are presented below.

2.2.2 The information provided by an RCR is divided in two sections: the aeroplane performance calculation section, which contains information that is directly relevant in a performance computation; and the situational awareness section, which contains information that the flight crew should be aware of for a safe operation but does not have a direct impact on the performance assessment.

2.2.3 The aeroplane performance calculation section is a string of grouped information with clear identifiers to distinguish it from the situational awareness section, or from the aeroplane performance calculation section of another runway. The information included in the aeroplane performance calculation section consists of:

a) *Aerodrome location indicator*. The four-letter ICAO location indicator, in accordance with *Location Indicators* (Doc 7910).

b) *Date and time of the assessment.* Especially important whenever there is active precipitation, as the flight crew can assess the magnitude of its evolution since the report was generated. It should be understood that reports are snapshots at a given date and time and do not indicate a prediction of conditions at a later date and time.

c) *Lower runway designation number.* The information is conveyed per third of the runway. The direction of reporting information relating to these thirds is always from the end with the lower designator number (except in a report by ATC, which will always be in the operational direction). The reference length for the runway is described in 2.3.2 and in line with this, not all of the runway length to which the report applies may be relevant to the particular operation (take-off or landing). In case of differences between the different thirds, the pilot should assess which parts of the reported conditions are relevant.

d) *Runway condition code for each runway third.* This code classifies the available braking action in one of seven categories. This code is a direct input into a landing performance assessment at time of arrival but should also never be disregarded for take-off. As conditions are always reported in the direction of the lower runway designator in the RCR, pilots are expected to attribute the information from each runway third correctly for their intended operation.

e) *Per cent coverage contaminant for each runway third.* Contamination is reported only when the coverage exceeds 10 per cent. Runway contamination affects aeroplane performance only when the coverage exceeds 25 per cent in at least one third. However, the flight crew should exercise judgement as to the location of the contamination in the perspective of the portion of the runway that the aircraft will be using for the intended operation. Runway inspectors are advised to focus on the area around the wheel tracks when assessing coverage.

f) *Depth of loose contaminant; dry snow, wet snow, slush or standing water for each runway third.* This information is conditional. For contaminants other than standing water, slush, wet snow or dry snow, the depth is not reported. The position of this type of information in the information string is then identified by /NR/.

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1. The minimum elements to be transmitted on ATIS are presented in Circular 355 section 4.68

g) *Condition description for each runway third.* Only one type of contamination is reported for each runway third (this includes layered contaminants) and the runway inspector should include the contaminant type most prevalent or most relevant to performance. In contentious cases, contamination judged to be secondary may additionally be reported in the free text section.

h) *Width of runway to which the RWYCCs apply, if less than published width.* Whenever clearing cannot occur on the entire width of the runway, the aerodrome personnel may report only the contaminant remaining on the cleared centre portion of the runway. This item indicates the width of this section. RWYCCs apply only to this centre section.

2.2.4 Examples of the RCR aeroplane performance calculation section are given below:

EADD 02170055 09L 5/5/5 100/100/100 NR/NR/NR WET/WET/WET

EADD 02170135 09R 5/2/2 100/50/75 NR/06/06 WET/SLUSH/SLUSH

EADD 02170225 09C 2/3/3 75/100/100 06/12/12 SLUSH/WET SNOW/WET SNOW

2.2.5 The situational awareness section consists of the following items, with guidance on how the flight crew should consider situational awareness in briefings and actual flight operations in cold weather conditions:

a) *Reduced runway length.* The flight crew should check that the correct landing distance available (LDA)/take-off distance available (TODA)/take-off run available (TORA)/accelerate-stop distance available (ASDA) is used in performance calculations, and verify the position of the runway threshold in use.

b) *Drifting snow on the runway.* Be aware of the optical illusion of a “moving runway” in crosswind conditions.

c) *Loose sand on the runway.* Be aware of sand ingestion to engines if using reverse thrust. Adjust performance calculations according to the intended use of reversers.

d) *Chemical treatment on the runway.* Some operators may collect this information because of brake wear.

e) *Snowbanks on the runway.* Be aware of snowbanks if cleared width is less than full runway width. There is a danger of losing directional control or snow ingestion into the engines.

f) *Snowbanks on taxiway.* Avoid taxiing to keep clear of snow ingestion.

g) *Snowbanks adjacent to the runway.* Avoid taxiing to keep clear of snow ingestion.

h) *Taxiway conditions.* Adjust taxiing speed & techniques accordingly.

i) *Apron conditions.* Adjust taxiing speed & techniques accordingly.

j) *State approved and published use of measured friction coefficient.* Use only if approved by the operator.

k) *Plain language remarks.* Note any other relevant information.

2.2.6 An example of the RCR situational awareness section is given below. All individual messages in the situational awareness section end with a full stop sign to distinguish the message from subsequent messages:

RWY 09L SNOWBANK R20 FM CL. RWY 09R ADJ SNOWBANKS. TWY B POOR. APRON NORTH POOR.

2.3 RUNWAY CONDITION CODE (RWYCC)

2.3.1 The RWYCC is a single-digit number describing the deceleration and lateral control capability for the runway surface condition. They are assigned to each runway third whenever the coverage of any water-based contaminant on that runway third exceeds 25 per cent. It is the total assessment of the slipperiness of the surface, as judged by the trained and competent aerodrome personnel and based on given procedures and all information available, and enables flight crew to determine the effect of the runway surface condition on aeroplane deceleration performance and control. There are seven surface condition levels associated with RWYCC numbers zero to six and they represent conditions that range from too slippery to operate on (zero), to completely dry conditions (six). Each RWYCC (except zero) is matched with a corresponding aeroplane deceleration performance level. Airport operations staff assign the RWYCC based on the conditions observed in their physical evaluations of runway conditions, which are then included in the RCR as discussed in the previous section. Measured coefficients of friction should no longer be communicated to pilots but restricted to use by the airport staff in consolidating the runway surface condition assessment made from observed surface contamination characteristics like type, depth and temperature. As a general rule, the runway contaminant type and depth permit determination of a RWYCC, but a RWYCC can never give contaminant type and depth.

2.3.2 The reference runway length will typically be the full length of asphalt or concrete available for take-off or landing. However, it should be noted that when a stopway exists at the airport, it is excluded from the scope of the runway surface for which RWYCC are assigned. This is shown in Figure 2-1, which illustrates the runway thirds and RWYCCs for runways with and without, a displaced threshold. It is important for the flight crew to be aware that the stopways will see less traffic than the rest of the runway surface and may therefore be subject to more accumulation of contamination. If the condition of the stopway is significantly different from the rest of the runway, this should be reported in the free text comments of the RCR.

2.3.3 As new information becomes available, there may be a need to revise the RWYCC assigned. The RWYCC may be downgraded or upgraded in accordance with the procedures contained in the PANS-Aerodromes (Doc 9981). New information may be acquired by aerodrome personnel from additional observations of the runway surface. Reports from pilots following aeroplane operations on the runway, known as an air-report (AIREP) and that reflect the impact of the surface condition on the braking action of the aeroplane, also allow the aerodrome personnel to revise the RWYCC assigned. More information on AIREPs is provided in section 2.4 of this chapter.

2.3.4 The airport staff use any updated information to downgrade or upgrade a RWYCC in accordance with the procedures associated with the runway condition assessment matrix (RCAM). The RCAM provides a combination of available information (runway surface conditions, including runway state and contaminant; pilot report of runway braking action) in order to assess the RWYCC. The RCAM is a tool to be used when assessing runway surface conditions. It is not a standalone document and is used in compliance with the associated assessment procedures. The RWYCC and runway braking action are mapped against each other, enabling aerodrome personnel to factor in all available information and update the assigned RWYCC if necessary. Such a decision cannot be taken by a flight crew on the approach, as it must be supported by all other observations.

2.3.5 Upgrading a primary RWYCC 5, 4, 3 or 2 determined from the observed contaminant type is not allowed. The flight crew may thus trust the reported RWYCC if it is equal or lower than the corresponding contaminant stated as plain language. A RWYCC 1 or 0 can, in exceptional cases, be upgraded to a maximum of 3 even when the contaminant that has caused this primary classification has not been removed. It may have been treated with sand or gravel, or simply provide exceptional friction due to its inherent characteristics, as assessed by trained aerodrome personnel.

2.3.6 Some circumstances are prone to rapid changes in the runway surface conditions and, therefore, how conditions affect aeroplane braking action and lateral control. In such cases, the flight crew may ask for a recent report, if the last available report may not correctly reflect the prevailing conditions at the time of landing. Examples of such conditions are active precipitation and when the runway is contaminated with compacted snow or ice with an outside air temperature (OAT) above -3°C or a difference between OAT and dewpoint of 3°C or less. If a recent report is not available, the flight crew should consider an appropriate lower RWYCC in their assessment of the worst likely degradation of the conditions.

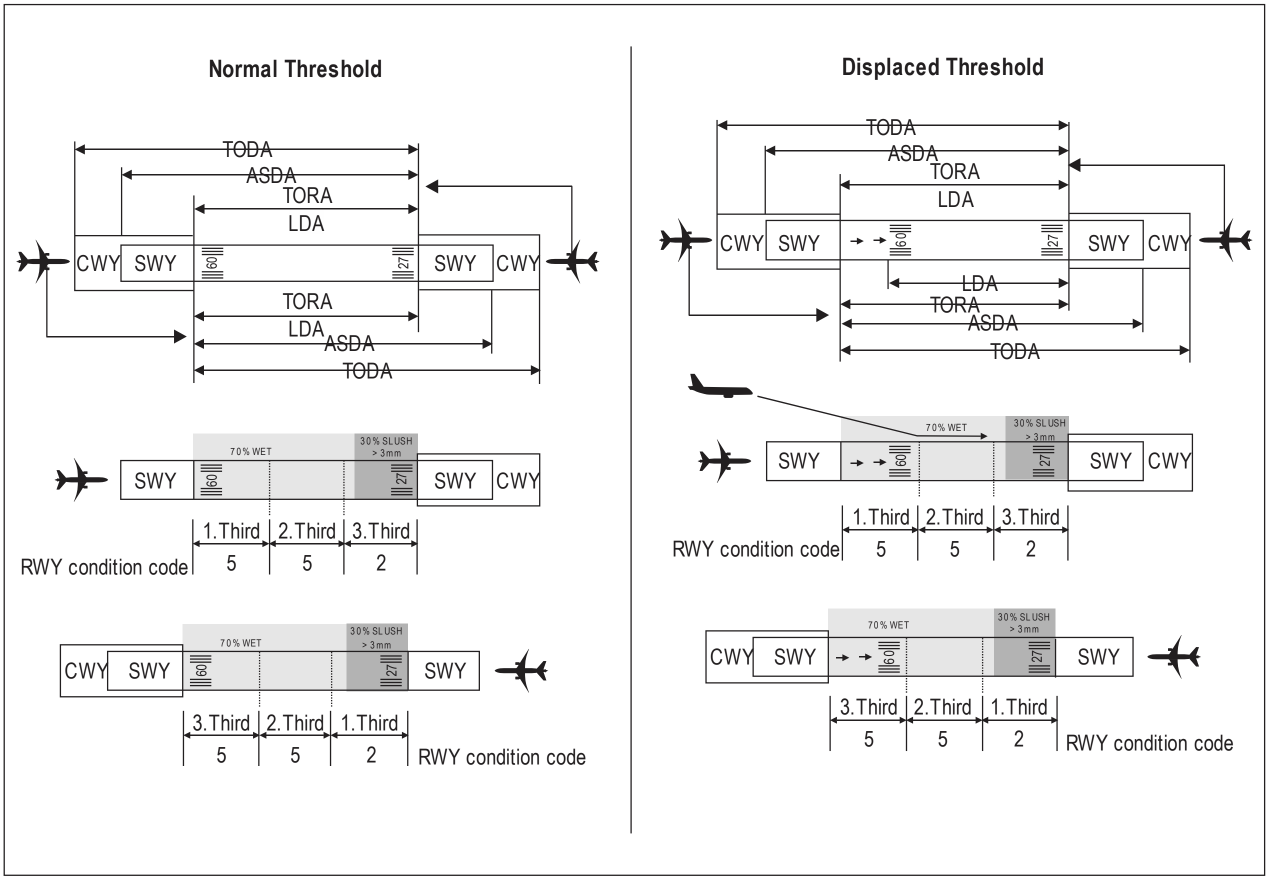

Figure 2-1 Reporting of runway condition code from ATS to flight crew for runway thirds (PANS-Aerodromes (Doc 9981) Part II)

2.3.7 Information about sanding and chemical treatment information is shown in the situational awareness section of the RCR. The aerodrome operator decides how to use these treatments as they best understand their effectiveness. Inadequately applied sand or sand displaced by aeroplane traffic may not be efficient and the initial effect of chemicals may be a degradation of the achievable friction. As the reported RWYCC already considers their effect on performance, no automatic extra credit can be attributed to sanding or chemical treatment when calculating the landing distance. Loose sand in RCR is for flight crew situational awareness and is intended to mitigate the risk of foreign object debris (FOD) to the engines.

2.4 PILOT REPORT AFTER LANDING

2.4.1 The role of the pilot in the runway surface condition reporting process does not end once the aeroplane safely exits the runway. While the aerodrome operator is responsible for generating the RWYCC for a runway, pilots are responsible for providing accurate braking action reports. Annex 6, Part I, 4.4.2.1 mandates that the flight crew make AIREPs whenever they observe worse runway braking action than previously reported. It is up to the pilot to assess the manner in which an aircraft responds to the application of wheel brakes. These reports provide feedback to the aerodrome operator regarding the accuracy of the assigned RWYCCs relative to the runway surface conditions actually experienced. Table 2-1 shows the correlation of pilot reports of runway braking action with RWYCCs (this table forms part of the overall RCAM).

Table 2-1. Correlation of runway condition code and pilot reports of runway braking action

Pilot report of runway braking action	*Description*	*RWYCC*
N/A		6
GOOD	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	5
GOOD TO MEDIUM	Braking deceleration OR directional control is between good and medium.	4
MEDIUM	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	3
MEDIUM TO POOR	Braking deceleration OR directional control is between medium and poor.	2
POOR	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	1
LESS THAN POOR	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	0

Note.— Operations in conditions where LESS THAN POOR braking action prevails are prohibited.

2.4.2 Air traffic control (ATC) relays the pilot reports of runway braking action to the aerodrome operator who in turn uses them in conjunction with the RCAM to determine if the RWYCC should be downgraded until the runway surface condition is improved. These reports thus play an important part in the cycle of runway surface condition assessment and reporting. Since both the ATC and the aerodrome operator rely on accurate runway braking action reports, pilots should become familiar with this terminology and use it when providing controllers with runway braking action reports. If the differences between two consecutive levels of the categories between “GOOD” (RWYCC 5) and “LESS THAN POOR” (RWYCC 0) are too subtle for the pilot to detect, the pilot may report on a coarser scale of “GOOD”, “MEDIUM” and “POOR”.

2.4.3 During periods of increased traffic flow, runway inspection and maintenance may be less frequent and should be sequenced with aeroplane arrivals. Aerodrome operators may depend on runway braking action reports to confirm that the runway surface condition is not deteriorating below the assigned RWYCC. Whenever requested by ATC, or if the assessed runway braking action is less than previously reported, pilots should provide a braking action report. This is especially important where the experienced braking action differs from the braking action associated with any RWYCC currently in effect. When the braking occurrence and the report match up, the pilot and the aerodrome operator gain additional confidence in the reported runway codes. AIREPs play an important role in preventing runway excursions as reports of runway braking action below the assigned RWYCC may influence a subsequent pilot’s decision to continue with a landing. A report from a preceding aeroplane is all the more reliable when it emanates from another aircraft with landing performance capabilities similar to his/her own. The pilot should, however, be conscious that even similar aeroplanes may be operated at a very different mass and approach speeds. Aircraft control or safety should not be jeopardized during taxiing when communicating the report; pilots should provide the report only when it is safe to do so.

2.4.4 There can be difficulties in making reports of braking action for the pilot since these reports are intended to characterize only one of the aeroplane deceleration elements: the availability of wheel braking. When operating on long dry or wet runways, pilots apply low autobrakes or partial pedal braking. For most landings, only idle reverse thrust is used. Landing on slippery or contaminated runways requires a different technique and results in the energy dissipation by the aerodynamic means, use of reverse thrust, and applied wheel braking in different proportions than during a "normal" landing. Aerodynamic drag and reverse thrust are most effective at high speed and initially can, by themselves, generate a deceleration rate that can be close to that experienced in non-performance limited landings. The lack of wheel-to-ground friction during the high speed portion of the landing may thus not be immediately apparent to the pilot, although reduced lateral control due to reduced cornering forces may be an indicator of reduced wheel-to-ground friction. As the aeroplane decelerates, drag and reverse thrust become less effective and thrust reversers may be stowed between 70 and 60 kts, in line with manufacturer recommendations for normal landings (they can typically remain deployed to full stop if necessary, but when it is not required to ensure a safe stop, manufacturers recommend stowage to avoid re-ingestion). During the lower speed portion of the landing, the deceleration is, to a large extent, created by the wheel brakes. It is consequently in this phase that the reduced braking action is most noticeable to the pilot. The pilot should, however, attempt to characterize the entire length of runway used during the stop in an AIREP.

2.4.5 Furthermore, flight crew must understand that a report will only be relevant when the braking demand has exceeded the braking action available, i.e. the anti-skid system, if installed, has regulated brake pressure below that commanded by the pilot or the autobrake system, to avoid skidding and maintain a close-to-optimum slip ratio. The braking is then called "friction limited". Braking occurs when the tire is slowed relative to the runway by applying pressure on the brakes. The maximum braking force occurs when the tire speed is between 7 and 15 per cent slower than the ground speed of the aeroplane, referred to as the slip ratio. On slippery runways, the tire may have a tendency to stop due to lack of friction. Most modern airplanes are equipped with anti-skid systems that prevent such skidding from occuring and optimize the slip ratio for maximum braking. Friction-limited braking thus occurs when the pilot, or the anti-skid system when available, must adjust brake pressure to avoid skidding. There is usually no indication in the cockpit to inform the pilot that the anti-skid system is cycling. Skidding may not occur on all wheels simultaneously.

2.4.6 When using manual braking, the pilot can, to some extent, judge the available braking action by the amount of pedal deflection, above which, no increase in deceleration occurs. Brake pressure control may not be linear with pedal deflection. When using autobrakes, the system targets an overall airplane deceleration rate. At low target values, the system may release the brake pressure to a large extent when the target can be achieved with aerodynamic and reverse thrust only. In autobrake mode, the pilot can only detect lack of braking action when the target deceleration is not achieved; i.e. the braking demand is above the existing capability and the braking is friction limited. Cockpit deceleration indications may not be accurate enough to indicate whether the requested deceleration is achieved or not. In such cases, the commander needs to use their best judgement on whether to report braking action.

2.4.7 A condition where a valid braking action report can be observed rarely occurs over the full length or width of a runway. Therefore, when possible, the flight crew should communicate the sections of runway in which wheel braking was applied and/or directional control difficulties were encountered, e.g. "Braking Action Medium on last third of runway 08" or "Braking Action Poor on high-speed exit Bravo Runway 20."

2.5 TRAINING REQUIREMENTS

2.5.1 Both airline operators and flight crew should be appropriately trained on runway surface condition assessment and reporting, and on the impact on the aeroplane performance data. While the methodology establishes a clear link between the observation, reporting and accounting for runway surface conditions in performance, it also creates new paths for errors that should be highlighted during the proactive training of crew. As the assessment of the runway condition, friction measurement, and estimation of braking action are not an exact science, it is important that training emphasizes that the methodology provides a toolset permitting an approximate assessment of the aeroplane performance rather than establishing exact aeroplane behaviour in terms of numbers.

2.5.2 The overall time for initial training on the global reporting format should be no less than 1.5 hours and include face-to-face elements with an instructor in addition to self-study. Having the appropriate attitude and mind-set should also be part of the objectives met in addition to the knowledge and skills required.

