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OPERATIONAL MEASURES FOR DEALING WITH THE PROBLEM OF TAKING OFF FROM SLUSH- OR WATER-COVERED RUNWAYS

Prepared by the Airworthiness Committee and
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TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	3
1. Introduction	5
2. Engine Ingestion Problems	6
3. The Effect of Slush on Take-off Performance	6
4. Clearance and Prevention of Build-up	8
5. Measurement	8
6. Reporting and Notification	9
APPENDIX I.- Estimation of Performance Effects and Influence of Parameters	10
APPENDIX II.- Methods for Measuring Aeroplane Behaviour in Slush . .	20
APPENDIX III.- Airworthiness Requirements Relating to Operations in Slush, published in the United States and the United Kingdom	23

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FOREWORD

1. At its Fourth Meeting, held in Montreal in October-November 1960, the Airworthiness Committee studied, among other subjects, the effect on aeroplane performance of characteristics of the runway surface. It recognized that the problem posed by the presence of slush or water on runways was an important one. The information available on this subject was not then considered to be sufficient to establish new specifications for inclusion in the PAMC on Aeroplane Performance (Circular 58-AN/53); however, it was considered that such information would be very useful to airworthiness and operations authorities, operators and pilots, for guidance. To this end the Committee developed an appropriate text which the Air Navigation Commission, at the Twenty-ninth Meeting of its Thirty-fifth Session, on 15 December 1960, authorized for issuance as an ICAO Circular. In due course Circular 60-AN/55 - Operational Measures for Dealing with the Problem of Taking off from Slush - or Water-covered Runways - was issued.
2. At its Fifth Meeting, held in Montreal in May-June 1962, the Airworthiness Committee briefly examined, in the light of new information made available, the subject of drag due to slush on runways, and accordingly developed an Addendum No. 1 to Circular 60-AN/55. The Air Navigation Commission, at the Second Meeting of its Forty-first Session on 23 October 1962, approved the issuance of Addendum No. 1 to Circular 60-AN/55.
3. The subject was further studied at the informal meeting of the Members of the Airworthiness Committee, held in London in September 1966, and at the Committee's Seventh Meeting, held in Montreal in November-December 1966, because it was evident that the guidance material currently contained in Circular 60-AN/55 and Addendum No. 1 had been outdated by subsequent knowledge and research. At the Seventh Meeting, an ad hoc Working Group was formed to study and examine fully the performance aspects of the subject.
4. An interim report of this ad hoc Working Group, including a first draft of a revised Circular, was submitted to the Fifth Air Navigation Conference, held in Montreal in November-December 1967, and was the subject of Recommendation 5/33 of that Conference. This recommended that the text be further developed and that consideration be given to including operational measures for dealing with the problem of landing on slush- or water-covered runways.
5. At the Eighth Meeting of the Airworthiness Committee, held in Amsterdam in April-May 1968, a draft revision of the Circular 60-AN/55, prepared by the ad hoc Working Group, was examined and a corrected draft was agreed. As amended, the Eighth Meeting recommended to the Air Navigation Commission the issuance of this revised Circular. The Air Navigation Commission authorized issue of this revised edition of Circular 60-AN/55 at the Eighteenth Meeting of its Fifty-eighth Session on 26 June 1968. It is to be noted that, in so doing, the Air Navigation Commission did not pass judgement on, or endorse, the technical contents recommended by the Airworthiness Committee.
6. In addition to completing action on the operational measures for dealing with the problem of taking off from slush- or water-covered runways, the Eighth Meeting of the Airworthiness Committee took into account the views expressed at the Fifth Air Navigation Conference and considered the operational aspects of the effect on landing performance of such contaminants on runway surface. Here, however, it was agreed that information

on the effect of available braking friction should be included in the Aeroplane Flight Manual rather than in the revised Circular 60-AN/55/2, although it was recognized that at that time practical methods suitable for international standardization were insufficiently developed.

7. States are invited to use the specifications contained in Circular 60-AN/55/2 and to notify ICAO of the extent to which they are being applied. Should any State find it desirable or necessary to adopt any significant variations from the specifications, that State is invited to notify the Organization of these differences.

PROVISIONAL ACCEPTABLE MEANS OF COMPLIANCE -
OPERATIONAL MEASURES FOR DEALING WITH THE PROBLEM
OF TAKING OFF FROM SLUSH- OR WATER-COVERED RUNWAYS

Introductory Note.- Throughout this circular the term "slush" is used to cover the whole range of precipitation densities from that of dry snow to that of free standing water.

1.- INTRODUCTION

1.1 There are a number of problem areas in the operation of civil transport aeroplanes which, although they existed for piston-engined types, have become acute only with the introduction of turbine-engined aeroplanes. Not the least of these is associated with operations from slush-covered runways.

