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PROVISIONAL ACCEPTABLE MEANS OF COMPLIANCE

AEROPLANE FLYING QUALITIES

(Related to the PAMC on Performance)

Prepared by the Airworthiness Committee and published by authority of the Secretary General

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PROVISIONAL ACCEPTABLE MEANS OF COMPLIANCE
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(Related to the PAMC on Performance)

FOREWORD

General

1. The Standards in Annex 8, Airworthiness of Aircraft, are of the nature of broad specifications stating objectives rather than methods of realizing those objectives. In order to indicate by example the level of airworthiness intended by the Standards of that Annex, some specifications of a more detailed and quantitative nature have been included in the same volume under the title "Acceptable Means of Compliance". The Foreword to Annex 8 indicates the obligation under the Convention, resulting from the introduction of Acceptable Means of Compliance.

2. When the Annex was adopted on 13 December 1961, the Standards on the subjects: Aeroplane Performance, Strength under Flight Loads, Reciprocating Engines, Turbine Engines, Propellers and Navigation Lights including Anti-Collision Lights were supplemented by Acceptable Means of Compliance. The absence of provisions of that type pertaining to other subjects was considered either as recognition by the Council that the Standards in themselves defined a sufficiently accurate level of airworthiness, or as a recognition by the Council that due to the technical developments going on in a subject at the time of adoption of the Annex, it had not yet been possible to establish a more precise technical specification than that in the Standards themselves.

3. It is the essence of the Acceptable Means of Compliance that they permit variations in overall methods as well as in detailed application. Therefore, Contracting States, in establishing national codes that will ensure compliance with the Standards, will sometimes need guidance as to the departures from Acceptable Means of Compliance that are suitable for the certification of aircraft other than those specified in their Range of Validity, and also as to the use of methods developed too recently to have behind them the suitable background of experience deemed necessary for introduction of an Acceptable Means of Compliance.

4. The guidance material is established by ICAO as "Provisional Acceptable Means of Compliance", a class of specification that does not impose any obligation under the Convention. The Provisional Acceptable Means of Compliance are not, like the Standards or the full-fledged Acceptable Means of Compliance, established by agreement between Contracting States; instead, they reflect an agreement reached by an international body of experts to the effect that a specification is worthy of trial.

5. Trial application of Provisional Acceptable Means of Compliance in national regulations or practices is intended to build up the amount of experience that, eventually, would lead to the introduction of an Acceptable Means of Compliance on the same subject.

6. The Provisional Acceptable Means of Compliance now presented in this Circular was prepared by the Airworthiness Committee, a body of experts authorized by the Council and functioning under the direction of the Air Navigation Commission. The Airworthiness Committee included this Provisional Acceptable Means of Compliance in its report, issued at the end of its Sixth Meeting which took place in Paris from 10 to 30 June 1964 on the understanding that final agreement on the text of this PAMC would be obtained by correspondence between Airworthiness Committee Members and the Secretariat. The Air Navigation Commission, after satisfying itself that this Provisional Acceptable Means of Compliance was properly co-ordinated with the Standards of Annex 8 and related material, and that the policies of the Organization have been followed, authorized issue of this Provisional Acceptable Means of Compliance at the 2nd Meeting of its Fiftieth Session, on 23 September 1965. It is to be noted that in so doing, the Air Navigation Commission did not pass judgment on, or endorse, the technical contents recommended by the Airworthiness Committee.

Development of the PAMC on Aeroplane Flying Qualities

7. Since 1957 considerable work has been undertaken in several countries on the preparation of new airworthiness codes or on the improvement of existing codes on performance and flying qualities, particularly in relation to turbine-powered aeroplanes. After evaluating the progress made, the Airworthiness Committee, at its First Meeting (October - November 1957), recognized that there was good promise for developing sets of specifications which all its members could consider as worthy of trial.

8. After comprehensive study of problems related to Flying Qualities the Airworthiness Committee agreed at its Fourth Meeting (October - November 1960) that the most urgent task was the development of PAMC material on those flying qualities for which specifications were needed to supplement the PAMC on Aeroplane Performance.

9. A tentative draft PAMC on Aeroplane Flying Qualities (related to the PAMC on Performance) was developed at the Fifth Meeting of the Airworthiness Committee (May - June 1962). However it was decided to revise the specifications contained in the draft before recommending it for issue. An informal meeting was held in London in November 1963 to discuss the results of the revision and revised wording was agreed for a number of requirements. In other cases, where it was not possible to agree upon wording, the problem areas were defined.

10. At the Sixth Meeting (June 1964) the problem areas were discussed and a new text for the draft PAMC on Aeroplane Flying Qualities (related to the PAMC on Performance) was prepared and evaluated. It was agreed that where identical specifications appeared in both the PAMC on Performance and the draft PAMC on Flying Qualities the specifications should be retained in each document so that they could be read more easily; however, where cross references were possible, these should be made. After considerable discussion which showed a large measure of acceptance for the draft PAMC it was agreed that Members should give further consideration to the proposed PAMC and would communicate their findings to ICAO. Final agreement was obtained by correspondence at the end of July 1965.

Applicability

11. This PAMC contains specifications providing for a level of flying qualities equivalent to that intended by the provisions of 2. 3 of Part III of Annex 8 to the Convention made effective on 1 April 1962, when applied to aeroplanes falling within the range of applicability set out in 1. 1 of Part III of Annex 8, and further limited by the applicability clause herein.

12. No study has been made of the applicability of this PAMC to aircraft having design characteristics other than those of transport aeroplanes envisaged to enter in service within the next few years. While use of this PAMC for the certification and operation of these other aircraft may contribute to the experience needed to improve the specifications themselves, it appears that variations from the specifications might be needed. This, for example, may be the case for aeroplanes having supersonic cruising speeds; for those in which lift is produced by the direct utilization of power; and for those which have lift characteristics such that the maximum lift coefficient is obtained over a wide range of incidences.