2.5.3 A training syllabus should include the following, as a minimum (a more complete list of training items is presented in the *Assessment, Measurement and Reporting of Runway Surface Conditions* (Cir 355), Appendix H):

a) The history of runway surface condition reporting:

  1) accident history; and

  2) reasoning and description of the reporting method.

b) The purpose of new runway surface condition reporting.

c) Matrix fundamentals:

  1) RCAM layout:

    i) differences between those published for aerodromes and flight crew;

    ii) format in use;

    iii) the use of runway friction measurements;

    iv) the use of temperature;

    v) the concept of "performance buckets" and ICAO runway surface condition codes;

  2) runway contaminant definitions;

  3) depth measurements;

  4) runway coverage: errors in the reporting percentage coverage and how reporting in thirds can produce highly deceptive information to the flight crews;

  5) use of the term "slippery wet": conditions must be effectively observed and reported; and

  6) downgrading or upgrading criteria.

d) Flight crew related actions:

  1) the difference between a calculation and an assessment;

  2) effects of aircrew task loading on receiving condition reporting; and

  3) pilot braking AIREPs: pilots must understand the physics the reports represent as well as the techniques necessary to produce an accurate observation.

e) Types of runway contamination and its effects:

  1) general types of contaminant;

i) solid;

ii) loose; and

iii) deformable.

f) Aircraft performance:

1) effects of contamination during take-off;

2) effects of contamination during landing;

3) airport items used for landing;

i) visual cues; and

ii) Category III cues;

4) the components of a pilot braking report;

i) how to give an accurate report; and

ii) when reports are not valid;

g) Operational observations with friction devices: the friction measuring devices must be properly calibrated and operated and should meet the standard and correlation criteria set by the State.

h) Critical areas of the runway;

i) Safety considerations;

1) types of errors possible;

2) mindfulness principals necessary for high reliability; and

3) safety reporting.

j) Documentation and records.

2.5.4 The introduction of the runway surface condition assessment and reporting format has highlighted some specific areas that should be addressed as part of a training plan, including:

— *Techniques used as a best practice for one organization may not be applicable for others.* Example: Airports that operate frequently in winter conditions may develop observational techniques that rely on extensive experience and apprenticeship. Other airports may find it hard to match that same level of expertise. Using vehicle braking observations, for example, may not be a best practice if the airport is not exposed to winter conditions long enough to maintain this type of corporate knowledge.

— *Misunderstanding terminology.* Technical discussions on runway observations and aircraft vehicle performance can have similar sounding terms and even numbers: “MU” being a primary example. Anyone using an RCAM should understand what the terms are, and how they are related.

— *Timeliness of communication.* Beyond 180 NM, flight crews may obtain information from airports in order to make runway surface condition assessments. Between 180 and 40 NM, any change in condition reporting must be communicated to the flight crew. Within 40 NM, any change in runway surface condition must be pro-actively communicated to the aircraft. Any change in condition that occurs too quickly for the flight crew to take notice of can invalidate their assessment and lead to unexpected risk.

— *Conflicting reports between pilots and aerodromes.* There may be a range of aeroplane performance indicators for a given runway. In some cases, the AIREP of braking action may be more accurate than the condition report. These reports can be more or less conservative than the original report by the aerodrome. If an operator wishes to base their risk management process on an AIREP that is less conservative than a runway condition report, the process must be carefully designed to demonstrate and maintain an equivalent level of quality assurance regarding risk exposure.

— *Operational bias*. Much of the observational criteria for an RCAM depends on judgment that can be subject to social, political and economic pressures. The differences between 3 mm and 5 mm of contaminant or between wet snow and slush can have a large effect on operations. It is a human factors norm that people tend to bias perceptions in favour of what they expect to hear and see, and disregard information that does not fit into a pre-planned expectation. This lack of mindfulness can contribute greatly to errors in the perception, assessment and reporting of runway surface conditions from flight crews and airports.

2.6 GENERAL CONSIDERATIONS FOR AEROPLANE PERFORMANCE ON CONTAMINATED RUNWAYS

2.6.1 As previously discussed, the RCR reflects the runway braking capability as a function of the surface conditions. With this information, the flight crew can derive the necessary stopping distance of an aircraft under the prevailing conditions from the performance information provided by the aeroplane manufacturer. Aeroplane deceleration results from a combination of factors. First, there are the aerodynamic drag forces generated by the airframe and, in particular, the ground spoilers. Second, reverse thrust may be used if available. Finally, deceleration occurs from wheel-to-ground friction, which is of course influenced by the runway surface, as well as by manual or automated braking of the aeroplane. Performance computations assume a homogenous distribution of the contaminant along the entire length and width of the runway. Coverage reported as 25 per cent may be significantly less and is provided only for situational awareness. Performance calculations may then assume a dry or wet runway as appropriate, but any coverage in excess of 25 per cent should be considered as though the entire runway is covered. In other words a runway will be considered contaminated if one of the thirds has contaminant coverage in excess of 25 per cent.

2.6.2 The difficulties for a pilot to make an accurate report as illustrated here have led to research and development activities that use aircraft data recorded during the ground run to identify the available braking action objectively. Such technologies are now becoming available to assist the pilot in this task.

2.6.3 The RCR restricts the list of layered contaminants that can be reported. The most frequent cases are included, but some scenarios cannot be reported with specific terminology. In those cases, the aerodrome operator will strive to report the performance-relevant condition. When necessary, free text may be used to describe the actual condition of the runway. In most cases, layered contaminants lead to less than poor braking action and do not permit operation unless appropriately mitigated by the airport in order to upgrade the reported RWYCC. An exception to this is dry snow on top of compacted snow or wet snow on top of compacted snow, which is classified as medium braking action. The reported depth of this contaminant refers only to the top layer of loose snow and may be used in selecting the appropriate contaminant for performance computations, when the manufacturer has chosen to provide landing performance as a function of contamination rather than RWYCC. Even when this is not the case, the flight crew should ensure that the reported depth does not exceed the maximum depth of loose snow.

2.6.4 Aeroplane performance tables and computation tools assume a homogenous contaminant type and depth along the entire runway length and width. However, there may be significant differences reported between the runway thirds. The flight crew may use the most penalizing contaminant for performance computation, which may be excessively conservative. For this reason, the operator may have policies about disregarding a part of the runway. In such cases, the operator should give explicit guidance for crosswind analysis. For example, the flight crew could use only the two last thirds for landing distance calculations; or if the runway end was much more slippery than the first two thirds and it is possible to bring the aeroplane to a full stop in the less slippery part (two first thirds), the flight crew could be given a possibility to omit the last third. Computations accounting for different conditions in each runway third are not available from manufacturers, as regulation specifies that the contaminant should be assumed to be evenly distributed for establishing performance. Additionally, this capability may not be desirable as the computed landing distance with this method has been shown to be very sensitive to aeroplane speed evolution vs. location on the runway; it may not be representative of what will be achieved during the actual stop.

2.6.5 Any change to the normal runway length available for take-off and landing is always communicated by NOTAM. The RCR may mirror the NOTAM if there is a change to the landing distance available, as a reminder for inbound flight crew. Departing flight crews should have fresh NOTAMs and calculate take-off performance accordingly. If, for any reason, part of the runway length has not been cleared in due time, the runway is considered to be usable by its full length and the un-cleared contaminant should be reflected in the RWYCC in the RCR. Policies mentioned in paragraph 2.6.7 may be applied, and the flight crew may also consider postponing the landing. The cleared runway width may also be limited for various reasons in adverse weather. This situation is often ad hoc and NOTAM communications may be too slow to reach flight crews in time. Therefore, a partially cleared width may be reported by RCR. Operators should have explicit policies for partial cleared runways, i.e. a defined minimum cleared width for each aeroplane type and possible reductions in the maximum permitted crosswind. The aerodrome should update the report whenever a significant change, relevant to aircraft performance, occurs to the runway condition, but this may be difficult in an active weather event. Note also that the maximum validity period of a SNOWTAM is 8 hours.

2.6.6 For both grooved or porous friction course (PFC) runways, and non-grooved or non-PFC runways, experience has shown that wheel braking is degraded when the runway is very wet. The root cause of the wet runway stopping performance shortfall is not fully understood; however, runway characteristics that appear to be contributors include texture (polished or rubber contaminated surfaces), drainage, puddling in wheel tracks and active precipitation. An analysis of this data indicates that 30 to 40 per cent of additional stopping distance may be required in certain cases where the runway is very wet, but not flooded. Wheel braking may be degraded when the runway is very wet, even when the runway has not been reported as “slippery wet”. If active moderate or heavy precipitation exists, the operator should consider additional conservatism in their assessment of performance at time of landing that is over and above that already calculated for wet conditions.

2.6.7 Possible methods of applying additional conservatism when operating on a runway that is degraded when very wet include assuming a braking action of medium (RWYCC 3) when computing performance at time of landing or increasing the factor applied to such an assessment established with landing performance data for RWYCC 5 (good braking action). A pilot should consider reduced crosswind limits and ensure the prompt application of braking means after touch-down, including the use of maximum reverse thrust until a safe stop is assured.

2.6.8 Operators should be aware of the runway maintenance program and wet runway friction capability at the airports in which they operate. Mitigation should be considered at airports where aircraft operators have a reason to suspect that the runway is not maintained in a condition such as to provide surface friction characteristics at or above the minimum friction level specified by the State (see Annex 14, Volume I, 10.2.2) while very wet during active precipitation.

2.6.9 Whenever an operator uses a performance credit for specific operations on grooved or PFC runways, the performance data has usually been prepared appropriately by the manufacturer and was approved by the State of the Operator. Its use may be subject to operational conditions and procedures. It is the responsibility of the operator to ensure that the runway has been constructed and maintained in accordance with the applicable guidance, such as those laid out in the *Aerodrome Design Manual* (Doc 9157). The extent of the performance credit given to the data should not be assumed to be valid systematically on all runways that, in appearance, have grooved or PFC surfaces.

Chapter 3

TAKE-OFF PERFORMANCE

3.1 GENERAL

3.1.1 Aeroplane manufacturers or type certificate holders publish take-off performance information (for example, runway limitations, climb capability and flight path) in the flight manual that complies with the regulation of the State of Design. Certification standards are harmonized among States to a great extent for dry and wet runway; however, no guidance on how to establish certification compliance is included in this manual. Guidance is provided for performance limitations during the initial climb and for ensuring obstacle clearance throughout the departure sector.

3.1.2 Performance information for contaminated runways has not been required by all States and may have been developed to a variety of standards. Subsequent sections of this chapter provide guidance on how this data should be derived for consistency with the information provided in the RCR.

3.2 TAKE-OFF PERFORMANCE LIMITATIONS

3.2.1 Standards on the limitations for aeroplane mass are presented in Annex 6. No aeroplane should commence a take-off at a mass which exceeds the take-off mass specified in the flight manual for the altitude of the aerodrome and for the ambient temperature existing at the time of the take-off. Furthermore, no aeroplane should commence a take-off at a mass which exceeds the mass at which, in accordance with the minimum distances for take-off scheduled in the flight manual, compliance with the following is shown:

a) the take-off run required should not exceed the take-off run available;

b) the accelerate-stop distance required should not exceed the accelerate-stop distance available; and

c) the take-off distance required should not exceed the take-off distance available. When showing compliance with this requirement, the same value of the decision speed (V_1) for the continued and discontinued take-off phases should be used.

3.2.2 Operators must consider all the influencing factors when calculating take-off performance. The following parameters should be considered when determining the take-off distances:

a) the pressure altitude at the aerodrome;

b) the ambient temperature at the aerodrome;

c) the runway surface conditions, as listed in the definition of the runway surface descriptors, and the type of the runway surface;

d) the runway slope in the direction of the take-off;

e) not more than 50 per cent of the reported headwind component or not less than 150 per cent of the reported tailwind component; and

f) the loss, if any, of runway length due to alignment of the aeroplane prior to take-off.

Note.— The length required for aeroplane alignment with the runway axis should be determined in compliance with the minimum clearance distances between the outer main wheel of the aeroplane and the edge of the taxiway or runway given in Annex 14, Volume 1, 3.9.3.

3.2.3 Credit is not taken for the length of the stopway or the length of the clearway unless they comply with the relevant specifications in Annex 14, Volume I. Credit is not taken for the length of the clearway on wet or contaminated runways for the one engine inoperative calculation.

3.3 TAKE-OFF OBSTACLE CLEARANCE LIMITATIONS

3.3.1 No aeroplane should commence a take-off at a mass in excess of that indicated in the flight manual to correspond with a net take-off flight path, which clears all obstacles either by at least a height of 10.7 m (35 ft) vertically or at least 90 m (300 ft) plus 0.125 D laterally, where D is the horizontal distance the aeroplane has travelled from the end of take-off distance available (or the end of the take-off distance if a turn is scheduled before the end of the TODA). Exceptions include situations where the intended track of the aeroplane does not include any change of heading greater than 15° for operations conducted in visual meteorological conditions (VMC) by day, or for operations conducted with navigation aids such that the pilot can maintain the aeroplane on the intended track with the same precision as for operations conducted in VMC by day. Obstacles at a distance greater than 300 m (1000 ft) and 600 m (2000 ft) on either side of the intended track need not be cleared if the navigation system under one engine inoperative (OEI) conditions provides a two standard deviation accuracy of 150 m (500 ft) and 300 m (1 000 ft) respectively. For aeroplanes with a wingspan of less than 60 m (200 ft), a horizontal obstacle clearance of half the aeroplane wingspan plus 60 m (200 ft), plus 0.125D may be used.

Note.— For obstacle clearance in case of required navigation performance authorization required (RNP AR) terminal area procedures, please refer to the Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual (Doc 9905).

3.3.2 Different horizontal distances on either side of the intended track, up to which obstacle clearance has to be ensured, may apply. For VMC by day, obstacles should be considered if their distance from the intended track is within 300m (1000ft) for track changes of less than 15 degrees, and 600m (2000ft) for track changes of more than 15 degrees. For operations conducted in IMC, or VMC by night, obstacles should be considered if their distance from the intended track is within 900 m (3000 ft) for track changes of less than 15 degrees. Obstacles at a distance greater than 900 m (3000 ft) on either side of the intended track need not be cleared.

3.3.3 When determining the allowable deviation of the net take-off flight path in order to avoid obstacles by at least the distances specified, it is assumed that the aeroplane is not banked before the clearance of the net take-off flight path above the end of the TORA is at least one half of the wingspan but not less than 15.2 m (50 ft) high and that the bank thereafter does not exceed 15°, except as provided in the next paragraph. The net take-off flight path considered is for the altitude of the aerodrome and for the ambient temperature and not more than 50 per cent of the reported headwind component or not less than 150 per cent of the reported tailwind component existing at the time of take-off. The take-off obstacle accountability area defined above should include the effect of crosswinds.

3.3.4 An aeroplane may be operated with bank angles of more than 15° below 120 m (400 ft) above the elevation of the end of the take-off run available, provided special procedures are used that allow the pilot to fly the desired bank angles safely under all circumstances. Bank angles should be limited to not more than 20° between 30 m (100 ft) and 120 m (400 ft), and not more than 25° above 120 m (400 ft). Methods approved by the State of the Operator should be used to account for the effect of bank angle on operating speeds and flight path including the distance increments resulting from increased operating speeds. The manufacturer generally provides a climb gradient decrement for a 15° bank turn. For bank angles of less than 15°, a proportionate amount should be applied unless the manufacturer has provided other data.

3.3.5 Unless otherwise specified in the flight manual or other performance or operating manuals from the manufacturer, acceptable adjustments to assure adequate stall margins and gradient corrections are provided in Table 3-1.

Table 3-1. Loss of gradient in a turn

Bank	Speed	Gradient correction
15°	V_2	1 x 15° gradient loss
20°	V_2 + 5 kt	2 x 15° gradient loss
25°	V_2 + 10 kt	3 x 15° gradient loss

3.3.6 The net take-off flight path in which the aeroplane is banked by more than 15° should clear all obstacles by a vertical distance of at least 15.2 m (50 ft) within the horizontal distance specified at the beginning of this chapter. The use of bank angles greater than those mentioned above should be subject to the approval from the State of the Operator. Conditions for obtaining approval may include:

a) Approved data contained in the flight manual for the required increase of operating speed and data to allow the construction of the flight path considering the increased bank angles and speeds.

b) Availability of visual guidance for navigation accuracy.

c) Specifications for weather minima and wind limitations for each runway.

d) Adequate knowledge by the flight crew of the route to be flown and of the procedures to be used.

3.3.7 In accordance with the definitions used in preparing the take-off distance and take-off flight path data provided in the flight manual, the net take-off flight path is considered to begin at a height of 10.7 m (35 ft) above the runway or clearway at the end of the take-off distance determined for the aeroplane. The take-off distance is the longest of the following distances:

a) 115 per cent of the distance with all engines operating from the start of the take-off to the point at which the aeroplane is 10.7 m (35 ft) above the runway or clearway;

b) the distance from the start of the take-off to the point at which the aeroplane is 10.7 m (35 ft) above the runway or clearway, assuming failure of the critical engine occurs at the point corresponding to the decision speed (V1) for a dry runway; or

c) if the runway is wet or contaminated, the distance from the start of the take-off to the point at which the aeroplane is 4.6 m (15 ft) above the runway assuming failure of the critical engine occurs at the point corresponding to the decision speed (V1) for a wet or contaminated runway.

3.3.8 The net take-off flight path, determined from the data provided in the flight manual in accordance with the previous paragraph, should clear all relevant obstacles by a vertical distance of 10.7 m (35 ft). When taking off on a wet or contaminated runway and an engine failure occurs at the point corresponding to the decision speed (V1) for a wet or contaminated runway, this implies that the aeroplane can initially be as much as 6 m (20 ft) below the net take-off flight path in accordance with the statements above for dry runways and, therefore, may clear close-in obstacles by only 10.7 m (15 ft). When taking off on wet or contaminated runways, the operator should exercise special care with respect to obstacle assessment, especially if a take-off is obstacle-limited and the obstacle density is high.

3.3.9 For the purpose of the take-off obstacle clearance analysis, the end of the take-off flight path occurs when:

a) the aeroplane has reached the minimum crossing altitude (MCA) at a fix or the minimum en-route altitude (MEA) for a route to the intended destination; or

b) the aeroplane is able to comply with en-route obstacle clearance requirements (Chapter 4); or

c) the aeroplane has reached the altitude at which it may be safely guided; or

d) the aeroplane has reached a fix and altitude from which an approach may be initiated, if the operator's emergency procedure calls for an immediate return to the departure airport or a diversion to the departure alternate in the event of an engine failure during take-off.

3.3.10 When determining the limiting take-off mass, the obstacle analysis should be carried out to the end of the take-off segment as defined in the previous paragraph. Operators should note that the end of the take-off segment is determined by the gross flight path of the aeroplane, but the obstacle analyses must use the net flight path data. However, once the aeroplane has transitioned to en-route configuration, final take-off speed (V_{FTO}) is reached, and the height difference between the net and the gross flight path exceeds the minimum obstacle clearance (MOC) specified in PANS-OPS (Doc 8168), Volume 1, 1.4.1, whichever point is higher, obstacles may be considered cleared when the gross flight path clears them by the MOC.

3.3.11 In the event that the aeroplane cannot return to and land at the departure airport, the take-off flight path should join a suitable en-route path to the planned destination or to another suitable airport. It may be necessary to address extended times and alternate fuel requirements when climbing in a holding pattern with reduced climb gradients associated with one-engine-inoperative turns.

3.4 OBSTACLE CLEARANCE ON STANDARD INSTRUMENT DEPARTURES (SID)

3.4.1 To cover for an engine failure while flying the SID, the operator should establish contingency procedures to satisfy the net take-off flight path requirements and to provide a safe route, avoiding obstacles, for aeroplane to either comply with the en-route requirements or land at either the aerodrome of departure or at a take-off alternate aerodrome. Although there is no clear guidance on obstacle clearance and obstacle accountability area on the SID, the operator might consider using the net-take-off flight path requirements (section 3.3).

