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AIRCRAFT ENGINES

Airworthiness Standards for Installation and Type Certification

Title 14—Aeronautics and Space

CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

[Docket No. 11010; Amdt. Nos. 1-23; 21-40; 23-15; 25-36; 27-9; 29-10; 33-6]

AIRCRAFT AND AIRCRAFT ENGINES—CERTIFICATION PROCEDURES AND TYPE CERTIFICATION STANDARDS

The purpose of these amendments is to change the procedural requirements relating to the type certification of aircraft and aircraft engines, to update and improve the airworthiness standards applicable to the type certification of aircraft engines, and to incorporate new standards applicable to engines used on supersonic airplanes. In addition, other new airworthiness standards are made applicable to aircraft on which engines type certificated to previous standards are to be installed.

These amendments are based on the notice of proposed rulemaking (Notice No. 71-12) published in the FEDERAL REGISTER on May 5, 1971 (36 FR 8383). Except for minor editorial changes, and except as specifically discussed hereinafter, these amendments and the reasons therefor are the same as those proposed in Notice 71-12. Numerous comments relating to these proposals were received in response to the notice and except for those indicating agreement or merely repeating issues discussed and disposed of in the notice, the FAA's disposition of the significant comments is discussed below. In general, comments received that were beyond the scope of the notice are not discussed but will be retained for consideration in connection with other rulemaking projects as appropriate. Based on the relevant comments and upon further review within the FAA, a number of changes have been made to the proposed rules. In addition, various non-substantive changes of a clarifying and editorial nature have been made. Since these changes impose no additional burden on any person, they may be adopted without further notice and public procedure.

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

Two of the proposals of the original notice concerning engine rotor system unbalance (§§ 25.1305 and 33.29) have been implemented by a separate rulemaking action, Amendments 25-35 and 33-5, effective March 1, 1974, that were published in the FEDERAL REGISTER on January 15, 1974 (39 FR 1831).

The following discussion is keyed to the like-numbered proposals contained in Notice No. 71-12:

PART 1—DEFINITIONS AND ABBREVIATIONS

Proposal 1—One commentator objected to the inclusion of a turbosupercharger as part of the engine in the proposed definition of aircraft engines in § 1.1, asserting that in some instances it should be classified as an accessory. However, the intent of the proposal was that turbosuperchargers be included as part of the engine whether or not they are additionally classified as accessories. The definition as adopted has been revised to clarify that a turbosupercharger is part of an engine whether or not it is also an appurtenance or an accessory.

Proposal 2—Several commentators suggested that the term "stop" be deleted from the definition of "idle thrust" as proposed in § 1.1 since a stop is normally associated with the power control lever or throttle, rather than with the engine fuel control device as suggested in the notice. The FAA agrees with the comment to the extent that the term "idle thrust" should be related to the power control lever and has changed the definition by replacing the term "fuel control device" with "power control lever." Since the term "stop" is appropriate with this revision, it need not be deleted.

One commentator pointed out that several of the proposed amendments used the term "type" in reference to engines and that the word "type" was defined in relation to aircraft in § 1.1 but not to engines. For internal consistency, the definition of "type" has been amended to include the meaning of the term with respect to the certification of aircraft engines.

PART 21—CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS

Proposal 1—Several commentators suggested that the stress analysis called for in proposed § 21.15(c) for the engine rotor, spacer, and rotor shaft would not normally be available at the time of application for a type certificate, but would be available before actual certification. The FAA agrees and, upon further consideration, has determined that inclusion of the requirement under the type certification standards will allow an applicant to complete and submit a stress analysis after application for a type certificate and before certification. The requirement for a stress analysis has therefore been removed from § 21.15(c) and relocated in a new § 33.62 under the design and construction requirements for turbine aircraft engines.

Proposal 2—Several commentators recommended deletion of that portion of the proposed § 21.35(f) which requires 300 hours of flight test operations for aircraft incorporating engines of a type not previously used in a type certificated aircraft. They contended that the rule discriminated against new engine types, and that unnecessary economic hardships and delays in the aircraft certification program would be imposed. However, experience with newly certificated engine types has demonstrated to the FAA that there is a need for more thorough flight testing of newly certificated engine types, and the regulation with respect to hours of operation is adopted as proposed. Furthermore, the suggestion of one commentator that allowance be made for the use of experimental engines that differ only in minor ways from the type certificated engine has not been adopted because the FAA believes it could lead to uneven administration of the rule.

One commentator questioned whether the phrase "engines that conform to a type certificate" in subparagraph (f)(1) required just one or a full complement of the newly type certificated engines in a multi-engine aircraft. As indicated in the explanation in the Notice, the intent of the FAA is that "engines" means all the engines in the aircraft. To eliminate any ambiguity, the wording has been changed to specifically call for a full complement of engines.

Proposal 3—No public comment was received on the proposal to amend § 21.97 and the section is adopted as proposed.

PART 23—AIRWORTHINESS STANDARDS: NORMAL, UTILITY, AND ACROBATIC CATEGORY AIRPLANES

Proposal 1—One commentator questioned whether proposed § 23.951(b) would prohibit several fuel tanks from gravity feeding through non-return valves to a single collector box from which the fuel pumps would draw fuel. Such an arrangement is not prohibited and the rule would allow any combination of tanks to be used so long as means are taken to prevent air from being introduced into the system.

In response to the suggestion contained in several comments, the icing requirement of paragraph (c) of proposed § 23.951 has been reworded to clarify that it is applicable solely to turbine engine aircraft, since fuel icing is peculiar to turbine fuels. Additionally, since the requirement is intended to preclude interrupted functioning of the fuel system rather than to require operation for an indefinite time, the rule has been revised to require "sustained" operation rather than "continuous" operation.

Proposal 2—Several commentators questioned whether an applicant would have to comply with amended § 23.997 as proposed, if the similar rule in § 33.67 had already been complied with by the engine manufacturer. The FAA proposed the new requirements to assure that newly certificated aircraft would meet the standards prescribed in § 33.67. Thus, if the aircraft manufacturer incorporated an engine which had been type certificated under new § 33.67 the fuel system would already conform to the rule and nothing further would be required. If, however, the aircraft manufacturer incorporated an engine which had not been certificated under the new § 33.67 he would have to take the necessary action to comply with new § 23.997.

Several commentators questioned whether the proposed rule would require that each and every filter in the fuel system, including small screens and so-called "last chance filters," meet the requirements of paragraph (a) through (d) of proposed § 23.997. The FAA intended that at least one filter upstream of the fuel metering device and the engine driven displacement pump meet

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these requirements, and the section has been clarified accordingly.