Future Related Work

13. It should be noted that this PAMC, specifically related to Performance, is not intended to deal with all aspects of aeroplane flying qualities. At a later date an addition to this PAMC to cover such subjects as dynamic stall, unconventional stall identification, range of trim and problems posed by flight out of trim, and rate of roll will be considered. The extensive problems associated with the dynamic stability about all the three axes are intended to be dealt with in a separate PAMC to be prepared later. It should also be noted that problems associated with flying in conditions of severe turbulence and future problems associated with new forms of aircraft (SST, STOL or VTOL transport aeroplanes) have yet to be studied.

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PROVISIONAL ACCEPTABLE MEANS OF COMPLIANCE
AEROPLANE FLYING QUALITIES

(Related to the PAMC on Performance)

APPLICABILITY

This PAMC is applicable to landplanes, other than STOL, VTOL and SST, having two or more piston or turbine engines. No study has been made of the applicability of this PAMC for automatically controlled landings. (See also paragraph 14 of the Foreword to the PAMC on AEROPLANE PERFORMANCE).

1. - GENERAL

1. 1 Introduction

1. 1. 1 The PAMC prescribes qualities which the aeroplane should possess and proof of compliance is established by tests made in conditions selected to cover all appropriate ranges of conditions; it does not include a schedule of handling tests.

1. 1. 2 In the course of establishing compliance with the PAMC, a general qualitative assessment of the handling qualities should be made. If this assessment reveals any unusual features not specifically covered by the PAMC, additional tests should be carried out to establish that the qualities in these respects are satisfactory.

1. 2 Presentation

1. 2. 1 Chapter 1, General, contains general specifications and definitions applicable to the PAMC as a whole. The complete list of requirements included in this PAMC (other than the determination of stalling speed and stalling characteristics) are summarized in Table "A".

1. 2. 2 Chapter 2, Specific conditions, defines the configurations and conditions associated with each requirement and indicates the meaning associated with the symbols by which they are denoted in Table "A".

1. 2. 3 Chapter 3, Requirements - Stability and Control, prescribes the flying qualities with which compliance is to be shown.

1. 2. 4 Chapter 4, Requirements - Stalling, prescribes the determination of the stalling speed and the stalling characteristics.

1. 3 Generally Applicable Conditions

1. 3. 1 The PAMC specifications are associated with no appreciable atmospheric turbulence. However, general controllability should be evaluated in reasonably turbulent air to show that no undue deterioration of flight characteristics occurs.

1.3.2 These PAMC specifications should be complied with at all combinations of weight and centre of gravity position, within the range(s) of loading conditions, including the range of fuel loading conditions, for which certification is desired. This includes also that the most adverse lateral displacements of the centre of gravity under all normally expected conditions of operation should be considered, where applicable.

1.3.3 Each specification should be complied with at all altitudes relevant to the particular requirement and in all temperature conditions relevant to the altitude in question, within the ranges of altitude and temperature for which the aeroplane is to be certificated.

1.3.4 Except for the specifications related to handling on or near the ground, compliance with the specifications should be established out of ground effect.

1.3.5 The aeroplane configuration may be made variable with weight, altitude and temperature to an extent considered compatible with the operating procedures of the aeroplane in service. The position of those parts which affect the aeroplane configuration, but which are not specifically defined in the requirements, shall be those which would be appropriate to the stage of flight under consideration.

1.3.6 It shall be shown that:

a) any failures which are reasonably probable can be counteracted in flight with little difficulty and will not become hazardous before detection and correction, and

b) any more serious failures or combinations of failures, the likelihood of which is remote, can be counteracted in flight without extreme hazard to the occupants.

1.3.6.1 The term failure is used to mean anticipated failures of devices and systems and likely errors of the operating crews.

Note.- Interpretation of failures will be assessed as follows:

a) Reasonably probable (within the probability range 1:1.000 to 1:100.000)

A probability in the range from that failure rate appropriate to failure of one engine on existing transport aeroplanes, up to the rate defined in b) below.

b) Remote (within the probability range 1:100.000 to 1:10.000.000)

A probability in the range from the value appropriate to two engines failing in en route flight on existing transport aeroplanes, up to the rate defined in c) below.

c) Extremely remote (with a probability rate less than 1:10.000.000)

A probability in the range of values appropriate to wing failure due to an extreme gust load on existing transport aeroplanes.

1.3.6.2 In showing compliance with the specifications, automatic devices should be allowed to operate during the tests in their normal manner including any time delays in their operation.

1.3.7 When the handling qualities of the aeroplane are partly or wholly dependent on the operation of an auxiliary service and this service is dependent on the operation of one or more engines, then for each specification which includes consideration of the failure of one or more engines, the determination of the critical engine or engines and the assessment of the handling qualities should take account of the possibility of such engine or engines being stopped.

1.4 Definitions

Power — The word "power" is used throughout this PAMC to indicate the power and/or thrust which is available under specified conditions and in accordance with the PAMC on Performance.

The expression "power-off" is used to indicate the minimum idling power that can normally be selected in flight.

An engine is considered inoperative when the power and/or thrust developed is equivalent to that obtained with zero fuel consumption.

Trimming — The reduction to zero of the mean control forces needed to maintain straight flight at a given speed.

V_{FE} — The maximum speed with wing-flaps in a prescribed extended position.

V_{LE} — The maximum speed at which the aeroplane can be flown safely with the landing gear extended.

V_{LOF} — The lift-off speed.

V_{MCA} — The minimum control speed in free air.

V_{MCG} — The minimum control speed on the ground.

V_{MCL} — The minimum control speed in approach and landing.

V_{MCLC} — The minimum control speed in approach and landing for continued approaches.

V_{MCLD} — The minimum control speed in approach and landing for discontinued approaches.

V_{MO} — The maximum permissible operating speed, appropriate to the en route configuration.

V_{MU} — The minimum unstick speed.