3.4.2 For an operator to determine that a departure maintains a safe obstacle clearance with an engine failure, they should consider that an engine failure may occur at any point on the departure flight path. The possibility of an engine failing after passing the point at which the OEI track diverges from the normal departure track should be considered. Judicious selection of this point may simplify the procedure and minimize the difficulty of this analysis. This is generally achieved by keeping the two tracks identical for as far as is practical.

3.4.3 In some cases, two or more special OEI tracks may be required to accommodate all potential engine failure scenarios. An analysis of an engine failure after take-off may require additional performance data to that already provided in the flight manual. For the purpose of the supplemental flight path analysis, manufacturers should supply operators with appropriate means of computing a combination of all engine flight path followed by an assumed engine inoperative flight path, be it either in a document or a computer program. To support this analysis, obstacle and terrain information for the terminal area should be provided by the State of the Aerodrome, ideally in electronic format in compliance with PANS-AIM (Doc 10066), Chapter 5.

3.5 OPERATIONS ON CONTAMINATED RUNWAYS

3.5.1 The impact on take-off performance of an aeroplane due to a contaminated runway, for example with water, snow, slush or ice covering, is sufficiently well understood to allow manufacturers to make available performance data that will permit a reasonable determination of the performance to be expected. This takes into account the reduced wheel-to-ground friction, including aquaplaning considerations, displacement, compression, and impingement drag. However, this determination can only be accurate for the prevailing conditions if the relevant parameters have been accurately observed, assessed and reported in line with the assumptions on which the performance data is based.

3.5.2 Take-off computations must consider the effect of the contaminant on both the acceleration and the deceleration segments. This is why take-off performance must be produced specifically for each type of winter contaminant and the operable range of depths of loose contaminants. When affected by loose contaminants of significant depth (above 3 mm), the RWYCC alone does not permit a conservative description of the effect of the runway surface condition on aeroplane take-off performance, in particular during the acceleration portion. Operations are prohibited beyond the maximum depth of the prevailing contaminant for which data has been provided.

3.5.3 When publishing such supplementary take-off performance analysis, manufacturers should provide aeroplane performance data consistent with the runway surface condition reporting terms, as defined in Annex 14, Volume 1, 1.1. For the purposes of take-off performance, the primary description used is the type and depth of contaminant, as they can significantly affect the ability of the aeroplane to accelerate (slush, standing water, snow) and the ability to decelerate and therefore stop (wet runway and all contaminants). Specific runway surface conditions for which a take-off performance analysis should be provided are:

a) wet (or associated equivalent conditions);

b) frost;

c) slippery wet;

d) compacted snow ⩽-15°C;

e) compacted snow >-15°C;

f) dry snow;

g) wet snow;

h) dry snow on top of compacted snow;

i) wet snow on top of compacted snow;

j) standing water;

k) slush; and

l) ice (cold and dry).

Note 1.— Runway surface conditions listed in the previous paragraph are consistent with the reporting procedures of the PANS-Aerodromes (Doc 9981).

Note 2.— A runway is "slippery wet" if braking deceleration for the wheel braking or directional control is noticeably reduced, even when the water depth is less than 3 mm. "Slippery wet" is not reported as such in the RCR. The fact that a runway surface or portions thereof are failing the minimum friction level set or agreed by the State of the Aerodrome is promulgated by a NOTAM identifying sections of runway that become slippery when wet. Whenever such a runway is wet, the report will show a RWYCC of no more than 3 for the appropriate runway third.

3.5.4 For wet and contaminated take-off performance, the following modifications to the standard methods of computing dry runway take-off performance calculation method are considered acceptable:

a) reduction of the screen height from 10.7 m (35 ft) to 4.6 m (15 ft) when computing the engine inoperative take-off distance;

b) credit for reverse thrust when calculating the required accelerate-stop distance, when available, reliable and controllable (effect of engine failure on available reverse thrust must be considered); and

c) for the purpose of obstacle clearance, the take-off flight path shall be considered to begin 10.7 m (35 ft) above the take-off surface at the end of the take-off distance even though the wet and contaminated runway take-off distance is defined to end at a height of 4.6 m (15 ft).

3.5.5 For runways covered with slush, snow, or standing water, the effect of the contaminant from the start of the take-off roll until the aeroplane has lifted off or come to a stop in case of rejected take-off should be considered. Determining the physical effects of the contaminants may be done by computation or by demonstration. The computation should be based on a uniform contaminant depth. For the purposes of take-off performance calculations, 3 mm or less of snow, slush or standing water on the runway surface can be considered a wet runway.

3.5.6 The following should be assumed when computing the take-off performance based on a contaminant that affects acceleration or deceleration capability:

a) the assumed contaminant specific gravity should be as defined in the following table:

Table 3-2. Specific gravity of loose contaminants

Runway description	*Specific gravity*
Dry snow	0.2
Wet snow	0.5
Slush	0.85
Standing water	1.0

b) reported depths for which wheel braking effect and contaminant drag should be considered:

Table 3-3. Depth ranges of loose contaminants

Runway description	*Reported depths (mm)*
Dry snow	>3 – 130
Wet snow	>3 – 30
Slush	>3 – 15
Standing water	>3 – 15

3.5.7 In the absence of appropriate test data or specific analysis, the effect of contaminant on drag and wheel braking should be based on parameters for the specific aeroplane to the greatest degree possible using assessment methods found acceptable by the competent authority of State of Design.

3.5.8 The list of reportable contaminants has been expanded from that for which performance data has usually been generated by manufacturers, so it may be the case that specific data for the new contaminants may not be available. As it is not possible to base take-off performance solely on the reported RWYCC, the following paragraphs provide guidance when considering newly defined contaminant in take-off performance considerations, based on the typical set of contaminants for which data has usually been generated. It is recommended that this guidance be confirmed with the original data provider whenever possible.

— *Frost.* Take-off data for a wet runway should be appropriate. Under some conditions, frost may become very slippery, in which case the assumption of a wet runway would be neither appropriate or conservative.

— *Slippery wet.* If the slippery portions of the runway are known, the manufacturer or operator may recommend an appropriate method to account for the performance penalty, such as to reduce the ASDA by the cumulative length of slippery portions, or to consider reduced or partial braking capability. The method should not unduly penalize operational procedures (such as prohibiting assumed temperature).

— *Compacted snow >-15°C*. Data provided in accordance with the European Union Aviation Safety Agency's (EASA) acceptable means of compliance (AMC) 25.1591 or European Joint Aviation Authorities (JAA) AMJ25X1591 will be appropriate for compacted snow at or below -15°C and should not be used when more slippery conditions are reported (i.e. below RWYCC 4). When data for low depths of dry snow, wet snow or slush is used, drag effects may lead to an optimistic assessment.

— *Dry snow or wet snow.* Guidance for establishing performance models for these contaminants has become available relatively recently and specific performance data may not be available except for the most recent type designs. Because specific friction of the order of RWYCC 3 is applied in conjunction with specific drag effects, and because it has been determined that equivalences based on contaminant density may not be relevant, use of performance data for another loose contaminant may not be entirely conservative. For some aircraft types, data published for various slush depths has been found to be acceptable in most conditions.

— *Dry snow or wet snow on top of compacted snow*. For these layered contaminants, the assumption is that the underlying compacted snow has no impact on take-off performance. When the airports report a depth of dry or wet snow on top of compacted snow, this depth relates only to the top layer of loose snow, as that is the performance-relevant information. For a report of a layer exceeding 3mm of dry snow on compacted snow or wet snow on compacted snow, performance can be assessed as if there was the loose snow layer only. Below this depth, the appropriate compacted snow performance data may be used.

— *Ice (cold and dry)*. JAA's and EASA's means of compliance define a very low wheel–to-ground friction coefficient for computations of performance on icy runways. This low value was originally considered to be representative of wet ice. In accordance with Annex 14, Volume I Standards, operations on a runway affected by wet ice should be discontinued until the situation can be remedied. Wheel-to-ground friction coefficients for ice in cold and dry conditions may exceed these assumptions considerably, as reflected by the table in section 5.2. Use of data established in accordance with EASA AMC 25.1591 or JAA AMJ25X1591 is thus conservative and may be used for reported icy conditions associated with a RWYCC 1.

3.5.9 The suggested equivalences above assume that the RWYCC reported along with the contaminant and depth is consistent with the classification shown in the RCAM of the PANS-Aerodromes (Doc 9981). However, in accordance with the procedures associated with the RCAM, the aerodrome personnel may use all other observations to downgrade or upgrade the RWYCC from that usually associated with a contaminant. Operators should provide recommendations in their operations manual on how to determine performance in such situations, considering that contaminant drag effects may not allow to identify simply a contaminant representative of the reported condition. In case of doubt, the prudent approach is to delay take-off. However, due to the low exposure to rejected take-off, it may be sufficient to determine performance in nominal conditions and to adopt appropriate operational procedures such as considering reduced crosswind limits or using the full length of available runway and potentially avoiding a rolling take-off.

3.5.10 In some cases, in particular during winter operations involving runways on which chemicals, wet sand or gravel have been applied, the airport may report better than nominal braking action for compacted snow or icy runways. Improved performance for such conditions may be used, subject to prior approval from the State of the Operator.

3.5.11 To address take-off performance assessment for layered contaminants, or in the case of different types of contaminants present on different runway thirds, operators should provide a policy to their flight crew.

3.5.12 Aerodrome operators may report that runways have been cleared only on a limited width around the centreline. Operators should have clear policies regarding the minimum cleared width acceptable and the height of snow banks beyond this width. More constraining crosswind limits may apply. Some manufacturers recommend determining take-off performance with penalties for narrow runways (increased minimum control speed on ground (V_{MCG})).

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Chapter 4

EN-ROUTE PERFORMANCE

4.1 GENERAL

4.1.1 Aeroplane manufacturers publish net drift down flight paths in the aeroplane flight manual (AFM) that comply with a harmonized certification regulation; this regulation is not addressed in this manual.

4.1.2 Aeroplane operators should comply with the en-route limitations stated in the sections below, as applicable. This compliance may be established allowing for consumption of fuel and oil.

4.2 ONE ENGINE INOPERATIVE (OEI)

4.2.1 No aeroplane should commence a take-off at a mass in excess of that which, in accordance with the OEI en-route net flight path data supplied in the flight manual, permits compliance with either of the two following paragraphs at all points along the route. The net flight path has a positive slope at 450 m (1 500 ft) above the aerodrome where the landing is assumed to be made after engine failure. The net flight path used is for the ambient temperatures anticipated along the route. In meteorological conditions where icing protection systems are to be operable, the effect of their use on the net flight path data is taken into account.

4.2.2 The slope of the net flight path is positive at an altitude of at least 300 m (1 000 ft) above all terrain and obstructions along the route, within 9.3 km (5 NM), when lateral navigation accuracy is at least 5 NM , or otherwise 18.5 km (10 NM), on either side of the intended track.

4.2.3 The net flight path permits the aeroplane to continue flight from the cruising altitude to an aerodrome where it can land. It must vertically clear, by at least 600 m (2 000 ft), all terrain and obstructions along the route, within 9.3 km (5 NM), when lateral navigation accuracy is at least 5 NM , or otherwise within 18.5 km (10 NM), on either side of the intended track. The following provisions are applied:

a) the engine is assumed to fail at the most critical point along the portion of the route;

b) the effects of winds on the flight path are considered;

c) fuel jettisoning is permitted to an extent consistent with reaching the aerodrome with satisfactory fuel reserves, if a safe procedure is used; and

d) the aerodrome where the aeroplane is assumed to land after engine failure meets the appropriate aerodrome operating minima at the expected time of use.

4.3 TWO ENGINES INOPERATIVE — AEROPLANES WITH THREE OR MORE ENGINES

4.3.1 At no point along the intended track should an aeroplane with three or more engines be more than 90 minutes away from an aerodrome (at all engines' normal cruising power or thrust, as applicable), at which the distance specifications for alternate aerodromes are observed and where a safe landing can be made, unless the aeroplane complies with the specific two engine inoperative provisions below.

4.3.2 An aeroplane should not commence a take-off at a mass in excess of that which, according to the two-engine inoperative en-route net flight path data shown in the flight manual, permits the aeroplane to continue the flight from the point where two engines are assumed to fail simultaneously to an aerodrome at which the landing distance specification for alternate aerodromes is complied with, and where a safe landing can be made. The net flight path is cleared vertically, by at least 600 m (2 000 ft), of all terrain and obstructions along the route, within 9.3 km (5 NM), when lateral navigation accuracy is at least 5 NM , or otherwise within 18.5 km (10 NM), on either side of the intended track. The net flight path considered is for the ambient temperatures anticipated along the route. In altitudes and meteorological conditions where icing protection systems are to be operable, the effect of their use on the net flight path data is taken into account. The following provisions apply:

a) the two engines are assumed to fail at the most critical point of that portion of the route where the aeroplane is at more than 90 minutes, at normal cruising power or thrust, as applicable, at standard temperature in still air, away from an aerodrome at which the landing distance specification for alternate aerodromes is complied with and where a safe landing can be made;

b) the net flight path has a positive slope at 450 m (1 500 ft) above the aerodrome where the landing is assumed to be made after the failure of two engines;

c) fuel jettisoning is permitted to an extent consistent with the next paragraph, if a safe procedure is used; and

d) the aeroplane mass at the point where the two engines are assumed to fail is considered to be not less than that which would include sufficient fuel to proceed to the aerodrome and to arrive there at an altitude of at least 450 m (1 500 ft) directly over the landing area and thereafter to fly for 15 minutes at cruise power and/or thrust.

Chapter 5

LANDING PERFORMANCE

5.1 GENERAL

5.1.1 The overall landing distance of an aeroplane consists of three segments; an airborne segment, a transition segment and a final stopping configuration (full braking) segment. These segments are illustrated in Figure 5-1.

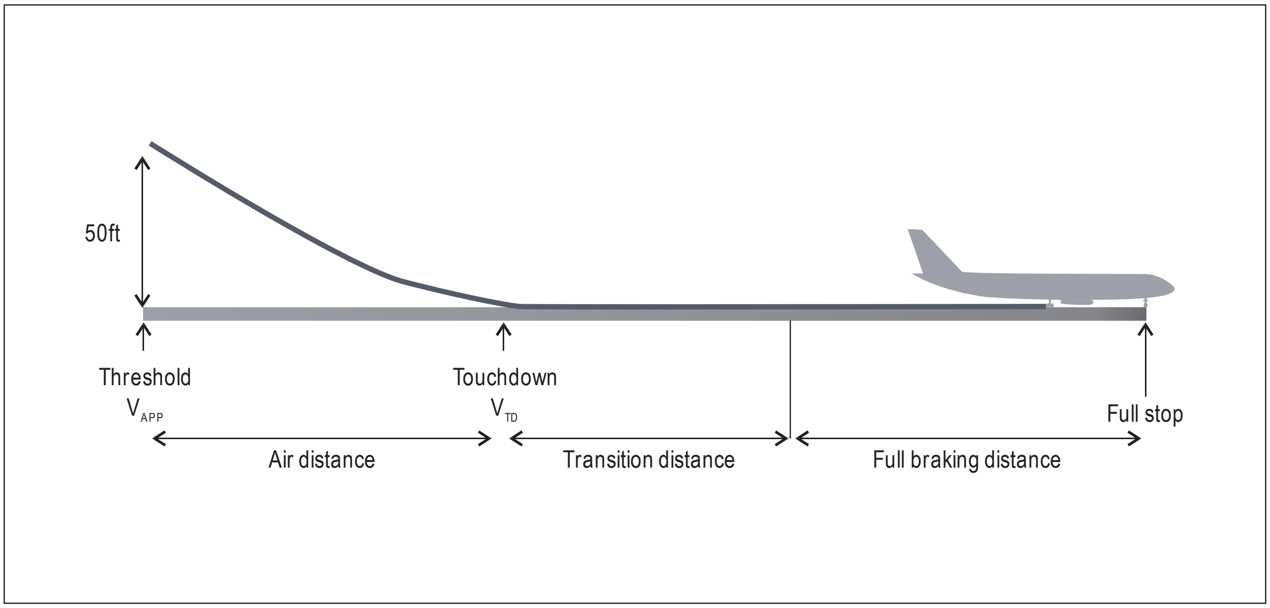

Figure 5-1. Three segments of overall landing distance

5.1.2 The air distance is the distance from a height of 15 m (50 ft) above the landing surface to the point of main gear touchdown. The air distance achieved during any individual landing at any specific runway is a function of the runway approach guidance, runway slope, use of any aeroplane features or equipment (for example, heads-up guidance, auto flight systems, etc.), pilot technique and the inherent flare characteristics of the specific aeroplane.

5.1.3 The transition distance is the distance travelled from the point of main gear touchdown to the point where all deceleration devices used in determining the landing distance are operating.

5.1.4 The final stopping (full braking) segment begins at the end of the transition segment, which is the point at which all deceleration devices used in determining the landing distance are operating.

5.1.5 The expected landing performance of the aeroplane should be checked by the crew at two stages in the cycle of an operation, in accordance with Annex 8, Part IIIB, 2.2.7, which states that the performance certification standards applicable to landing must be considered separately depending on the time at which the assessment of performance limitations is being made. These two stages are as follows and each are discussed in more detail later in this chapter:

a) at aeroplane dispatch: performance check at time of take-off; and

b) during approach preparation: performance check at time of landing.

5.1.6 The distances used at time of dispatch have been allowed to be derived under more aggressive assumptions that were not representative of the way landing is trained and carried out in line operations. The motivation for the new set of landing distances to be used at time of landing is to provide a realistic prediction of the landing distance that can be achieved in line with standard operating procedures. They also take into account all parameters that influence the length of a landing, some of which were previously neglected under the assumption that dispatch factors would provide sufficient margins in most conditions.

5.1.7 While the structure of the models used to determine the two different landing distances is quite similar, the ambition for better representation by the calculated distance of the actual stop in given conditions requires some significant changes to the way the model is built. This is described in section 5.4.

5.2 LANDING PERFORMANCE DATA

5.2.1 The landing performance data should be derived and published by the aeroplane manufacturer. Data should be provided for all the different uses of deceleration devices available and recommended for the airplane type, such as maximum manual braking (and autobrake for the performance check at time of landing) and thrust reverser system settings (contaminated runway only for performance check at time of take-off). Performance data should be presented to the intended user in a format that can be easily understood and applied. This principle should be followed when the information is presented as tables, charts and figures, and when it is determined interactively with computation tools, such as electronic flight bags (EFBs).

5.2.2 Landing performance data may be published as tabulated information in either the flight manual or the operations manual. Tabulated data should be supplemented with electronic computation tools and such tools should comply with applicable industry norms. These computation tools should be designed in such way that actively supports the flight crew in establishing the worst acceptable condition rather than only calculating for the user-defined conditions.

5.2.3 If the data for the performance check at time of landing is not approved by the State of Design, it should be labelled as advisory. In any case, the assumptions on which the data was built should be made available, in particular regarding whether any margin is basically included in the data. Instructions for its use should be provided. Any limitations of the data and the operations it covers should be clearly stated, for example maximum contaminant depths. Operators should provide guidance on maximum crosswind as a function of the runway surface condition.

5.2.4 Landing distance data should cover all normal operations with all engines operating within the normal landing operating envelope. The effect of each of the parameters affecting landing distance should be provided and should take into account the following:

a) approved landing configurations, including Category III landing guidance where approved;

b) approved deceleration devices (wheel brakes, speed brakes and spoilers);

c) reverse thrust, including pilot and system delays for its selection and activation, as well as recommendations for stowing at low speed;

d) pressure altitudes within the approved landing operating envelope;

e) mass, up to the maximum take-off mass (to cover overweight landing);

f) winds within the approved landing operating envelope:

1) not more than 50 per cent of the nominal wind components along the landing path opposite to the direction of landing; and

2) not less than 150 per cent of the nominal wind components along the landing path in the direction of landing;

g) crosswinds, including limits for reverse thrust use, if necessary. The flight crew may have to reduce reverse thrust or store the reversers to restore directional control; and

h) icing conditions, as applicable.

In addition, the performance check at time of landing should account for:

a) 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;

b) temperatures within the approved landing operating envelope; and

c) runway slopes within the approved landing operating envelope.