In response to a question raised by one commentator concerned with the availability of heat for the required filter or strainer, the FAA wishes to point out that the requirement for icing protection in turbine engine fuel systems, set forth in § 23.951, applies to the entire fuel system.

As proposed, § 23.997(b) would require a drain. Upon further consideration it has been determined that an equivalent of the drain could be provided by having the strainer or filter easily removable for drain purposes and this alternative has been incorporated into the regulation.

Proposal 3—One commentator questioned whether the oil sump of a dry sump engine would be considered as expansion space under the proposal. If the sump is in fact part of the oil tank, then the sump provides the expansion space specified in § 23.1013(b)(1). Further amendment of the requirement is not considered necessary and § 23.1013 (b)(1) is adopted as proposed.

One commentator requested clarification of the phrase "that might reduce the flow of oil," used in proposed § 23.1013 (e). Several other commentators suggested that the phrase was inconsistent with, but should be identical to, proposed § 25.1013. The FAA agrees with these comments and has revised the section to make it consistent with § 25.1013 in this respect, by specifying that any oil tank outlet screen or guard may not reduce the flow of oil below a safe value at any operating temperature.

Proposal 4—One commentator suggested that the more technically correct term "differential pressure" be used in place of "pressure," in paragraph (c) of § 23.1015. The FAA believes, however, that the present term is adequately understood in the industry, and has not caused any misunderstanding in the past. The paragraph is therefore adopted as proposed.

Proposal 5—Several commentators expressed the belief that the proposed § 23.1019 might be interpreted to require each and every oil strainer or filter in the system including small so-called "last chance" filters to conform to all the requirements of paragraph (a). The intent of the FAA is to require at least one oil strainer or filter that will filter all the oil that passes through the lubricating system while conforming to the requirements of the section. The rule as adopted has been reworded to make this clear. Another commentators objected to the word "conveys" as inappropriate in the lead-in sentence of paragraph (a). The FAA agrees and has changed the wording to refer to a strainer or filter through which all of the engine oil flows.

Several commentators interpreted the requirement of subparagraph (a)(1) for normal oil flow through the bypass as possibly requiring identical flow and proposed the word "adequate" in place of "normal." The FAA does not agree that the word "normal" means identical and used the word normal to mean normal for the system within its operating range. Therefore, the wording as proposed has been retained.

One commentator stated that filters should be serviced on a routine and normal maintenance basis rather than relying upon an indicator as proposed in subparagraph (a)(3). In this connection it should be noted, however, that the rule does not call for relaxing of any maintenance procedures but adds an additional item which will contribute to safety by providing a quick means of inspecting for possible filter contamination.

It was assumed in one comment that the standard engine oil pressure gauge would qualify as an "indicator" as required in proposed subparagraph (a)(3). While it was considered that a separate indicator would be provided, nevertheless, if the applicant can demonstrate that the oil pressure gauge would adequately perform the function of the indicator, a separate indicator would not be required. Upon further consideration, the function of the indicator in terms of contamination of the screen has been reworded for clarity.

Several commentators questioned whether the wording of subparagraph (a)(4) was realistic in requiring that no contaminants be released through the filter bypass. As proposed, the requirement stated an absolute prohibition against release of contaminants. The FAA agrees that the intended purpose may be met by requiring the bypass to be designed to minimize release of contaminants, and the requirement is reworded accordingly.

Proposal 6—Several commentators objected to the requirement in proposed § 23.1093 for operation in falling and blowing snow on the basis that no standard is specified as to the intensity or the amount of falling snow or the degree of blowing involved. They further point out that no uniform means are provided for demonstrating compliance with the section and that a small or even minute amount of snow might satisfy the letter of the law of this section. One commentator offered detailed standards that could be adopted. However, it was not the intent that specifications for all possible conditions be included in the regulation but, rather, that an applicant select the limitations desired for his airplane and then demonstrate the ability to operate within those limitations.

Several commentators asserted that the specified liquid water content of 2 grams per cubic meter was not representative of actual conditions and would result in more stringent requirements for ground operation than for flight, while another suggested that the requirement for icing protection at idle should be applicable "on the ground" rather than at sea level. Upon further consideration, the FAA agrees that a reduction to 0.6 grams would provide an adequate and safe standard for icing protection at idle conditions on the ground and the requirement has been changed accordingly.

One commentator objected to the requirement for icing protection for 30 minutes at idle, stating that there was insufficient bleed air to adequately meet the requirement for this period of time. However, experience has demonstrated that it is practical and necessary for safety of flight, and that protection for the engine during prolonged idle prior to takeoff is essential to safety of operation. The proposal does not restrict the means for icing protection to engine bleed air, as suggested by the commentator, but allows any means or combination of means which the applicant chooses. With respect to bleed air, the intent of the requirement is that icing protection at idle be provided when the bleed air available for icing protection is at its critical condition. The section has been reworded to make this clear.

Proposal 7—Amendment 23–14, effective December 20, 1973, published in the FEDERAL REGISTER on November 19, 1973 (38 FR 31816), amended § 23.1183(a) to require that lines and fittings and components carrying gas, air, or flammable fluids in any area subject to engine fire conditions must be at least fire resistant. That amendment also amended the heading of the section, while retaining the requirement that flexible hose assemblies must be approved. Therefore, the section as amended by this Amendment, contains the provisions made effective by amendment 23–14 in addition to those proposed in Notice 71–12, including the revision of the latter discussed below. Inasmuch as the heading proposed in Notice 71–12 is inappropriate to the section as amended by Amendment 23–14, the heading adopted by the amendment is retained.

Stating that proposed § 23.1183, which concerns engine fire protection, is inappropriately included with aircraft airworthiness standards, one commentator suggested that it more correctly belongs in Part 33 relating to engine airworthiness requirements. However, while this and other sections do relate to engine airworthiness, they are included also in Part 23 and the other aircraft certification parts since it is the intent that aircraft certificated under applications made after the adoption of these amendments conform to the new updated sections of Part 33, whether or not they incorporate engines type certificated under the updated Part 33. Thus, to cover cases where such aircraft incorporate engines certificated under applications made before adoption of these amendments, the new engine standards that are appropriate are made effective as to the aircraft by being incorporated in the aircraft airworthiness sections.

One commentator questioned whether integral oil sumps on smaller reciprocating engines were considered to come within the meaning of flammable fluid tanks as that term was used in proposed § 23.1183. The FAA did not intend that they be included, and the rule as adopted specifically provides that integral oil sumps of less than 20 quart capacity need not be fireproof nor be enclosed by a fireproof shield.