1.2 There are three operational problems which arise when operating from slush-covered runways; first, that relating to take-off where the distance required for take-off is increased due to slush drag; second, that relating chiefly to take-off where slush spray thrown up by the wheels enters engine intakes causing serious loss of thrust or even complete stoppage of the engine, with consequent loss of performance; third, those relating to both take-off and landing where, due to reduced friction between tires and runway, there is reduced directional control and also reduced braking friction causing increased distances required for landing and for abandoned take-off. The purpose of this circular is chiefly to deal with the first of these problems although some mention is made of the second.

1.3 In determining the effects of slush on an aeroplane during take-off, there are a number of aspects of the problem to be considered:

- (a) The effect on aeroplane performance due to:
 - (i) retardation effects on aeroplane wheels running through the slush layer, and
 - (ii) drag due to impingement on the aeroplane of spray thrown up by the wheels;
- (b) The possibility of structural damage due to spray impingement;
- (c) The possibility of power loss or system malfunction due to spray ingestion;
- (d) The possibility of jammed landing gear due to filling of wheel wells with slush followed by freezing;
- (e) The possibility of wing flaps becoming inoperative due to accumulated slush.

1.4 The characteristics of turbine-engined aeroplanes which tend to make the problem more acute than for piston-engined aeroplanes are:

- (a) Higher take-off ground speeds mean that the presence of slush on the runway is much more significant from drag and damage considerations;
- (b) Increased sensitivity of take-off performance to drag increments due to:
 - (i) the greater proportion of the take-off distance being spent on the ground, and
 - (ii) the marked diminution in excess thrust which results from any attempt to lift off at speeds below the normal values;
- (c) Lower wing and engine height in relation to aeroplane length increase susceptibility to ingestion and impingement damage;
- (d) A tendency to operate from runways of critical length on a higher percentage of occasions.

1.5 The need to minimize ingestion effects and impingement damage will tend to impose upper limits on slush depths, whereas considerations of performance will tend to permit take-off in a range of slush conditions depending on take-off distance available.

1.6 It is the purpose of this circular to collect any currently available data which leads to a more complete understanding of the problem, and to suggest procedures in both the airworthiness and operations fields which will lead to effective control of the risk level associated with take-off from precipitation-covered runways.

2.- ENGINE INGESTION PROBLEMS

Considerable attention has been paid to the problem of ingestion of slush during take-off by manufacturers, operators and airworthiness authorities.

The consequence of this activity has been that most recent transport aeroplanes have either been demonstrated to be free of ingestion troubles or operating techniques developed which avoid any serious difficulty.

Note.- See Appendix III for extracts from U.S. and U.K. Airworthiness Requirements.

3.- THE EFFECT OF SLUSH ON TAKE-OFF PERFORMANCE

3.1 Typical increments to the take-off ground roll of a jet transport aeroplane are given in Table 1.

TABLE 1

Percentage increase in ground roll			
Thrust/Weight Ratio		0.3	0.2
Slush	10 mm (0.4 in)	18	22
	20 mm (0.8 in)	48	64

The assumptions made in the estimation of these increments are discussed in Appendix I which indicates a method for estimating effect of slush on take-off performance.

Note.- While the method of Appendix I allows the estimation of these effects at any slush depth or density, some operators may prefer in view of the difficulties of assessing the values of the depth or density accurately, to calculate the effects for only one or two critical values, for example:

Depth: For the limiting depth of slush or water for the aeroplane under consideration; this effect might then be used for all lesser depths.

Density: For one density in the dry snow range of possible densities, and one density in the slush/water range of possible densities. In each case, the worst density in the particular density range would have to be determined and used. Owing to the effects of aquaplaning, this might not be the highest density in the range of possible densities.

3.2 The discussion in Appendix I will illustrate the marked effect that a number of parameters can have on the performance effects of slush. Thus the figures quoted in Table 1 should be treated as a rough guide only.

3.3 Although Appendix I gives an outline of methods which can be used for estimating the effect of slush on take-off performance, operators may have difficulty in obtaining the basic aerodynamic data of their aeroplanes in sufficient detail of enable them to make performance estimates.

In the United States a Federal Aviation Agency Advisory Circular* states that: "the operations manual should include specific instructions showing the gross weight reduction and/or additional runway length required for the conditions described." The United Kingdom British Civil Airworthiness Requirements* specify requirements for the determination and scheduling in the Flight Manual of the effect of precipitation on take-off performance.

Thus, in cases where an aeroplane is manufactured or operated in either the United States or the United Kingdom, it may be possible to obtain suitable information on slush performance effects from the operators or manufacturers in those countries.

* See Appendix III for extracts from U.S. and U.K. Airworthiness Requirements.