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Aircraft Engine Airworthiness

FEDERAL AVIATION AGENCY

October 1, 1959

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Introductory Note

This manual contains in a consolidated form (1) Civil Air Regulations, Part 13, Aircraft Engine Airworthiness dated June 15, 1956, Amendments 13-1 through 13-3, and the editorial changes required by Special Regulation SR-430 effective December 31, 1958; and (2) the rules, policies, and interpretations issued by the Administrator in application to the various sections of the regulations.

FAA *rules* are issued pursuant to authority conferred upon the Administrator in the Civil Air Regulations. Such rules are mandatory and must be complied with.

FAA *policies* provide detailed technical information on recommended methods of complying with the Civil Air Regulations. Such policies are for the guidance of the public and are not mandatory in nature.

FAA *interpretations* define or explain words and phrases of the Civil Air Regulations. Such interpretations are for the guidance of the public and will be followed by the Agency in determining compliance with the regulations.

This manual is arranged to give the number, title, and text of each section of the regulations followed by any rules, policies, or interpretations applicable to that section. These rules, policies, or interpretations of the Administrator are identified by consecutive dash numbers appended to the regulation section number.

This manual supersedes Civil Aeronautics Manual 13 dated July 1959. As amendments and other pertinent materials pertaining to Part 13 are issued, they will be included in this manual.

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Aircraft Engine Airworthiness

Subpart A—General

Applicability and Definitions

13.0 *Applicability of this part.* This part establishes standards with which compliance shall be demonstrated for the issuance of and changes to type certificates for engines used on aircraft. This part, until superseded or rescinded, shall apply to all engines for which applications for type certification are made after the effective date of this part (August 20, 1938).

13.1 *Definitions.* As used in this part terms are defined as follows:

(a) *Administration.*

(1) *Administrator.* The Administrator is the Administrator of the Federal Aviation Agency.

(2) *Applicant.* An applicant is a person or persons applying for approval of an engine or any part thereof.

(3) *Approved.* Approved, when used alone or as modifying terms such as means, devices, specifications, etc., shall mean approved by the Administrator. (See sec. 13.18.)

(b) *General design.*

(1) *Standard atmosphere.* The standard atmosphere is an atmosphere (see NACA Technical Note 3182) defined as follows:

(i) The air is a dry, perfect gas.

(ii) The temperature at sea level is 59° F.,

(iii) The pressure at sea level is 29.92 inches Hg,

(iv) The temperature gradient from sea level to the altitude at which the temperature equals -69.7° F. is -0.003566° F./ft. and zero thereabove.

(v) The density ρ_0 at sea level under the above conditions is 0.002377 lbs. sec.²/ft.⁴

(2) *Brake horsepower.* Brake horsepower is the power delivered at the propeller shaft of the engine.

(3) *Take-off power or thrust.*

(i) Take-off power for reciprocating engines is the brake horsepower developed under standard sea level conditions and under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for the normal take-off, and limited in use to a maximum continuous period as indicated in the approved engine specification.

(ii) Take-off power for turbine engines is the brake horsepower developed under static conditions at specified altitudes and atmospheric temperatures and under the maximum conditions of rotor shaft rotational speed and gas temperature approved for the normal take-off, and limited in use to a maximum continuous period as indicated in the approved engine specification.

(iii) Take-off thrust for turbine engines is the jet thrust developed under static conditions at specified altitudes and atmospheric temperatures and under the maximum conditions of rotor shaft rotational speed and gas temperature approved for the normal take-off, and limited in use to a maximum continuous period as indicated in the approved engine specification.

[(4) *30-minute power for helicopter turbine engines.* 30-minute power for helicopter turbine engines is the maximum brake horsepower, developed under static conditions at specified altitudes and atmospheric temperatures, under the maximum conditions of rotor shaft rotational speed and gas temperature, and limited in use to periods of not over 30 minutes as shown on the engine data sheet.]

[(5)] *Maximum continuous power or thrust.*

(i) Maximum continuous power for reciprocating engines is the brake horsepower developed in standard atmosphere at a specified altitude and under the maximum conditions of crankshaft rotational speed and engine manifold pressure, and approved for use during periods of unrestricted duration.

(ii) Maximum continuous power for turbine engines is the brake horsepower developed at specified altitudes, atmospheric temperatures, and flight speeds and under the maximum conditions of rotor shaft rotational speed and gas temperature, and approved for use during periods of unrestricted duration.

(iii) Maximum continuous thrust for turbine engines is the jet thrust developed at specified altitudes, atmospheric temperatures, and flight speeds and under the maximum conditions of rotor shaft rotational speed and gas temperature, and approved for use during periods of unrestricted duration.

[(6)] *Gas temperature.* Gas temperature for turbine engines is the temperature of the gas stream obtained as indicated in the approved engine specification.

[(7)] *Manifold pressure.* Manifold pressure is the absolute pressure measured at the appropriate point in the induction system, usually in inches of mercury.

[(8)] *Critical altitude.*¹ The critical altitude is the maximum altitude at which in standard atmosphere it is possible to maintain without ram, at a specified rotational speed, a specified power or a specified manifold pressure. Unless otherwise stated, the critical altitude is the maximum altitude at which it is possible to maintain, at the maximum continuous rotational speed, one of the following:

(i) The maximum continuous power, in the case of engines for which this power

rating is the same at sea level and at the rated altitude,

(ii) The maximum continuous rated manifold pressure, in the case of engines the maximum continuous power of which is governed by a constant manifold pressure.

[(Amendment 13-5, 28 F.R. 304, Jan. 11, 1963, effective Feb. 12, 1963.)]

Certification

13.10 *Eligibility for type certificates.* An engine shall be eligible for type certification under the provisions of this part if it complies with the airworthiness provisions hereinafter established or if the Administrator finds that the provision or provisions not complied with are compensated for by factors which provide an equivalent level of safety: *Provided*, That the Administrator finds no feature or characteristic of the engine which renders it unsafe for use on aircraft.

13.11 *Designation of applicable regulations.* The provisions of this section shall apply to all engine types certificated under this part irrespective of the date of application for type certificate.

(a) Unless otherwise established by the Administrator, the engine shall comply with the provisions of this part together with all amendments thereto effective on the date of application for type certificate, except that compliance with later effective amendments may be elected or required pursuant to paragraphs (c), (d), and (e) of this section.

(b) If the interval between the date of application for type certificate and the issuance of the corresponding type certificate exceeds three years, a new application for type certificate shall be required, except that for applications pending on May 1, 1954, such three-year period shall commence on that date. At the option of the applicant, a new application may be filed prior to the expiration of the three-year period. In either instance the applicable regulations shall be those effective on the date of the new application in accordance with paragraph (a) of this section.

¹ These definitions may not apply in the case of less conventional engines such as compound, variable discharge turbines, etc.

(c) During the interval between filing the application and the issuance of a type certificate, the applicant may elect to show compliance with any amendment of this part which becomes effective during that interval, in which case all other amendments found by the Administrator to be directly related shall be complied with.

(d) Except as otherwise provided by the Administrator, pursuant to section 1.24 of this subchapter, a change to the type certificate (see sec. 13.13(b)) may be accomplished, at the option of the holder of the type certificate, either in accordance with the regulations incorporated by reference in the type

certificate pursuant to section 13.13(c), or in accordance with subsequent amendments to such regulations in effect on the date of application for approval of the change, subject to the following provisions:

(1) When the applicant elects to show compliance with an amendment to the regulations in effect on the date of application for approval of a change, he shall show compliance with all amendments which the Administrator finds are directly related to the particular amendment selected by the applicant.

(2) When the change consists of a new design or a substantially complete redesign of a major component of the engine, and the Administrator finds that the regulations incorporated by reference in the type certificate pursuant to section 13.13(c) do not provide complete standards with respect to such change, he shall require compliance with such provisions of the regulations in effect on the date of application for approval of the change as he finds will provide a level of safety equal to that established by the regulations incorporated by reference at the time of issuance of the type certificate.

(e) If changes listed in subparagraphs (1) and (2) of this paragraph are made, the engine shall be considered as a new type, in which case a new application for type certificate shall be required and the regulations together with all amendments thereto effective on the date of the new application shall be made applicable in accordance with paragraphs (a), (b), (c), and (d) of this section.

(1) A change in the principle of operation;

(2) A change in design, configuration, power limitations, or speed limitations, which the Administrator finds is so extensive as to require a substantially complete investigation of compliance with the regulations.