Proposal 8—As a result of the issuance of Amendment 23–14 (38 FR 31816), which contains new paragraphs, § 23.1305 (q) and (r), the proposed paragraphs (q), (r), (s), and (t) are redesignated (s), (t), (u), and (v), respectively. The following discussion is keyed to the new designations.

One commentator questioned whether the fuel strainer or filter indicator referred to in § 23.1305(t) were required on all filters, even "last chance" filters. Consistent with the requirements applicable to the strainers or filters themselves, § 23.1305(t) has been revised to make clear that the indicator required is for a fuel strainer or filter required under § 23.997. Similarly, § 23.1305(t) and (u) have been reworded in order to be consistent with §§ 23.997 and 23.1019, respectively, in regard to the degree of contamination that must be indicated. In response to a further comment, § 23.1305 (t) has been reworded to clarify that the desired indication is of the occurrence of contamination rather than the more stringent requirements of the degree of contamination as suggested in the Notice. This change achieves consistency between paragraphs (t) and (u).

One commentator questioned whether other presently installed gauges for other functions could be used as "indicators" to indicate the functioning of a heater as required in paragraph (v). As discussed above, in connection with the indicators required for oil strainers or filters, the FAA anticipates that the requirement will be met by installation of gauges to indicate the functioning of heaters. However, if a clear and positive indication can be obtained from other gauges used to portray functions different than direct heater functioning, the requirements of the section are met.

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

Proposed changes to §§ 25.951 (Proposal 1), 25.997 (Proposal 3), 25.1015 (Proposal 5), 25.1019 (Proposal 6), and 25.1093 (Proposal 7) were the subject of comments substantially the same as submitted for the proposed like-numbered sections of Part 23. As adopted, these Part 25 sections set forth the same requirements as proposed in Notice 71–12 except as they have been modified for the reasons given in the preamble discussion of the like-numbered Part 23 sections.

Proposal 2—No comments were received in response to the proposed deletion of § 25.977(b). That paragraph is accordingly revoked and marked reserved.

Proposal 4—The exemption contained in the last sentence of § 25.1013(a), concerning fireproofing of an integral oil sump of less than 20-quart capacity on a reciprocating engine, has been removed from this section and placed in § 25.1183 (a). This action involves no substantive change and achieves consistency with the parallel Part 23 section.

Proposal 8—Section 25.1183(a) has been further amended in connection with changes to § 25.1013(a) as noted under Proposal 4.

Proposal 9—Section 25.1305(c) has been amended so that it is substantively the same as the parallel provision of § 23.1305. The related Part 23 preamble discussion is applicable. The proposed new subparagraph 25.1305(d)(3), concerning an indicator to indicate rotor system unbalance, has already been adopted by a separate rulemaking action (Amdt. 25–35, 39 FR 1831).

One commentator stated that aircraft fuel systems have been designed without cockpit controlled fuel heat; therefore there is no need in proposed subparagraph (c)(8) for an indicator to indicate the proper functioning of any fuel heater. The section, however, only requires an indicator if a heater is used and the FAA believes it would supply necessary information to indicate heater functioning.

PART 27—AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

Proposed changes affecting §§ 27.951 (Proposal 1), 27.997 (Proposal 2), 27.1013 (Proposal 3), 27.1015 (Proposal 4), 27.1019 (Proposal 5), 27.1093 (Proposal 6), 27.1183 (Proposal 7), and 27.1305 (Proposal 8) were the subject of comments substantially the same as submitted for the proposed like-numbered sections of Part 23. The proposed amendments set forth in Notice 71–12 have been adopted except as explained in the preamble discussion of the like-numbered Part 23 sections.

PART 29—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

Proposed changes affected §§ 29.951 (Proposal 1), 29.997 (Proposal 2), 29.1013 (Proposal 3), 29.1015 (Proposal 4), 29.1019 (Proposal 5), 29.1093 (Proposal 6), 29.1183 (Proposal 7), and 29.1305 (Proposal 8) were the subject of comments substantially the same as submitted for the proposed like-numbered sections of Part 23. The proposed amendments set forth in Notice 71–12 have been adopted except as explained in the preamble discussion of the like-numbered Part 23 sections.

PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

Proposal 1—The comments received in response to proposed § 33.5 focused principally on the overhaul instructions that would be required by paragraph (e). The comments revealed widespread misunderstanding of the effect of requiring the engine manufacturer to set out the frequency of overhauls. In this connection, the FAA wishes to point out that overhaul instructions are necessary upon type certification because an engine might require overhaul at any time thereafter, and the ability to perform an overhaul should not be limited by lack of instructions. Furthermore, the manufacturer's statement of overhaul frequency is not established as an operating limitation but operates merely as a recommendation; it does not preclude the establishment of different overhaul intervals, nor does it preclude the "piecemeal" overhaul practice followed by operators using continuous airworthiness maintenance programs. It should be noted, however, that the initial overhaul time established under § 33.90 and referred to in § 33.7(c)(17) is an operating limitation that must be complied with regardless of the adoption of any other practice; the initial overhaul, whether accomplished "piecemeal" or otherwise, must be completed within the time established.

With regard to a question raised by one commentator concerning the requirements in § 33.5(e)(2) that certain component life limits be specified in the required instructions, the FAA wishes to call attention to the fact that no separate requirement is thus established that would have any effect on operators of the engines. The life limits of all components requiring replacement are established under other sections of Part 33 as operating limitations that must be complied with, and their publication in the required instructions is a convenience to operators.

Upon further review, § 33.5(a)(1) is revised to include a requirement that the installation instructions contain the maximum allowable loads for engine mounting attachments and related structure, which are required to be determined in complying with § 33.23. Similarly, § 33.5(a)(2) is revised to include a requirement for description of the pipes, wires, cables, ducts, and cowling covered by that section. That information is considered essential for installation, and FAA practice has been to require it for compliance with prior § 33.5.

Proposal 2—The effect of proposed § 33.7 was misunderstood by a number of commentators who objected to various ratings and limitations listed therein. Contrary to the apparent belief of those commentators, no ratings or limitations would be established independently under § 33.7; the section merely contains a list of ratings and limitations established either under applicable requirements of Part 33 that predate the Notice, or under proposed new requirements contained in the Notice. Consideration was thus given to the substance of the comments as they related to substantive requirements proposed in the Notice. Discussion of comments directed to § 33.7 but relating to proposed new requirements is found with other comments under the appropriate section. However, as a result of such comments, one substantive change has been made that affects § 33.7; no rating or limitation need be established for turbine engine internal cooling air flow, and proposed § 33.7(c)(12) has therefore been deleted, with attendant necessary renumbering of the succeeding subparagraphs. Other changes of an editorial nature have been made for internal consistency between § 33.7 and other Federal Aviation regulations.

