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PROVISIONAL
ACCEPTABLE MEANS OF COMPLIANCE

TURBINE ENGINES – TYPE TESTS

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TABLE OF CONTENTS

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PROVISIONAL ACCEPTABLE MEANS OF COMPLIANCE

TURBINE ENGINES - TYPE TESTS

FOREWORD

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 of 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 June 1957, the Standards on the subjects: Aeroplane Performance, Strength under Flight Loads, Reciprocating Engines, Turbine Engines, Propellers, and Navigation 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 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, could lead to the introduction of an Acceptable Means of Compliance on the same subject.

6. The Provisional Acceptable Means of Compliance presented in the First Edition of this Circular (Circular 51-AN/46) was developed by the Third Air Navigation Conference Meeting in September-October 1956. It was based on a revised Turbine Engines Type Test Schedule which had been agreed between the United States and the United Kingdom in February 1956. The level of airworthiness illustrated by this Provisional Acceptable Means of Compliance was intended to be at least as high as that exemplified by the Acceptable Means of Compliance on the subject within the covers of Annex 8, of which it was a revision. The revision affected mainly the endurance test. While the Acceptable Means of Compliance for Turbine Engines devotes only a proportion of the time to cyclic testing, the revised test in the earlier Provisional Acceptable Means of Compliance was fundamentally a cyclic test schedule. The Council, acting on the recommendation of the Air Navigation Commission, approved the issue of this Provisional Acceptable Means of Compliance at the Eleventh Meeting of its Twenty-Ninth Session on 30 November 1956. In approving the issue of this Provisional Acceptable Means of Compliance, the Council and the Air Navigation Commission did not pass judgement on, or endorse, the technical contents recommended by the Third Air Navigation Conference.

7. At its Fourth Meeting, the Airworthiness Committee, a body of experts authorized by the Council and functioning under the Air Navigation Commission, decided that a re-evaluation of the Provisional Acceptable Means of Compliance - Turbine Engines - was desirable with respect to its adequacy for rotorcraft. At the Fifth Meeting, the Airworthiness Committee examined a draft revision to the Provisional Acceptable Means of Compliance which, in addition to some refinements, included the concept of contingency ratings for turbine engines intended for use in multi-engined rotorcraft. However, in view of the lack of operational experience with such engines, the Airworthiness Committee decided to study the draft further with the intent of finalizing the revision at its next Meeting. At the Sixth Meeting, the Committee observed that there was still a number of areas in which differences existed and recommended that engine-manufacturing States attempt to resolve these differences prior to its next Meeting.

8. The Provisional Acceptable Means of Compliance presented in this Second Edition of the Circular was prepared by the Airworthiness Committee at its Seventh Meeting which was held from 22 November to 15 December 1966. It contains specifications on type tests for turbine engines without contingency ratings for use in aeroplanes and for turbine engines with contingency ratings for use in multi-engined helicopters. In the latter case, two alternative endurance tests have been included to provide for two different approaches, followed in major manufacturing States, relating to the maximum duration (30 minutes or unlimited) of the use of the intermediate contingency power. The Air Navigation Commission, after satisfying itself that this Provisional Acceptable Means of Compliance is properly co-ordinated with the ICAO Standards and related material and that the policies of the Organization have been followed, authorized issue of this revised edition of the Provisional Acceptable Means of Compliance at the Fourth Meeting of its Fifty-Fourth Session on 31 January 1967. 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.

9. States are invited to use these specifications 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 such differences.

TURBINE ENGINES - TYPE TESTS

APPLICABILITY

This Provisional Acceptable Means of Compliance (PAMC) contains specifications for turbine engines without contingency ratings for use in aeroplanes and for turbine engines with contingency ratings for use in multi-engined helicopters.

1. DEFINITIONS

Maximum contingency power and/or thrust. The power and/or thrust developed under standard sea-level static conditions, under the maximum conditions of rotational speed and exhaust gas temperature approved for use when a power-unit failure occurs during take-off or landing and limited in use for $2\frac{1}{2}$ minutes.

Take-off power and/or thrust rating. The power and/or thrust developed under standard sea-level static conditions, under the maximum conditions of rotational speed and exhaust gas temperature approved for use in normal take-off for a period of 5 minutes.

Intermediate contingency power and/or thrust. The power and/or thrust developed under standard sea-level static conditions, under maximum conditions of rotational speed and exhaust gas temperature approved for use when a power unit fails. The rating can be substantiated for a 30-minute period or a period of unrestricted duration, as specified.