13.12 Recording of applicable regulations. The Administrator, upon the issuance of a type certificate, shall record the applicable regulations with which compliance was demonstrated. Thereafter, the Admin-

istrator shall record the applicable regulations for each change in the type certificate which is accomplished in accordance with regulations other than those recorded at the time of issuance of the type certificate. (See sec. 13.11.)

13.13 Type certificate.

(a) An applicant shall be issued a type certificate when he demonstrates the eligibility of the engine by complying with the requirements of this part in addition to the applicable requirements in Part 1 of this subchapter.²

² Prior to approval for use of a type certificated engine on a certificated aircraft, the engine will be required to comply with pertinent provisions of the applicable aircraft airworthiness parts of the regulations in this subchapter.

(b) The type certificate shall be deemed to include the type design (see sec. 13.14 (b)), the operating limitations for the engine (see sec. 13.16), and any other conditions or limitations prescribed by the regulations in this subchapter.

(c) The applicable provisions of this part recorded by the Administrator in accordance with section 13.12 shall be considered as incorporated in the type certificate as though set forth in full.

13.14 Data required.

(a) The applicant for a type certificate shall submit to the Administrator such descriptive data, test reports, and computations as are necessary to demonstrate that the engine complies with the requirements of this part.

(b) The descriptive data required in paragraph (a) of this section shall be known as the type design and shall consist of such drawings and specifications as are necessary to disclose the configuration of the engine and all the design features covered in the requirements of this part, such information on dimensions, materials, and processes as is necessary to define the structural strength of the engine, and such other data as are necessary to permit by comparison the determination of the airworthiness of subsequent engines of the same type.

13.15 Inspections and tests. Inspections and tests shall include all those found neces-

sary by the Administrator to insure that the engine complies with the applicable airworthiness requirements and conforms to the following:

(a) All materials and products are in accordance with the specifications in the type design,

(b) All parts of the engine are constructed in accordance with the drawings in the type design,

(c) All manufacturing processes, construction, and assembly are as specified in the type design.

13.16 Required tests. The block tests prescribed in this part shall be conducted to establish the engine operating limitations, as chosen by the applicant, and the reliability of the engine to operate within those limitations. The provisions of paragraphs (a) through (d) of this section shall be applicable.

(a) The applicant shall furnish all testing facilities, including equipment and competent personnel, to conduct the prescribed block tests.

(b) An authorized representative of the Administrator shall witness such of the block tests as are necessary to verify the test report.

(c) The Administrator shall establish engine operating limitations determined on the basis of the engine operating conditions demonstrated during the block tests. Such operating limitations shall include those items relating to power, speeds, temperatures, pressures, fuels, and oils which he finds necessary for safe operation of the engine.

(d) It shall be permissible to use separate engines of identical design and construction in the vibration, calibration, detonation (if applicable), endurance, and operation tests prescribed in subpart B and C of this part, except that if a separate engine is used for the endurance test it shall be subjected to a calibration check before starting the endurance test.

13.17 Production certificates. (For requirements with regard to production certificates see Part 1 of this subchapter.)

13.18 Approval of materials, parts, processes, and appliances.

(a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the regulations in this subchapter. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

Note: The provisions of this paragraph are intended to allow approval of materials, parts, processes, and appliances under the system of Technical Standard Orders, or in conjunction with type certification procedures for an engine, or by any other form of approval by the Administrator.

(b) Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator and the manufacturer so certifies in a manner prescribed by the Administrator.

13.18-1 Approval of spark plugs for reciprocating engines (FAA policies which apply to sec. 13.18).

(a) *General.* Spark plugs are considered to be an integral part of an aircraft engine and therefore should be tested with the engine to determine that the spark plug-engine combination will operate and perform satisfactorily. Upon successful completion of the applicable tests specified in this section the spark plugs will be approved and listed on the pertinent Aircraft Engine Specification.¹ This approval may be extended to other approved models of the same series of engines having equal or lower BMEP ratings or different series of engines of the same manufacture having similar combustion chamber characteristics and equal or lower BMEP ratings.

(1) *Facilities for testing.* The applicant requesting approval for the spark plug should

¹ Aircraft engine specifications are contained in the Engine and Propeller Specifications which may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (Price \$3.00 domestic, \$4.00 foreign, which includes supplementary service.)

provide the necessary facilities, equipment, personnel, etc., for conducting the tests. If the applicant does not possess such facilities, he may arrange for the tests to be conducted by qualified personnel at any appropriate agency which is available to undertake the work. Such agencies might include engine manufacturers, airlines, schools, universities, etc.

(b) *Nomenclature.*

(1) *Spark plugs of new design.* Spark plugs of a type that has not been previously approved for use in any aircraft engine model.

(2) *Spark plugs of an approved type.* Spark plugs of a type that has been approved for use in one or more specific aircraft engine models.

(3) *Spark plugs of a design similar to an approved type.* Spark plugs of a given manufacturer which are similar to an approved type spark plug previously designed by that manufacturer. This classification does not include spark plugs of one manufacturer that may appear to be similar to approved spark plugs designed by another manufacturer.

(4) *New engine models.* Engines scheduled for, or undergoing type certification testing prior to approval.

(5) *Active engines.* Engines which are currently being produced under a Type and/or Production Certificate.

(6) *Obsolescent engines.* Engines not in production; somewhat inactive in service, but the type certificates for which have not been canceled.

(7) *Obsolete 150-hour engines.* Engines certificated under 150-hour endurance test, but the type certificates for which have been canceled.

(8) *Obsolete 50-hour engines.* Engines certificated under 50-hour endurance test, but the type certificates for which have been canceled.

(c) *Tests.*²

(1) *General.* For engines with 6 cylinders or less, a full set of spark plugs of one type should be installed. For engines with 7 cylinders or more, either a full set of one type or two half-sets of different types of spark plugs may be installed. During the block or ground tests it should be determined that the

spark plugs do not have an adverse effect in connection with the following:

- Starting.
- Acceleration.
- Preignition.
- Detonation.
- Fouling.
- Idling.
- R. P. M. drop.
- F/A ratio variations.
- Distribution—F/A—leaded fuel.
- T. O., M. C., cruising powers and speeds.
- Gap erosion rate.
- Mechanical breakdown.
- Ease of installation in engine.

(2) *Replacements.* Normal replacement of spark plugs is permissible during any test, i. e., up to 20 percent of the spark plugs may be replaced during any test provided related engine conditions are satisfactory.

(3) *Spark plug inspection.* At the completion of all block tests and at the intervals specified in each of the flight service tests the spark plugs should be inspected for any unsatisfactory conditions such as mechanical breakdown, gap erosion rate, fouling, etc.

(d) *Spark plugs for new engines.* All types of spark plugs proposed for use in new engines should be tested with the engine during the type certification tests.

(e) *Spark plugs for active engines.*

(1) *Spark plugs of new design or of a type that has been approved for use with other engine models.* Either of the procedures outlined below may be used to substantiate the airworthiness of spark plugs of these categories.

(i) *Block test.* This test should be conducted in accordance with the requirements of sections 13.151 through 13.155.

(ii) *Ground and flight service test.*

(a) A 50-hour engine block test should be conducted in accordance with the requirements of section 13.154. The total time of each test run should be one-third of the time specified in that section; however, the time may be varied to meet special conditions. The vibration, calibration and detonation tests prescribed in sections 13.151 through 13.153 should be conducted during this test.

(b) The flight portion of the test should be conducted under normal operating

² Table 1 provides a ready reference to spark plug testing requirements for various types of engines.

conditions for 200 hours on an experimental (NX) basis. The spark plugs should be inspected in accordance with paragraph (c) (3) of this section at 30- to 50-hour intervals.

(2) *Spark plugs of a design similar to an approved type.* The manufacturer of a spark plug that is approved for a lower rated engine of a series of engines may modify the basic spark plug by changing its characteristics to accommodate the higher IMEP of other engines of the same series with higher hp. ratings. The modified spark plugs will be granted approval for use with all engines of the particular model involved upon satisfactory completion of either of the procedures in paragraph (1) of this paragraph or the following ground and flight service test:

(i) *Ground test.* A 50-hour engine block test should be conducted in accordance with the requirements of section 13.154. The total time of each test run should be one-third of the time specified in that section; however, the time may be varied to meet special conditions. The vibration, calibration and detonation tests prescribed in sections 13.151 through 13.153 should be conducted during this test. Upon satisfactory completion of this test, approval will be granted for limited use of the spark plug in aircraft for the purpose of flight service testing in not more than two aircraft as follows:

(ii) *Flight service test.*

(a) When installed in engines of aircraft being operated under Parts 40, 41 or 42 of this subchapter, 250 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 30- to 50-hour intervals.