Proposal 3—No public comment was received on the proposed deletion of § 33.13, and the section has been revoked and marked "reserved."

Proposal 4—Several comments were received that contained objections to the

start-stop stress cycle described in proposed § 33.14 as not being representative of a typical operating cycle that would produce the stresses to be accounted for by the requirement. In particular, there was objection to the requirement that disc and spacer temperatures be stabilized after stopping the engine in order to complete a cycle. The FAA agrees that final temperature stabilization should not be necessary where an applicant can show that the components experience the complete stress range without such stabilization, and the definition of a start-stop stress cycle as adopted includes a provision to allow for such a showing.

Another commentator suggested that the operating limitation be defined as the number of cycles to a detectable crack rather than to failure. The FAA regards a crack as a failure and the rule as adopted applies not only to cracks but to other types of failures which may occur prior to the occurrence of a detectable crack.

A commentator recommended that spacers be deleted from the section because they would not normally be critical. The FAA disagrees; spacers are a critical item in low cycle fatigue, and the requirement, in this regard, is adopted as proposed.

One commentator stated the belief that the establishment of component life limits would result in a complicated and time-consuming process for extending component life. The FAA points out that the listing of this limit on the type certificate as required by this section provides only an initial limit and will not in any way complicate the procedure for extending the limit. In this connection, the section as adopted is revised to clarify that the required operating limitations and the provision for increasing them apply individually to each rotor disc and spacer.

Proposal 5—Several commentators objected to the new standard of protection proposed in § 33.17(b) for external lines, fittings, and components as unnecessary because the matter is adequately covered in paragraphs (a) and (c) of that section, while another commentator asserted that, due to considerations of airflow and venting, the requirement should be imposed only on the airframe. The FAA does not agree with these positions. The new requirement in (b) for protection against ignition of leaking flammable fluids is necessary to deal with possible impingement of such fluids on hot surfaces. Furthermore, since engine design necessarily includes considerations of airflow and venting, this requirement in Part 33 will assure that those considerations take account of possible ignition of leaking flammable fluid that could result from its impingement on engine components.

In response to comments questioning the applicability of proposed § 33.17(c) to integral oil sumps on the smaller reciprocating engines, the requirement as adopted is revised to exclude such sumps having less than a 20-quart capacity. The requirement is thus made consistent with the parallel requirements in the aircraft airworthiness parts.

One commentator believed that a clear definition of "fireproof" and "fire resistant" was lacking in the regulations and suggested that temperature, duration and flame intensity should be specified as part of any definition. The definitions in § 1.1 of the regulations include both "fireproof" and "fire resistant" and any further changes to these definitions would be outside the scope of the Notice.

One commentator questioned whether under paragraph (e), the accumulation of fluid is interpreted as occurring inside of the engine and suggested that the section should specify unwanted flammable fluid. The FAA agrees that the section is intended to refer to unwanted flammable fluid and is directed to areas internal to the engine. The requirement as adopted is reworded accordingly.

Proposal 6—The comments received in response to proposed § 33.25 expressed general agreement with the intent of the requirement as understood by the commentators. However, several of the comments indicated a need for clarification regarding the applicability of limit loads to accessory drives and mounting attachments. The FAA agrees that the intent of the proposal was that the limit load requirement apply to accessory drives and mounting attachments and the section as adopted is reworded to make this clear.

In addition, as suggested by one commentator, a provision has been added to make clear that the use of engine oil for lubrication of accessory drives and mounting attachments is permitted, with appropriate sealing provisions.

Proposal 7—It was pointed out that reference to "excessive speed, temperature, and vibration" in proposed § 33.27 (a) was vague in view of the very specific requirements in proposed paragraph (d). Since it was the intent of the proposal to relate the two requirements, § 33.27(a) as adopted is revised to clearly refer to the specific tests included in the section.

Several commentators objected to the speeds proposed in the overspeed tests required in § 33.27. They expressed the opinion that the rotor speed strength demonstrations which are currently accepted by the FAA and which are 5 percent lower in all cases than the proposed requirements demonstrate an adequate margin of strength. In this connection, one commentator pointed to 6 million hours of service experience with no disc bursts. The FAA finds compelling merit in these comments and upon further consideration the overspeed requirements as adopted are 5 percent less than those proposed.

Several commentators believed that the proposal to use a test article fabricated with minimum qualities allowed by the specification was an impractical requirement. They expressed the opinion that to conform to the proposal as written would require a component made with all the minimum properties of the specifications, a condition which could not be met. The FAA agrees with these comments and upon further consideration has deleted the proposal.

Several commentators objected to the proposed paragraph (c) of § 33.27 regarding cooling airflow as being too restrictive. They pointed out that in designs where there is more than one cooling passage, one passage could be blocked and still allow passage of an adequate flow of cooling air. While this might be less than normal cooling airflow it might still ensure adequate cooling. The FAA agrees that the proposed requirement would not accomplish the intended purpose and, in connection with the deletion of other proposed requirements relating to cooling airflow that were determined to be impracticable (see discussion relating to §§ 33.7 and 33.87), the section is adopted without the proposed paragraph (c).

Proposal 8—One commentator expressed the opinion that the instrument connection markings required in proposed § 33.29 would be unnecessary if it could be shown that there was no possibility of an instrument being connected to the wrong connection. The FAA agrees that this would satisfy the requirements of the rule and, accordingly, the section as adopted is revised to specifically allow this. In addition, the section has been revised by deletion of the word "new" which was inadvertently included in the proposal, to clarify that it applies to all engine limitations.

The proposed requirement relating to rotor system unbalance contained in proposed § 33.29(b), as noted previously in this preamble, has been adopted in a separate rulemaking action (Amdt. 33–5; 39 FR 1831).

Proposal 9—The only public comment received in response to the proposed new § 33.42 recommended deletion of the requirement but gave no reason for the recommendation. The section is adopted as proposed.

Proposal 10—A comment was received that questioned the speed range that would be applicable to the proposed requirement in § 33.43(a) for a vibration survey with a cylinder not firing. As proposed, the requirement implies the same speed range that is applicable to the engine with all cylinders firing. The FAA agrees that this would be impractical and the requirement is revised to specify that the applicable speed range is from idle to maximum desired takeoff speed rating.

Several commentators questioned whether the vibration test survey specified in paragraph (a) required the same propeller used for the endurance test or a propeller of the same configuration. The FAA intended that the same configuration of propeller could be used for the tests and the rule as adopted is revised to clarify the intent for both propellers and loading devices.