V_R	The rotation speed.
V_S	The stalling speed.
V_{TD}	The touch-down speed.
V_{Tmin}	The minimum threshold speed.
V_{Tmax}	The maximum threshold speed.
V_1	The decision speed.
V_2	The initial climb-out speed.

2. - SPECIFIC CONDITIONS

This Chapter prescribes the stages, configuration and conditions in which the requirements are to be made by defining the meaning of the symbols appearing in the columns of Table "A" headed 2. 1 - Stages, 2. 2 - Initial configuration and 2. 3 - Changes in configuration.

2. 1 Stages

The following flight stages have to be taken into consideration:

2. 1. 1 Take-off run

2. 1. 2 Take-off flight path

2. 1. 3 En route climb

2. 1. 4 En route

2. 1. 5 Approach

2. 1. 6 Discontinued approach

2. 1. 7 Landing

2. 1. 8 Balked landing (Landing climb)

2. 2 Initial configuration

The initial configurations are composed from conditions indicated by the following symbols. They are associated with the requirements for the various flight stages as listed in Table "A". The requirements for the various flight stages are indicated by cross references under the columns headed "3 - Requirements" in Table "A", and are defined in the following paragraphs.

2. 2. 1 Speeds

V_2	A speed equal to V_2.
V_2 + 10 kts	A speed equal to V_2 + 10 kts.
1. $2V_S$	A speed equal to 1. $2V_S$.
1. $3V_S$	A speed equal to 1. $3V_S$.
1. $3V_S$ - 1. $4V_S$	Any speed from 1. $3V_S$ to 1. $4V_S$.
1. $4V_S$	A speed equal to 1. $4V_S$.
1. $3V_S$ - V_{FE}	Any speed from 1. $3V_S$ to V_{FE}.

$1.3V_S - V_{LE}$	Any speed from $1.3V_S$ to V_{LE}.
$1.3V_S - V_{MO}$	Any speed from $1.3V_S$ to V_{MO}.
Climb	A speed range including V_2 and the scheduled climbing speed for the configuration and power prescribed.
n-1 en route	The one-engine-inoperative en route speed selected by the applicant.
n-2 en route	The two-engine-inoperative en route speed selected by the applicant.
n-1 approach	The one-engine-inoperative approach speed selected by the applicant.
n-2 approach	The two-engine-inoperative approach speed selected by the applicant.
V_{Tmin} + 10 kts	A speed equal to V_{Tmin} + 10 kts.
$V_{Tmin} - 1.4V_S$	Any speed from V_{Tmin} to $1.4V_S$.
V_{Tmax}	A speed equal to V_{Tmax} at a height of 10.7 m (35 feet) above the runway.
V_{Tmin}	A speed equal to V_{Tmin} at a height of 10.7 m (35 feet) above the runway.
$0.9V_{Tmin}$	A speed equal to $0.9V_{Tmin}$ (with the aeroplane airborne, but close to the ground).
$V_{TD} - V_S$	Any speed from V_{TD} to V_S (with the aeroplane on the ground).

2.2.2 Flaps

take-off	Wing flaps in each position to be used in take-off.
retract	Wing flaps retracted.
all positions	Wing flaps in extreme flight positions and at each intermediate position for which a gate or detent mechanism is provided.
en route climb	Wing flaps in the positions used in establishing compliance with the en route climb performance specifications of the PAMC on Aeroplane Performance.
en route	Wing flaps in the appropriate en route position.

	final	Wing flaps in each position to be used in final approach.
	final n-1	The one-engine-inoperative final approach wing flap position.
	final n-2	The two-engine-inoperative final approach wing flap position.
	landing	In the position(s) provided for landing.
	landing n-1	The one-engine-inoperative wing flap position for landing.
	landing n-2	The two-engine-inoperative wing flap position for landing.
2.2.3	Gear	
	up	Landing gear retracted.
	down	Landing gear extended.
2.2.4	Power	
	take-off	Take-off power.
	maximum continuous	Maximum continuous power.
	level	Power for level flight in the appropriate configuration, but not greater than maximum continuous power.
	level $1.2V_S$	Power required for level flight at $1.2V_S$.
	descent 3^o	Power required to maintain a gradient of descent of 3^o.
	off	Power-off.
	appropriate	The power appropriate to the specified condition.
	n	All engines operative.
	n-1	Critical engine inoperative.
	n-2	Two critical engines inoperative (applicable only to aeroplanes with three or more engines).
2.2.5	Propeller	
	take-off	The propeller of the inoperative engine in the recommended take-off position, except that

	a different position of the propeller may be acceptable in the case of automatic feathering or automatic pitch-coarsening.
feathered	The propeller of the inoperative engine feathered.

2.2.6 Trim

trim I	The trimming controls in the recommended position for the specified configuration.
trim II	The aeroplane trimmed for the initial conditions.
trim III	The aeroplane in the trimmed condition which would obtain on crossing the runway threshold when using the operational approach and landing technique recommended in the Aeroplane Flight Manual.

2.2.7 Devices

The lift or drag producing devices, other than wing flaps or landing gear are set for the recommended position for the flight stage under consideration.

2.3 Changes in Configuration

Some of the requirements are related to rapid changes in the initial configuration, indicated in 2.2. In each case, the most critical rate of change which can be expected in normal operation shall be considered. The changes, indicated in Table "A", are specified as follows:

flap extension	The wing flaps are extended as rapidly as possible over their full range, except that smaller movements may be made where the design of the flap system prevents greater movement.
flap retraction	The wing flaps are retracted as rapidly as possible over their full range, except that smaller movements may be made where the design of the flap system prevents greater movement.
gear extension	The landing gear is extended by normal means of operation.
gear retraction	The landing gear is retracted by normal means of operation.
devices extension	The devices producing drag and lift, other than wing flaps or the landing gear, are extended as rapidly as possible between any neighbouring gated and/or extreme positions.
critical engine out	The critical engine is suddenly made inoperative.

critical engine out increase power	The critical engine is made inoperative and the power of the operating engine(s) is increased to maintain an angle of descent of 3^{o}.
throttles closed	The throttles of the operating engine(s) are fully closed.
throttles open	The power of the operating engine(s) is increased until maximum take-off power conditions are reached.
throttles open, balked landing	The wing flaps are retracted to the position recommended by the balked landing procedure in the Aeroplane Flight Manual together with a simultaneous application of maximum take-off power.
throttles open, discontinued approach	The power of the operating engine(s) is increased until the maximum take-off power conditions are reached and the changes of configuration made in accordance with the approach procedure specified in the Aeroplane Flight Manual.