(b) When installed in engines of aircraft being operated under Part 43 of this subchapter, 100 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 20- to 25-hour intervals.

(f) *Spark plugs for obsolescent engines.*

(1) *Spark plugs of a new design or of a type that has been approved for use with other engine models.* The test procedures outlined in paragraph (e) (1) of this section apply.

(2) *Spark plugs of a design similar to an approved type.* It sometimes happens that the spark plug manufacturer may wish to tailor or redesign a type of spark plug previously approved for use in certain engines in order that the redesigned spark plug will be suitable for use in an obsolescent engine of a different series of engines. Upon satisfactory completion of the block test and the applicable flight service test specified below, the redesigned spark plug will be granted approval for use in all engines of the particular model involved.

(i) *Block test.* This test should be conducted using the procedure of paragraph (e) (2) (i) of this section. Upon satisfactory completion of this block test, approval will be granted for limited use of the spark plug in aircraft for the purpose of flight service testing in not more than two aircraft as follows:

(ii) *Flight service test.* (a) When installed in engines of aircraft being operated under Parts 40, 41 or 42 of this subchapter, 150 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 25- to 30-hour intervals.

(b) When installed in engines of aircraft being operated under Part 43 of this subchapter, 50 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 10- to 15-hour intervals.

(g) *Spark plugs for obsolete 150-hour engines.*

(1) *Spark plugs of new design.* The test procedures outlined in paragraph (e) (1) of this section apply.

(2) *Spark plugs of a design similar to an approved type.* Upon satisfactory completion of the preignition test and the applicable flight service test specified below, spark plugs of a type, or similar to a type which has been previously approved for use in one or more specific engine models, will be granted approval for use with all obsolete engine models for which the approved spark plug used in the preignition rating test has been granted approval.

(i) *Comparative single cylinder preignition test.* This test should be conducted on a single cylinder engine acceptable to the FAA and should consist of the following: six approved

spark plugs of a type currently considered acceptable for use in the obsolete engine and six test spark plugs of the type for which approval is desired should be tested to establish comparative preignition ratings. If the average IMEP rating of the test spark plugs falls within the range of plus or minus ten percent ($\pm 10\%$) of the average rating established for the approved type spark plugs, the test plug will be approved for limited use in an aircraft for the specific purpose of accomplishing one of the following flight service tests:

(a) When installed in not more than one-half of the engines of not more than two aircraft being operated under Parts 40, 41 or 42 of this subchapter, 150 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 25- to 30-hour intervals.

(b) When installed in engine(s) of not more than one aircraft being operated under Part 43 of this subchapter, 100 hours of flight under normal operating conditions should be conducted and the spark plugs inspected in accordance with paragraph (c) (3) of this section at 20- to 25-hour intervals.

(h) *Spark plugs for obsolete 50-hour engines.*

(1) *Spark plugs of new design.* Either of the following procedures may be used to substantiate the airworthiness of spark plugs in this category:

(i) *Block test.* A 50-hour block test under conditions similar to those specified for the original type certification tests of the engine.

(ii) *Ground and flight service test.*

(a) The ground test should be a 10-hour endurance test under conditions similar to those specified for the original type certification of the engine.

(b) The flight portion of the test should be conducted under normal operating conditions for 90 hours on an experimental (NX) basis. The spark plugs should be inspected in accordance with paragraph (c) (3) of this section at 25- to 30-hour intervals.

(2) *Spark plugs of a design similar to an approved type.* Upon satisfactory completion of the preignition test and the flight service test specified below, spark plugs of a type, or similar to a type which has been previously approved

for use in one or more specific engine models, will be granted approval for use with all obsolete 50-hour engine models for which the approved spark plug used in the preignition rating test has been granted approval.

(i) *Comparative single cylinder preignition test.* The test procedures outlined in paragraph (g) (2) (i) should be followed.

(ii) *Flight service test.* Upon satisfactory completion of the preignition test a 50-hour flight service test should be conducted under normal operating conditions in one airplane only. The spark plugs should be inspected in accordance with paragraph (c) (3) of this section at 20- to 30-hour intervals.

(i) *Alteration to approved spark plugs.*

(1) *Major changes.* Any major change to an approved type spark plug requires substantiation normally by engine testing. A description of the change and substantiating data should be submitted to the FAA for evaluation and/or approval to determine whether testing is necessary before installing the modified spark plug in a certificated engine. Major changes include:

(i) Any alteration or modification which will appreciably change the IMEP rating of the spark plug.

(ii) The substitution of nonequivalent materials for the fabrication of major parts and assemblies of the spark plug.

(iii) Any other change which may adversely affect the operating characteristics and the airworthiness of the spark plug.

(2) *Minor changes.* Minor changes do not require FAA approval prior to incorporation in certificated engines, but should be included in the semi-annual drawing submittal for subsequent FAA approval. Minor changes include:

(i) Slight variations in tolerances and clearances.

(ii) Change to equivalent or improved material in minor parts.

(iii) Improvements in surface treatment of external areas.

(iv) Any other minor change which does not adversely affect the operating characteristics and the airworthiness of the spark plug.

(3) *Spark plugs tested by engine manufacturers.* The spark plug manufacturer sup-

plies detailed information (usually on blue prints) to the engine manufacturer with respect to changes or alterations to approved type spark plugs. The engine manufacturer should include these changes in engine parts drawing submittals to the FAA.

(4) *Spark plugs tested by others than engine manufacturers.* Spark plug manufacturers and others who have obtained approval of a spark plug without testing by an engine manufacturer should submit all changes or alterations to the spark plug direct to the FAA.

(j) *Spark plugs for military engines.*

(1) *Military approved spark plugs.*

(i) Spark plugs approved by the military services for use in military engines whose commercial counterpart has been type certificated in accordance with CAR will be granted approval upon request for use in the civil counterpart of the military engine, providing their service experience in military operations has been satisfactory.

(ii) Spark plugs approved by the military services for use in a surplus military engine model which has subsequently been certificated under Group 5-E Specifications of the Aircraft Engine Listing,³ may be granted automatic approval for use in the engine, provided the military service experience of the spark plug has been satisfactory.

(2) *Replacement spark plugs for military engines.*

(i) The test procedures outlined in paragraph (e), except paragraph (e) (2) (ii) (b) of this section will apply to new or replacement spark plugs proposed for use in surplus military engines installed in aircraft being operated under Parts 40, 41 or 42 of this subchapter.

(ii) The test procedures outlined in paragraph (f), except paragraph (f) (2) (ii) (a) of this section will apply to new or replacement spark plugs proposed for use in surplus military engines installed in aircraft being operated under Part 43 of this subchapter.

³ See footnote 1, page 4.

TABLE 1—SPARK PLUG TEST SCHEDULE

Engine classification	New type spark plug		Approved spark plugs modified	
	Block test (hours)	Flight test (hours)	Block test (hours)	Flight test (hours)
New engines.....	150.....	0.....		
Active engines:				
(a) Air carrier aircraft.....			50 plus.....	250 NC
(b) Nonair carrier aircraft.....			50 plus.....	100 NC
Obsolescent engines:				
(a) Air carrier aircraft.....	150.....	0.....	50 plus.....	150 NC
(b) Nonair carrier aircraft.....	50 plus.....	200 NX	50 plus.....	50 NC
Obsolete engines:				
(a) 150-hour engines:				
(1) Air carrier aircraft.....			Preignition test plus.....	150 NC
(2) Nonair carrier aircraft.....			Preignition test plus.....	100 NC
(b) 50-hour engines:				
(1) Air carrier aircraft.....	No engines used 50 or 100 NX		No engines used	
(2) Nonair carrier aircraft.....			Preignition test plus.....	50 NC

(19 F. R. 7998, Dec. 3, 1954, effective Dec. 15, 1954.)

13.19 Changes in type design. (For requirements with regard to changes in type design and the designation of applicable regulations therefor, see section 13.11 (d) and (e), and Part 1 of this subchapter.)

Identification and Instruction Manual

13.20 Identification plate. A fireproof identification plate shall be securely attached to the engine in a location which will be readily accessible when the engine is installed on an aircraft. The identification plate shall contain the identification data required by section 1.50 of this chapter.