5.2.5 Appropriate information should be provided for a minimum equipment list and configuration deviation list items that affect landing distance. Landing distances for non-normal configurations should also be included. A landing distance assessment should be based on data that is consistent with the recommended method of operating the aeroplane.

5.3 PERFORMANCE CHECK AT TIME OF TAKE-OFF

5.3.1 Overview

5.3.1.1 Since aeroplane dispatch may occur significantly before the expected arrival time at the intended destination, the existence and quality of weather forecasts and conditions may be limited. The performance check at time of take-off must conservatively consider any unknowns. The resulting distance is more of an allowance than it is intended to be a best assessment of the actual capabilities of the aircraft as achievable in line operations.

5.3.1.2 An aeroplane should not commence a take-off at a mass such that, allowing for normal consumption of fuel and oil in flight to the aerodrome of destination and to the destination alternate aerodromes, the mass on arrival will exceed the landing mass specified in the flight manual for the altitude of each of the aerodromes involved and for the anticipated conditions at the time of landing.

5.3.2 Aerodrome of destination

Dry runways

5.3.2.1 An aeroplane should not commence a take-off at a mass in excess of that which permits the aeroplane to be brought to a full stop landing at the aerodrome of intended destination from the threshold:

a) for turbo jet powered aeroplanes, within 60 per cent of the LDA; and

b) for turbo-propeller aeroplanes, within 70 per cent of LDA.

5.3.2.2 The mass of the aeroplane is assumed to be reduced by the mass of the fuel and oil expected to be consumed in flight to the aerodrome of intended destination. The above should be shown, assuming:

a) the aeroplane is landed on the most favourable runway and in the most favourable direction in still air, and

b) the aeroplane is landed on the runway which is the most suitable for the wind conditions anticipated at the aerodrome at the time of landing, taking due account of the probable wind speed and direction, of the ground handling characteristics of the aeroplane, and of other conditions (i.e. landing aids, terrain). If compliance cannot be shown with this provision, the aeroplane may be taken off if a destination alternate aerodrome is designated which permits compliance with requirements for destination and alternate aerodromes.

5.3.2.3 If the forecast meteorological conditions for the destination aerodrome do not allow complying with all of the above, the aeroplane should only be dispatched if an alternate aerodrome is designated that allows full compliance.

5.3.2.4 For this compliance demonstration, the following factors should consider, at minimum:

a) the altitude of the aerodrome;

b) the runway slope in the direction of the landing, if greater than ± 2.0 per cent; and

c) not more than 50 per cent of the headwind component or not less than 150 per cent of the tailwind component.

Wet or contaminated runways

5.3.2.5 When the appropriate weather reports or forecasts, or a combination thereof, indicate that the runway at the estimated time of arrival may be wet, the LDA should be at least 115 per cent of the required landing distance determined for dry runways.

5.3.2.6 A landing distance on a wet runway shorter than that prescribed above, but not less than that required for dry runways, may be used if the flight manual includes specific additional information about landing distance on wet runways.

5.3.2.7 When the appropriate weather reports or forecasts or a combination thereof indicate that the runway at the estimated time of arrival may be contaminated, the landing distance available should be the greater of:

a) the required landing distance for wet runways; or

b) the landing distance determined in accordance with contaminated landing distance data with a safety margin acceptable to the State of the Operator, unless a destination alternate aerodrome is designated for which full compliance is shown with landing performance at time of take-off requirements for destination and alternate aerodromes.

5.3.2.8 When complying with required landing performance on wet and contaminated runways, the above criteria for dry runways should be applied accordingly, except when specific safety margins acceptable to the State of the Operator are applied.

5.3.2.9 For a destination aerodrome where a landing depends on a specified wind component, the aeroplane may be dispatched if two alternate aerodromes are designated that permit full compliance with all of the above.

5.3.3 Automatic landing distance performance data

In cases where a landing requires the use of an automatic landing system, the landing mass of the aeroplane should be determined in accordance with the automatic landing distance for the appropriate surface condition, as given in the AFM or equivalent document, but should not be higher than that determined in accordance with the previous two sections, as applicable. Increments due to system features such as beam location or elevations, or procedures such as use of over speed, should also be included.

5.3.4 Destination alternate aerodrome

No aerodrome should be designated as a destination alternate aerodrome unless the aeroplane, at the mass anticipated at the time of arrival at such aerodrome, can comply with landing performance at time of take-off requirements for dry runways and wet runways, in accordance with the landing distance required for the altitude of the alternate aerodrome and in accordance with other applicable operating requirements for the alternate aerodrome.

5.3.5 Performance standards

5.3.5.1 The runway length assessment for the destination and destination alternate aerodromes should be based on the flight manual landing performance information provided by the manufacturer and defined in accordance with Annex 8, IIIB, 2.2.7 e). The required runway length at the expected landing mass should be based on the performance considerations appropriate to the expected surface conditions.

5.3.5.2 For take-off alternates and en-route alternates, distances at time of landing indicated in 5.4 that can realistically be achieved in line operations may be used if accepted by the State of the Operator. Overweight landing procedures may be considered for take-off and en-route diversion planning. For aeroplanes equipped with fuel jettison systems, expected landing mass may be reduced to allow for fuel jettisoning, provided the operator can demonstrate that flight crews are properly trained and that diversion fuel requirements are not compromised.

5.3.5.3 Alternate aerodromes selected for a particular flight should be further evaluated to ensure the sufficient runway length for the conditions at the expected time of arrival, as part of the dispatch planning assessment. This assessment should consider probable wind speed and direction as well as expected runway surface condition.

5.3.5.4 While for the destination and destination alternates, the performance reference is Annex 8, Part IIIB 2.2.7.1 e), once in flight the crew will refer to the distance determined in accordance with paragraph f) of that section. This distance, when including the operational factor recommended in 5.4.3 (landing distance margin), may in some cases, and in particular on contaminated runways, exceed the landing distance considered at dispatch. When arrival conditions are expected to be marginal, it is recommended to make a preliminary calculation of the distance at time of landing (see section 5.4) at dispatch, in order to anticipate operational limitations at destination and nominate suitable destination alternates.

5.4 PERFORMANCE CHECK AT TIME OF LANDING

5.4.1 Overview

5.4.1.1 During the approach at the intended aerodrome, the landing conditions are fairly well known and any expected changes from the conditions anticipated when the performance check at take-off was conducted can be reasonably assessed. The intent is to produce a best assessment of the distance needed for landing under the prevailing conditions, considering the operational parameters, such as approach speed and braking devices, intended to be used. It begins with acquiring the latest available weather information and the RCR via the ATIS, ATC or other means of determining the landing mass.

5.4.1.2 Annex 6, Part I, 4.4.11[1] mandates a systematic in-flight landing performance assessment based on a factored distance at time of landing, furnished for the prevailing conditions. The flight crew should initiate a performance check at time of landing on every flight. Operators must have a systematic method for determining that the distance at the time of landing is adequate based on the conditions that exist at the time of arrival. This check may require a computation of landing distances based on the latest available information on weather and runway surface condition. In many cases, it can be sufficient to confirm the validity of a previous assessment or verify the current conditions against pre-determined worst acceptable conditions for the airport.

5.4.1.3 The performance check at time of landing or confirmation of the validity of dispatch calculations should be done before top of descent. While the in-flight procedures in Annex 6, Part I, 4.4.1.2 specify an elevation of 300 m (1000 ft) above the aerodrome, the intent is not for an actual computation to take place at this point where it would distract attention from essential flying tasks. Rather, the intent is for the flight crew to monitor the actual conditions throughout the approach to ensure that they do not degrade below a minimum acceptable condition, as determined previously with the anticipated landing distance based on actual outside conditions. The recommended time for this determination is during approach preparation before the start of the final descent.

5.4.1.4 In the majority of cases, the landing distance check can be satisfied by confirming that the assumptions used at the time of dispatch are still adequate, and no further calculations are required during approach preparation. Depending on applicable regulation and the certification basis of the aeroplane, the dispatch landing field length could be the same as that specified in the aeroplane's flight manual, based on the appropriate operating regulations, or an operational performance check that reflects the actual conditions expected at the time of arrival and includes appropriate margins, which may be required (see below).

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5.4.1.5 However, there will be cases where the assumptions used at dispatch will be inadequate and the flight crew will need to evaluate the performance at the destination or alternate airport. Examples of conditions requiring a calculation at time of arrival of landing distance required include (but are not limited to):

a) runway surface condition, as reported by RCR and consistent with the procedures described in PANS-Aerodromes (Doc 9981), are worse than assumed at dispatch;

b) winds are worse than assumed at dispatch;

c) runway changed from the runway(s) used in the dispatch calculations;

d) excessive operational approach speed additives; and

e) wet runway with “slippery wet” NOTAM, or braking action, reported as less than “good”.

Note.— Judgment may be required based on the location and extent of the section of runway declared “slippery wet”.

5.4.1.6 For the purpose of the performance assessment at time of landing, weather conditions and runway surface conditions should be accounted for, as reported for the intended time of landing. This implies that performance data is presented against the terminology defined in Annex 14, Volume I, Definitions and used in the RCAM in PANS-Aerodromes (Doc 9981). In addition, the planned aeroplane configuration, approach guidance, automation and deceleration means intended to be used should be considered. The computation should reflect any minimum equipment list (MEL)/configuration deviation list (CDL) items or in-flight failures affecting landing performance and operational choices such as autoland, autothrust and autobrakes.

5.4.2 Approach runway overrun awareness and alerting systems

It is good airmanship to compare the distance at time of landing with the in-air alerting threshold of a runway overrun awareness and alerting systems, if installed. However, the flight crew should be aware of the limitations of such systems. It may not always be approved for use for contaminated runways (worse than wet).

5.4.3 Dealing with ambiguous information

5.4.3.1 If, for any reason, the information seems ambiguous to the flight crew, they should actively search for clarification. Error may include the improper insertion of data into the computation tool or outdated information. All available sources should be used to clarify conflicting information. In the case of unresolved situations of ambiguity, the flight crew should use conservative decision making and prioritize flight safety.

5.4.3.2 Some States may continue to provide measured friction values in the RCR. There is no strong correlation between the measured coefficient of friction (mu-value, μ) and aeroplane braking action, especially for slush and wet snow. Although studies have also shown that measured friction coefficients depend greatly on the device used and they do not correlate uniformly with aeroplane performance, a State may provide friction measurements in the dedicated situational awareness section of the RCR. This information should only be used for performance calculations if the operator has an approved procedure for correlating the reported friction with airplane performance (braking action). Operators should, in this case, have procedures for flight crews on how to use this information. When such procedures are not available, the flight crew should request and rely on RWYCC for the performance assessment. The flight crew must be aware that this information may vary from State to State and require specific methods of correlation.

5.4.4 Air distance

5.4.4.1 The air distance determined for dispatch may not be appropriate for use in making time-of-arrival landing performance assessments. Depending on the method of determining the air distance agreed with the certifying authority, it may be shorter than the distance the average pilot is likely to achieve in normal operations. Changes in aeroplane configuration, speed, power, and thrust used to determine the landing distance for time-of-arrival landing performance assessments should be made using procedures established for operation in service. These procedures should:

a) be consistently executed in service by crews of average skill;

b) use methods or devices that are safe and reliable; and

c) include allowances for time delays that may reasonably be expected in service.

5.4.4.2 Reasons why this air distance may not be achievable in line operations include but are not limited to:

a) the methods used by some manufacturers to provide landing distance in their flight manuals allow the air distance to be based on a steeper-than-normal approach angle of -3.5°, followed by a flare in which the touchdown rate of descent can be as high as 2.4 m (8 ft) per second;

b) air distance is based on beginning at a referenced speed (V_{REF}), whereas the operating procedures may recommend a higher speed, particularly when headwinds are present; and

c) some manufacturers wish to determine the maximum capability of the aeroplane during the certification process.

5.4.4.3 The air distance used for time of arrival landing performance assessments should be determined analytically, as the distance traversed over a time period of 7 seconds at a speed of 98 per cent of the recommended speed over the landing threshold, also referred to as the final approach speed (V_{APP}). This represents a flare time of 7 seconds and a touchdown speed (V_{TD}) of 96 percent of V_{APP}. V_{APP} should be consistent with the recommended procedures and training material of the TC holder, including any speed additives, such as may be used for winds or icing. The effect of higher speeds, to account for variations that occur in operations or through the operating procedures of individual operators, should also be provided.

5.4.4.4 If the air distance is determined directly from flight test data instead of the analytical method provided in the preceding paragraph, the flight test data should meet the following criteria:

a) procedures should be consistent with the recommended procedures and training for operations in service of the TC holder. These procedures should address the recommended final approach airspeed, flare initiation height, thrust/power reduction height and technique, and target pitch attitudes;

b) at a height of 15 m (50 ft) above the runway surface, the aeroplane should be at an airspeed no slower than the recommended final approach airspeed; and

c) the touchdown rate of descent should be in the range of 0.3 m to 1.2 m (1 to 4 ft) per second.

Note.— This criterion should not be construed to mean that all of the landing data used to determine the air distance may have a touchdown rate of descent of 1.2 m (4 ft) per second. The flight test data should contain a range of touchdown rates ranging from 0.3 m to 1.2 m (1 to 4 ft) per second.

5.4.4.5 The air distance for the distance at time of landing may also apply to autoland or similar low visibility guidance systems, as long as the demonstrated flare time and V_{TD}/V_{APP} from the autoland testing do not exceed the values of those parameters used in determining the manual landing distance. If they do exceed the values used in determining the manual landing distance, then the demonstrated flare time and V_{TD}/V_{APP} from the autoland and/or low visibility guidance system demonstrations should be used for computing the air distance when determining the autoland and/or low visibility guidance system landing distance. The autoland/low visibility guidance system test data used for this determination should be from a representative set of airports and not include extreme glide path intercept points or runway slopes.

5.4.4.6 For landing performance data developed for special operational concepts, examples steep approach or short field landing, the air distance and transition time should reflect the demonstrated performance in line with the applicable procedures, such as prescribed configurations, approach speed increments and flare heights. Considerations could be given to specific training requirements.

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

5.4.4.8 An air distance as short as 300 m (1 000 ft) may be approved by the State of the Operator. Approval of air distances shorter than that based on a time of 7 seconds at a speed of 98 per cent of the recommended speed over the runway threshold should be subject to the development of specific training, procedures and associated measures to minimize the risk of overruns or undershoots, such as:

a) training in touchdown control and short field landing techniques;

b) identification of required touchdown point and training to assure go-around procedures are initiated, if unable to achieve a suitable touchdown point;

c) approach guidance and runway markings on the specific runway are consistent with a shorter air distance;

d) operational data provided to the crew for the specific runway, conditions and aircraft landing configuration, without the need for interpolation; and

e) the flight techniques assumed in the creation of the performance data used for a shorter air distance are based on flight techniques to be used in the shorter air distance operation. For example, the assumed speed bleed-off used in the performance data must be consistent with the trained flight techniques for flaring the aircraft.

5.4.5 Transition distance

5.4.5.1 The speed at the start of the transition segment is at least 96 per cent of the final approach speed. The transition distance should be based on the recommended procedures for use of the approved means of deceleration, both in terms of sequencing and any cues for initiation. Reasonably expected time delays should also be taken into account. The application of wheel brakes, speed brake deployment and deployment of thrust reversers, or reversing of the propeller, should be considered.

5.4.5.2 For procedures that call for the initiation of deceleration devices beginning at nose gear touchdown, the minimum time for each pilot action taken to deploy or activate a deceleration means should be the demonstrated time, but no less than one second. For procedures that call for the initiation of deceleration devices beginning prior to nose gear touchdown, the minimum time for each pilot action taken to deploy or activate a deceleration means should be the demonstrated time plus one second. For deceleration means that are automatically deployed or activated (for example, auto-speed brakes or autobrakes), the demonstrated time may be used with no added delay time.

5.4.5.3 The distance for the transition segment and the speed at the start of the final stopping configuration segment should include the expected evolution of the braking force achieved over the transition distance. The evolution of the braking force should take into account any differences that may occur for different runway surface conditions or pilot-reported braking actions as the airplane transitions to the full braking configuration.

5.4.6 Ground distance

The ground distance is calculated with all deceleration means intended to be used and for the prevailing surface conditions as characterized by the RWYCC. The wheel to ground friction coefficient assumptions associated with each RWYCC are detailed in section 5.5.1. It ends at the nose gear position when the airplane comes to a complete stop.

5.4.7 Landing distance margin

5.4.7.1 Before commencing an approach, it should be confirmed that, in accordance with the performance provided for that purpose, the aeroplane can be stopped with appropriate margins within the LDA. A minimum margin of 15 per cent versus the operational landing distance is considered to be appropriate (see below).

5.4.7.2 The distance used for a time of landing assessment, based on Annex 8, Part IIIB, 2.2.7.1 f) should include a safety margin of at least 15 per cent when based on manual wheel braking. This safety margin represents the minimum distance that should exist between the expected operational landing distance at the estimated time of landing and the landing distance available, accounting for all known variables such as the meteorological (temperature and wind) and runway surface conditions, runway slope, threshold crossing height and airspeed, aeroplane configuration and mass, and the intended use of aeroplane ground deceleration devices.

5.4.7.3 When developed in accordance with the recommendations of this section, the distance at time of landing is a distance that can realistically be achieved in line operations but does not include margins. It assumes a stabilized approach in outside conditions consistent with the computation assumptions. As long as they do not occur simultaneously in an unfavourable manner, the minimum acceptable margin above appropriately covers the effects of variations, such as:

a) variations in the flare execution or deceleration means application by the pilot, variations in touchdown speed due to turbulence or the impact of cross-wind;

b) unreported runway surface degradation due to weather and in the case of wet runway surface, issues such as texture loss and precipitation rate;

c) inaccuracy or lack in timeliness of runway surface condition reporting;

d) variability of wind; and

e) aircraft system failures late during the approach and landing phase.

5.4.7.4 An error in condition reporting by one RWYCC is rarely covered by the recommended margin of 15 per cent, as illustrated in Figure 5-2. Aerodrome operational personnel should accurately report runway surface conditions rather than seek a systematically conservative assessment. Conservatism is recommended in the judgement of observations versus criteria such as 3 mm depth or 25 per cent coverage, but not on the RWYCC. “Conservatism” is different from “downgrade” motivated by other observations or local knowledge. The fact that flight crews are asked to evaluate the worst acceptable runway surface condition is an additional safeguard against lack of conservatism.

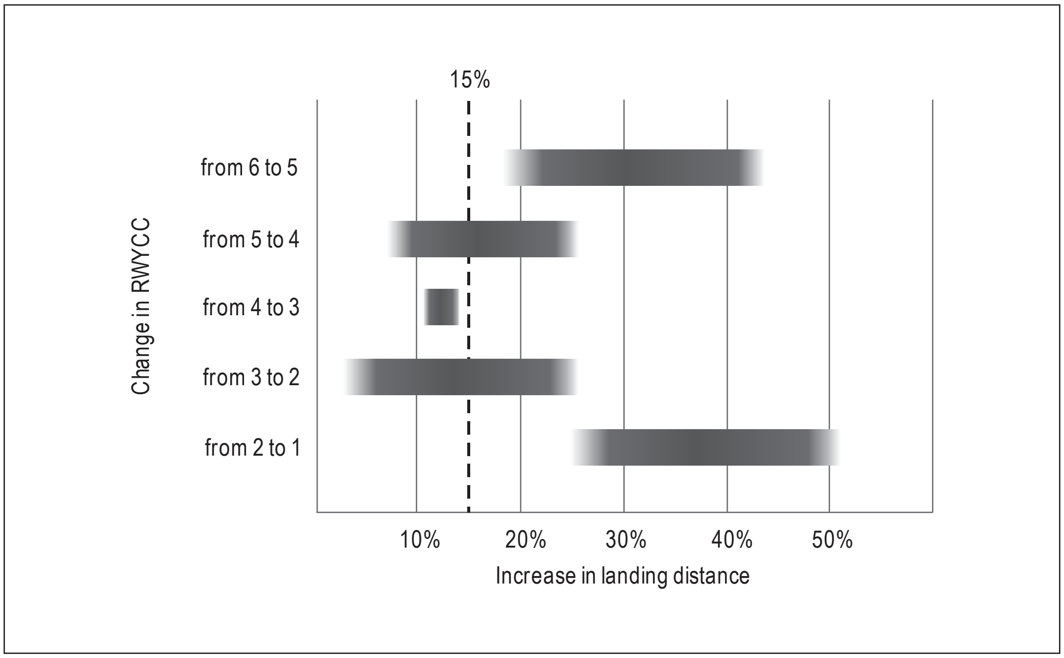

Figure 5-2. Distance Increments between RWYCCs

5.4.7.5 When landing on a dry or wet runway with autobrake in sufficient visibility, less than the full 15 per cent margin may exist to the LDA if the full 15 per cent margin exists for the operational landing distance calculated for maximum manual braking. Restricting the selection of autobrake by mandating the full margin on the autobrake distance may lead to operations with unnecessarily high deceleration settings or even without arming of autobrake before landing with the intent to use pedal braking. The use of autobrake minimizes brake wear and ensures the timely use of deceleration means. The flight crew can override autobrake whenever required.