Note.- The term "balked landing" is used to mean a climb made with an initial configuration of landing flap and gear down. The term "discontinued approach" is used to mean a climb made with an initial configuration of approach flap and gear down.

3. - REQUIREMENTS - STABILITY AND CONTROL

The requirements to be met for the various flight stages are indicated by references on the right hand side of Table "A" and are given in specific terms in this Chapter 3.

3.1 Stability

3.1.1 Longitudinal stability

3.1.1.1 When longitudinal stability is required in Table "A", it shall be demonstrated that, at the prescribed conditions, the slope of the stick force/speed curve is stable at all speeds within 85% and 115% of the trimmed speed.

3.1.1.2 It shall also be demonstrated that, to obtain and maintain speed above or below the trimmed speed, a push or a pull respectively is necessary at all speeds between the minimum speed in steady unstalled flight and the maximum permissible speed appropriate to the configuration, except that:

i) the control force necessary to maintain a speed differing by as little as possible but, in any event, less than 10% from the trimmed speed may be supplied by control system friction, and

ii) departures up to 15% from the trimmed speed need not be considered if they would cause elevator control forces exceeding 23 kg (50 lb) or if the speed would then exceed any limiting speed for the configuration.

3.1.1.3 To obtain, without re-trimming, any speed within 15% of the trimmed speed considered, the elevator stick force, including the force necessary to overcome friction, should not be excessive. The assessment of whether a control force is considered excessive will be influenced by the ease of applying it and the general level of control forces for the aeroplane.

3.1.1.4 It should be ascertained in flight that the above requirements will be met with the critical engine inoperative in the critical case for stability with the engines operating.

3.1.2 For the associated conditions see Table "A".

3.2 Ability to Trim

Where Table "A" refers to "trim" under the columns headed "Longitudinal" "Lateral" and "Directional", it is to be interpreted that it shall be possible to trim the aeroplane completely in that condition.

3.3 Control Forces

The maximum permitted control forces during dynamic manoeuvres, expressed in kilogrammes (within the brackets the corresponding value in pounds), are shown in Table "A" in the column headed "3.3 - Control forces". The maximum permitted control forces where out-of-trim conditions are permitted, are shown in Table "A" in the columns headed "3. 2 - Trim".

Note 1.- Control forces are conditioned by the duration of their application, by the aircraft's design and disposition of controls and by whether or not the pilot has other physical movements to perform at the same time. It is thus difficult to fix absolute control force limits in terms of exact kilogrammes or pounds. The figures quoted in Table "A" should be considered in this light.

Note 2.- Control forces may also be limited below these maximum figures, if they are considered excessive by reason of difficulty of applying the forces or by reason of incompatibility with the general level of control forces for the aeroplane.

3. 4 V_{MC} Minimum Control Speeds

3. 4. 1 Minimum control speed on the ground V_{MCG}

3. 4. 1. 1 The minimum control speed on the ground V_{MCG}, in terms of calibrated airspeed, should be the minimum speed at which, the critical engine having been made suddenly inoperative at that speed and having been recognized by the pilot, it is possible to maintain control of the aeroplane with the engine still inoperative, using primary aerodynamic controls alone, and thereafter maintain a straight path parallel to that originally intended. In demonstrating the minimum control speed on the ground V_{MCG}, the rudder force required to maintain control should not exceed 68 kg (150 lb) and it should not be necessary to reduce power on the remaining engines. During the manoeuvre, the aeroplane should not assume any dangerous attitude, nor should it require exceptional skill, strength, or alertness on the part of the pilot to prevent excessive yaw and lateral displacement before recovery is complete.

Note 1.- In requiring demonstration of the controllability by primary aerodynamic controls alone, this specification provides for adequate control on a reasonably critical runway surface condition, and for moderate cross-wind. It is acceptable to demonstrate controllability on a wet, well-soaked runway with no major areas of measurable depth of water covering the runway, and by using all available directional control means with which the aeroplane is equipped. Wet controllability demonstration will be accepted as being applicable to both wet and dry runway surfaces.

Note 2.- It is acceptable that the information on the effect of the cross-wind be established by means of computations based on data from a limited amount of flight testing supplemented by data obtained by wind-tunnel experimentation.

Note 3.- When applying the specification relating to the minimum value of V_{MCG}, it is usual to consider a maximum lateral deviation consistent with the width of the runways from which the aeroplane is likely to be operated. A value of 9 metres (30 feet) for this maximum deviation has been used by some airworthiness authorities.

3. 4. 1. 2 The general conditions of acceleration, attitude and contact with the take-off surface, at the time the engine failure becomes evident to the pilot, should be no more favourable than those obtained at the engine failure point of each one-engine-inoperative take-off distance determined in accordance with the PAMC on Aeroplane Performance.

3.4.1.3 For the associated conditions see Table "A".

3.4.2 Minimum control speed in free air V_{MCA}.

3.4.2.1 The minimum control speed V_{MCA}, in terms of calibrated airspeed, should be the speed at which, when the critical engine is suddenly made inoperative during straight steady flight with zero bank at that speed, it is possible to maintain control of the aeroplane with the engine still inoperative and to maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with an angle of bank not in excess of 5^{o}.