One commentator recommended that § 33.43(a) be revised to exclude the propeller shaft or other output shafts from the vibration survey. The FAA does not agree that they should be excluded since they are the most vital components requiring vibration measurements and

tests. However, this does not include any accessory drive shafts, which are required to be loaded under § 33.43(c) in order to assess the effects of such loads on the propeller or other output shaft.

One commentator regarded that the number of cycles to demonstrate compliance for fatigue testing of steel shafts specified in § 33.43(b) should be 10 million rather than 10½ million cycles: The FAA agrees that 10 million cycles represents an accepted standard and the requirement is revised accordingly.

A commentator recommended that § 33.43(c) which requires accessories to be loaded during the vibration tests be deleted as being unnecessary for torsional surveys. The FAA does not agree; the purpose of the test is to disclose possible adverse vibration effects, including any that might be contributed by accessories.

Proposal 11—Several commentators objected to the proposed § 33.45(b) requirement for a recalibration after the endurance test as being impracticable, and unnecessarily adding to the endurance test. They suggested that the intent of the section, to ensure that any power loss during the endurance test be determined, could be met by modifying the rule to require a "power check" in place of a recalibration. The FAA agrees that a full recalibration is not required to determine power loss and the section is revised to require a power check in place of a recalibration. In addition, since the section permits use of measurements taken during the final portion of the endurance test, reference to the finish of that test has been deleted.

Proposal 12—Upon further consideration, the parenthetical statement in the first sentence of paragraph (a) of proposed § 33.49 is revised to clarify that the additional testing requirements that apply to a turbosupercharger are completely covered in § 33.49(e)(1)(iii) (proposed § 33.49(e)(1)(iv)). An applicant may elect to run the engine-turbosupercharger combination an additional 50 hours in complying with that requirement, but it is not necessary to do so.

One commentator felt that in § 33.49, the accessory loading provision referred to in paragraph (a) could be interpreted to require the limit load to be applied during all operations. The intent of this rule is to require limit loads only during operation at rated maximum continuous power and rated takeoff power, and the section is revised accordingly.

One commentator recommended that instead of requiring maximum cylinder temperatures during all of the endurance running at maximum and takeoff powers that a shorter time period would adequately demonstrate cylinder assembly integrity. The FAA agrees with the recommendation and the rule as adopted requires testing with cylinder and oil inlet temperatures specified, for 35 hours, the time currently used in certification practice. Furthermore, the FAA agrees with another commentator that as long as the cylinder temperatures are monitored the intent of the section will be met, and the requirement is revised to refer to cylinder temperature, deleting reference to the cylinder barrel and head.

A commentator recommended that the altitude testing requirements for turbosupercharged engines be deleted and the tests be run at sea level condition. The FAA does not agree. The altitude testing requirements are necessary. However, the section as adopted is revised by rewording the lead-in sentence of § 33.49(e) to allow as an alternative that altitude tests may be simulated, and by deleting proposed § 33.49(e)(1)(iii).

Proposal 13—Several commentators objected that the proposed requirement in § 33.55(b) that all adjustment settings and functioning characteristics that can be established independent of installation on the engine be unchanged at teardown is unnecessarily restrictive. The FAA agrees that the intent of the proposal would be satisfied if those functioning characteristics remain within limits established at the beginning of the endurance test, and the requirement is revised accordingly.

Several commentators believed that the requirement proposed in § 33.55(c) that components conform to the type design after the endurance test was too severe, especially since this would require parts to remain within drawing tolerances. The FAA does not agree. The type design includes dimensions within which a component may change in service. A component that sustains wear beyond those limits during a 150-hour endurance test has not met minimum airworthiness standards.

Proposal 14—The last sentence of § 33.57(b) as proposed is amended to require the engine "or" its parts to be subjected to additional tests if required instead of the engine "and" its parts.

As discussed in connection with Proposal 1 of Part 21, new § 33.62 is added to require stress analysis of certain engine parts.

Proposal 15—A commentator recommended revision of proposed § 33.65 to include reference to the allowable engine operating limitations in order to clarify that there could not be a finding of noncompliance if any of the undesired effects resulted from operations beyond those limitations. The section is intended to apply only to operations that are within allowable operating limitations as set forth in the manufacturer's operating instructions and the requirement is revised to make this clear.

In addition, the section is revised to delete the reference to inlet air distortion caused by cross-wind, which is adequately covered by the manufacturer's specification of limiting inlet air distortion, and to ice ingestion, which is adequately covered by other requirements.

Proposal 16—Several commentators recommended that § 33.66 be clarified to avoid the interpretation that a reduction in engine performance due to bleed air would be an "adverse effect on the engine." To preclude this possible misinterpretation, the section is revised accordingly.

Proposal 17—Several commentators suggested that paragraph (a) of § 33.67 be revised to allow for the use of seals and locking devices as alternatives to making the fuel control adjusting means inaccessible. The FAA agrees that these alternative means may be used to achieve the desired intent and the section is revised accordingly.

Several commentators expressed doubt that it should be necessary to add any water to saturated fuel since upon cooling the saturated water would precipitate out, thus representing the most critical condition. The FAA does not agree that the amount of water which may precipitate out properly represents the most critical amount of free water possible in the system. The added water is necessary to simulate critical conditions.

Several commentators expressed doubt that § 33.67(b)(6) could be literally complied with and suggested that the aim of the rule was that all means be taken to prevent the release of contaminants, and that an insignificant amount of contaminant release should not violate the rule. The FAA agrees with this comment and the rule as adopted requires design of the bypass to minimize release of contaminants.

Other revisions to the section have been made for the reasons set forth in the discussion relating to § 23.997, which contains like requirements.

Proposal 18—The comments received in response to proposed § 33.68 were similar to those received in connection with the substantively similar provisions contained in proposal 6 of Part 23, § 23.1093. The section is revised in accordance with the discussion pertaining to revisions of that section.

Proposal 19—Several commentators objected to the requirement in § 33.69 for two igniters; however, this is the requirement of the present rule and the only proposed change to the rule is the requirement for a single igniter for fuel augmentation systems. No objections were received to this provision.

Proposal 20—Several commentators objected to the requirement in § 33.71(b)(6) for cockpit indication of oil filter contamination, where no bypass is incorporated. However, the FAA considers the addition of a cockpit indicator to be necessary in the interest of safety in order to enable the flight crew to prevent engine failure due to oil starvation, that might occur if all required filters in the lubrication system do not incorporate the protection of a filter bypass.