13.21 Instruction manual. The applicant shall prepare and make available an approved manual containing instructions for the installation, operation, servicing, maintenance, repair, and overhaul of the engine.

Note: It is not intended to limit the form of the manual to a single document.

Subpart B—Reciprocating Engines

Design and Construction

13.100 Scope. The provisions of this subpart shall apply to reciprocating engines.

(a) The engine shall not incorporate design features or details which experience has shown to be hazardous or unreliable. The suitability of all questionable design details or parts shall be established by tests.

(b) The design and construction provisions of this subpart shall be applicable to the engine when it is installed, operated, and maintained in accordance with the instruction manual prescribed in section 13.21 and when fitted with an appropriate propeller.

13.101 Materials. The suitability and durability of all materials used in the engine shall be established on a basis of experience or tests. All materials used in the engine shall conform to approved specifications which will insure their having the strength and other properties assumed in the design data.

13.102 Fire prevention.

(a) The design and construction of the engine and the materials used shall be such as

to minimize the possibility of occurrence and spread of fire because of structural failure, overheating, or other causes.

(b) External lines and fittings which convey flammable fluids shall be at least fire-resistant. The possibility of flammable fluid-carrying lines deteriorating from heat, vibration, or fluid pressure so as to cause a fire hazard shall be minimized by appropriate design, shielding, or routing. The fire-resistant standards of section 4b.1(g)(2) of this subchapter shall be applicable.

13.103. Vibration. The engine shall be designed and constructed to function throughout its normal operating range of crankshaft rotational speeds and engine powers without inducing excessive stress in any of the engine parts because of vibration and without imparting excessive vibration forces to the aircraft structure.

13.104 Durability. All parts of the engine shall be designed and constructed to minimize the development of an unsafe condition of the engine between overhaul periods. Compressor and turbine rotor cases shall be designed to provide for containment of damage from rotor blade failure.

13.110 Fuel and induction system.

(a) The fuel system of the engine shall be designed and constructed to supply an appropriate mixture of fuel to the cylinders throughout the complete operating range of the engine under all flight and atmospheric conditions.

(b) The intake passages of the engine through which air or fuel in combination with air passes for combustion purposes shall be designed and constructed to minimize the danger of ice accretion in such passages. The engine shall be designed and constructed to permit the use of a means for ice prevention.

(c) The type and degree of fuel filtering necessary for protection of the engine fuel system against foreign particles in the fuel shall be specified. It shall be demonstrated that foreign particles passing through the prescribed filtering means will not critically impair engine fuel system functioning.

(d) All passages in the induction system which conduct a mixture of fuel and air

shall be self-draining, so as to prevent a liquid lock in the cylinders, in all attitudes which the applicant establishes as those the engine can have when the aircraft in which it is installed is in the static ground attitude.

13.111 Ignition system. All spark ignition engines shall be equipped with either a dual ignition system having at least two spark plugs per cylinder and two separate electrical circuits with separate sources of electrical energy, or with an ignition system which will function with equal reliability in flight.

13.112 Lubrication system.

(a) The lubrication system of the engine shall be designed and constructed so that it will function properly in all flight attitudes and atmospheric conditions in which the airplane is expected to operate.

(b) In wet sump engines the provision of paragraph (a) of this section shall be complied with when only one-half of the maximum lubricant supply is in the engine.

(c) The lubrication system of the engine shall be designed and constructed to permit the installation of a means for cooling of the lubricant.

(d) The engine shall be designed and constructed in such a manner that the crankcase is vented to the atmosphere so as to preclude leakage of oil resulting from excessive pressure within the crankcase.

13.113 Engine cooling. The engine shall be designed and constructed to provide the necessary cooling under conditions in which the airplane is expected to operate.

13.114 Engine mounting attachments. The mounting attachments and structure of the engine shall have sufficient strength, when the engine is mounted on an aircraft, to withstand the loads arising from the loading conditions prescribed in the airworthiness parts of the regulations in this subchapter applicable to the aircraft involved.

13.115 Accessory attachments. Accessory drives and mounting attachments shall be designed and constructed so that the engine will operate properly with the accessories attached. The design of the engine shall incorporate provisions for the exami-

nation, adjustment, or removal of all essential engine accessories.

13.116 Turbine rotors. To minimize the probability of failure of turbine rotors, the provisions of paragraphs (a) and (b) of this section shall be complied with.

(a) Turbine rotors shall be demonstrated to provide sufficient strength to withstand damage inducing factors such as those which might result from abnormal rotor speeds, temperatures, or vibration.

(b) The design and functioning of engine control devices, systems, and instrumentation shall be such as to give reasonable assurance that those engine operating limitations which affect turbine rotor structural integrity will not be exceeded in service.

Block Tests

13.150 General. The engine, including all essential accessories, shall be subjected to the block tests and inspections prescribed in sections 13.151 through 13.157.

13.151 Vibration test. A vibration survey shall be conducted to investigate crankshaft torsional and bending vibration characteristics over the operational range of crankshaft rotational speed and engine power normally used in flight (including low-power operation), from idling speed to either 110 percent of the desired maximum continuous speed rating, or 103 percent of the desired take-off speed rating, whichever is higher. The survey shall be conducted with a representative propeller. If a critical speed or speeds are found to be present in the operating range of the engine, changes in design of the engine shall be made for their elimination prior to the conduct of the endurance test specified in section 13.154, or the endurance test shall include operation under the most adverse vibration condition for a period sufficient to establish the ability of the engine to operate without fatigue failure.

13.152 Calibration tests. The engine shall be subjected to such calibration tests as are necessary to establish its power characteristics and the conditions for the endurance test specified in section 13.154. The

results of the power characteristics calibration tests shall constitute the basis for establishing the characteristics of the engine over its entire operating range of crankshaft rotational speeds, manifold pressures, fuel/air mixture settings, and altitudes. Power ratings shall be based upon standard atmospheric conditions. (See also sec. 13.16 (d).)

13.153 *Detonation test.* A test shall be conducted to establish that the engine can function without detonation throughout its range of intended conditions of operation.

13.154 *Endurance test.* The endurance test of an engine with a representative propeller shall include a total of 150 hours of operation and, depending upon the type and contemplated use of the engine, shall consist of one of the series of runs specified in paragraphs (a) through (c) of this section, whichever series is applicable. The runs shall be performed in such periods and order as are found appropriate by the Administrator for the specific engine. During the endurance test the engine power and the crankshaft rotational speed shall be controlled within ± 3 percent of the specified values.

(a) *Single-speed engines.* For engines not incorporating a supercharger and for those incorporating a single-speed supercharger, the following series of runs shall apply:

(1) A 30-hour run shall be conducted consisting of alternate periods of 5 minutes at take-off power and speed, and 5 minutes at maximum best economy cruising power or at maximum recommended cruising power.

(2) A 20-hour run shall be conducted consisting of alternate periods of $1\frac{1}{2}$ -hours at maximum continuous power and speed, and $\frac{1}{2}$ hour at 75 percent maximum continuous power and 91 percent maximum continuous speed.

(3) A 20-hour run shall be conducted consisting of alternate periods of $1\frac{1}{2}$ hours at maximum continuous power and speed, and $\frac{1}{2}$ hour at 70 percent maximum continuous power and 89 percent maximum continuous speed.

(4) A 20-hour run shall be conducted consisting of alternate periods of $1\frac{1}{2}$ hours at maximum continuous power and speed, and $\frac{1}{2}$ hour at 65 percent maximum continuous power and 87 percent maximum continuous speed.

(5) A 20-hour run shall be conducted consisting of alternate period of $1\frac{1}{2}$ hours at maximum continuous power and speed, and $\frac{1}{2}$ hour at 60 percent maximum continuous power and 84.5 percent maximum continuous speed.

(6) A 20-hour run shall be conducted consisting of alternate periods of $1\frac{1}{2}$ hours at maximum continuous power and speed, and $\frac{1}{2}$ hour at 50 percent maximum continuous power and 79.5 percent maximum continuous speed.

(7) A 20-hour run shall be conducted consisting of alternate periods of $2\frac{1}{2}$ hours at maximum continuous power and speed, and $2\frac{1}{2}$ hours at maximum best economy cruising power or at maximum recommended cruising power.

(b) *Two-speed engines.* For engines incorporating a two-speed supercharger, the following series of runs shall apply:

(1) A 30-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 5 minutes at take-off power and speed, and 5 minutes at maximum best economy cruising power or at maximum recommended cruising power. If a take-off rating is desired in the higher gear ratio, 15 hours of the 30-hour run shall be conducted in the higher gear ratio in alternate periods of 5 minutes at the observed horsepower obtainable with the take-off critical altitude manifold pressure and take-off speed, and 5 minutes at 70 percent high ratio maximum continuous power and 89 percent high ratio maximum continuous speed.