3.4.2.2 In demonstrating the minimum control speed specified in 3.4.2.1, it should not be necessary to reduce power on the remaining engines, and the rudder force required to maintain flight control should not be greater than 68 kg (150 lb).

Note.- It is recommended, that where possible, the rudder control force required to maintain control at the initial climb-out speed V_2 (See PAMC on Aeroplane Performance, Part I, 6.2.3) should not exceed 41 kg (90 lb) during take-off demonstrations specified in Part I, paragraph 6.4 of the PAMC on Aeroplane Performance.

3.4.2.3 During recovery from the manoeuvre the aeroplane should not assume any dangerous attitude, nor should it require exceptional skill, strength or alertness on the part of the pilot to prevent a change of heading in excess of 20^{o} and an angle of bank in excess of 30^{o} before recovery is complete.

Note.- A time delay of 2 seconds between the engine failure and the pilot recognition is considered to be adequate.

3.4.2.4 The value of V_{MCA}, determined in accordance with 3.4.2.1 to 3.4.2.3, should not exceed $1.15V_S$ associated with the maximum take-off weight with:

a) the remaining engine(s) operating at the available take-off power and/or thrust;

b) the weight of the aeroplane corresponding with the minimum control speed being demonstrated, except that V_{MCA} need not be demonstrated below V_S relative to the condition;

c) the aeroplane in the take-off configuration existing at the point of the flight path under consideration, except that the landing gear is retracted;

d) the aeroplane trimmed for take-off;

e) the aeroplane airborne and the ground effect negligible;

f) the centre of gravity in the most unfavourable position within the allowable range.

3.4.2.5 These conditions are also summarized in Table "A".

Note.- The increase of the minimum control speed which would result if the automatic feature were inoperative should be investigated. If this increase exceeds 10% it should be considered, in the light of the particular circumstances, whether the nominal value of the minimum control speed should be increased.

3.4.3 Minimum control speed in approach and landing V_{MCL}

3.4.3.1 A minimum control speed in approach and landing V_{MCLD} (discontinued approach) should be determined with one engine inoperative and, in addition, for aeroplanes with three or more engines, with two engines inoperative, for the prescribed conditions.

These speeds should be such that is is possible, without re-trimming, to:

a) close the throttles of the operating engine(s) fully,

b) increase the power of the operating engine(s) until maximum take-off power conditions are reached,

without encountering dangerous flight characteristics.

3.4.3.2 A minimum control speed in approach and landing V_{MCLC} (continued approach) should be determined with all engines operating and one engine inoperative, at which it is possible to fail the critical operating engine and to increase power on the remaining operating engine(s) to that required to continue at an angle of descent of 3^{o} without encountering dangerous flight characteristics.

3.4.3.3 For associated conditions see Table "A".

3.5 Controllability

3.5.1 Longitudinal control during take-off

3.5.1.1 The take-off technique should be consistent with that adopted in establishing the take-off performance according to the PAMC on Performance, and should be such that:

a) It should be possible to leave the trimming control in the recommended take-off position from the starting point to a height of 120 metres (400 feet) without excessive control forces being required whether or not engine failure occurs.

b) It should be possible for the aeroplane to lift off the ground at V_{MU} and, maintaining a positive climb, continue the take-off without displaying any hazardous characteristics.

c) It should be demonstrated that reasonably expected variations in service from the take-off procedures established by the applicant for the operation of the aeroplane (e.g. rotations at speeds higher than V_R), will not result in unsafe flight characteristics.

d) It should be demonstrated that rotation of the aeroplane so that it lifts off at a speed not more than 93% of the established V_{LOF} speed and attains a speed not less than $0.93V_2$ prior to reaching a height of 10.7 metres (35 feet), will not result in unsafe flight characteristics.

e) It should be demonstrated that reasonably expected variations of trim conditions in service do not result in unsafe flight characteristics.

f) It should be demonstrated that no tendency for longitudinal oscillation which is not readily controllable, occurs during take-off.

g) It should be possible for tail-wheel aeroplanes to raise the tail-wheel from the ground during take-off at an airspeed not greater than $0.8V_S$ without an excessive control force being needed, when the aeroplane is being taken-off with the recommended technique, according to the PAMC on Aeroplane Performance.

3.5.1.2 For associated conditions see Table "A".

3.5.2 Directional control during take-off

3.5.2.1 At all points in the groundborne portion of a take-off conducted with the recommended technique, it should be possible to prevent excessive lateral translational divergence from the intended take-off path in the event of sudden failure of the critical engine. There should also be determined a minimum width of runway within which a pilot accustomed to the aeroplane could, in the event of sudden unexpected engine failure, prevent, without undue difficulty, the aeroplane wheels from running off the edge of the runway. The maximum cross-wind component with which each runway width can be associated should be recorded.

3.5.2.2 Compliance with this specification should be shown in take-offs which are discontinued from all speeds up to the highest engine failure speed for which performance data are scheduled, and in continued take-offs in which failure of the critical engine occurs at all speeds from the lowest engine failure speed for which performance data are scheduled to the rotation speed. Nose-wheel steering may be used to the extent that this is compatible with the other flight crew duties. No differential braking should be used until a decision to stop has been taken.

3.5.2.3 For associated conditions see Table "A".

3.5.3 Cross-wind accountability

3.5.3.1 A cross-wind should be determined at and below which it is safe, respectively, to take-off or to land, irrespective of the side from which the wind is blowing. The cross-wind component should be determined for continued take-offs and for landings at sea level on a smooth, dry, hard-surfaced runway with all engines operating, using the recommended take-off or landing technique as appropriate according to the PAMC on Aeroplane Performance. The take-off cross-wind component should not be less than 20 knots.

Note.- A maximum demonstrated cross-wind may be initially determined and then revised in the light of experience.

3.5.3.2 Information should be included in the Aeroplane Flight Manual on the effects of wet runway surfaces on the limiting cross-wind component determined in accordance with 3.5.3.1.