As indicated by other commentators, the words "extreme temperature" as used in proposed § 33.71(c)(9) could be taken to require compliance at temperatures beyond the intended operating range. Such a result would be contrary to the intent of the requirement and the section as adopted is revised to refer to maximum operating temperature. In response to other comments the differential pressure requirement in subparagraph (c)(9) is reworded to clarify that

it may not be less than 5 p.s.i. above the maximum operating pressure of the tank.

One commentator considered that the lack of a requirement for a bypass was a serious deficiency in the proposal. The FAA has considered this question many times including extensive discussion at government-industry airworthiness meetings and has determined that due to the serious divergence of opinion the use of a bypass should at present be optional. If no bypass is used, however, the applicant must comply with other safeguards contained in the section to ensure safe operation of the lubrication system.

The remainder of the comments were similar to those made in response to proposals 3, 4, and 5 of Part 23 and have been responded to in discussion of those proposals. The section has been reworded in part to conform with the changes made to the sections involved in those proposals.

Proposal 21—One commentator recommended that § 33.72 should refer to a "main" filter only. The FAA does not agree; the requirements are meant to apply to each filter or screen incorporated in the system.

Proposal 22—Several commentators believed that § 33.75 as written was confusing and ambiguous. The printed notice was incorrectly worded and the section is rewritten to read correctly.

Several commentators suggested that the word "burst" in subparagraph (b) was ambiguous and needed further definition. The FAA agrees and, accordingly, a further descriptive phrase, "penetrate its case," is added.

One commentator suggested that the phrase "improper operations" be substituted for "bad operation". The FAA agrees with the suggestion and the section incorporates this change.

One commentator objected to consideration of multiple failures, to avoid consideration of an infinite number of possible failures. The analysis however does not require that all possible multiple failures be considered, but uses the accepted standard of consideration of only the probable single or multiple failures.

Proposal 23—One commentator suggested that § 33.77(a)(2) be clarified to ensure that a burst meant uncontained burst that penetrates the case. The FAA agrees that this is the intent of the section and it is revised accordingly.

Several commentators suggested that the footnote to the table be modified to permit the option of demonstrating containment on a component basis for all the test items. The FAA does not agree that this would adequately account for secondary effects except in the case of blade containment in fan engines as noted.

Several commentators expressed doubt that the proposed rate of ingestion of 1½ pound birds was supported by ornithological data or actual flight experience. They suggested that a lesser rate be used. The FAA, after further study and consideration, agrees. Accordingly, the ingestion rate for 1½ pound birds is established at one for the first 300 square inches of inlet area and at one for each 600 additional square inches or fraction thereof, of up to a maximum of 8 birds.

The practical reality of a 4-inch hailstone was questioned in some of the comments. The FAA, after further study, has determined that this size will probably not be encountered in actual flight conditions and the section is amended to delete the requirement.

Several commentators believed that the amount of sand and gravel specified was excessive and not representative of actual conditions. After further consideration, the FAA agrees that the amount proposed should be reduced and the section is revised accordingly.

The FAA agrees with the point raised by several commentators that, in § 33.77(c), some power or thrust loss should be permitted since the ingestion of these objects will certainly cause a temporary power loss. Accordingly, the requirement is revised to permit power or thrust loss that is not "sustained." In addition, § 33.77(f) is revised, upon further consideration, to require testing for water ingestion to take place under takeoff operating conditions rather than the proposed "maximum cruise." This reflects current practice in engine certification.

The ¼ by 1 inch bolt test is deleted since the test for the broken rotor blade is a more stringent test and will adequately account for the effects of the bolt.

A comment was received that objected to the provision in proposed § 33.77(d)(3) relating to obstruction of induction airflow by foreign objects that are stopped by a protective device. The FAA wishes to point out that the subject provision does not state a requirement that must be met by all applicants. Rather, it provides an alternative to testing for the effects of objects that can be stopped by a protective device and prevented, by deflection out of the airflow path or by some other means, from obstructing the induction airflow in any way.

In addition, a new paragraph (e) is included in § 33.77 to incorporate the suggestion offered by some commentators that the effects of ingestion of some foreign objects can be accounted for by the effects of others. Thus, in showing compliance with § 33.77(a) the applicant is required to test only for that object that is shown to have the most severe effect. Similarly, for compliance with (b), testing is required for sand and gravel and either the 3 ounce or 1½ pound birds, depending on the size of the engine inlet, as designated in § 33.77(f).

Proposed paragraph (e) is redesignated as paragraph (f).

Proposal 24—One commentator recommended that in § 33.79(a) an acceptable means of compliance to demonstrate cooling be provided for the guidance of the applicant. The FAA, upon further consideration agrees that the section does not adequately establish a definable objective and the proposal is withdrawn for further study. Proposed paragraphs (b) through (f) are redesignated (a) through (e), respectively.

One commentator believed that paragraph (e) of the proposed rule could be misinterpreted as allowing a loss of thrust to the unaugmented engine in an amount equal to that added by the augmentor. To avoid possible misinterpretation, the requirement, adopted in § 33.79(d), is reworded to clarify that the loss of thrust mentioned means only the thrust that is provided by augmentation. Furthermore, upon further consideration, the FAA has revised the requirement to refer only to failure or malfunction of augmentor combustion, since the effects of other possible augmentor failures on engine thrust cannot be reliably predicted.

One commentator recommended clarification of proposed paragraph (f) to ensure that the rotational speed mentioned be the minimum rotational speed at which the thrust augmentation functions. This is the original intent of the paragraph and it is modified accordingly.

Proposal 25 — One commentator pointed out an error in the explanation of proposed changes to § 33.81. Instead of referring to § 33.43, it should have referred to § 33.87. No change to the adopted rule itself is necessary, however.

Proposal 26—No comments were received on the proposed new § 33.82, and the section is adopted as proposed.

Proposal 27—Several commentators recommended that the requirement in § 33.83 for testing to 110 percent of the desired maximum continuous speed rating be deleted because certain high performance turbine engines may not be capable of achieving this overspeed condition. Upon further consideration, the FAA agrees with the commentators' position and the requirement is deleted.

Other revisions to the section have been made for the reasons set forth in the discussion relating to § 33.43, which contains like requirements.

Proposal 28—Revisions have been made to § 33.85 for the reasons set forth in the discussion relating to § 33.45, which contains like requirements.

Proposal 29—Several commentators requested that the surface temperature requirement be deleted from proposed § 33.87(a)(3) as being difficult to simulate on a test stand. The section is intended by the FAA to require that if an engine external temperature limit be specified by the applicant as being critical, then the applicant must demonstrate satisfactory operation at that temperature. It is pointed out that only those temperatures specified by the applicant need be held at their specified values and the requirement is reworded to clarify this. In addition, the section is revised to provide allowance for more than one test run if all parameters cannot be held at the required values simultaneously.