(2) A 15-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 1 hour at maximum continuous power and speed, and $\frac{1}{2}$ hour at 75 percent maximum continuous power and 91 percent maximum continuous speed.

(3) A 15-hour run shall be conducted consisting of alternate periods in the lower

gear ratio of 1 hour at maximum continuous power and speed, and $\frac{1}{2}$ hour at 70 percent maximum continuous power and 89 percent maximum continuous speed.

(4) A 30-hour run shall be conducted in the higher gear ratio at maximum continuous power and speed.

(5) A 5-hour run shall be conducted consisting of alternate periods of 5 minutes in each of the supercharger gear ratios. The first 5 minutes of the test shall be conducted at normal rated speed in the higher gear ratio and the observed horsepower obtainable with 90 percent of the normal rated manifold pressure in the higher gear ratio under sea level conditions. The condition for operation for the alternate 5 minutes in the lower gear ratio shall be that obtained by shifting to the lower gear ratio at constant speed.

(6) A 10-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 1 hour at maximum continuous power and speed, and 1 hour at 65 percent maximum continuous power and 87 percent maximum continuous speed.

(7) A 10-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 1 hour at maximum continuous power and speed, and 1 hour at 60 percent maximum continuous power and 84.5 percent maximum continuous speed.

(8) A 10-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 1 hour at maximum continuous power and speed, and 1 hour at 50 percent maximum continuous power and 79.5 percent maximum continuous speed.

(9) A 20-hour run shall be conducted consisting of alternate periods in the lower gear ratio of 2 hours at maximum continuous power and speed, and 2 hours at maximum best economy cruising power and speed or at maximum recommended cruising power.

(10) A 5-hour run shall be conducted in the lower gear ratio at maximum best economy cruising power and speed or at maximum recommended cruising power and speed.

Note: Where simulated altitude test equipment is not available and when operating in the higher gear ratio, the runs may be conducted at the observed horsepower obtained with the critical altitude manifold pressure or specified percentages thereof, and the fuel-air mixtures may be adjusted rich enough to suppress detonation.

(c) *Helicopter engines.* For engines to be eligible for use on helicopters, the following series of runs shall apply:

(1) A 35-hour run shall be conducted consisting of alternate periods of 30 minutes each at take-off power and speed, and at maximum continuous power and speed.

(2) A 25-hour run shall be conducted consisting of alternate periods of $2\frac{1}{2}$ hours each at maximum continuous power and speed, and at 70 percent maximum continuous power at maximum continuous speed.

(3) A 25-hour run shall be conducted consisting of alternate periods of $2\frac{1}{2}$ hours each at maximum continuous power and speed, and at 70 percent maximum continuous power at 80 to 90 percent maximum continuous speed.

(4) A 25-hour run shall be conducted consisting of alternate periods of $2\frac{1}{2}$ hours each at 80 percent maximum continuous power at take-off speed, and at 80 percent maximum continuous power at 80 to 90 percent maximum continuous speed.

(5) A 25-hour run shall be conducted consisting of alternate periods of $2\frac{1}{2}$ hours each at 80 percent maximum continuous power at take-off speed, and at either maximum continuous power at 110 percent maximum continuous speed or at take-off power at 103 percent take-off speed, whichever condition results in the greater speed.

(6) A 15-hour run shall be conducted at 105 percent maximum continuous power and 105 percent maximum continuous speed or at full throttle and corresponding speed at standard sea level carburetor entrance pressure, provided that 105 percent of the maximum continuous power is not exceeded.

13.155 *Operation test.* The operation test shall include all testing found by the Administrator to be necessary to demonstrate backfire characteristics, starting, idling, acceleration, overspeeding, functioning of propeller and ignition, and any other opera-

tional characteristic of the engine. If the engine incorporates a multispeed supercharger drive, the design and construction shall be such that the supercharger can be shifted from operation at the lower speed ratio to the higher and the power appropriate to the manifold pressure and speed settings for maximum continuous power at the higher supercharger speed ratio can be obtained within 5 seconds.

13.156 *Engine component tests.*

(a) For those systems which cannot be adequately substantiated by endurance testing in accordance with the provisions of section 13.154, additional tests shall be conducted to establish that components are capable of functioning reliably in all normally anticipated flight and atmospheric conditions.

(b) Temperature limits shall be established for those components which require temperature controlling provisions in the aircraft installation to assure satisfactory functioning, reliability, and durability.

13.157 *Teardown inspection.* After completion of the endurance test the engine shall be completely disassembled and a detailed inspection shall be made of the engine parts to check for fatigue and wear.

13.158 *Engine adjustments and parts replacements.* During the block tests servicing and minor repairs of the engine shall be permissible. If major repairs or replacement of parts are found necessary during the tests or in the teardown inspection, the parts in question shall be subjected to such additional tests as are found by the Administrator to be necessary.

Subpart C—Turbine Engines

Design and Construction

13.200 *Scope.* The provisions of this subpart shall apply to turbine engines.

(a) The engine shall not incorporate design features or details which experience has shown to be hazardous or unreliable. The suitability of all questionable design details or parts shall be established by tests.

(b) The design and construction provisions of this subpart shall be applicable to

the engine when it is installed, operated, and maintained in accordance with the instruction manual prescribed in section 13.21 and when fitted with an appropriate propeller (if used).

13.201 *Materials.* The suitability and durability of all materials used in the engine shall be established on a basis of experience or tests. All materials used in the engine shall conform to approved specifications which will insure their having the strength and other properties assumed in the design data.

13.202 *Fire prevention.*

(a) The design and construction of the engine and the materials used shall be such as to minimize the possibility of occurrence and spread of fire because of structural failure, overheating, or other causes.

(b) External lines and fittings which convey flammable fluids shall be at least fire resistant. The possibility of flammable fluid carrying lines deteriorating from heat, vibration, or fluid pressure so as to cause a fire hazard shall be minimized by appropriate design, shielding, or routing. The fire-resistant standards of section 4b.1(g)(2) of this subchapter shall be applicable.

13.203 *Vibration.* The engine shall be designed and constructed to function throughout its normal operating range of rotational speeds and engine powers without inducing excessive stress in any of the engine parts because of vibration and without imparting excessive vibration forces to the aircraft structure.

13.204 *Durability.* All parts of the engine shall be designed and constructed to minimize the development of an unsafe condition of the engine between overhaul periods. Compressor and turbine rotor cases shall be designed to provide for containment of damage from rotor blade failure.

13.205 *Surge characteristics.* The engine shall be free of detrimental surge throughout its operating range in the minimum ambient air temperature in which it is to be operated.

13.210 *Fuel and induction system.*

(a) The fuel system of the engine shall be designed and constructed to supply an ap-

propriate mixture of fuel to the combustion chamber(s) throughout the complete operating range of the engine under all flight and atmospheric conditions.

(b) The intake passages of the engine through which air or fuel in combination with air passes for combustion purposes shall be designed and constructed to minimize the danger of ice accretion in such passages. The engine shall be designed and constructed to permit the use of a means for ice prevention.

(c) The engine, with icing protection systems operating if provided, shall be capable of operation throughout the flight power range without accumulation of ice on the engine components such as to adversely affect engine operation or cause a serious loss of power and/or thrust, in continuous maximum and intermittent maximum icing conditions as defined in section 4b.1(b) (7) and (8) of this subchapter.

(d) The type and degree of fuel filtering necessary for protection of the engine fuel system against foreign particles in the fuel shall be specified. It shall be demonstrated that foreign particles passing through the prescribed filtering means will not critically impair engine fuel system functioning.

(e) If air is bled from the compressor for protection of the engine in icing conditions, provision shall be made for positive indication that air is being directed to the proper passages.

13.211 Ignition system. All engines shall be equipped with an ignition system for starting the engine on the ground and in flight. An electric ignition system shall have at least two igniters and two separate secondary electric circuits.

13.212 Lubrication system. The lubrication system of the engine shall be designed and constructed so that it will function properly in all flight attitudes and atmospheric conditions in which the airplane is expected to operate.

13.213 Engine cooling. The engine shall be designed and constructed to provide the necessary cooling under conditions in which the airplane is expected to operate.