5.4.7.6 The flight crew may disregard the operational margin in exceptional circumstances, e.g. emergency situations. Not all aeroplane configurations resulting from the in-flight failures of aircraft systems are emergencies, and some emergencies are independent of system failures affecting landing performance. Exceptional circumstances may not be restricted to cases where an emergency is declared, and it is not intended that the flight crew declare an emergency to be permitted to land with less than the full 15 per cent margin, unless otherwise required.

5.4.8 Minimum Compliance

5.4.8.1 Many manufacturers have developed advisory data that uses different assumptions from those described in this manual and that may be acceptable to the State of Operator for the performance check at time of landing if it can be appropriately mapped to the runway surface conditions listed in the RCAM. Such data should, at minimum, reflect operational procedures and, in addition to the parameters for which aeroplane flight manual distances are supplied, account for approach speed increments, runway slope and outside temperature.

5.4.8.2 For some older aeroplanes out of production but still in service, fully compliant data for the time of landing assessment may not be available. This is especially true for those manufacturers no longer in business. In this case, the landing distance factors (LDFs) depicted in Table 5-1 apply. The LDFs provided include a 15 per cent safety margin and an air distance representative of normal operational practices. They account for variations of temperature up to international standard atmosphere (ISA) +20°C, runway slopes between -2 per cent and +2 per cent and an average approach speed increment of 5 kts up to 20 kts. They may not be conservative for all configurations in case of unfavourable combinations of these parameters. To calculate the landing distance required (LDR), multiply the flight manual landing distance (dry, un-factored) by the applicable LDF in Table 5-1 for the runway conditions existing at the time of arrival. If the landing distances furnished in the flight manual are presented as factored landing distances, then those data must be adjusted to remove the applicable dispatch factors applied to that data.

Table 5-1. Landing distance factors

Runway condition code	*6*	*5*	*4*	*3*	*2*	*1*
Braking action	Dry	Good	Good-to-medium	Medium	Medium-to-poor	Poor
Turbojet, no reverse	1.67	2.6	2.8	3.2	4.0	5.1
Turbojet, with reverse	1.67	2.2	2.3	2.5	2.9	3.4
Turboprop[2]	1.67	2.0	2.2	2.4	2.7	2.9

Note .— The LDFs can apply to any type of anti-skid system, i.e. fully-modulating, quasi-modulating or on-off system.

5.5 BRAKING PERFORMANCE ON CONTAMINATED RUNWAYS

5.5.1 Wheel braking coefficient matrix

5.5.1.1 The tire-to-ground braking coefficients presented in Table 5-2 were set by a group of experts, based on their experience and accepted performance levels on different surfaces, as defined by EASA. They were verified to the greatest degree possible by the latest industry flight testing, as embodied by the Joint Winter Runway Friction Measurement Program, which was active from 1995 to 2004. These coefficients may need to be revised if future industry-level acceptance of new information becomes available.

5.5.1.2 The changes made to the models of the EASA AMC were made to ensure a logical progression of landing distances from one RWYCC to the next. The EASA models had originally been set up to be appropriate, albeit conservative, for the braking action to be expected for various “discrete” contaminants, but the RCAM introduced a hierarchy, and thus a continuum, in terms of slipperiness. It is thus important that when the RWYCC drops by one level, stopping distances increase. The tyre-to-ground friction value for RWYCC 3 was thus set a little below the value defined in AMC 25.1591 for loose snow (0.16 vs. 0.17) and the ground-speed dependent tyre-to-ground of RWYCC 2 was defined as half of the wet value, capped at 0.16 at low speed. While these choices were more conservative than the EASA values, the friction for RWYCC 1 was increased above the EASA value for icy runway. The latter had historically been chosen to cover melting or wet ice and set at the same value of 0.05 also assumed for aquaplaning. This was justified by the intent not to maintain runways open for operations at such low levels of braking action and lateral control.

[2] *These LDFs apply only to modern turboprops with efficient disking drag. For older turboprops without adequate disking drag use the turbojet, no reverse LDFs.*

5.5.1.3 Provisions of performance credit for wet, grooved or PFC runways have been made. However, no specific runway code was assigned to such runways. A grooved or PFC runway is considered as an enhancement to safety that would be dissipated if performance credit was given systematically. Additionally, minimum friction thresholds are not differentiated in applicable standards between a smooth runway and one that has been prepared to maintain improved grip in wet conditions. There are thus no provisions in place to ensure that performance credit is maintained over time.

Table 5-2. Wheel braking coefficients for RWYCC, contaminant types and AIREPS

RWYCC	Runway surface condition description	Pilot-reported braking action	Wheel braking coefficient
6	**DRY**	—	90 per cent of certified value used to comply with Annex 8, Part IIIB, 2.2.7.1 e) and f) (see Note 1 & 2)
5	**FROST** **WET** (runway surface is covered by any visible dampness or water up to, and including, 3 mm deep.) **SLUSH** (up to and including 3 mm depth) **DRY SNOW** (up to and including 3 mm depth) **WET SNOW** (up to and including 3 mm depth)	Good	Per method defined in Note 3 below.
4	**COMPACTED SNOW** (Outside air temperature -15°C or below)	Good to medium	0.20 (see Note 4)
3	**WET** ("slippery wet" runway) **DRY SNOW** (more than 3 mm depth) **WET SNOW** (more than 3 mm depth) **DRY SNOW ON TOP OF COMPACTED SNOW** (any depth) **WET SNOW ON TOP OF COMPACTED SNOW** (any depth) **COMPACTED SNOW** (outside air temperature above -15°C)	Medium	0.16 (see Note 4)
2	**STANDING WATER** (more than 3 mm depth) **SLUSH** (more than 3 mm depth)	Medium to poor	a) for speeds below 85 per cent of the aquaplaning speed (see Note 5): 50 per cent of the wheel braking coefficient determined for RWYCC=5, but no greater than 0.16; and b) for speeds at 85 per cent of the aquaplaning speed (see Note 5) and above 0.05 (see Note 4).

RWYCC	Runway surface condition description	Pilot-reported braking action	Wheel braking coefficient
1	**ICE**	Poor	0.07 (see Note 4).
0	**WET ICE** **WATER ON TOP OF COMPACTED SNOW** **DRY SNOW OR WET SNOW ON TOP OF ICE**	Less than poor	Not applicable (no operations in less than poor conditions).

Note 1.—Applicable 5 November 2020

Note 2.— 100 per cent of the wheel braking coefficient used to comply with Annex 8, Part IIIB, 2.2.7.1 may be used if the testing from which that braking coefficient was derived was conducted on portions of runways containing operationally representative amounts of rubber contamination and paint stripes.

Note 3.—From the Annex to ED Decision 2007/020/R (EASA Certification Specification Amendment 4) dated 27 December 2007: the wet runway braking coefficient of friction for a smooth wet runway is defined as a curve of friction coefficient versus ground speed and must be computed as follows:

a) *the maximum tyre-to-ground wet runway braking coefficient of friction is defined as*

Type pressure (psi)	*Maximum braking coefficient (tyre-to-ground)*
50	$\mu_{t/gMAX} = -0.0350\left(\frac{V}{100}\right)^3 + 0.306\left(\frac{V}{100}\right)^2 - 0.851\left(\frac{V}{100}\right) + 0.883$
100	$\mu_{t/gMAX} = -0.0437\left(\frac{V}{100}\right)^3 + 0.320\left(\frac{V}{100}\right)^2 - 0.805\left(\frac{V}{100}\right) + 0.804$
200	$\mu_{t/gMAX} = -0.0331\left(\frac{V}{100}\right)^3 + 0.252\left(\frac{V}{100}\right)^2 - 0.658\left(\frac{V}{100}\right) + 0.692$
300	$\mu_{t/gMAX} = -0.0401\left(\frac{V}{100}\right)^3 + 0.263\left(\frac{V}{100}\right)^2 - 0.611\left(\frac{V}{100}\right) + 0.614$

Where:

Tyre pressure = maximum aeroplane operating tyre pressure (psi);

$\mu_{t/gMAX}$ = maximum tyre-to-ground braking coefficient;

V = aeroplane true ground speed (knots); and

Linear interpolation may be used for tyre pressures other than those listed.

b) *the maximum tyre-to-ground wet runway braking coefficient of friction must be adjusted to take into account the efficiency of the anti-skid system on a wet runway. Anti-skid system operation must be demonstrated by flight testing on a smooth wet runway and its efficiency must be determined. Unless a specific anti-skid system efficiency is determined from a quantitative analysis of the flight testing on a smooth wet runway, the maximum tyre-to-ground wet runway braking coefficient of friction must be multiplied by the efficiency value associated with the type of anti-skid system installed on the aeroplane:*

Type of anti-skid system Efficiency value

On-off	*0.30*
Quasi-modulating	*0.50*
Fully modulating	*0.80*

Note 4.—These tyre-to-ground braking coefficients assume a fully modulating anti-skid system. For quasi modulating systems, multiply the listed braking coefficient by 0.625. For on-off systems, multiply the listed braking coefficient by 0.375. (See AC 25-7D[3] to determine the classification of an anti-skid system.) Airplanes without anti-skid systems will need to be addressed separately on a case-by-case basis.

Note 5.—The aquaplaning speed, VP, is given by the equation VP = 9 √P, where VP is the ground speed in knots and P is the tire pressure in lb/in2.

5.5.1.4 The calculation of the final stopping configuration distance should be based on the braking coefficients associated with the RWYCCs including the effect of aquaplaning, if applicable. Landing performance data for use at time of arrival should be provided for the RWYCCs 6 through 1 for the approved operational envelope for landing. Landing performance data is not provided for RWYCC 0 because this is not a performance category. When a runway condition corresponding to RWYCC 0 is observed either by the aerodrome personnel or reported by a flight crew, flight operations should cease on this runway until the aerodrome improves the runway condition.

5.5.1.5 The manufacturer should provide supplemental landing data based on the RWYCC which can be cross referenced to a runway description and AIREP. In this method, the operational landing performance data will not account for the decelerating drag effect of slush, standing water or snow. The manufacturer may choose to provide a second dataset based on a runway description of the contaminant type and depth.

5.5.1.6 The RCAM provides a performance-wise classification of runways that are reported as slippery wet in accordance with Annex 14, Volume 1, 2.9.9, due to rubber contamination or otherwise degraded runway friction. ICAO provisions promulgate that runways should be reported as slippery wet when it is in a condition which fails to provide surface friction characteristics at or above the minimum friction level specified by the State of the Aerodrome. However, no associated aeroplane performance was previously available to allow operators and flight crew to take this information into account in their performance assessment. When such a runway is wet, an RWYCC 3 is reported in the RCR and an appropriate computation can be made.

5.5.2 Accounting for drag of loose contaminants

5.5.2.1 Loose contaminants result in additional contaminant drag due to the combination of displacement of the contaminant by the airplane tires and impingement of the contaminant spray on the airframe. This contaminant drag provides an additional force helping to decelerate the airplane, which reduces the distance needed to stop the airplane. Because contaminant drag increases with contaminant depth, the deeper the contaminant is, the shorter the stopping distance will be. The procedure for reporting contaminant depths is to report the mean depth of the contaminant along the reported portion of the runway surface. Contaminant depths are unlikely to be uniform over the runway surface (or a reported portion of the runway surface), so it is possible there will be areas of lesser contaminant depth. Contaminant depths are reported in RCR whenever, above a specified minimum depth, there is a significant change in the contaminant layer, as specified in PANS-Aerodromes (Doc 9981).

5.5.2.2 However, the actual contaminant depth may be less than the reported depth in a stable weather environment (that is, no additional precipitation onto the runway surface), and it is likely to decrease as successive airplanes traverse through it and displace the contaminant. If the actual contaminant depth is less than the reported value, using the reported

3. FAA Advisory Circular AC 25-7D, Flight Test Guide for Certification of Transport Category Airplanes

value to determine contaminant drag will result in a higher drag level than actually exists, leading to an optimistic stopping distance prediction. Therefore, it is recommended not to include the effect of contaminant drag in the calculation of landing distances for time-of-arrival landing performance assessments. If the effect of contaminant drag is included, it should be limited to no more than the drag resulting from 50 per cent of the reported depth.

5.5.2.3 If the effect of contaminant depth is included in the landing distance data, then data should be provided for the reportable contaminant depths identified in PANS-Aerodromes (Doc 9981), up to the maximum contaminant depth for each contaminant for which landing operations are permitted.

Note.— Due to issues of potential structural damage from spray impingement and engine ingestion, the maximum recommended depths for landing operations for loose contaminants are shown in the table below, unless greater depths are demonstrated to be free of structural damage and engine ingestion issues.

Table 5-3. Maximum recommended depths for landing operations for loose contaminants

Loose contaminant	*Maximum depth*	*Specific gravity*
Standing water	*15 mm*	*1.00*
Slush	*15 mm*	*0.85*
Dry snow	*130 mm*	*0.20*
Wet snow	*30 mm*	*0.50*

5.5.2.4 If the effect of contaminant depth is included in the landing distance data, then data should be provided for the specific gravities in the Table 5-3.

5.5.2.5 The reduction of drag above aquaplaning speed may be accounted for where appropriate.

5.6 PROCEDURES FOR LANDING ON LENGTH-LIMITED RUNWAYS

The general guidance for flight crew in this section considers landing performance limitations due to runway length only. It does not consider missed approach climb requirements, obstacles in missed approach areas, runway bearing strength or other limiting factors.

5.6.1 During the approach preparation and briefing

Consider the following elements during the approach preparation phase of the landing:

a) acquire the latest available meteorological and RCR, preferably not more than 30 minutes before the expected landing time. In dynamic weather conditions, the latest available information on the runway condition must be used;

b) evaluate the likelihood of significant changes to runway surface conditions, based on the age of the report and evolution of outside conditions. Be aware that winter runway conditions may change not just due to meteorological and environmental effects, such as active precipitation or changes in temperature, humidity or solar radiation, but also due to mechanical factors such as traffic and removal. Depending on the operational context, the flight crew should reasonably assess the worst case in which the currently reported runway condition may degrade to;

c) set limits for deteriorating conditions by preparing for the worst case scenario, check performance and crosswind capability. Establish to which value a parameter (wind/RWYCC) can deteriorate before a safe landing is no longer assured. Include this value in the approach briefing for enhanced collision risk model (CRM) during the approach;

d) evaluate if another runway can provide significantly better safety margins (due to different LDAs, greater margins may be achieved in tail wind conditions). Request this runway as desired to reduce risk exposure;

e) in performance calculations:

   1) use the correct RWYCC. Calculate for other RWYCCs if there is a chance for a late RWYCC change;

   2) use the correct elevation and slope if not automatically set. A higher aerodrome elevation increases the ground speed at which the aeroplane approaches. A higher approach speed has a large impact in terms of the length of the ground roll. A downward slope has a significant impact on the deceleration on slippery runways;

   3) use conservative wind assumptions in variable and gusty conditions, i.e. use an increased tail- or reduced headwind. Wind is measured and reported as an average value over a certain time at a height of 10 m; the real wind may vary from this value. A conservative wind assumption ensures that late changes can be evaluated simply and without doubt as to their performance effect;

   4) use conservative temperature assumptions, i.e. use a higher temperature if it is expected to increase, for example, due to sun rise. Higher temperatures increase the ground speed at which the aeroplane approaches;

   5) do not use a higher QNH[4]/QFE[5] than reported. What matters to performance is the pressure altitude. Assuming a higher air pressure leads to a reduced pressure altitude at given elevation;

   6) interpret the RWYCC correctly:

      i) when RWYCC is given on each runway third, apply company procedures when available (see Chapter 2, 2.4). By default, use the worst RWYCC of the three for the whole runway;

      ii) if receiving RWYCC, AIREP and/or friction measurement, consider using the worst reported condition; and

      iii) consider RWYCC reporting time and rapidly changing weather, as described above. Assess the worst likely degradation if necessary;

f) insert the intended approach speed. The energy to be dissipated during the landing roll increases with the square of the speed;

4. The atmospheric pressure adjusted to mean sea level.
5. The air pressure at the current ground level.

g) select the intended braking method. Dispatch considers maximum effort manual braking immediately after main gear touchdown. Autobrakes target a specified deceleration rate for a given setting and typically include a longer delay after touchdown. Many operators include the use of autobrakes in their standard operating procedures. The achievable landing distance without overriding with manual braking may thus be significantly increased;

h) select the intended flap and reverse settings. Higher flap settings allow lower approach speeds. Lower flap settings improve go-around climb capability. Most manufacturers recommend the use of maximum reverse on contaminated runways. Calculated distances typically consider reverser stowage around 70 to 60 kt to avoid re-ingestion of the reversed airflow. Reverse thrust may need to be deselected during the ground roll to regain lateral control on slippery surfaces;

i) select the correct use of automation (autopilot/autothrust). Avoid autoland if possible. The use of autothrust typically requires an increment on the minimum certified approach speed. Autoland is designed to ensure touchdown on the runway centreline, but typically results in increased flare distance as the system is not aiming at a specific touchdown point the way a pilot would;

j) remember to include any defects and their influence. The loss of system failures can lead to an increase of approach speed and/or the loss of braking means (spoilers, brakes or reversers). It may not be advisable to attempt landing on contaminated runways with or without partial reverse thrust available, or with an inoperative anti-skid system;

k) compare calculations to x-check;

l) check that the x-wind is within limits;

m) set autobrake as required;

n) brief the intended flying methods thoroughly; and

o) note the runway safety areas and arresting systems. Pilots must be aware of an arresting system when installed in lieu of a runway end safety area (RESA).

5.6.2 Approach

Consider the following elements during the approach phase of the landing:

a) ensure that all landing distance calculation parameters are still valid (current) and that the runway surface condition has not degraded to a level below the worst acceptable condition determined in the approach preparation. This assessment should be biased on the wind reported by the aerodrome routine meteorological report (METAR) whenever it is more conservative than that provided by air traffic control. It may be more representative of prevailing conditions as it is averaged over a longer period;

b) arm spoilers;

c) fly the correct approach speed. Excess approach speed increases the stopping distance by around 8 per cent per 5 kt and can additionally lead to extended flare;

d) fly a stabilized approach. Be stable latest at 1000 ft above ground level (AGL);

e) avoid autoland, follow manufacturer restriction on the use of auto-rollout on contaminated runways;

f) use the correct aiming point;

g) just before touchdown, ensure the airplane trajectory is parallel to the runway centreline. Lateral control may be reduced on contaminated runways; and

h) if all of the above are not fulfilled, go around.

5.6.3 Touchdown

Consider the following elements for the touchdown phase of the landing:

a) touch down on the centreline at the intended touchdown point;

b) with a brief flare, make a firm touchdown to ensure the weight is on the wheels. A firm touchdown ensures spin-up of the tires, even on slippery runway, and a correct initialization of the anti-skid system, ensuring its efficiency. Aerodynamic braking is less efficient than wheel braking. A slow derotation can delay the autobrake onset;

c) apply wheel braking as soon as possible, in accordance with the operations manual;

d) lower the nose gear without delay. Nose gear ground contact ensures better lateral control and maximum lift dumping, which increases the landing gear load and thus braking force;

e) apply appropriate reverse as soon as possible, in accordance with the operations manual; and

f) do not initiate go-around after selecting the reverse thrust as reversers may not stow correctly.