Maximum continuous power and/or thrust. The power and/or thrust developed under standard sea level static conditions, under the maximum conditions of rotational speed and exhaust gas temperature approved for use during period of unrestricted duration.

Approach idling conditions. The condition of minimum rotational speed associated with landing approach (the minimum being that commensurate with satisfactory acceleration at anticipated flight conditions), and the maximum exhaust gas temperature at this speed.

Ground idling conditions. The conditions of minimum rotational speed associated with zero forward speed and the maximum exhaust gas temperature at this rotational speed.

Exhaust gas temperature. The average temperature of the exhaust gas stream obtained in an approved manner.

Maximum engine overspeed. The maximum engine rotational speed that has been determined to have no detrimental effect on the engine when used for a stated period of time.

2. DECLARATION

2.1 The conditions and limitations which are intended to govern the operation of the engine are declared. The declaration includes at least the following information:

a) a brief description of the engine and its essential design features;

b) engine rating and all operating limitations (e.g. characteristics of propelling nozzle intended for use in flight, rotational speed, temperature, power and/or thrust);

c) fuel or fuels to be used;

d) lubricating oil to be used;

e) coolant to be used, if any;

f) limitations on operating temperatures and pressures;

g) accessories to be fitted for the tests.

2.2 After completion of the tests the maximum permissible torque and maximum overhung moment for each accessory are specified.

3. TESTS

3.1 Scope

3.1.1 Turbine engines of conventional design are subjected to the tests prescribed herein. Satisfactory completion of the tests of the Provisional Acceptable Means of Compliance is accepted as establishing the characteristics.

3.2 Conditions

3.2.1 A single engine of the design and construction submitted for approval completes satisfactorily the vibration, calibration, endurance and functional tests prescribed herein, except that it is permissible to use one or more identical engines for the vibration, calibration and functional tests. The engine to be used for the endurance tests should be subjected to a calibration check before starting the endurance test.

3.2.2 Throughout these tests, unless otherwise prescribed in this Provisional Acceptable Means of Compliance, all accessory drives are fitted either with representative accessories, or with equivalent means of simulating the loads for which the engine is designed.

3.2.3 Before starting and after completing the tests, a full strip examination of the endurance test engine, including measurement of wear, distortion and creep is made and recorded, except that the strip examination before the start of the tests is sometimes omitted when the wear, distortion and creep can be evaluated by other means.

3.2.4 All tests are made with a declared representative air intake, jet pipe and propelling nozzle of the basic engine as applicable. The propelling nozzle area is sometimes modified for the purpose of the running specified at maximum conditions including power, rpm, and gas and oil inlet temperatures.

3.2.5 In the case of turbo-jet engines, suitable means for measuring the static jet thrust are to be provided for the tests.

3.2.6 In the case of turbo-propeller engines, the calibration tests and checks are carried out on a suitable dynamometer test bench or by use of an approved type of torque dynamometer, the static jet thrust being determined by suitable means.

3.2.7 Maximum permissible airbleed for aircraft purposes is demonstrated during 5 cycles of the endurance test, unless substantiated by acceptable separate tests.

3.2.8 The time consumed in changing power and/or thrust settings during the entire test is deducted from the duration time at the lower settings.

3.2.9 Substantiation of maximum accessory shaft power extracted and other accessory loads may be accomplished either by appropriately loading the accessory pads during the 150-hour test, or by means of equivalent separate tests.

3.2.10 Power control lever motion for acceleration and deceleration runs are made from one extreme position to the other in not more than one second except for turbo-props whenparticular propeller control characteristics may necessitate longer times up to two seconds.

3.2.11 In lieu of overspeed testing during the type test, equivalent overspeed testing of rotor components and other affected components may be conducted.

3.2.12 Maximum temperatures. All take-off and maximum continuous running during the 150-hour test is run at the maximum desired hot gas temperature and oil inlet temperature level for substantiation. During the accelerations and short periods at take-off power, attempts are made to run at the maximum temperatures but, because of the unstabilized conditions, a lower temperature reading is acceptable. In general, essentially the average maximum temperatures are utilized to establish the official maximum temperature limits within practical accuracy limits.

3.2.13 Minimum oil pressure limit. Ten hours of operation during the 150-hour endurance test are run at the minimum oil pressure limit, but separate equivalent tests may also be acceptable.

3.2.14 When atmospheric conditions make it impossible to obtain the shaft power for which approval is requested on a turbo-propeller engine, the shaft power may be substantiated by other separate tests.

3.3 Vibration Test

3.3.1 A vibration survey is conducted to investigate the vibration characteristics throughout the operating range of rotational speed.