Note.- It is acceptable that the information on the effect of wet surfaces be established by means of computations based on data from a limited amount of flight testing supplemented by data obtained by wind tunnel experimentation.

3.5.3.3 For associated conditions see Table "A".

3.5.4 Control during turns

3.5.4.1 It should be possible, using a favourable combination of controls, to roll the aeroplane adequately from a steady 30° banked turn through an angle of 60°, so as to reverse the direction of the turn in either way. The manoeuvre should not take more than 11 seconds in the take-off configuration and not more than 7 seconds in the landing configuration.

Note.- This specification may prove to be a limitation to V_2.

3.5.4.2 For associated conditions see Table "A".

3.5.5 Lateral and directional control

3.5.5.1 The aileron and rudder control travel and forces shall increase steadily (but not necessarily in constant proportion) as the angle of sideslip is increased, when the aeroplane is in a straight steady sideslip in either direction.

3.5.5.2 The rudder pedal force shall not reverse and increased rudder angle shall not produce decreased angle of sideslip when the aeroplane is in a sideslip at angles greater than the maximum in 3.5.5.1 (up to that at which the full rudder control travel is employed or a rudder pedal force of 82 kg (180 lb) is reached).

3.5.5.3 During the above manoeuvres from zero to maximum sideslip, stick force and travel shall not be excessive.

3.5.5.4 It should be possible, while maintaining the aeroplane laterally level within 5 degrees, to yaw suddenly and to recover in either direction up to changes of heading of 15 degrees, except that the change of heading at which the rudder pedal force exceeds 82 kg (180 lb), or at which full rudder travel is obtained, need not be exceeded.

3.5.5.4.1 This specification should be met without dangerous characteristics such as control over-balance or sudden loss of height.

3.5.5.5 For associated conditions see Table "A".

3.5.6 Control with two engines inoperative

3.5.6.1 For aeroplanes with three or more engines, a technique should be established for adequate control and safe handling in cruising flight with the critical two engines inoperative. The technique established for cruising flight should permit the realization of whatever two-engines-inoperative performance is established in accordance with the en route climb specification in the PAMC on Aeroplane Performance.

3.5.6.2 For associated conditions see Table "A".

3.5.7 Information on approach and landing technique

3.5.7.1 Approach and landing technique should be determined in accordance with paragraph 3.3 of Part I of the PAMC on Aeroplane Performance, (particularly the test procedure should be such that they can be consistently executed in a safe and reliable manner) and scheduled in the Flight Manual according to paragraph 11.3 of Part I of the PAMC on Aeroplane Performance.

3.5.7.1.1 These techniques should be valid for instrument approaches by night and day in visibility conditions which, where adequate visual aids are provided, are not more favourable than the lowest weather minima for which operational approval is to be given.

3.5.7.1.2 These techniques should cover approaches and landings with all engines operating, one engine inoperative and, for aeroplanes with three or more engines, two engines inoperative.

3.5.7.1.3 The items connected with the technique which should be determined are:

a) the speeds and configuration of the various stages of the final approach down to the commencement of the landing flare-out;

b) the minimum threshold speed and the maximum threshold speed which are determined in accordance with the PAMC on Performance, and a statement of their significance.

3.5.7.2 The procedure should be such that:

a) steady approach can be maintained from the beginning of the approach to the point where the decision to land is taken;

b) a satisfactory degree of speed stability, control of gradient of descent, and lateral and directional control is available during the steady approach;

c) the desired descent path can be maintained and changes of configuration or power can be made without requiring exceptional skill;

d) the final steady approach speed with the wing flaps in the approach position enables the achievement of the relevant target threshold speed selected.

3.5.7.3 Approach speeds should be not less than:

a) with all engines operating

V_{MCLC} (one engine inoperative) appropriate to the configuration.

b) with one engine inoperative

V_{MCLD} (one engine inoperative) appropriate to the configuration plus 5 knots.

Note.- The speeds V_{MCL} (two engines inoperative) appropriate to the configuration should be determined and stated in the Flight Manual. It is recommended that approach speed with one engine inoperative should be higher than V_{MCL} (two-engines-inoperative) and that the two-engines-inoperative approach speed should be not less than V_{MCLC} + 5 knots.

3.5.7.4 For associated conditions see Table "A".

3.5.8 Control in discontinued approach

3.5.8.1 It should not require exceptional skill or alertness on the part of the pilot, when making a discontinued approach,

a) to maintain control,

b) to prevent any steepening of the initial flight path,

c) to make a smooth transition to climbing flight.

3.5.8.2 For associated conditions see Table "A".

3.5.9 Control in landing run

It should not require exceptional skill, strength or alertness on the part of the pilot:

a) to establish the landing distances determined in accordance with the landing specifications of the PAMC on Aeroplane Performance;

b) to control the aeroplane in turbulent wind conditions, or on rough landing surfaces likely to be encountered in operation, or with the critical engine inoperative;

c) to maintain a straight path until the speed has fallen to $0.5V_S$, without the use of differential engine power or differential braking, when landing on a smooth dry hard-surfaced runway and touching down with power-off at the maximum touch-down speed.

Note.- The maximum touch-down speed is determined so that the elapsed time from the 10.7 metres (35 feet) height point to the touch-down of the main landing gears is not less, in seconds, than $(13-0.045V_{Tmax})$, with V_{Tmax} expressed in knots, except that a longer time should be required if the touch-down characteristics of the aeroplane are such that a safe touch-down cannot be made within that time.

3.5.10 Control in balked landing

3.5.10.1 It should not require exceptional skill or alertness on the part of the pilot, when carrying out a balked landing,

a) to maintain control,

b) to prevent any steepening of the initial flight path, and

c) to make a smooth transition to climbing flight.