5.6.4 Deceleration

Consider the following elements for the deceleration phase of the landing:

a) maintain all deceleration methods, including reverse, until the pilot can ensure that the airplane will stop on the remaining runway. While normal procedures usually prompt reverser reduction to idle around 70 to 60 kts, a reverse thrust can be maintained to full stop when required;

b) maintain aerodynamic control during the whole deceleration;

c) in case of loss of directional control (airplane weathercocking), reduce the reverse thrust to idle. Apply appropriate reverse again after gaining directional control;

d) to achieve asymmetric braking when required on slippery runways, completely release the pedal on the opposite side of the desired turn, as a partial release may not result in commanding less than the friction limited braking;

e) remember that “popular” runway exit points usually provide less braking action than surrounding surfaces; and

f) slow down to a very slow taxi speed before attempting to turn the tiller.

Chapter 6

MISSED APPROACH

6.1 GENERAL

6.1.1 Performance certification requirements for missed approach are harmonized between States. Manufacturers publish mass limitations for minimum approach climb gradient and landing climb gradient requirements.

6.1.2 Taken by themselves, these mass limitations do not provide any assurance of compliance with climb constraints considered in operational go-around procedures published by aerodromes in accordance with the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168), and they do not assure obstacle clearance during a go-around with one engine out. This chapter complements the current regulatory requirements with operational considerations to ensure the safety of the flight in case of an engine failure.

6.2 OPERATIONAL PERFORMANCE LIMITATIONS FOR A MISSED APPROACH

6.2.1 Instrument approaches require a minimum missed approach gradient of 2.5 per cent, published missed approach gradients may exceed this value. If published gradients can be achieved without penalty, no further analysis is required. To avoid undue penalty, an obstacle clearance analysis for OEI missed approaches or rejected landings may need to be conducted. While it is not necessary to perform such an analysis for each flight, dispatch or landing mass limitation assessment, it is appropriate to provide information to the flight crews on the safest way to perform such a manoeuver, should it be required. The intent is to identify the best option or options for a safe lateral ground track and flight path to follow in the event that a missed approach, balked landing, rejected landing or go-around is necessary. To accomplish this, the operator may develop the methods and criteria for the analysis of one-engine-inoperative procedures that best reflect that operator's operational procedures.

6.2.2 Generally, published missed approach procedures provide adequate terrain clearance. However, further analysis may be required in the following circumstances:

a) published missed approach has a climb gradient requirement;

b) departure procedure for the runway has a published minimum climb gradient;

c) a special OEI take-off procedure is required; or

d) there are runways that are used for landing but not for take-off.

To support this analysis, obstacle and terrain information for the terminal area should be provided by the State of the Aerodrome.

Note.— Operators should incorporate procedures for converting required climb gradients to required climb rates in pilot and dispatcher aeroplane performance sections of their approved training programs.

6.2.3 A distinction must be made between a missed approach and a rejected landing. A OEI missed approach from the minimum descent altitude (height) (MDA(H)), decision altitude (height) (DA(H)), or above, can frequently be flown following the published missed approach procedure. A rejected landing from a lower altitude may require some other procedure (e.g., following the same one-engine-inoperative procedure as used for take-off). In any case, the pilot should be advised of the appropriate course of action when the published missed approach procedure cannot be safely executed.

Assessment considerations

6.2.4 Operators may accomplish such assessments generically for a particular runway, procedure, aircraft type and expected performance and need not perform this assessment for each specific flight. Operators may use simplifying assumptions to account for the transition, reconfiguration and acceleration distances following go-around (e.g., use expected landing mass, anticipated landing flap settings).

6.2.5 The operator should use the best available information or methods from applicable flight manuals or supplementary information from aeroplane or engine manufacturers. If performance or flightpath data are not otherwise available to support the necessary analysis from the above sources, the operator may develop, compute, demonstrate or determine such information to the extent necessary to provide for safe obstacle clearance.

6.2.6 The operational considerations should include:

a) go-around configuration transitions from approach to missed approach configuration, including expected flap settings and flap retraction procedures;

b) expected speed changes and effect on vertical flight profile;

c) appropriate engine failure and shutdown (feathering if applicable) provisions, if the approach was assumed to be initiated with all engines operative;

d) any lateral differences of the missed approach flight path from the corresponding take-off flight path;

e) suitable balked landing obstacle clearance until reaching instrument approach, missed approach or en-route procedurally protected airspace; and

f) any performance or gradient loss during turning flight.

6.2.7 Methods used for take-off analysis (such as improved climb), OEI maximum angle climb or other such techniques may be used.

6.2.8 Operators may make obstacle clearance assumptions similar to those applied to corresponding take-off flight paths in the determination of net vertical flight path clearance or lateral track obstacle clearance.

6.2.9 Refer to the guidance in the following section for methods of establishing procedures for adequate obstacle clearance during go-around.

"One way" airports or other special situations

6.2.10 Where obstacle clearance is determined by the operator to be critical, such as for:

a) airports in mountainous terrain that have runways that are used predominantly for landing in one direction and take-off in the opposite direction ("one way in" and "opposite way out"); or

b) runways at which the planned landing mass is greater than the allowed take-off mass.

6.2.11 The operator should provide the following guidance to the flight crew:

a) the flightpath providing the best ground track for obstacle clearance, and

b) the maximum mass at which a missed approach or rejected landing can safely be accomplished under various conditions of temperature, wind and aeroplane landing configuration.

6.3 ESTABLISHING OBSTACLE CLEARANCE DURING A MISSED APPROACH

6.3.1 Instrument approach procedures may include a minimum go-around gradient exceeding the standard minimum 2.5 per cent. Such go-around gradients are typically applicable up to a given altitude or a given location along the go-around flight path. They are published as all-engine gradients that may be conditioned by obstacle clearance but may also be set to meet noise or ATC constraints. Thus, they may be penalizing when considering an engine failure for the go-around computation as per applicable regulations.

6.3.2 A simple analysis may involve only checking that the published climb gradient can be achieved up to the published altitude constraint. The published gradient defines a plane that may not be penetrated up to the altitude constraint. Verifying that the published climb gradient is complied with at airport elevation would not fulfil this requirement as available thrust, and thus climb capability, decreases with altitude. However, verifying climb capability at the constraint altitude would be penalizing. Checking the published climb gradient at an appropriate intermediate height between runway elevation and the constraint altitude assures that published climb constraints are met up to the constraint altitude.

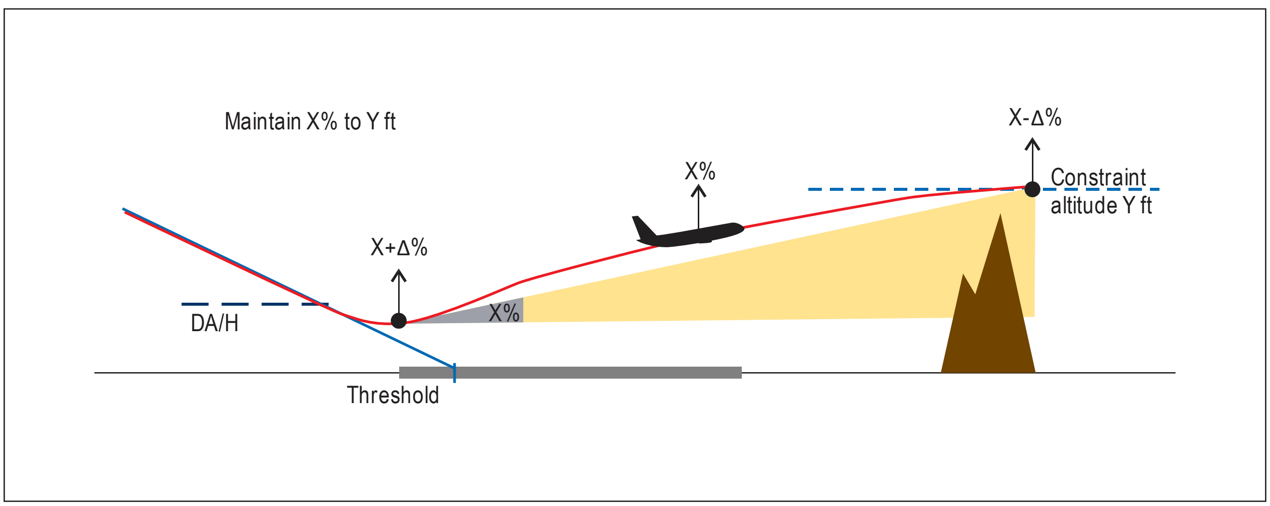

Figure 6-1. Checking climb gradient capability for a missed approach

6.3.3 Whenever compliance with published go-around gradients with one engine inoperative limits the maximum allowable landing mass, it may be beneficial to conduct a specific obstacle clearance analysis. Regulations do not specify the criteria for obstacle clearance during go-around, but it is generally considered that flying an Engine Out Standard Instrument Departure developed for the same runway, will in most cases be safe as these procedures consider a gross to net gradient penalty, an obstacle clearance of 35 to 50 ft and the certified time limit on applying maximum take-off thrust (10 or 5 minutes depending on the applicable certification standard). They are also developed for higher mass than that typically occurring at landing.

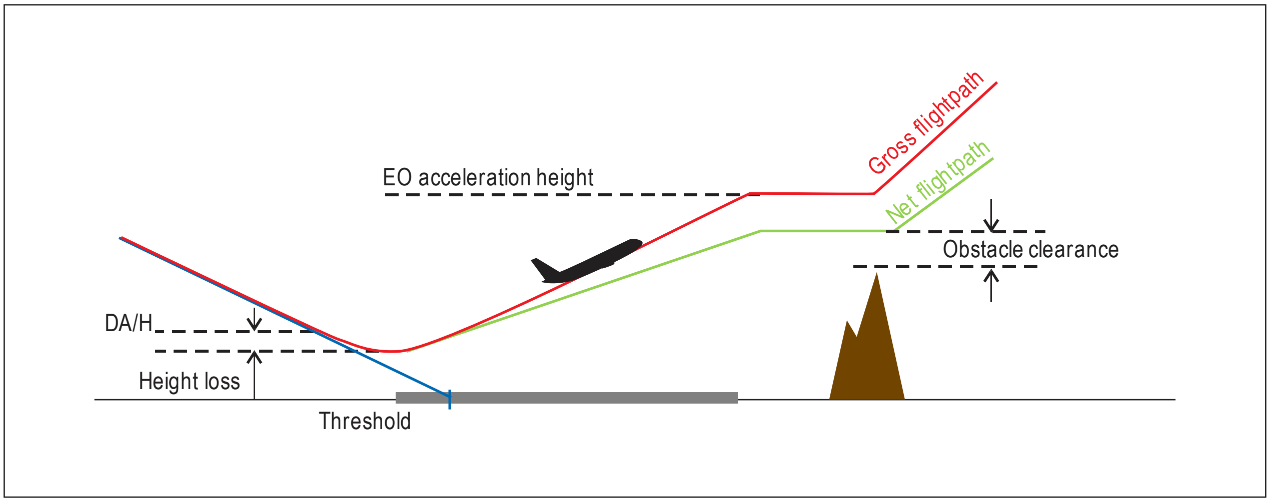

Figure 6-2. Obstacle analysis for a missed approach

6.3.4 If no Engine Out Standard Instrument Departure is available for the runway, a specific procedure may have to be developed. Aspects to consider for such a study are:

a) decision height;

b) aeroplane mass, approach speed and configuration;

c) outside conditions such as wind and temperature;

d) aeroplane acceleration capability;

e) appropriate obstacle clearance criteria (margin on gross flight path, clearance height, loss of gradient in turns);

f) aeroplane flight path and procedure end point (typically minimum obstacle clearance altitude, en-route altitude or a holding fix); and

g) maximum take-off and go-around thrust time limit.

6.3.5 For high altitude constraints, an intermediate acceleration and clean-up may be required to comply with the latter criterion.

6.3.6 The obstacle accountability area for missed approaches as defined in regulatory texts has been set out for all-engine procedure design. Obstacle accountability areas for take-off do not apply to go-around but provide a baseline for the identification of relevant obstacles during go-around. In defining the obstacle accountability area, the precision of the aeroplane guidance (visual, conventional, PBN) should be considered.

6.3.7 In most cases, identification of the critical obstacle and the required gradient to clear this obstacle will allow dispatchers and flight crews to check go-around criteria on a day to day basis with their standard performance information and tools.

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Appendix A

EXAMPLE 1 — Prior Operational Provision Applicable from 14 July 1949

A.1. PURPOSE AND SCOPE

1.1 The purpose of this appendix is to illustrate the level of performance intended by the provisions of Annex 6 Chapter 5 as applicable to the types of aeroplanes described below.

1.2 The SARPs in Annex 6, effective on 14 July 1949, contained specifications similar to those adopted by some Contracting States for inclusion in their national performance codes. A very substantial number of civil transport aeroplanes have been manufactured and are being operated in accordance with these codes. Those aeroplanes are powered with reciprocating engines including turbo-compound design. They embrace twin-engined and four-engined aeroplanes over a mass range from approximately 4 200 kg to 70 000 kg over a stalling speed range, V_{s_0}, from approximately 100 to 175 km/h (55 to 95 kt) and over a wing loading range from approximately 120 to 360 kg/m^2. Cruising speeds range over 555 km/h (300 kt). Those aeroplanes have been used in a very wide range of altitude, air temperature and humidity conditions. At a later date, the code was applied with respect to the evaluation of certification of the so-called "first generation" of turboprop and turbo-jet aeroplanes.

1.3 Although only past experience can warrant the fact that this appendix illustrates the level of performance intended by the SARPs of Annex 6, Chapter 5, it is considered to be applicable over a wide range of aeroplane characteristics and atmospheric conditions. Reservation should however be made concerning the application of this appendix with respect to conditions of high air temperatures. In certain extreme cases, it has been found desirable to apply additional temperature and/or humidity accountability, particularly for the obstacle limited take-off flight path.

1.4 This appendix is not intended for application to aeroplanes having short take-off and landing (STOL) or vertical take-off and landing (VTOL) capabilities.

1.5 No detailed study has been made of the applicability of this example to operations in all-weather conditions. The validity of this example has not therefore been established for operations that may involve low decision heights and be associated with low minima operating techniques and procedures.

A.2. STALLING SPEED — MINIMUM STEADY FLIGHT SPEED

2.1 For the purpose of this appendix, the stalling speed is the speed at which an angle of attack greater than that of maximum lift is reached, or, if greater, the speed at which a large amplitude pitching or rolling motion, not immediately controllable, is encountered, when the manoeuvre described in 2.3 is executed.

Note.— It should be noted that an uncontrollable pitching motion of small amplitude associated with pre-stall buffeting does not necessarily indicate that the stalling speed has been reached.

2.2 The minimum steady flight speed is that obtained while maintaining the elevator control in the most rearward possible position when the manoeuvre described in 2.3 is executed. This speed would not apply when the stalling speed defined in 2.1 occurs before the elevator control reaches its stops.

2.3 Determination of stalling speed — minimum steady flight speed

2.3.1 The aeroplane is trimmed for a speed of approximately 1.4 V_{S1}. From a value sufficiently above the stalling speed to ensure that a steady rate of decrease is obtainable, the speed is reduced in straight flight at a rate not exceeding 0.5 m/s^2 (1 kt/s) until the stalling speed or the minimum steady flight speed, defined in 2.1 and 2.2, is reached.

2.3.2 For the purpose of measuring stalling speed and minimum steady flight speed, the instrumentation is such that the probable error of measurement is known.

2.4 V_{S_0}

V_{S_0} denotes the stalling speed if obtained in flight tests conducted in accordance with 2.3, or the minimum steady flight speed (measured in CAS), as defined in 2.2, with:

a) engines at not more than sufficient power for zero thrust at a speed not greater than 110 per cent of the stalling speed;

b) propeller pitch controls in the position recommended for normal use during take-off;

c) landing gear extended;

d) wing flaps in the landing position;

e) cowl flaps and radiator shutters closed or nearly closed;

f) centre of gravity in that position within the permissible landing range which gives the maximum value of stalling speed or of minimum steady flight speed;

g) aeroplane mass equal to the mass involved in the specification under consideration.

2.5 V_{S_t}

V_{S_t} denotes the stalling speed if obtained in flight tests conducted in accordance with 2.3, or the minimum steady flight speed, (measured in CAS), as defined in 2.2, with:

a) engines at not more than sufficient power for zero thrust at a speed not greater than 110 per cent of the stalling speed;

b) propeller pitch controls in the position recommended for normal use during take-off;

c) aeroplane in the configuration in all other respects and at the mass prescribed in the specification under consideration.

A.3 Take-off

3.1 Mass

The mass of the aeroplane at take-off is not to exceed the maximum take-off mass specified in the flight manual for the altitude at which the take-off is to be made.

3.2 Performance

The performance of the aeroplane as determined from the information contained in the flight manual is such that:

a) the accelerate-stop distance required does not exceed the accelerate-stop distance available;

b) the take-off distance required does not exceed the take- off distance available;

c) the take-off path provides a vertical clearance of not less than 15.2 m up to D = 500 m (50 ft up to D = 1 500 ft) and 15.2 + 0.01 [D – 500] m (50 + 0.01 [D – 1 500] ft) thereafter, above all obstacles lying within 60 m plus half the wing span of the aeroplane plus 0.125D on either side of the flight path, except that obstacles lying beyond 1 500 m on either side of the flight path need not be cleared.

The distance D is the horizontal distance that the aeroplane has travelled from the end of the take-off distance available.

Note.— This need not be carried beyond the point at which the aeroplane would be able, without further gaining in height, to commence a landing procedure at the aerodrome of take-off or, alternatively, to attain the minimum safe altitude for commencing flight to another aerodrome.

However, the lateral obstacle clearance is liable to be reduced (below the values stated above) when, and to the extent that, this is warranted by special provisions or conditions which assist the pilot to avoid inadvertent lateral deviations from the intended flight path. For example, particularly in poor weather conditions, a precise radio aid may assist the pilot to maintain the intended flight path. Also, when the take-off is made in sufficiently good visibility conditions, it may, in some cases, be possible to avoid obstacles which are clearly visible but may be within the lateral limits noted in 3.2 c).

Note 1.— The procedures used in defining the accelerate-stop distance required, the take-off distance required and the take-off flight path are described in the Appendix to this example.

Note 2.— In some national codes similar to this example, the specification for "performance" at take-off is such that no credit can be taken for any increase in length of accelerate-stop distance available and take-off distance available beyond the length specified in Section 1 for take-off run available. Those codes specify a vertical clearance of not less than 15.2 m (50 ft) above all obstacles lying within 60 m on either side of the flight path while still within the confines of the aerodrome, and 90 m on either side of the flight path when outside those confines. It is to be observed that those codes are such that they do not provide for an alternative to the method of elements (see the Appendix to this example) in the determination of the take-off path. It is considered that those codes are compatible with the general intent of this example.

3.3 Conditions

For the purpose of 3.1 and 3.2, the performance is that corresponding to:

a) the mass of the aeroplane at the start of take-off;

b) an altitude equal to the elevation of the aerodrome;

and for the purpose of 3.2:

c) the ambient temperature at the time of take-off for 3.2 a) and b) only;

d) the runway slope in the direction of take-off (landplanes);

e) not more than 50 per cent of the reported wind component opposite to the direction of take-off, and not less than 150 per cent of the reported wind component in the direction of take-off. In certain cases of operation of seaplanes, it has been found necessary to take account of the reported wind component normal to the direction of take-off.

3.4 Critical point

In applying 3.2, the critical point chosen for establishing compliance with 3.2 a) is not nearer to the starting point than that used for establishing compliance with 3.2 b) and 3.2 c).

3.5 Turns

In case the flight path includes a turn with bank greater than 15 degrees, the clearances specified in 3.2 c) are increased by an adequate amount during the turn, and the distance D is measured along the intended track.