3.3.2 If excessive vibration is found to be present in the operating range of the engine, suitable remedial measures are taken prior to the endurance tests.

3.3.3 If moderate vibration is found to exist in the operating range of the engine, either remedial measures are taken, or the engine is to be suitably tested during endurance tests. The objective is to establish the ability of the engine to operate without fatigue failure.

3.4 Calibration Test

3.4.1 The engine is calibrated, to establish the operating characteristics for the purpose of rating the engine, and establishing the conditions for the endurance test specified.

3.4.2 All accessories not required for engine operation are disconnected during this test.

3.5 Endurance Test Schedules (see Table A at end)

The 150-hour endurance test includes twenty-five 6-hour cycles as follows:

3.5.1 Turbine engines without contingency ratings for aeroplanes

3.5.1.1 Take-off and idling

One hour of alternate 5-minute periods at take-off power and/or thrust and at idling power and/or thrust. For engines with augmentation that materially increases turbine inlet temperature or speed, the period of running at take-off conditions is at the augmentation rating. For engines with augmentation which does not materially increase turbine inlet temperature or speed, the amount of running with the augmentation means operating is established.

3.5.1.2 Maximum continuous and take-off

Thirty minutes at maximum continuous power and/or thrust, except during 10 of the 25 test cycles; this period is conducted at take-off power and/or thrust.

3.5.1.3 Maximum continuous

One hour and thirty minutes at maximum continuous power and/or thrust.

3.5.1.4 Incremental runs

Two and one-half hours at fifteen approximately equal speed and time increments between maximum continuous speed and ground idle speed. For engines operating at constant speed, the thrust and/or power may be varied in lieu of speed. In the event significant peak vibration exists at any condition between ground idle and maximum continuous conditions, the number of increments chosen may be altered to increase the amount of running conducted at the peak vibrations up to an amount not to exceed 50 percent of the total time spent in incremental running.

3.5.1.5 Acceleration and deceleration runs

Thirty minutes of accelerations and decelerations from idling power and/or thrust to take-off power and/or thrust consisting of six cycles each of 5 minutes duration made up of $4\frac{1}{2}$ minutes at idling power and/or thrust and 30 seconds at take-off power and/or thrust.

3.5.2 Turbine engines with contingency ratings for multi-engined helicopters

3.5.2.1 Engines with a $2\frac{1}{2}$-minute maximum contingency rating and/or a 30-minute intermediate contingency rating

Note:- Where a $2\frac{1}{2}$-minute rating is not required the maximum contingency running is conducted at take-off conditions.

3.5.2.1.1 Maximum contingency, take-off and idling

One hour of alternate 5-minute periods at take-off power and/or thrust and at idling power and/or thrust except that, during the third and sixth take-off power periods, operate only $2\frac{1}{2}$ minutes at take-off power and the remaining $2\frac{1}{2}$ minutes at maximum contingency power ($2\frac{1}{2}$-minute power). The developed powers and/or thrusts at take-off, $2\frac{1}{2}$-minute and idling conditions and their corresponding rotor speed and gas temperature conditions should be as established by the power control in accordance with the schedule established by the manufacturer.

3.5.2.1.2 Intermediate contingency power (30-minute power)

Thirty minutes at intermediate contingency power and/or thrust.

3.5.2.1.3 Maximum continuous power and/or thrust

Two hours at the maximum continuous power and/or thrust.

3.5.2.1.4 Incremental runs

Two hours at the successive power-lever positions corresponding with not less than 12 approximately equal speed and time increments between maximum continuous engine rotational speed and ground or minimum idle rotational speed. For engines operating at constant speed, the thrust and power may be varied in place of speed.

3.5.2.1.5 Acceleration and deceleration runs

Thirty minutes of accelerations and decelerations, consisting of six cycles from idling power and/or thrust to take-off power and/or thrust and maintained at the take-off power-lever position for 30 seconds and at the idling power-lever position for approximately $4\frac{1}{2}$ minutes.

3.5.2.2 Engines with a $2\frac{1}{2}$-minute maximum contingency rating and an intermediate contingency rating of unlimited duration

Note:- Where a $2\frac{1}{2}$-minute rating is not required the maximum contingency running is conducted at take-off conditions.

1 hour 25 minutes at maximum continuous power

15 minutes in three 5-minute cycles, each cycle comprising:

a) Acceleration.

b) $2\frac{1}{2}$-minutes at intermediate contingency power.

c) Deceleration.

d) $2\frac{1}{2}$-minutes at ground idling conditions.