Several commentators objected to subparagraph (a)(4) of § 33.87 which had called for fuels, lubricants, and hydraulic fluids with the lowest thermal breakdown

temperatures allowed by their specifications to be used during the tests. They felt that this was practically an impossible requirement because of the unavailability of fluids and lubricants with all the minimum properties called for. The FAA agrees, and the requirement is revised to call for specified fluids and lubricants used during the endurance tests to conform to their respective specifications.

One commentator suggested that § 33.87(a)(6) be amended to require that only shear and overload loads be tested and that the requirement for other loading during the endurance tests be deleted. The FAA does not agree, but intended that the endurance test simulate actual operation and include testing of the accessories drives themselves as well as other portions of the engine. This requires loading of those drives, and the rule is adopted as proposed.

Several commentators questioned whether the limit load for accessories specified in subparagraph (a)(6) should apply only during maximum power operation. This is the intended construction of the section, and it is amended to reflect this intent.

One commentator expressed concern that compliance with § 33.87(a)(8) which calls for cooling air simulation could not be demonstrated since in a particular engine there may be many divisions of cooling air-flow which might make it virtually impossible to individually regulate each separate cooling airflow path. The FAA agrees with the commentator's position and the proposal is withdrawn for further study.

Several commentators suggested that the references to supersonic engines be deleted because of the lack of foreseeable need for such engines. The FAA does not agree. One of the purposes in formulating these new amendments is to establish standards for that new generation of engines, especially since the FAA is in the process of presently certificating such engines.

One commentator pointed out that the proposal did not include the false start tests of the present rule. This was an inadvertent omission and those false start tests are included in the adopted rule.

Proposal 30—The phrase "for installation in an engine" is deleted from § 33.88 as being surplusage.

Proposal 31—One commentator requested that a better definition be used in § 33.89(b) for the term "extreme ambient temperature and altitude." The FAA agrees that, taken literally, the requirement could be unnecessarily burdensome. Accordingly, the wording is modified to read "maximum and minimum operating ambient temperature" and "maximum operating altitude." In addition, upon further consideration, the last sentence of the proposed requirement is deleted as unnecessary.

Proposal 32—One commentator believed that for the overhaul test of § 33.90 two starts per hour was unnecessarily severe and suggested that a number representative of intended operation might be substituted for the stated requirement. The FAA agrees that if the applicant could show that a lesser number of starts would be more representative of intended operation for the particular engine that this would adequately comply with the intent of the section, and the section is revised accordingly. Furthermore, since this revision eliminates the distinction in the section between airplane and rotorcraft engines, the requirement is expressed in a single paragraph, rather than in (a) and (b) as proposed.

In response to several comments, § 33.90 as adopted is revised to clarify that the requirement applies only to engines being originally type certificated; it does not apply to engines being certificated through amendments to existing type certificates or through supplemental type certification procedures.

Several commentators recommended deleting the entire section as proposed. They expressed the opinion that it it was unreasonable to require the completion of an overhaul test in addition to the endurance test as a condition of type certification and believed that past practices were adequate to establish an initial overhaul period. One commentator stated that the 150 hour endurance test, because of its accelerated nature, should be equivalent to a 1000 hour overhaul period. The FAA does not agree. This additional overhaul test is necessary since experience on certain engines has shown that the endurance test has not been equivalent to longer service operations, especially for periods as long as 1000 hours.

Proposal 33—Several commentators pointed out that the oil tank requirement in paragraph (c) of proposed § 33.91 was redundant with a similar proposed requirement in proposed § 33.71 (c)(9). The specified test requirements for oil tanks are covered under § 33.71 (c)(9) and reference to oil tanks is, therefore, not included in § 33.91(c) as adopted. References to "extreme temperature" and "the sum of 5 p.s.i. and the maximum operating pressure" in the requirements specified in § 33.91(c) have been revised for reasons discussed in connection with Proposal 20, this Part (§ 33.71). In addition, and for the same reason, references to "extreme temperature" in § 33.91(d) have been replaced by "maximum and minimum operating temperature", and the requirement to test while cycling operating conditions from "one extreme to another" has been rewritten to require cycling between maximum and minimum operating conditions.

Proposal 34—Several commentators expressed the opinion that the tests required under § 33.92 are unnecessary for engines that are to be used in single engine aircraft. One commentator further suggested that the time period of 3 hours may not be appropriate to a practical situation but rather, the time period and r.p.m. should be based upon the conditions arising from a recommended flight technique following an engine failure at a critical point in the flight path. Another commentator expressed doubt that windmilling for 3 hours without oil was a normal expectancy. The FAA does not agree. It is not possible, at the time of certification, to know the end use or particular intended flight conditions for each engine. It is therefore necessary to establish a general criterion which will adequately demonstrate a degree of safety for conditions that a turbine engine would likely encounter on a typical and usual route structure. The 3 hour time period specified does represent a time period representative of an expected route structure and windmilling for 3 hours without oil is a reasonable possibility.

One commentator recommended that the proposed rule be clarified to specifically allow for the engine windmilling speed to either decrease or stop due to freezing of bearings. The proposal as written does not specifically mention this condition. However, the FAA agrees that this would be a satisfactory means of accomplishing the intent of the section and the rule is revised to allow for this condition.

One commentator recommended deletion of the entire section because he believed there was insufficient experience pointing out a need for these tests and because the proposal implies a flight test as a condition of engine certification. The FAA finds that experience establishes the need for these tests and points out that flight tests are not specifically required by the rule.

Proposal 35—The changes to § 33.93 are similar to those made for § 33.55, which was the subject of similar comments. The changes and comments are discussed in connection with Proposal 13, this Part.

Proposal 36—The changes to § 33.99 are similar to those made for § 33.57, which was the subject of similar comments. The changes and comments are discussed in connection with Proposal 14, this Part.

Finally, it should be noted that a number of the rule changes contained in this Amendment deal with subjects for which proposals were received for inclusion in the 1974–75 Airworthiness Review Program (Notice 74–5; 39 FR 5785). As indicated in that Notice and in Notice 74–5A (39 FR 18662), inviting comment on the proposals received, rule making procedures separate from the Airworthiness Review could result in removal of proposals from further consideration during the Airworthiness Review Program. The FAA was determined that the following FAA proposals presently being processed in the 1974–75 Airworthiness Review relate to issues that are covered by the rules adopted by these Amendments, and need not, and will not, be given further

consideration during the 1974–75 Airworthiness Review:

Proposal No.	FAR'S	Subject
677 (with respect to proposed paragraph (q) only).	§ 23.1305	Powerplant instruments.
752	§ 25.997	Fuel strainer or filter.
784	§ 25.1305	Powerplant instruments.
863	§ 27.1305	Do.
941	§ 29.1183	Lines and fittings.
947	§ 29.1305	Powerplant instruments.