13.214 Engine mounting attachments. The mounting attachments and structure of the engine shall have sufficient strength, when the engine is mounted on an aircraft, to withstand the loads arising from the loading conditions prescribed in the airworthiness parts of the regulations in this subchapter applicable to the aircraft involved.

13.215 Accessory attachments. Accessory drives and mounting attachments shall be designed and constructed so that the engine will operate properly with the accessories attached. The design of the engine shall incorporate provisions for the examination, adjustment, or removal of all essential engine accessories.

13.216 Turbine rotors. To minimize the probability of failure of turbine rotors, the provisions of paragraphs (a) and (b) of this section shall be complied with.

(a) Turbine rotors shall be demonstrated to provide sufficient strength to withstand damage inducing factors such as those which might result from abnormal speeds, temperatures, or vibration.

(b) The design and functioning of engine control devices, systems, and instrumentation shall be such as to give reasonable assurance that those engine operating limitations which affect turbine rotor structural integrity will not be exceeded in service.

13.217 Power or thrust response.

The design and construction of the engine shall be such as to enable an increase, under static conditions, from flight idle power or thrust to 95 percent of takeoff power or thrust in not over 5 seconds.

Block Tests

13.250 General. The engine, including all essential accessories, shall be subjected to the block tests and inspections prescribed in sections 13.251 through 13.257. In addition, throughout the tests, unless otherwise applicable, the controlled air extraction shall be zero.

13.251 Vibration test. A vibration survey shall be conducted to investigate the vibration characteristics of the engine over the

operational range of rotational speed and engine power. If critical vibration is found to be present in the operating range of the engine, changes in design of the engine shall be made for its elimination prior to the conduct of the endurance test specified in section 13.254, or the endurance test shall include operation under the most adverse vibration condition for a period sufficient to establish the ability of the engine to operate without fatigue failure.

13.252 *Calibration tests.*

(a) The engine shall be subjected to such calibration tests as are necessary to establish its power characteristics and the conditions for the endurance test specified in section 13.254. The results of the power characteristics calibration tests shall constitute the basis for establishing the characteristics of the engine over its entire operating range of speeds, pressures, temperatures, and altitudes. Power ratings shall be based upon standard atmospheric conditions. (See also sec. 13.16(d).)

(b) Prior to the endurance test the power control(s) shall be adjusted to produce the maximum allowable gas temperatures and rotor speeds at take-off operating conditions. Such adjustment shall not be changed during the relevant calibration tests and the relevant runs of the endurance test.

13.254 *Endurance test.* The endurance test of an engine with a representative propeller (if applicable) shall include a total of 150 hours of operation consisting of 25 periods of 6 hours each as specified in [either paragraph (a) or (b) of this section.] The runs shall be performed in, whichever is applicable, such order as is found appropriate by the Administrator for the specific engine. During the endurance test, the engine power and/or thrust and the engine rotational speed shall not be less than 100 percent of the specified values except that substantiating evidence shall be submitted if the engine parameters are not controlled within this limitation. Each period of the 150-hour endurance test shall be conducted as follows:

[(a) *All engines except helicopter engines for which a 30-minute rating is desired.*]

[(1)] *Take-off and idling.* One hour of alternate 5-minute periods shall be conducted at take-off power and/or thrust and at idling power and/or thrust. The developed powers and/or thrusts at take-off and idling conditions and their corresponding rotor speed and gas temperature conditions shall be as established by the power control(s) in accordance with the schedule established by the manufacturer. It shall be permissible to control manually during any one period the rotor speed and power and/or thrust while taking data to check performance. For engines with augmented take-off ratings which involve increases in turbine inlet temperature, rotor speed, or shaft power, this period of running at take-off shall be at the augmented rating. For engines with augmented take-off ratings which do not materially increase operating severity, the amount of running conducted at the augmented rating shall be established by the Administrator. In changing the power setting after each period, the power-control lever shall be moved in the manner prescribed in paragraph (e) of this section.

[(2)] *Maximum continuous and take-off.* Fifteen periods each of 30 minutes' duration shall be conducted at maximum continuous power and/or thrust, and 10 periods each of 30 minutes' duration shall be conducted at take-off power and/or thrust.

[(3)] *Maximum continuous power and/or thrust.* One hour and 30 minutes shall be conducted at the maximum continuous power and/or thrust.

[(4)] *Incremental cruise power and/or thrust.* Two hours and 30 minutes shall be conducted at the successive power lever positions corresponding to at least 15 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/or power may be varied in lieu of speed. In the event significant peak vibrations exist anywhere between ground idle and maximum continuous conditions, the number of increments chosen may be altered to increase the amount of

running conducted while being subjected to the peak vibrations up to an amount not to exceed 50 percent of the total time spent in incremental running. (See also sec. 13.251.)

[(5)] *Acceleration and deceleration runs.* Thirty minutes shall be conducted of accelerations and decelerations consisting of 6 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. In complying with the provisions of this paragraph, the power-control lever shall be moved from one extreme position to the other in not more than one second, except where different regimes of control operations are incorporated necessitating scheduling of the power-control lever motion in going from one extreme position to the other, a longer period of time shall be acceptable but in no case shall this time exceed 2 seconds.

[(6)] *Starts.* One hundred starts shall be made, of which 25 starts shall be preceded by at least a 2-hour engine shutdown. Ten starts shall be false engine starts pausing for the applicant's specified minimum fuel drainage time before attempting a normal start. Ten starts shall be normal restarts with not longer than 15 minutes since engine shutdown. It shall be acceptable to make the remaining starts after completion of the 150 hours of endurance testing.

[(7)] *Maximum temperatures.* The limiting maximum hot gas and, when practicable, oil inlet temperatures shall be substantiated by operation at these limits during all the takeoff and maximum continuous running of the endurance test except where the test periods are of 5 minutes or shorter duration and do not always permit stabilization.

[(b)] *Helicopter engines for which a 30-minute rating is desired.*

[(1)] *Takeoff and idling.* One hour of alternate 5-minute periods shall be conducted at takeoff power and thrust and at idling power and thrust. The developed powers and thrusts at takeoff and idling conditions and their corresponding rotor speed and gas

temperature conditions shall be as established by the power control(s) in accordance with the schedule established by the manufacturer. It shall be permissible to control manually during any one period the rotor speed and power and thrust while taking data to check performance. For engines with augmented takeoff ratings which involve increases in turbine inlet temperature, rotor speed, or shaft power, this period of running at rated takeoff power shall be at the augmented rating. In changing the power setting after each period, the power-control lever shall be moved in the manner prescribed in subparagraph (5) of this paragraph.

[(2)] *30-minute power.* Thirty minutes shall be conducted at 30-minute power and/or thrust.

[(3)] *Maximum continuous power and thrust.* Two hours shall be conducted at the maximum continuous power and thrust.

[(4)] *Incremental cruise power and thrust.* Two hours shall be conducted 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, it shall be permissible to vary the thrust and power in lieu of speed. In the event significant peak vibrations exist anywhere between ground idle and maximum continuous conditions, the number of increments chosen shall be altered to increase the amount of running conducted while being subjected to the peak vibrations up to an amount not exceeding 50 percent of the total time spent in incremental running. (See also sec. 13.251.)

[(5)] *Acceleration and deceleration runs.* Thirty minutes shall be conducted of accelerations and decelerations consisting of 6 cycles from idling power and thrust to take-off power and thrust and maintained at the takeoff power lever position for 30 seconds and at the idling power lever position for approximately $4\frac{1}{2}$ minutes. In complying with the provisions of this subparagraph, the

power-control lever shall be moved from one extreme position to the other in not more than one second except that, where different regimes of control operations are incorporated necessitating scheduling of the power-control lever motion in going from one extreme position to the other, a longer period of time shall be acceptable but in no case shall this time exceed 2 seconds.

[(6) *Starts.* One hundred starts shall be made, of which 25 starts shall be preceded by at least a 2-hour engine shutdown. Ten starts shall be false engine starts pausing for the applicant's specified minimum fuel drainage time before attempting a normal start. Ten starts shall be normal restarts, each performed not more than 15 minutes after engine shutdown. It shall be acceptable to make the remaining starts after completion of the 150 hours of endurance testing.

[(7) *Maximum temperatures.* The limiting maximum hot gas and oil inlet temperatures shall be substantiated by operation at these limits during all the takeoff, 30-minute power, and maximum continuous running of the endurance test except where the test periods are not longer than 5 minutes and do not permit stabilization.]

[(Amendment 13-5, 28 F.R. 304, Jan. 11, 1963, effective Feb. 12, 1963.)]