3.5.10.2 For associated conditions see Table "A".

4. - REQUIREMENTS - STALLING

4. 1 General

Stall tests should be executed to establish compliance with the following specifications:

a) During stall demonstration it should be possible to produce and to correct roll and yaw by unreversed use of the aileron and rudder controls up to the moment the aeroplane is stalled, i. e. the normal methods of control available should be such that the aeroplane in straight flight can be maintained substantially level laterally and on a substantially constant heading up to the stall.

b) During stall demonstration there should occur no abnormal nose-up pitching and the longitudinal control force should be a pull force up to and including the stall.

c) During the approach to the stall it should be possible promptly to prevent the aeroplane from stalling.

d) It should be possible to make a safe stall recovery according to 4. 5 by normal use of the controls without exceeding the maximum permissible airspeed appropriate to the configuration or the allowable limit load factors.

4. 2 Test Procedure

The stall demonstration should be conducted as follows:

a) With the aeroplane trimmed for straight flight at the trim speed used when determining the stalling speed V_S (see 4. 7) in accordance with the PAMC on Aeroplane Performance and from a speed sufficiently above the stalling speed to ensure steady conditions, the elevator control should be applied at a rate such that the aeroplane speed reduction does not exceed one knot per second until the aeroplane is stalled (as defined in b) or, if the aeroplane is not stalled, until the control reaches the stop.

b) The aeroplane should be considered stalled when at an angle of attack greater than that of maximum lift, the aeroplane commences a pitching, rolling or yawing motion which cannot be readily arrested, or when the elevator control reaches the stop, whichever occurs first, when the manoeuvre described in a) is executed.

c) Recovery from the stall should be effected by normal recovery techniques, starting as soon as the aeroplane is stalled.

4. 3 Conditions

4. 3. 1 Stalls in steady flight with symmetrical power, in straight flight and in 30° banked turns.

Wing flaps	In each position likely to be used in flight.
Landing gear	Retracted and extended.

Power	Power-off, and all engines operating at the power necessary to maintain level flight at 1.55V_S with the wing flaps in the final approach position, the landing gear retracted and the aeroplane at maximum sea-level landing weight. For the purpose of this specification, the final approach wing flap position should be a position selected by the applicant for the final stages of the approach with all engines operating; it should not be less extended than the final approach position, one engine inoperative.

4.3.2 Stalls in steady straight flight with asymmetrical power

Wing flaps	Retracted.
Landing gear	Retracted.
Power	The critical engine inoperative. Each of the remaining engines operating at 75% of maximum continuous power, except that the power need not be greater than that at which the wings can be held level laterally by the use of maximum control travel or forces up to the point at which the aeroplane stalls.
Propeller	The propeller of the inoperative engine may be idling at zero thrust, or stopped, at the discretion of the applicant.

4.4 Stall Warning

Clear and distinctive stall warning should be apparent to the pilot with sufficient margin to prevent inadvertent stalling of the aeroplane under all expected conditions of flight. The warning should not disappear until the speed is decreased down to V_S and subsequently increased again to V_S plus this margin. The margin should not be so great that the stall warning would operate at any of the normal operating speeds at which performance is measured. It should be acceptable for the warning to be furnished either through the inherent aerodynamic qualities of the aeroplane or by a reliable device with a remote probability of failure (see 1.3.6) which would give clearly distinguishable indications.

Note.- A stall warning beginning at a speed of 8 knots or 7% above the stalling speed, whichever is the smaller, is normally considered sufficient margin. Other margins may be acceptable depending upon the degree of clarity, duration and distinctiveness of the warning and upon other characteristics of the aeroplane evidenced during the approach to the stall and during the recovery after the stall.

4.5 Behaviour Following a Stall

4.5.1 Recovery from straight flight stalls with symmetrical power

In straight flight stalls, the roll occurring between the stall and the completion of the recovery should not exceed a safe limit, assumed to be approximately 30°.

4.5.2 Recovery from turning flight stalls with symmetrical power

In turning flight stalls with bank up to 30°, the motion of the aeroplane following the stall should not be so violent or extreme as to make it difficult with normal piloting skill to effect a prompt recovery and regain control of the aeroplane. The roll occurring between the stall and the completion of the recovery should not exceed a safe limit, assumed to be an increment of approximately 30°.

4.5.3 Recovery from straight flight stalls with asymmetrical power

In straight flight stalls with asymmetrical power the aeroplane should not display any undue spinning tendency; it should be possible, with normal skill, strength or alertness on the part of the pilot, to make a safe recovery without exceeding an angle of bank of 60°. In the recovery, it should be acceptable to throttle back the operating engines, but power should not be applied to the inoperative engine.

4.6 Control Near the Stall

It should be possible to pitch the aeroplane nose-downwards so that a prompt recovery to a speed equal to 1.4V_S can be made.

Associated conditions

Airspeed	Initial steady airspeed - all values between the trim speed used in showing compliance with 4.7 e) and the stalling speed.
Wing flaps	Each position likely to be used in flight.
Landing gear	Extended and retracted.
Power	Power-off and maximum continuous power on all engines.
Initial trim	The most adverse of the trim setting likely to be used for steady flight at the power being used.

4.7 Definition of the Speed V_S

The speed V_S should denote the minimum calibrated speed in flight at which the aeroplane can develop a lift equal to the weight of the aeroplane, the lift being the aerodynamic force perpendicular to the flight path.

Note.- In flight tests to determine V_S, it is not possible to achieve a load factor of unity and it is necessary to utilize the data obtained during the stall demonstration to establish the speed corresponding with a load factor (n) of unity normal to the flight path, the stalling speed V_S defined in 4.7 above being the minimum value of $\frac{V}{\sqrt{n}}$ obtained.

Associated conditions

a) Zero thrust at the stalling speed, or engines idling and throttles closed if it is shown that the resultant thrust does not lower the stalling speed appreciably.

b) If applicable, propeller pitch controls in the position necessary for compliance with a), the aeroplane in all other respects (flaps, landing gear, etc.) in the particular configuration corresponding with that in connection with which V_S is being used.

c) The weight of the aeroplane equal to the weight in connection with which V_S is being used to determine compliance with a particular specification.

d) The centre of gravity in the most unfavourable position within the allowable range appropriate to the weight being considered.

e) The aeroplane trimmed for straight flight at a speed not less than $1.2V_S$ nor greater than $1.4V_S$.

