CIVIL AIR REGULATIONS

PART 13—AIRCRAFT ENGINE AIRWORTHINESS

As amended to June 15, 1956

CIVIL AERONAUTICS BOARD

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TITLE 14—CIVIL AVIATION

Chapter I—Civil Aeronautics Board

Subchapter A—Civil Air Regulations

PART 13—AIRCRAFT ENGINE AIRWORTHINESS

REVISION OF PART

Because of the number of outstanding amendments to Part 13 there follows a revision of Part 13 incorporating all amendments thereto which were in effect on June 15, 1956.

By the Civil Aeronautics Board.

[SEAL] M. C. MULLIGAN, *Secretary.*

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AUTHORITY: §§ 13.0 to 13.257 issued under sec. 205, 52 Stat. 984; 49 U. S. C. 425. Interpret or apply secs. 601, 603, 52 Stat. 1007, as amended, 1009, as amended; 49 U. S. C. 551, 553.

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 This part, until superseded or rescinded, shall apply to all engines for which applications for type certification are made after the effective date of this part (August 20, 1938).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 Civil Aeronautics.

(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 § 13.18.)

(b) *General design*—(1) *Standard atmosphere.* The standard atmosphere is an atmosphere 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 −67° F. is −0.003566° F./ft. and zero thereabove.

(v) The density ρ_0 at sea level under the above conditions is 0.002378 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.* Take-off power is the brake horsepower developed under standard sea level conditions, under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for use in the normal take-off, and limited in use to a maximum continuous period as indicated in the approved engine specification.

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

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

(6) *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.

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

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

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 Board, 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.

(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 Board, or by the Administrator pursuant to § 1.24 of this subchapter, a change to the type certificate (see § 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 § 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 § 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 Administrator 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 § 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.[1]

(b) The type certificate shall be deemed to include the type design (see § 13.14 (b)), the operating limitations for the engine (see § 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 § 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 necessary 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 subparts 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 proce-

[1] 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.

dures 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.

§ 13.19 *Changes in type design.* (For requirements with regard to changes in type design and the designation of applicable regulations therefor, see § 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 § 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 § 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.* 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.

§ 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.

§ 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.

§ 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.

§ 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 examination, adjustment, or removal of all essential engine accessories.

BLOCK TESTS

§ 13.150 *General.* The engine, including all essential accessories, shall be subjected to the block tests and inspections prescribed in §§ 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 § 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 § 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 § 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 1½-hours at maximum continuous power and speed, and ½ 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 1½ hours at maximum continuous power and speed, and ½ 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 1½ hours at maximum continuous power and speed, and ½ hour at 65 percent maximum continuous power and 87 percent maximum continuous speed.

(5) A 20-hour run shall be conducted consisting of alternate periods of 1½ hours at maximum continuous power and speed, and ½ 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 1½ hours at maximum continuous power and speed, and ½ 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 2½ hours at maximum continuous power and speed, and 2½ 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 ½ 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 ½ 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 2½ 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 2½ 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 2½ 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 2½ 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 operational characteristic of the engine.

§ 13.156 *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.

§ 13.157 *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 § 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.* 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.

§ 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.

§ 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 appropriate 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.

§ 13.211 *Ignition system.* All engines shall be equipped with an ignition system for starting the engine on the ground and in flight.

§ 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.

BLOCK TESTS

§ 13.250 *General.* The engine, including all essential accessories, shall be subjected to the block tests and inspections prescribed in §§ 13.251 through 13.257. In addition, throughout the tests, unless otherwise chosen by the applicant, 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 § 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.

NOTE: The vibration survey usually need consist of external measurements only, unless the Administrator finds that internal measurements are necessary in a particular case.

§ 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 § 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 § 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 30 periods of 5 hours each as specified in this section. It shall be permissible to conduct each run of the endurance test, except the runs prescribed in paragraphs (a) and (f) of this section, with one predetermined engine variable (i. e., speed or gas temperature) held constant and with the position of the power lever(s) recorded. The runs shall be performed in such order as is found appropriate by the Administrator for the specific engine. Each period of the 150-hour endurance test shall be conducted as follows:

(a) *Take-off and idling.* One hour of alternate 5-minute periods shall be conducted at maximum take-off power and/or thrust and at idling power and/or thrust. In changing the power setting after each period, the power-control lever shall be moved in the manner prescribed in paragraph (f) of this section. 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 speed and power and/or thrust while taking data to check performance.

(b) *91 percent take-off power and/or thrust.* Thirty minutes shall be conducted at the power lever position corresponding with either 91 percent take-off power and/or thrust or maximum continuous power and/or thrust, whichever is the greater.

(c) *Maximum continuous power and/or thrust.* One hour and 30 minutes shall be conducted at the power lever position corresponding with maximum continuous power and/or thrust.

(d) *90 percent maximum continuous power and/or thrust.* One hour shall be conducted at the power lever position corresponding with 90 percent maximum continuous power and/or thrust.

(e) *75 percent maximum continuous power and/or thrust.* Thirty minutes shall be conducted at the power lever position corresponding with 75 percent maximum continuous power and/or thrust.

(f) *Acceleration and deceleration runs.* Thirty minutes shall be conducted of accelerations and decelerations consisting of five cycles from idling power and/or thrust to take-off power and/or thrust and maintained at the take-off power and/or thrust for approximately 30 seconds and at the idling power and/or thrust for approximately 5 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 1 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.

(g) *Starts.* Seventy-five starts shall be made of which 30 starts shall be preceded by a 2-hour shutdown. It shall be acceptable to make the remaining starts after the completion of the 150 hours of endurance testing.

§ 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 *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.

§ 13.257 *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.

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