13.255 *Operation test.* The operation test shall include all testing found by the Administrator to be necessary to demonstrate starting, idling, acceleration, overspeeding, functioning of propeller (if applicable) and ignition, and any other operational characteristic of the engine.

13.256 *Engine component tests.*

(a) For those systems which cannot be adequately substantiated by endurance testing in accordance with the provisions of section 13.254, additional tests shall be conducted to establish that components are capable of functioning reliably in all normally anticipated flight and atmospheric conditions.

(b) Temperature limits shall be established for those components which require temperature controlling provisions in the

aircraft installation to assure satisfactory functioning, reliability, and durability.

13.257 *Teardown inspection.* After completion of the endurance test the engine shall be completely disassembled and a detailed inspection shall be made of the engine parts to check for fatigue and wear.

13.258 *Engine adjustments and parts replacements.* During the block tests servicing and minor repairs of the engine shall be permissible. If major repairs or replacement of parts are found necessary during the tests or in the teardown inspection, the parts in question shall be subjected to such additional tests as are found by the Administrator to be necessary.

13.259 *Engine-propeller systems tests.*

The following tests shall be conducted, where applicable, with a propeller installed which will be representative of the type used on a typical aircraft installation. They may be included in the endurance run or otherwise performed in a manner acceptable to the Administrator.

(a) Feathering operation: 25 cycles.

(b) Negative torque and/or thrust system operation: 25 cycles from maximum continuous power.

(c) Automatic decoupler operation: 25 cycles from maximum continuous power (if repeated decoupling and recoupling in service is the intended function of the device).

(d) Reverse thrust operation: 175 cycles from the flight-idle position to full reverse and 25 cycles at maximum continuous power from full forward to full reverse thrust. At the end of each cycle the propeller shall be operated in reverse pitch for a period of 30 seconds at the maximum rotational speed and power declared by the applicant for reverse pitch operation.

13.260 *Thrust reversers.*

If the engine incorporates a reverser, the endurance, calibration, operation, and vibration tests prescribed in this part shall be run with the reverser installed. In complying with the provisions of this section, the power control lever shall be moved from one extreme position to the other in not more than one second except, where regimes of control

operations are incorporated necessitating scheduling of the power control lever motion in going from one extreme position to the other, a longer period of time shall be acceptable but in no case shall this time exceed 3 seconds. In addition, the tests prescribed in paragraphs (a) and (b) of this section shall be applicable. These tests may be scheduled as part of the endurance run.

(a) If the reverser is intended for use only as a braking means on the ground, 175 reversals shall be made from flight-idle forward thrust to maximum reverse thrust and 25 reversals shall be made from maximum forward to maximum reverse thrust. After

each reversal, the reverser shall be operated at full reverse thrust for a period of 30 seconds.

(b) If the reverser is intended for use in flight, the provisions of paragraph (a) of this section shall apply, except that, after each reversal, the reverser shall be operated at full reverse thrust for a period of one minute.

Note: The provisions of section 4b.407 apply to the complete reverser system, including that portion which is an integral part of the engine.

(Amendment 13-4, 27 F.R. 3003, March 30, 1962, effective May 3, 1962.)

Addendum

Preambles of Amendments to Civil Air Regulations Part 13

NOTE

Part 13 of the Civil Air Regulations was last revised by the Civil Aeronautics Board with an effective date of June 15, 1956. This was not a general revision of the part, but only a reprint to incorporate outstanding amendments. This revision was published in the Federal Register on June 20, 1956 (21 F.R. 4305).

Amendment 13-1

Miscellaneous Amendments Resulting From
the 1956 Annual Airworthiness Review

Adopted: July 8, 1957
Effective: Aug. 12, 1957
Published: July 16, 1957
(22 F.R. 5569)

There are contained herein amendments with respect to various issues stemming from the 1956 Annual Airworthiness Review.

There exist certain differences in detail between the Civil Air Regulations effective heretofore and military specifications with respect to the endurance testing of turbine engines. These differences have caused some difficulty in the approval for civil use of engines developed for the military services. Accordingly, informal discussions were held between engine manufacturers and interested government agencies as a result of which a proposal for the amendment of Part 13 was submitted to the Board. The changes being made reflect in substance the proposal submitted differing, however, in that no provision is made to permit deducting the time in changing power settings from the endurance times specified for the various power and/or thrust conditions. Also, the changes herein require consideration of the augmented take-off rating in connection with the tests specified in paragraphs (b), (c), and (g) of section 13.254.

In addition, a change is being made to section 13.210 to require that a turbine engine be demonstrated to be capable of operation without serious power loss under icing conditions as specified in Part 4b of the Civil Air Regulations. Concurrently with this amendment, changes are being made in Part 4b relative to the intermittent maximum icing conditions to cover conditions more critical to turbine engine operation.

Important substantive provisions are being included in new sections 13.116 and 13.216 relative to the structural integrity of turbine rotors under abnormal operating conditions and relative to the reliability and safety of systems, devices, and instruments affecting turbine rotor structural integrity. To this end, these new provisions are intended to require taking into account in the design of the turbine rotor, and its associated systems, all practicable safeguards.

There is also being included a provision in sections 13.104 and 13.204 which requires turbine engine rotor cases to be designed so as to contain damage resulting from rotor blade failure.

The definitions in section 13.1(b) are being changed to incorporate appropriate definitions with respect to turbine engine power and thrust. These new definitions are formulated to be generally applicable to the power and thrust of turbine engines under specified conditions of altitude, atmosphere, and flight speeds. It is not anticipated that these new definitions will affect the past procedure of rating engines under standard atmospheric conditions.

Several other changes of comparatively less substantive importance are also included.

Interested persons have been afforded an opportunity to participate in the making of this amendment (21 F.R. 9217), and due consideration has been given to all relevant matter presented.

Amendment made changes in sections 13.1, 13.102, 13.104, 13.156, 13.202, 13.204, 13.210, 13.250, 13.254, 13.256, and added new sections 13.116, and 13.216.

Amendment 13-2

Miscellaneous Amendments Resulting From
the 1957 Annual Airworthiness Review

Adopted: Apr. 15, 1958
Effective: May 17, 1958
Published: Apr. 19, 1958
(23 F.R. 2594)

There are contained herein amendments with respect to fuel system filters for both reciprocating and turbine engines and endurance testing of turbine engines stemming from the 1957 Annual Airworthiness Review.

The amendments dealing with fuel system filters are intended to insure that foreign particles in the fuel which would have an adverse effect on the fuel system will be removed. It is, therefore, required that the engine manufacturer specify the type of filtration necessary and demonstrate that foreign particles passing through the filter will not impair the fuel system functioning.

There is also an amendment to section 13.254. It has been found that the specification of power and/or thrust and of engine rotational speed of a tolerance of ± 3 percent for the endurance test is unduly burdensome on the engine manufacturer. The amendment contained herein requires that the endurance test be conducted with the engine power and/or thrust and engine rotational speed at not less than 100 percent of the specified values.

Interested persons have been afforded an opportunity to participate in the making of this amendment (22 F.R. 9116), and due consideration has been given to all relevant matter presented.

Amendment made changes in sections 13.110 and 13.210.

Amendment 13-3

Miscellaneous Amendments Resulting From
the 1958 Annual Airworthiness Review

Adopted: Aug. 24, 1959
Effective: Oct. 1, 1959
Published: Sept. 1, 1959
(24 F.R. 7076)

There are contained herein amendments as a result of the 1958 Annual Airworthiness Review.

A provision is being added to section 13.110 to require that the induction system be self-draining in static attitudes to prevent liquid locks and later malfunctioning of the engine.

A provision is being added to section 13.112 to require venting of the crankcase to the atmosphere to prevent pressurization of the crankcase high enough to cause oil leaks which present fire hazards.

A provision is being added to section 13.155 to require that for engines incorporating a multispeed supercharger drive the supercharger be shifted from operation at the lower speed to the higher and the appropriate power be obtained at the higher supercharger speed within 5 seconds. This capability is necessary to prevent supercharger drive system damage resulting from prolonging the time to shift speeds and to assure that the appropriate power can be obtained.

A provision is being added to section 13.210 to require means to indicate functioning of the compressor air bleed system for protection of the engine during icing conditions. This will permit the flight crew to know that the engine portion of the ice protection system is available for use.

Section 13.211 is being amended to require for turbine engines that an electric ignition system (if used) shall have at least two igniters and two separate secondary electric circuits. This will afford reliability similar to that obtained with reciprocating engines employing dual electric ignition systems.