TABLE "A"

	2. Specific conditions								3. Requirements								
Stages	2.2. Initial configuration							2.3. Changes	3.1. Stab.	3.2 Trim			3.3. Control forces			3.4 V_{MC}	3.5. Controllability
2.1.	Speed 2.2.1.	Flaps 2.2.2.	Gear 2.2.3.	Power 2.2.4.		Propeller 2.2.5.	Trim 2.2.6.		Long. 3.1.1.	Long.	Lat.	Dir.	Long.	Lat.	Dir.		
2.1.1.	Take-off run											kg (lb)	kg (lb)	kg (lb)	kg (lb)		
		take-off	down	take-off	n	take-off	trim I	crit.engine out							68(150)	V_{MCG}	3.5.1. Long.control in take-off. 3.5.2. Dir.control in take-off. 3.5.3. Crosswind accountability.
2.1.2.	Take-off flight path																
1.		take-off	up	take-off	n	take-off	trim II	crit.engine out							68(150)	V_{MCA}	
2.	V_2 + 10 kts	"	"	"	"		"	no	stab.	trim	trim	trim					
3.	V_2	"	"	"	n-1	feathered	"	"	"	"	"	18(40)					{ 3.5.4. Control during turns. 3.5.5. Yaw with asymm. power.
4.	V_2 + 10 kts	retracted	"	"	n		"	"		"	"	trim					
5.	"	"	"	max.cont.	"		"	"		"	"	"					
6.	1.2 V_S		"		n-1	feathered	"			"	"	4.5(10)					3.5.5. Yaw with asymm. power.
7.	1.4 V_S	all pos.	down	take-off	n		"	flap retraction					22.7(50)				
2.1.3.	En-route climb																
1.	Climb	en-route climb	up	max.cont.	n		trim II	no	stab.								
2.		en-route climb	"	"	"		"	crit.engine out							68(150)	V_{MCA}	
2.1.4	En-route																
1.	1.3 V_S-V_{MO}	en-route	up	level	n		trim II	no	stab.	trim	trim	trim					
2.	1.3 V_S-V_{LE}	"	down	"	"		"	"	"	"	"	"					
3.	n-1 en-route	"	up	max.cont.	n-1	feathered	"	"		"	"	"					
4.	n-2 en-route	"	"	"	n-2	"	"	"		"	"	"					3.5.6. Control with 2 engines inoperative.
2.1.5.	Approach																
1.	1.4V_S	all pos.	down	level	n		trim II	flap extension					22.7(50)				
2.	"	"	"	"	"		"	devices extens.					17(37.5)*	(see below)			
3.	n-1 approach	final n-1	"	"	n-1	feathered		no		trim	trim	trim					3.5.5. Yaw with asymm. power.
4.	n-2 approach	final n-2	"	"	n-2	"		"		"	"	18(40)					3.5.5. Yaw with asymm. power.
5.	1.3V_S	final	"	desc. 3°	n		trim II	"									3.5.4. Control during turns.
6.	1.3V_S-V_{FE}	"	"	off	n			"	stab.	"	"	"					
7.	"	"	"	level	n			"	"	"	"	"					
8.		" n-1	"	desc. 3°	n-1	feathered	trim II	throttles clos.								V_{MCLD}	} 3.5.7. Information on approach and landing technique.
9.		" n-1	"	"	n-1	"	"	" open								V_{MCLD}	
10.		" n-2	"	"	n-2	"	"	" clos.								V_{MCLD}	
11.		" n-2	"	"	n-2	"	"	" open								V_{MCLC}	
12.		" n	"	"	n		"	{ crit.eng.out								V_{MCLC}	} 3.5.7. Information on approach and landing technique.
13.		" n-1	"	"	n-1	"	"	inc.power								V_{MCLC}	
14.	1.4V_S	all pos.	up	level	n		"	gear down					17(37.5)				
2.1.6.	Discontinued approach																
1.	V_{Tmin}+10 kts	final	down	desc. 3°	n-1	feathered	trim II	throttles open, disc.app.					17(37.5)	9(20)	41(90)		3.5.8. Control in disc.approach
2.	1.3V_S	all pos.	"	off	n		"	throttles open					17(37.5)				
3.	1.3V_S	"	"	take-off	n		"	gear up					17(37.5)				
2.1.7.	Landing																
1.	1.3V_S-1.4V_S	landing	down	off	n		trim II	no	stab.								
2.	"	"	"	level 1.2V_S	n		"	"	"								
3.	1.4V_S	"	"	off	n			"		trim	trim	trim					
4.	V_{Tmin}-1.4V_S	"	"	desc. 3°	n			"		"	"	"					
5.		" n-1	"	"	n-1	feathered	trim II	throttles clos.								V_{MCL}	} 3.5.3. Crosswind accountability.
6.		" n-1	"	"	n-1	"	"	throttles open								V_{MCL}	
7.		" n-2	"	"	n-2	"	"	throttles clos.								V_{MCL}	
8.		" n-2	"	"	n-2	"	"	throttles open								V_{MCL}	3.5.9. Control in landing run.
2.1.8.	Balked landing																
1.	V_{Tmin}	landing	down	approp.	n		trim III	throttles open, balked landing					17(37.5) 22.7(50)				} 3.5.10. Control in balked landing.
2.	0.9V_{Tmin}	"	"	"	"		"	"					22.7(50)				
3.	V_{TD}-V_S	"	"	"	"		"	"					17(37.5)				
4.	V_{Tmax}	"	"	off	"		"	throttles open					17(37.5)				

*When the device is likely to be selected a number of times during the approach it should comply with a force of 9 kg (20 lb).

- END -

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The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the ICAO Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

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