A.4. EN-ROUTE

4.1 One engine inoperative

4.1.1 At all points along the route or planned diversion therefrom, the aeroplane is capable, at the minimum flight altitudes en-route, of a steady rate of climb with one engine inoperative, as determined from the flight manual, of at least

1) $K\left(\frac{V_{S_0}}{185.2}\right)^2 m/s$, V_{S_0} being expressed in km/h;

2) $K\left(\frac{V_{S_0}}{100}\right)^2 m/s$, V_{S_0} being expressed in kt;

3) $K\left(\frac{V_{S_0}}{100}\right)^2 ft/min$, V_{S_0} being expressed in kt;

and K having the following value:

$K = 4.04 - \frac{5.40}{N}$ in the case of 1) and 2); and

$K = 797 - \frac{1\,060}{N}$ in the case of 3)

where N is the number of engines installed.

It should be noted that minimum flight altitudes are usually considered to be not less than 300 m (1 000 ft) above terrain along and adjacent to the flight path.

4.1.2 As an alternative to 4.1.1, the aeroplane is operated at an all engines operating altitude such that, in the event of an engine failure, it is possible to continue the flight to an aerodrome where a landing can be made in accordance with section 5.3 of this appendix, the flight path clearing all terrain and obstructions along the route within 8 km (4.3 NM) on either side of the intended track by at least 600 m (2 000 ft). In addition, if such a procedure is utilized, the following provisions are complied with:

a) the rate of climb, as determined from the flight manual for the appropriate mass and altitude, used in calculating the flight path is diminished by an amount equal to:

1) $K\left(\frac{V_{S_0}}{185.2}\right)^2 m/s$, V_{S_0} being expressed in km/h;

2) $K\left(\frac{V_{S_0}}{100}\right)^2 m/s$, V_{S_0} being expressed in kt;

3) $K\left(\frac{V_{S_0}}{100}\right)^2 ft/min$, V_{S_0} being expressed in kt;

and K having the following value:

$K = 4.04 - \frac{5.40}{N}$ in the case of 1) and 2); and

$K = 797 - \frac{1\,060}{N}$ in the case of 3)

where N is the number of engines installed;

b) the aeroplane complies with 4.1.1 at 300 m (1 000 ft) above the aerodrome used as an alternate in this procedure;

c) after the engine failure considered, account is taken of the effect of winds and temperatures on the flight path;

d) it is assumed that the mass of the aeroplane as it proceeds along its intended track is progressively reduced by normal consumption of fuel and oil;

e) it is customary to assume such fuel jettisoning as is consistent with reaching the aerodrome in question.

4.2 Two engines inoperative

(applicable only to aeroplanes with four engines)

The possibility of two engines becoming inoperative when the aeroplane is more than 90 minutes at all engines operating cruising speed from an en-route alternate aerodrome is catered for. This is done by verifying that at whatever such point such a double failure may occur, the aeroplane in the configuration, and with the engine power specified in the flight manual, can thereafter reach the alternate aerodrome without coming below the minimum flight altitude. It is customary to assume such fuel jettisoning as is consistent with reaching the aerodrome in question.

A.5. LANDING

5.1 Mass

The calculated mass for the expected time of landing at the aerodrome of intended landing or any destination alternate aerodrome is not to exceed the maximum specified in the flight manual for the elevation of that aerodrome.

5.2 Landing distance

5.2.1 *Aerodrome of intended landing*

The landing distance at the aerodrome of the intended landing, as determined from the flight manual, is not to exceed 60 per cent of the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

5.2.2 *Alternate aerodromes*

The landing distance at any alternate aerodrome, as determined from the flight manual, is not to exceed 70 per cent of the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

Note.— The procedure used in determining the landing distance is described in the Additional Information section of this example.

5.3 Conditions

For the purpose of 5.2, the landing distances are not to exceed those corresponding to:

a) the calculated mass of the aeroplane for the expected time of landing;

b) an altitude equal to the elevation of the aerodrome;

c) for the purpose of 5.2.1 a) and 5.2.2 a), still air;

d) for the purpose of 5.2.1 b) and 5.2.2 b), not more than 50 per cent of the expected wind component along the landing path and opposite to the direction of landing, and not less than 150 per cent of the expected wind component in the direction of landing.

ADDITIONAL INFORMATION

PROCEDURES USED IN DETERMINING TAKE-OFF AND LANDING PERFORMANCE

1. GENERAL

1.1 Unless otherwise specified, Standard Atmosphere and still air conditions are applied.

1.2 Engine powers are based on a water vapour pressure corresponding to 80 per cent relative humidity in standard conditions. When performance is established for temperature above standard, the water vapour pressure for a given altitude is assumed to remain at the value stated above for standard atmospheric conditions.

1.3 Each set of performance data required for a particular flight condition is determined with the engine accessories absorbing the normal amount of power appropriate to that flight condition.

1.4 Various wing flap positions are selected. These positions are permitted to be made variable with mass, altitude and temperature in so far as this is considered consistent with acceptable operating practices.

1.5 The position of the centre of gravity is selected within the permissible range so that the performance achieved in the configuration and power indicated in the specification under consideration is a minimum.

1.6 The performance of the aeroplane is determined in such a manner that under all conditions the approved limitations for the engine are not exceeded.

1.7 The determined performance is so scheduled that it can serve directly in showing compliance with the aeroplane performance operating limitations.

2. TAKE-OFF

2.1 General

2.1.1 The take-off performance data are determined:

a) for the following conditions:

1) sea level;

2) aeroplane mass equal to the maximum take-off mass at sea level;

3) level, smooth, dry and hard take-off surfaces (landplanes);

4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

1) atmospheric conditions, namely: altitude and also pressure-altitude and temperature;

2) aeroplane mass;

3) steady wind velocity parallel to the direction of take-off;

4) steady wind velocity normal to the direction of take-off (seaplanes);

5) uniform take-off surface slope (landplanes);

6) type of take-off surface (landplanes);

7) water surface condition (seaplanes);

8) density of water (seaplanes);

9) strength of current (seaplanes).

2.1.2 The methods of correcting the performance data to obtain data for adverse atmospheric conditions include appropriate allowance for any increased airspeeds and cowl flap or radiator shutter openings necessary under such conditions to maintain engine temperatures within appropriate limits.

2.1.3 For seaplanes, appropriate interpretations of the term landing gear, etc., are made to provide for the operation of retractable floats, if employed.

2.2 TAKE-OFF SAFETY SPEED

2.2.1 The take-off safety speed is an airspeed (CAS) so selected that it is not less than:

a) $1.20V_{S_t}$, for aeroplanes with two engines;

b) $1.15V_{S_t}$, for aeroplanes having more than two engines;

c) 1.10 times the minimum control speed V_{MC} established, as prescribed in section 2.3;

where V_{S_t} is appropriate to the configuration, as described in 2.3.1 b), c) and d).

2.3 Minimum control speed V_{S_t}

2.3.1 The minimum control speed, V_{MC}, is determined not to exceed a speed equal to 1.2 V_{S_t}, where V_{S_t} corresponds with the maximum certificated take-off mass with:

a) maximum take-off power on all engines;

b) landing gear retracted;

c) wing flaps in take-off position;

d) cowl flaps and radiator shutters in the position recommended for normal use during take-off;

e) aeroplane trimmed for take-off;

f) aeroplane airborne and ground effect negligible.

2.3.2 The minimum control speed is such that, when any one engine is made inoperative at that speed, it is possible to recover control of the aeroplane with the one engine still inoperative, and to maintain the aeroplane in straight flight at that speed either with zero yaw or with a bank not in excess of 5 degrees.

2.3.3 From the time at which the engine is made inoperative to the time at which recovery is complete, exceptional skill, alertness or strength on the part of the pilot is not required to prevent any loss of altitude other than that implicit in the loss of performance, or any change of heading in excess of 20 degrees, nor does the aeroplane assume any dangerous attitude.

2.3.4 It is demonstrated that to maintain the aeroplane in steady straight flight at this speed after recovery, and before retrimming, does not require a rudder control force exceeding 800 N and does not make it necessary for the flight crew to reduce the power of the remaining engines.

2.4 Critical point

2.4.1 The critical point is a selected point at which, for the purpose of determining the accelerate-stop distance and the take-off path, failure of the critical engine is assumed to occur. The pilot is provided with a ready and reliable means of determining when the critical point has been reached.

2.4.2 If the critical point is located so that the airspeed at that point is less than the take-off safety speed, it is demonstrated that, in the event of sudden failure of the critical engine at all speeds down to the lowest speed corresponding with the critical point, the aeroplane is controllable satisfactorily and that the take-off can be continued safely, using normal piloting skill, without reducing the thrust of the remaining engines.

2.5 Accelerate-stop distance required

2.5.1 The accelerate-stop distance required is the distance required to reach the critical point from a standing start and, assuming the critical engine to fail suddenly at this point, to stop if a landplane, or to bring the aeroplane to a speed of approximately 6 km/h (3 kt) if a seaplane.

2.5.2 Use of braking means in addition to, or in lieu of, wheel brakes is permitted in determining this distance, provided that they are reliable and that the manner of their employment is such that consistent results can be expected under normal conditions of operation, and provided that exceptional skill is not required to control the aeroplane.

2.5.3 The landing gear remains extended throughout this distance.

2.6 Take-off path

2.6.1 *General*

2.6.1.1 The take-off path is determined either by the method of elements, 2.6.2, or by the continuous method, 2.6.3, or by any acceptable combination of the two.

2.6.1.2 Adjustment of the provisions of 2.6.2.1 c) 1) and 2.6.3.1 c) is permitted when the take-off path would be affected by the use of an automatic pitch changing device, provided that a level of performance safety exemplified by 2.6 is demonstrated.

2.6.2 *Method of elements*

2.6.2.1 In order to define the take-off path, the following elements are determined:

a) The distance required to accelerate the aeroplane from a standing start to the point at which the take-off safety speed is first attained, subject to the following provisions:

1) the critical engine is made inoperative at the critical point;

2) the aeroplane remains on or close to the ground;

3) the landing gear remains extended.

b) The horizontal distance traversed and the height attained by the aeroplane operating at the take-off safety speed during the time required to retract the landing gear, retraction being initiated at the end of 2.6.2.1 a) with:

1) the critical engine inoperative, its propeller windmilling and the propeller pitch control in the position recommended for normal use during take-off, except that, if the completion of the retraction of the landing gear occurs later than the completion of the stopping of the propeller initiated in accordance with 2.6.2.1 c) 1), the propeller may be assumed to be stopped throughout the remainder of the time required to retract the landing gear;

2) the landing gear extended.

c) When the completion of the retraction of the landing gear occurs earlier than the completion of the stopping of the propeller, the horizontal distance traversed and the height attained by the aeroplane in the time elapsed from the end of 2.6.2.1 b) until the rotation of the inoperative propeller has been stopped, when:

1) the operation of stopping the propeller is initiated not earlier than the instant the aeroplane has attained a total height of 15.2 m (50 ft) above the take-off surface;

2) the aeroplane speed is equal to the take-off safety speed;

3) the landing gear is retracted;

4) the inoperative propeller is windmilling with the propeller pitch control in the position recommended for normal use during take-off.

d) The horizontal distance traversed and the height attained by the aeroplane in the time elapsed from the end of 2.6.2.1 c) until the time limit on the use of take-off power is reached, while operating at the take-off safety speed, with:

1) the inoperative propeller stopped;

2) the landing gear retracted.

The elapsed time from the start of the take-off need not extend beyond a total of 5 minutes.

e) The slope of the flight path with the aeroplane in the configuration prescribed in 2.6.2.1 d) and with the remaining engine(s) operating within the maximum continuous power limitations, where the time limit on the use of take-off power is less than 5 minutes.

2.6.2.2 If satisfactory data are available, the variations in drag of the propeller during feathering and of the landing gear throughout the period of retraction are permitted to be taken into account in determining the appropriate portions of the elements.

2.6.2.3 During the take-off and subsequent climb represented by the elements, the wing flap control setting is not changed. Only changes made before the critical point has been reached, and not earlier than 1 minute after the critical point has been passed, are permitted; in this case, it is demonstrated that such changes can be accomplished without undue skill, concentration or effort on the part of the pilot.

2.6.3 *Continuous method*

2.6.3.1 The take-off path is determined from an actual take-off during which:

a) the critical engine is made inoperative at the critical point;

b) the climb-away is not initiated until the take-off safety speed has been reached and the airspeed does not fall below this value in the subsequent climb;

c) retraction of the landing gear is not initiated before the aeroplane reaches the take-off safety speed;

d) the wing flap control setting is not changed. Only changes made before the critical point has been reached, and not earlier than 1 minute after the critical point has been passed, are permitted; in this case, it is demonstrated that such changes can be accomplished without undue skill, concentration or effort on the part of the pilot;

e) the operation of stopping the propeller is not initiated until the aeroplane has cleared a point 15.2 m (50 ft) above the take-off surface.

2.6.3.2 Suitable methods are provided and employed to take into account, and to correct for, any vertical gradient of wind velocity which may exist during the take-off.

2.7 Take-off distance required

The take-off distance required is the horizontal distance along the take-off flight path from the start of the take-off to a point where the aeroplane attains a height of 15.2 m (50 ft) above the take-off surface.

2.8 Temperature accountability

Operating correction factors for take-off mass and take-off distance are determined to account for temperature above and below those of the Standard Atmosphere. These factors are obtained as follows:

a) For any specific aeroplane type, the average full temperature accountability is computed for the range of mass and altitudes above sea level and for ambient temperatures expected in operation. Account is taken of the temperature effect both on the aerodynamic characteristics of the aeroplane and on the engine power. The full temperature accountability is expressed per degree of temperature in terms of a mass correction, a take-off distance correction and a change, if any, in the position of the critical point.

b) Where 2.6.2 is used to determine the take-off path, the operating correction factors for the aeroplane mass and take-off distance are at least one half of the full accountability values. Where 2.6.3 is used to determine the take-off path, the operating correction factors for the aeroplane mass and take-off distance are equal to the full accountability values. With both methods, the position of the critical point is further corrected by the average amount necessary to assure that the aeroplane can stop within the runway length at the ambient temperature, except that the speed at the critical point is not less than a minimum at which the aeroplane can be controlled with the critical engine inoperative.

3. LANDING

3.1 General

The landing performance is determined:

a) for the following conditions:

1) sea level;

2) aeroplane mass equal to the maximum landing mass at sea level;

3) level, smooth, dry and hard landing surfaces (landplanes);

4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

1) atmospheric conditions, namely: altitude and also pressure-altitude and temperature;

2) aeroplane mass;

3) steady wind velocity parallel to the direction of landing;

4) uniform landing-surface slope (landplanes);

5) type of landing surface (landplanes);

6) water surface condition (seaplanes);

7) density of water (seaplanes);

8) strength of current (seaplanes).

3.2 Landing distance

The landing distance is the horizontal distance between that point on the landing surface at which the aeroplane is brought to a complete stop or, for seaplanes, to a speed of approximately 6 km/h (3 kt) and that point on the landing surface which the aeroplane cleared by 15.2 m (50 ft).

3.3 Landing technique

3.3.1 In determining the landing distance:

a) immediately before reaching the 15.2 m (50 ft) height, a steady approach is maintained, landing gear is fully extended, with an airspeed of not less than 1.3 V_{S_0};

b) the nose of the aeroplane is not depressed in flight nor the forward thrust increased by application of engine power after reaching the 15.2 m (50 ft) height;

c) the wing flap control is set in the landing position, and remains constant during the final approach, flare out and touch down, and on the landing surface at air speeds above 0.9 V_{S_0}. When the aeroplane is on the landing surface and the airspeed has fallen to less than 0.9 V_{S_0}, change of the wing-flap-control setting is permitted;

d) the landing is made in a manner such that there is no excessive vertical acceleration, no excessive tendency to bounce and no display of any uncontrollable or otherwise undesirable ground (water) handling characteristics, and such that its repetition does not require either an exceptional degree of skill on the part of the pilot or exceptionally favourable conditions;

e) wheel brakes are not used in a manner such as to produce excessive wear of brakes or tires, and the operating pressures on the braking system are not in excess of those approved.

3.3.2 In addition to, or in lieu of, wheel brakes, other reliable braking means are permitted to be used in determining the landing distance, provided that the manner of their employment is such that consistent results can be expected under normal conditions of operation and that exceptional skill is not required to control the aeroplane.

3.3.3 The gradient of the steady approach and the details of the technique used in determining the landing distance, together with such variations in the technique as are recommended for landing with the critical engines inoperative, and any appreciable variation in landing distance resulting therefrom, are entered in the flight manual.

Appendix B

EXAMPLE 2 — Prior Operational Provision Applicable from 1 MAY 1953

B.1. PURPOSE AND SCOPE

1.1 The purpose of this appendix is to illustrate the level of performance intended by the provisions of Annex 6, Chapter 5, as applicable to the types of aeroplanes described below.

1.2 This material was contained in substance in Attachment A to the now superseded edition of Annex 6, which became effective on 1 May 1953. It is based on the type of requirements developed by the Standing Committee on Performance* with such detailed changes as are necessary to make it reflect as closely as possible a performance code that has been used nationally.

1.3 A substantial number of civil transport aeroplanes have been manufactured and are being operated in accordance with these codes. Those aeroplanes are powered with reciprocating engines, turbo-propellers and turbo-jets. They embrace twin- engined and four-engined aeroplanes over a mass range from approximately 5 500 kg to 70 000 kg, over a stalling speed range, V_{S_0}, from approximately 110 to 170 km/h (60 to 90 kt), and over a wing loading range from approximately 120 to 350 kg/m^2. Cruising speeds range up to 740 km/h (400 kt). Those aeroplanes have been used in a very wide range of altitude, air temperature and humidity conditions.

1.4 Although only past experience can warrant the fact that this appendix illustrates the level of performance intended by the SARPs of Annex 6, Chapter 5, it is considered to be applicable, except for some variations in detail as necessary to fit particular cases, over a much wider range of aeroplane characteristics. Reservation should, however, be made concerning one point. The landing distance specification of this appendix, not being derived from the same method as other specifications, is valid only for the range of conditions stated in the example for this appendix.

1.5 This appendix is not intended for application to aeroplanes having STOL or VTOL capabilities.

1.6 No detailed study has been made of the applicability of this appendix to operations in all-weather conditions. The validity of this example has not therefore been established for operations which may involve low decision heights and be associated with low weather minima operating techniques and procedures.

B.2. TAKE-OFF

2.1 Mass

The mass of the aeroplane at take-off is not to exceed the maximum take-off mass specified in the flight manual for the altitude and temperature at which the take-off is to be made.

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* The ICAO Standing Committee on Performance, established as a result of recommendations of the Airworthiness and Operations Divisions at their Fourth Sessions, in 1951, met four times between 1951 and 1953.

2.2 Performance

The performance of the aeroplane, as determined from the information contained in the flight manual, is such that:

a) the accelerate-stop distance required does not exceed the accelerate-stop distance available;

b) the take-off run required does not exceed the take-off run available;

c) the take-off distance required does not exceed the take-off distance available;

d) the net take-off flight path starting at a point 10.7 m (35 ft) above the ground at the end of the take-off distance required provides a vertical clearance of not less than 6 m (20 ft) plus 0.005D above all obstacles lying within 60 m plus half the wing span of the aeroplane plus 0.125D on either side of the intended track until the relevant altitude laid down in the operations manual for an en-route flight has been attained; only obstacles lying beyond 1 500 m on either side of the flight path need not be cleared.

The distance D is the horizontal distance that the aeroplane has travelled from the end of the take-off distance available.

Note.— This need not be carried beyond the point at which the aeroplane would be able, without further gaining in height, to commence a landing procedure at the aerodrome of take-off or, alternatively, has attained the minimum safe altitude for commencing flight to another aerodrome.

However, the lateral obstacle clearance is liable to be reduced (below the values stated above) when, and to the extent that, this is warranted by special provisions or conditions which assist the pilot to avoid inadvertent lateral deviations from the intended flight path. For example, particularly in poor weather conditions, a precise radio aid may assist the pilot to maintain the intended flight path. Also, when the take-off is made in sufficiently good visibility conditions, it may, in some cases, be possible to avoid obstacles which are clearly visible but may be within the lateral limits noted in 2.2 d).