Section 13.217 is being added to provide that the power or thrust of turbine engines can be increased under static conditions from flight idle to 95 percent of the takeoff rating in not over 5 seconds.

Section 13.259 is being added to specify criteria which are intended to assure that engine-actuated propeller controls function without detrimental effect on either the engine or the propeller.

Section 13.260 is being added to establish the airworthiness standard for thrust reversers. Detailed test provisions are specified for reversing systems intended for ground use only. For inflight reversing systems, these basic provisions are intended to be applied together with such other tests as are found necessary by the Administrator to assure the airworthiness of the device. A note is appended to this requirement to clarify the applicability of section 4b.407 to portions of reverser systems which are also integral parts of the engine.

Amendments which were proposed to establish fail safe criteria for automatic engine control systems, to provide that compressor rotors be designed and constructed to provide sufficient strength to withstand damage-inducing factors associated with engine operation, and to provide additional design considerations to assure the structural integrity of turbine rotors, are deferred pending the results of further study of the problems which are involved in these issues. For the same reason, a proposal to add a requirement establishing criteria to prevent unsafe conditions in the event of a single probable failure or malfunction of any single element in the engine, is also deferred.

Interested persons have been afforded an opportunity to participate in the making of this amendment (24 F.R. 128), and due consideration has been given to all relevant matter presented.

Amendment made changes in sections 13.110, 13.112, 13.155, 13.211, 13.210, and added new sections 13.217, 13.259, and 13.260.

Amendment 13-4

Miscellaneous Amendments Resulting From the First
Federal Aviation Agency Airworthiness Review

Adopted: Mar. 27, 1962
Effective: May 3, 1962
Published: Mar. 30, 1962
(27 F.R. 3003)

As a result of the First Federal Aviation Agency Airworthiness Review, the Agency published a notice of proposed rule making affecting several parts of the Civil Air Regulations. This notice was published in the FEDERAL REGISTER (26 F.R. 5130) and circulated as Civil Air Regulations Draft Release No. 61-12 dated June 8, 1961. There are contained herein amendments to Part 13 of the Civil Air Regulations which stem from this First FAA Airworthiness Review.

Presently effective section 13.260 requires, among other things, that thrust reversers be subjected to reversal tests and that, after each reversal, the reverser be operated at full reverse thrust for a period of one minute. A period of operation this long is unnecessary for reversers intended for use only as a braking means on the ground since the usual period of reverse thrust in operation has been shown to be between 20 and 30 seconds. Accordingly, the provision is revised by reducing the reverse thrust test time for such reversers from one minute per cycle to 30 seconds per cycle.

Concurrently, the provisions of section 13.260(b), dealing specifically with reversers intended for use in flight, are being amended to retain the requirement for a one-minute reversal operation. In addition, the proposed provision requiring such other tests to be conducted as are found necessary to insure safe and reliable operation of the reverser in flight is not being adopted. This provision unnecessarily repeats the requirement which appears elsewhere and could lead to an incorrect inference that flight tests of an engine might be required as a part of engine type certification.

Interested persons have been afforded an opportunity to participate in the making of this amendment, and due consideration has been given to all relevant matter presented.

Amendment changed "one minute" to "30 seconds" in section 13.260(a), and revised section 13.260(b).

Concurrently, the provisions of section 13.260(b), dealing specifically with reversers intended for use in flight, are being amended to retain the requirement for a one-minute reversal operation. In addition, the proposed provision requiring such other tests to be conducted as are found necessary to insure safe and reliable operation of the reverser in flight is not being adopted. This provision unnecessarily repeats the requirement which appears elsewhere and could lead to an incorrect inference that flight tests of an engine might be required as a part of engine type certification.

Interested persons have been afforded an opportunity to participate in the making of this amendment, and due consideration has been given to all relevant matter presented.

Amendment changed "one minute" to "30 seconds" in section 13.260(a), and revised section 13.260(b).

Amendment 13-5

30-Minute Power Rating for
Helicopter Turbine Engines

Adopted: Jan. 7, 1962
Effective: Feb. 12, 1963
Published: Jan. 11, 1963
(28 F.R. 304)

A notice of proposed rule making was published in the Federal Register April 10, 1962 (27 F.R. 3405), and circulated to the industry as Draft Release 62-15 dated April 4, 1962. This draft release proposed to amend Part 13 of the Civil Air Regulations by establishing a new 30-minute power rating for helicopter engines and a new endurance test schedule to be required for substantiating the rating.

The rules being adopted establish a new 30-minute power rating for certain helicopter engines and a new endurance test schedule for substantiating the rating. These rules will provide for a higher power, to be used in complying with helicopter performance requirements. They will affect the manufacturer of the helicopter engine primarily since they involve changes to the type certification requirements for such engines.

The presently effective provisions of Part 7 of the Civil Air Regulations require that certain rotorcraft takeoff and en route climb performance determinations be made with one engine inoperative and remaining engines operating at maximum continuous power. Representations from the industry have been made that a higher power could be used in making these determinations without adversely affecting safety and that improved helicopter performance would result. It has been recommended that rated takeoff power, if used within practical limits, could be used in place of maximum continuous power.

In response to these representations, the Agency has recently authorized type certification of twin turbine-powered transport category helicopters using takeoff power, in lieu of maximum continuous power, in establishing climb performance. The use of such takeoff power is limited to periods not exceeding 30 minutes in duration.

At the same time the Agency indicated that this performance requirement as well as other more comprehensive requirements, presently under study, would be incorporated into

existing Part 7 as soon as operating experience is obtained on the twin turbine-powered helicopters.

While the use of rated takeoff power by the helicopter manufacturers for the establishment of certain performance data for their twin turbine-powered helicopters results in the substantiation of such power for turbine engines installed in their helicopters, the Agency believes that in the future such substantiation should be accomplished prior to type certification and subsequent installation of the engine. While engine manufacturers may now substantiate their turbine engines for takeoff power for 30 minutes duration, the present rules do not specifically provide for a 30-minute power rating. Therefore, it is considered appropriate to amend the provisions of Part 13 to provide for the substantiation of turbine engines used in helicopters for this higher power during type certification of such engines where a rating at this higher power is desired. Accordingly, Part 13 is being amended by defining and adding a new rating of "30-minute power," which will be limited to periods of use not exceeding 30 minutes duration. To insure reliable operation at this power, a new test schedule is being added to section 13.254 for substantiating such power for turbine engines used in helicopters.

Comments on the draft release were received from interested persons and consideration has been given to all relevant matter presented. Several comments were received to the effect that the new rating should be optional and, in any case, applicable only to engines used in multiengine helicopters. The draft release provides that all helicopter turbine engines would be required to be type certificated in accordance with the new test schedule for the 30-minute power rating. The Agency concurs with these comments and the rating and test schedule are being made optional accordingly. Other comments calling attention to typographical or constructional errors in the draft release have also been accepted and appropriate changes have been made to the rules being amended.

A number of comments were made suggesting changes or additions which have not been incorporated in the rules being amended. One comment discussed the desirability of adopting, for commercial use, other special ratings used by the military services. Such ratings are not pertinent to the amendments as they were proposed and their inclusion is not warranted at this time. One comment requested deletion of the word "maximum" from the definition of 30-minute power. This deletion is not being made because it is intended that both takeoff power and 30-minute power would represent the maximum output at which the engine would be rated for type certification. There is presently in process a rule making action which would add the word "maximum" to takeoff power. This does not preclude the use of lower power in meeting helicopter performance certification requirements. In this connection, another comment considered the power level of the 30-minute rating indefinite, and that it could be declared higher than takeoff power by an engine manufacturer. It was also suggested that the rating be called a "contingency rating." The Agency considers that takeoff power and 30-minute power are properly defined for rating purposes. The question of whether the new rating should be termed "contingency power" was considered at length before publication of the draft release, and the Agency sees no purpose to be served by changing terminology at this time. Another comment considered the test schedule at 30-minute power to be inadequate, particularly in view of the relatively small amount of testing at maximum temperature. The comment recommended increasing the running time at takeoff power and at 30-minute power, and increasing the time at maximum temperature. The Agency believes that the periods of operation at various powers and temperatures represent reasonable minima for type certification and that consideration of increases in testing severity lie outside the scope of the problem at issue. Accordingly, no changes are being made to the test schedule as published in the draft release.

Amendment made changes in sections 13.1 and 13.254.