10 minutes comprising three cycles as follows:

a) Acceleration from 50% maximum continuous power.

b) (1st cycle) $2\frac{1}{2}$ minutes at maximum contingency power.
(2nd and 3rd cycles) $\frac{1}{2}$ minute at maximum contingency power.

c) Deceleration.

d) (1st cycle) $2\frac{1}{2}$ minutes at 50% maximum continuous power.
(2nd and 3rd cycles) 2 minutes at 50% maximum continuous power.

50 minutes at intermediate contingency power

40 minutes at maximum take-off power

2 hours 10 minutes in at least thirteen equal periods at approximately equal speed decrements between intermediate contingency power and ground idling conditions

30 minutes in six 5-minute cycles, each cycle comprising:

a) Acceleration.

b) (1st and 2nd cycles) $2\frac{1}{2}$ minutes at intermediate contingency power.
(Remaining cycles) $2\frac{1}{2}$ minutes at maximum take-off power.

c) Deceleration.

d) $2\frac{1}{2}$ minutes at ground idling and approach conditions alternately.

3.6 Starts

One hundred starts are made, of which:

a) twenty-five starts are preceded by a 2-hour or longer engine shutdown;

b) ten starts are false with the minimum specified combustion chamber drainage time between these successive starts;

c) ten starts are re-starts with not longer than 15 minutes between successive re-starts.

3.7 Functional test

The engine is subjected to whatever additional tests are considered necessary to establish the functional characteristics of the engine.

Note:- These tests are sometimes run in conjunction with the endurance test prescribed in 3.5.

3.8 Recalibration check

At the completion of the tests prescribed in applicable portions of 3.4.3.5, and 3.6, the endurance test engine is subjected to a calibration check to determine any change in power characteristics caused by these tests. There should be no substantial decrease in power and/or thrust as a result of these tests.

3.9 Power ratings

Power ratings are based upon the calibration test prescribed in 3.4 taking into account any appreciable deviations from the declared values occurring during the endurance test of 3.5 and under the following atmospheric conditions:

a) dry air (if correction is significant);

b) intake air temperature of 15°C (59°F);

c) atmospheric pressure of 1013.25 millibars (29.92 inches of mercury).

4.- ENGINE ADJUSTMENT AND PARTS REPLACEMENT DURING TESTS

4.1 During the tests of 3, allowable maintenance should be confined to servicing and minor repairs, except that major repairs or replacement of parts are made in exceptional circumstances in which case the parts in question are subjected to additional penalty tests. The extent of these penalty tests is dependent upon the nature and extent of the repairs or replacements involved.

TABLE A

Endurance Test Requirements for Turbine Engine Without Contingency Rating for Use in Aeroplanes and for Turbine Engines with Contingency Ratings for use in Multi-Engined Helicopters

(Reference Paragraph 3.5)

Total Number of Hours of Operation for 25 cycles

Condition	Aeroplanes Ref. Para. 3.5.1		Multi-Engined Helicopters Ref. Para. 3.5.2.1		Multi-Engined Helicopters Ref. Para. 3.5.2.2	
	Hours	Mins.	Hours	Mins.	Hours	Mins.
Max. Contingency	-	-	2	5	1	27½
Take-off	18	45	11	40	20	50
Intermediate Contingency	-	-	12	30	26	2½
Max. Continuous	45	0	50	0	35	25
Incremental	62	30	50	0	54	10
Idling	23	45	23	45	12	5
Total	150 hours		150 hours		150 hours	

- END -

ICAO TECHNICAL PUBLICATIONS

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.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications comprised in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) are approved by the Council for world-wide application. They comprise, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome. As in the case of Recommended Practices, the Council has invited Contracting States to notify any differences between their national practices and the PANS when the knowledge of such differences is important for the safety of air navigation.

REGIONAL SUPPLEMENTARY PROCEDURES (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

ICAO FIELD MANUALS derive their status from the International Standards, Recommended Practices and PANS from which they are compiled. They are prepared primarily for the use of personnel engaged in operations in the field, as a service to those Contracting States who do not find it practicable, for various reasons, to prepare them for their own use.

TECHNICAL MANUALS provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

AIR NAVIGATION PLANS detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO CIRCULARS make available specialized information of interest to Contracting States. This includes studies on technical subjects as well as texts of Provisional Acceptable Means of Compliance.

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(Doc 8554, AN-CONF/4). 309 pp. ..... U.S. $5.00

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Report of the Seventh Meeting.
Montreal, 22 November - 15 December 1966.
(Doc 8653-AN/887). 153 pp. ..... U.S. $2.50

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