Note.— The procedures used in determining the accelerate-stop distance required, the take-off run required, the take-off distance required and the net take-off flight path are described in the Additional Information section of this example.

2.3 Conditions

For the purpose of 2.1 and 2.2, the performance is that corresponding to:

a) the mass of the aeroplane at the start of take-off;

b) an altitude equal to the elevation of the aerodrome;

c) either the ambient temperature at the time of take-off, or a declared temperature giving an equivalent average level of performance;

and for the purpose of 2.2:

d) the surface slope in the direction of take-off (landplanes);

e) not more than 50 per cent of the reported wind component opposite to the direction of take-off, and not less than 150 per cent of the reported wind component in the direction of take-off. In certain cases of operation of seaplanes, it has been found necessary to take account of the reported wind component normal to the direction of take-off.

2.4 Power failure point

In applying 2.2, the power failure point chosen for establishing compliance with 2.2 a) is not nearer to the starting point than that used for establishing compliance with 2.2 b) and 2.2 c).

2.5 Turns

The net take-off flight path may include turns, provided that:

a) the radius of steady turn assumed is not less than that scheduled for this purpose in the flight manual;

b) if the planned change of direction of the take-off flight path exceeds 15 degrees, the clearance of the net take-off flight path above obstacles is at least 30 m (100 ft) during and after the turn, and the appropriate allowance, as prescribed in the flight manual, is made for the reduction in assumed gradient of climb during the turn;

c) the distance D is measured along the intended track.

B.3. EN-ROUTE

3.1 All engines operating

At each point along the route and planned diversion therefrom, the all engines operating performance ceiling appropriate to the aeroplane mass at that point, taking into account the amount of fuel and oil expected to be consumed, is not less than the minimum altitude (see Annex 6, Chapter 4, 4.2.6) or, if greater, the planned altitude which it is intended to maintain with all engines operating, in order to ensure compliance with 3.2 and 3.3.

3.2 One engine inoperative

From each point along the route and planned diversions therefrom, it is possible in the event of one engine becoming inoperative to continue the flight to an en-route alternate aerodrome where a landing can be made in accordance with 4.2 and, on arrival at the aerodrome, the net gradient of climb is not less than zero at a height of 450 m (1 500 ft) above the elevation of the aerodrome.

3.3 Two engines inoperative

(applicable only to aeroplanes with four engines)

For each point along the route or planned diversions therefrom, at which the aeroplane is more than 90 minutes flying time at all engines operating cruising speed from an en-route alternate aerodrome, the two engines inoperative net flight path is such that a height of at least 300 m (1 000 ft) above terrain can be maintained until arrival at such an aerodrome.

Note.— The net flight path is that attainable from the expected gradient of climb or descent diminished by 0.2 per cent.

3.4 Conditions

The ability to comply with 3.1, 3.2 and 3.3 is assessed:

a) either on the basis of forecast temperatures, or on the basis of declared temperatures giving an equivalent average level of performance;

b) on the forecast data on wind velocity versus altitude and locality assumed for the flight plan as a whole;

c) in the case of 3.2 and 3.3, on the scheduled gradient of climb or gradient of descent after power failure appropriate to the mass and altitude at each point considered;

d) on the basis that, if the aeroplane is expected to gain altitude at some point in the flight after power failure has occurred, a satisfactory positive net gradient of climb is available;

e) in the case of 3.2, on the basis that the minimum altitude (see Annex 6, Chapter 4, 4.2.6), appropriate to each point between the place at which power failure is assumed to occur and the aerodrome at which it is intended to alight, is exceeded;

f) in the case of 3.2, making reasonable allowance for indecision and navigational error in the event of engine failure at any point.

B.4. LANDING

4.1 Mass

The calculated mass for the expected time of landing at the aerodrome of intended landing or any destination alternate aerodrome is not to exceed the maximum specified in the flight manual for the altitude and temperature at which the landing is to be made.

4.2 Landing distance required

The landing distance required at the aerodrome of the intended landing or at any alternate aerodrome, as determined from the flight manual, is not to exceed the landing distance available on:

a) the most suitable landing surface for a landing in still air; and, if more severe,

b) any other landing surface that may be required for landing because of expected wind conditions at the time of arrival.

4.3 Conditions

For the purpose of 4.2, the landing distance required is that corresponding to:

a) the calculated mass of the aeroplane for the expected time of landing;

b) an altitude equal to the elevation of the aerodrome;

c) the expected temperature at which landing is to be made or a declared temperature giving an equivalent average level of performance;

d) the surface slope in the direction of landing;

e) for the purpose of 4.2 a), still air;

f) for the purpose of 4.2 b), not more than 50 per cent of the expected wind component along the landing path and opposite to the direction of landing, and not less than 150 per cent of the expected wind component in the direction of landing.

ADDITIONAL INFORMATION

PROCEDURES USED IN DETERMINING TAKE-OFF AND LANDING PERFORMANCE

1. GENERAL

1.1 Unless otherwise stated, reference humidity and still air conditions are applied.

1.2 The performance of the aeroplane is determined in such a manner that the approved airworthiness limitations for the aeroplane and its systems are not exceeded.

1.3 The wing flap positions for showing compliance with the performance specifications are selected.

Note.— Alternative wing flap positions are made available, if so desired, in such a manner as to be consistent with acceptably simple operating techniques.

1.4 The position of the centre of gravity is selected within the permissible range so that the performance achieved in the configuration and power indicated in the specification under consideration is a minimum.

1.5 The performance of the aeroplane is determined in such a manner that under all conditions the approved limitations for the engine are not exceeded.

1.6 While certain configurations of cooling gills have been specified based upon maximum anticipated temperature, the use of other positions is acceptable provided that an equivalent level of safety is maintained.

1.7 The determined performance is so scheduled that it can serve directly in showing compliance with the aeroplane performance operating limitations.

2. TAKE-OFF

2.1 General

2.1.1 The following take-off data are determined for sea level pressure and temperature in the Standard Atmosphere, and reference humidity conditions, with the aeroplane at the corresponding maximum take-off mass for a level, smooth, dry and hard take-off surface (landplanes) and for smooth water of declared density (seaplanes):

a) take-off safety speed and any other relevant speed;

b) power failure point;

c) power failure point criterion, e.g. airspeed indicator reading;

} associated with items d), e), f)

d) accelerate-stop distance required;

e) take-off run required;

f) take-off distance required;

g) net take-off flight path;

h) radius of a steady Rate 1 (180 degrees per minute) turn made at the airspeed used in establishing the net take-off flight path, and the corresponding reduction in gradient of climb in accordance with the conditions of 2.9.

2.1.2 The determination is also made over selected ranges of the following variables:

a) aeroplane mass;

b) pressure-altitude at the take-off surface;

c) outside air temperature;

d) steady wind velocity parallel to the direction of take-off;

e) steady wind velocity normal to the direction of take-off (seaplanes);

f) take-off surface slope over the take-off distance required (landplanes);

g) water surface condition (seaplanes);

h) density of water (seaplanes);

i) strength of current (seaplanes);

j) power failure point (subject to provisions of 2.4.3).

2.1.3 For seaplanes, appropriate interpretations of the term landing gear, etc., are made to provide for the operation of retractable floats, if employed.

2.2 Take-off safety speed

2.2.1 The take-off safety speed is an airspeed (CAS) so selected that it is not less than:

a) $1.20V_{S_t}$, for aeroplanes with two engines;

b) $1.15V_{S_t}$, for aeroplanes having more than two engines;

c) 1.10 times the minimum control speed, V_{MC}, established, as prescribed in section 2.3;

d) the minimum speed prescribed in 2.9.7.6;

where V_{S_t} is appropriate to the take-off configuration.

Note.— See Example 1 for definition of V_{S_t}.

2.3 Minimum control speed

2.3.1 The minimum control speed is such that, when any one engine is made inoperative at that speed, it is possible to recover control of the aeroplane with the one engine still inoperative and to maintain the aeroplane in straight flight at that speed either with zero yaw or with a bank not in excess of 5 degrees.

2.3.2 From the time at which the engine is made inoperative to the time at which recovery is complete, exceptional skill, alertness or strength on the part of the pilot is not required to prevent any loss of altitude other than that implicit in the loss of performance or any change of heading in excess of 20 degrees. The aeroplane also does not assume any dangerous attitude.

2.3.3 It is demonstrated that to maintain the aeroplane in steady straight flight at this speed after recovery and before retrimming does not require a rudder control force exceeding 800 N and does not make it necessary for the flight crew to reduce the power of the remaining engines.

2.4 Power failure point

2.4.1 The power failure point is the point at which sudden complete loss of power from the engine, critical from the performance aspect in the case considered, is assumed to occur. If the airspeed corresponding to this point is less than the take-off safety speed, it is demonstrated that, in the event of sudden failure of the critical engine at all speeds down to the lowest speed corresponding with the power failure point, the aeroplane is controllable satisfactorily and that the take-off can be continued safely, using normal piloting skill, without:

a) reducing the thrust of the remaining engines; and

b) encountering characteristics which would result in unsatisfactory controllability on wet runways.

2.4.2 If the critical engine varies with the configuration, and this variation has a substantial effect on performance, either the critical engine is considered separately for each element concerned, or it is shown that the established performance provides for each possibility of single engine failure.

2.4.3 The power failure point is selected for each take-off distance required and take-off run required, and for each accelerate-stop distance required. The pilot is provided with a ready and reliable means of determining when the applicable power failure point has been reached.

2.5 Accelerate-stop distance required

2.5.1 The accelerate-stop distance required is the distance required to reach the power failure point from a standing start and, assuming the critical engine to fail suddenly at this point, to stop if a landplane, or to bring the aeroplane to a speed of approximately 9 km/h (5 kt) if a seaplane.

2.5.2 Use of braking means in addition to, or in lieu of, wheel brakes is permitted in determining this distance, provided that they are reliable and that the manner of their employment is such that consistent results can be expected under normal conditions of operation, and provided that exceptional skill is not required to control the aeroplane.

2.6 Take-off run required

The take-off run required is the greater of the following:

1.15 times the distance required with all engines operating to accelerate from a standing start to take-off safety speed;

1.0 times the distance required to accelerate from a standing start to take-off safety speed assuming the critical engine to fail at the power failure point.

2.7 Take-off distance required

2.7.1 The take-off distance required is the distance required to reach a height of:

10.7 m (35 ft), for aeroplanes with two engines,

15.2 m (50 ft), for aeroplanes with four engines,

above the take-off surface, with the critical engine failing at the power failure point.

2.7.2 The heights mentioned above are those which can be just cleared by the aeroplane when following the relevant flight path in an unbanked attitude with the landing gear extended.

Note.— Section 2.8 and the corresponding operating requirements, by defining the point at which the net take-off flight path starts as the 10.7 m (35 ft) height point, ensure that the appropriate net clearances are achieved.

2.8 Net take-off flight path

2.8.1 The net take-off flight path is the one-engine-inoperative flight path which starts at a height of 10.7 m (35 ft) at the end of the take-off distance required and extends to a height of at least 450 m (1 500 ft) calculated in accordance with the conditions of 2.9, the expected gradient of climb being diminished at each point by a gradient equal to:

0.5 per cent, for aeroplanes with two engines,

0.8 per cent, for aeroplanes with four engines.

2.8.2 The expected performance with which the aeroplane is credited in the take-off wing flap, take-off power condition, is available at the selected take-off safety speed and is substantially available at 9 km/h (5 kt) below this speed.

2.8.3 In addition, the effect of significant turns is scheduled as follows:

Radius. The radius of a steady Rate 1 (180 degrees per minute) turn in still air at the various true airspeeds corresponding to the take-off safety speeds for each wing-flap setting used in establishing the net take-off flight path below the 450 m (1 500 ft) height point, is scheduled.

Performance change. The approximate reduction in performance due to the above turns is scheduled and corresponds to a change in gradient of:

$\left[0.5\left(\frac{V}{185.2}\right)^2\right]\%$ where V is the true airspeed in km/h; and

$\left[0.5\left(\frac{V}{100}\right)^2\right]\%$ where V is the true airspeed in knots.

2.9 Conditions

2.9.1 *Air speed*

2.9.1.1 In determining the take-off distance required, the selected take-off safety speed is attained before the end of the take-off distance required is reached.

2.9.1.2 In determining the net take-off flight path below a height of 120 m (400 ft), the selected take-off safety speed is maintained, i.e. no credit is taken for acceleration before this height is reached.

2.9.1.3 In determining the net take-off flight path above a height of 120 m (400 ft), the airspeed is not less than the selected take-off safety speed. If the aeroplane is accelerated after reaching a height of 120 m (400 ft) and before reaching a height of 450 m (1 500 ft), the acceleration is assumed to take place in level flight and to have a value equal to the true acceleration available, diminished by an acceleration equivalent to a climb gradient equal to that specified in 2.8.1.

2.9.1.4 The net take-off flight path includes transition to the initial en-route configuration and airspeed. During all transition stages, the above provisions regarding acceleration are complied with.

2.9.2 *Wing flaps*

The wing flaps are in the same position (take-off position) throughout, except:

a) that the flaps may be moved at heights above 120 m (400 ft), provided that the airspeed specifications of 2.9.1 are met and that the take-off safety speed applicable to subsequent elements is appropriate to the new flap position;

b) the wing flaps may be moved before the earliest power failure point is reached, if this is established as a satisfactory normal procedure.

2.9.3 *Landing gear*

2.9.3.1 In establishing the accelerate-stop distance required and the take-off run required, the landing gear are extended throughout.

2.9.3.2 In establishing the take-off distance required, retraction of the landing gear is not initiated until the selected take-off safety speed has been reached, except that, when the selected take-off safety speed exceeds the minimum value prescribed in 2.2, retraction of the landing gear may be initiated when a speed greater than the minimum value prescribed in 2.2 has been reached.

2.9.3.3 In establishing the net take-off flight path, the retraction of the landing gear is assumed to have been initiated not earlier than the point prescribed in 2.9.3.2.

2.9.4 *Cooling*

For that part of the net take-off flight path before the 120 m (400 ft) height point, plus any transition element which starts at the 120 m (400 ft) height point, the cowl flap position is such that, starting the take-off at the maximum temperatures permitted for the start of take-off, the relevant maximum temperature limitations are not exceeded in the maximum anticipated air temperature conditions. For any subsequent part of the net take-off flight path, the cowl flap position and airspeed are such that the appropriate temperature limitations would not be exceeded in steady flight in the maximum anticipated air temperatures. The cowl flaps of all engines at the start of the take-off are as above, and the cowl flaps of the inoperative engine may be assumed to be closed upon reaching the end of the take-off distance required.

2.9.5 *Engine conditions*

2.9.5.1 From the starting point to the power failure point, all engines may operate at maximum take-off power conditions. The operative engines do not operate at maximum take-off power limitations for a period greater than that for which the use of maximum take-off power is permitted.

2.9.5.2 After the period for which the take-off power may be used, maximum continuous power limitations are not exceeded. The period for which maximum take-off power is used is assumed to begin at the start of the take-off run.

2.9.6 *Propeller conditions*

At the starting point, all propellers are set in the condition recommended for take-off. Propeller feathering or pitch coarsening is not initiated (unless it is by automatic or auto-selective means) before the end of the take-off distance required.

2.9.7 *Technique*

2.9.7.1 In that part of the net take-off flight path prior to the 120 m (400 ft) height point, no changes of configuration or power are made which have the effect of reducing the gradient of climb.

2.9.7.2 The aeroplane is not flown or assumed to be flown in a manner which would make the gradient of any part of the net take-off flight path negative.

2.9.7.3 The technique chosen for those elements of the flight path conducted in steady flight, which are not the subject of numerical climb specifications, are such that the net gradient of climb is not less than 0.5 per cent.

2.9.7.4 All information which may be necessary to furnish to the pilot, if the aeroplane is to be flown in a manner consistent with the scheduled performance, is obtained and recorded.

2.9.7.5 The aeroplane is held on, or close to the ground until the point at which it is permissible to initiate landing gear retraction has been reached.

2.9.7.6 No attempt is made to leave the ground until a speed has been reached which is at least:

15 per cent above the minimum possible unstick speed with all engines operating;

7 per cent above the minimum possible unstick speed with the critical engine inoperative;

except that these unstick speed margins may be reduced to 10 per cent and 5 per cent, respectively, when the limitation is due to landing gear geometry and not to ground stalling characteristics.

Note.— Compliance with this specification is determined by attempting to leave the ground at progressively lower speeds (by normal use of the controls except that up-elevator is applied earlier and more coarsely than is normal) until it has been shown to be possible to leave the ground at a speed which complies with these specifications, and to complete the take-off. It is recognized that during the test manoeuvre, the usual margin of control associated with normal operating techniques and scheduled performance information will not be available.

2.10 Methods of derivation

2.10.1 *General*

The take-off field lengths required are determined from measurements of actual take-offs and ground runs. The net take-off flight path is determined by calculating each section separately on the basis of performance data obtained in steady flight.

2.10.2 *Net take-off flight path*

Credit is not taken for any change in configuration until that change is complete, unless more accurate data are available to substantiate a less conservative assumption; ground effect is ignored.

2.10.3 *Take-off distance required*

Satisfactory corrections for the vertical gradient of wind velocity are made.

3. LANDING

3.1 General

The landing distance required is determined:

a) for the following conditions:

   1) sea level;

   2) aeroplane mass equal to the maximum landing mass at sea level;

   3) level, smooth, dry and hard landing surfaces (landplanes);

   4) smooth water of declared density (seaplanes);

b) over selected ranges of the following variables:

   1) atmospheric conditions, namely: altitude, or pressure-altitude and temperature;

   2) aeroplane mass;

   3) steady wind velocity parallel to the direction of landing;

   4) uniform landing surface slope (landplanes);

   5) nature of landing surface (landplanes);

6) water surface condition (seaplanes);

7) density of water (seaplanes);

8) strength of current (seaplanes).

3.2 Landing distance required

The landing distance required is the measured horizontal distance between that point on the landing surface at which the aeroplane is brought to a complete stop or, for seaplanes, to a speed of approximately 9 km/h (5 kt) and that point on the landing surface which the aeroplane cleared by 15.2 m (50 ft) multiplied by a factor of 1/0.7.

Note.— Some States have found it necessary to use a factor of 1/0.6 instead of 1/0.7.

3.3 Landing technique

3.3.1 In determining the measured landing distance:

a) immediately before reaching the 15.2 m (50 ft) height, a steady approach is maintained, landing gear fully extended, with an airspeed of at least $1.3V_{S_0}$;

Note.— See Example 1 for definition of V_{S_0}.

b) the nose of the aeroplane is not depressed in flight nor the forward thrust increased by application of engine power after reaching the 15.2 m (50 ft) height;

c) the power is not reduced in such a way that the power used for establishing compliance with the balked landing climb requirement would not be obtained within 5 seconds if selected at any point down to touch down;

d) reverse pitch or reverse thrust are not used when establishing the landing distance using this method and field length factor. Ground fine pitch is used if the effective drag/weight ratio in the airborne part of the landing distance is not less satisfactory than that of conventional piston-engined aeroplane;

Note.— This does not mean that reverse pitch or reverse thrust, or use of ground fine pitch, are to be discouraged.

e) the wing flap control is set in the landing position, and remains constant during the final approach, flare out and touch down, and on the landing surface at airspeeds above $0.9V_{S_0}$. When the aeroplane is on the landing surface and the airspeed has fallen to less than $0.9V_{S_0}$, change of the wing-flap-control setting is acceptable;

f) the landing is made in a manner such that there is no excessive vertical acceleration, no excessive tendency to bounce, and no display of any other undesirable handling characteristics, and such that its repetition does not require either an exceptional degree of skill on the part of the pilot, or exceptionally favourable conditions;

g) wheel brakes are not used in a manner such as to produce excessive wear of brakes or tires, and the operating pressures on the braking system are not in excess of those approved.

3.3.2 The gradient of the steady approach and the details of the technique used in determining the landing distance, together with such variations in the technique as are recommended for landing with the critical engine inoperative, and any appreciable variation in landing distance resulting therefrom, are entered in the flight manual.

— END —

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