These amendments are made under the authority of sections 313(a), 601, and 603 of the Federal Aviation Act of 1958 (49 U.S.C. 1354(a), 1421, and 1423), and of section 6(c) of the Department of Transportation Act (49 U.S.C. 1655(c)).

In consideration of the foregoing, Parts 1, 21, 23, 25, 27, 29, and 33 of the Federal Aviation regulations are amended as follows, effective October 31, 1974:

PART 1—DEFINITIONS AND ABBREVIATIONS

1. Section 1.1 is amended to change the definition of "Aircraft engine" and by adding new definitions "idle thrust", "rated takeoff augmented thrust", and "rated maximum continuous augmented thrust"; by amending the definitions of "rated takeoff thrust", "rated maximum continuous thrust"; and by adding a new paragraph (3) to the definition of "type" to read as follows:

§ 1.1 General definitions.

* * * * *

"Aircraft engine" means an engine that is used or intended to be used for propelling aircraft. It includes turbosuperchargers, appurtenances, and accessories necessary for its functioning, but does not include propellers.

* * * * *

"Idle thrust" means the jet thrust obtained with the engine power control level set at the stop for the least thrust position at which it can be placed.

* * * * *

"Rated maximum continuous thrust", with respect to turbojet engine type certification, means the approved jet thrust that is developed statically or in flight, in standard atmosphere at a specified altitude, without fluid injection and without the burning of fuel in a separate combustion chamber, within the engine operating limitations established under Part 33 of this chapter, and approved for unrestricted periods of use.

* * * * *

"Rated maximum continuous augmented thrust", with respect to turbojet engine type certification, means the approved jet thrust that is developed statically or in flight, in standard atmosphere at a specified altitude, with fluid injection or with the burning of fuel in a separate combustion chamber, within the engine operating limitations established under Part 33 of this chapter, and approved for unrestricted periods of use.

* * * * *

"Rated takeoff thrust", with respect to turbojet engine type certification, means the approved jet thrust that is developed statically under standard sea level conditions, without fluid injection and without the burning of fuel in a separate combustion chamber, within the engine operating limitations established under Part 33 of this chapter, and limited in use to periods of not over 5 minutes for takeoff operation.

* * * * *

"Rated takeoff augmented thrust", with respect to turbojet engine type certification, means the approved jet thrust that is developed statically under standard sea level conditions, with fluid injection or with the burning of fuel in a separate combustion chamber, within the engine operating limitations established under Part 33 of this chapter, and limited in use to periods of not over 5 minutes for takeoff operation.

* * * * *

"Type", * * *

(3) As used with respect to the certification of aircraft engines means those engines which are similar in design. For example, JT8D and JT8D–7 are engines of the same type, and JT9D–3A and JT9D–7 are engines of the same type.

* * * * *

PART 21—CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS

2. Section 21.15 is amended by adding a new paragraph (c) to read as follows:

§ 21.15 Application for type certificate.

* * * * *

(c) An application for an aircraft engine type certificate must be accompanied by a description of the engine design features, the engine operating characteristics, and the proposed engine operating limitations.

3. Section 21.35 is amended by adding a new paragraph (f) to read as follows:

§ 21.35 Flight tests.

* * * * *

(f) The flight tests prescribed in paragraph (b)(2) of this section must include—

(1) For aircraft incorporating turbine engines of a type not previously used in a type certificated aircraft, at least 300 hours of operation with a full complement of engines that conform to a type certificate; and

(2) For all other aircraft, at least 150 hours of operation.

4. Section 21.97 is amended to read as follows:

§ 21.97 Approval of major changes in type design.

(a) In the case of a major change in type design, the applicant must submit substantiating data and necessary descriptive data for inclusion in the type design.

(b) Approval of a major change in the type design of an aircraft engine is limited to the specific engine configuration upon which the change is made unless the applicant identifies in the necessary descriptive data for inclusion in the type design the other configurations of the same engine type for which approval is requested and shows that the change is compatible with the other configurations.

PART 23—AIRWORTHINESS STANDARDS: NORMALITY, UTILITY, AND ACROBATIC CATEGORY AIRPLANES

5. Section 23.951 is amended to read as follows:

§ 23.951 General.

(a) Each fuel system must be constructed and arranged to insure a flow of fuel at a rate and pressure established for proper engine functioning under each likely operating condition, including any maneuver for which certification is requested.

(b) Each fuel system must be arranged so that—

(1) No fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F and having 0.75cc of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

6. Section 23.997 is amended to read as follows:

§ 23.997 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself; and

(d) Have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in Part 33 of this Chapter.

7. Section 23.1013 is amended by amending paragraph (b)(1), paragraph (c), paragraph (e) and by adding new paragraph (g), to read as follows:

§ 23.1013 Oil tanks.

* * * * *

(b) * * *

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent

space of not less than the greater of 10 percent of the tank capacity or 0.5 gallon, and each oil tank used with a turbine engine must have an expansion space of not less than 10 percent of the tank capacity.

* * * * *

(e) *Outlet.* There must be means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. No oil tank outlet may be enclosed by any screen or guard that would reduce the flow of oil below a safe value at any operating temperature. There must be a shutoff valve at the outlet of each oil tank used with a turbine engine, unless the external portion of the oil system (including the oil tank supports) is fireproof.

16. Section 25.1015 is amended by revising paragraph (b)(1) to read as follows:

§ 25.1015 Oil tank tests.

* * * * *

(b) * * *

(1) The test pressure—

(i) For pressurized tanks used with a turbine engine, may not be less than 5 p.s.i. plus the maximum operating pressure of the tank instead of the pressure specified in § 25.965(a); and

(ii) For all other tanks may not be less than 5 p.s.i. instead of the pressure specified in § 25.965(a); and

* * * * *

17. Section 25.1019 is amended to read as follows:

§ 25.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under Part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination of the screen before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 25.1305(c)(7).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

18. Section 25.1093 is amended by amending paragraph (b) to read as follows:

§ 25.1093 Induction system deicing and anti-icing provisions.

* * * * *

(b) *Turbine engines.* Each turbine engine must—

(1) Operate throughout its flight power range (including idling) without adverse effect on engine operation or serious loss of power or thrust under the icing conditions specified in Appendix C of this part, and in snow, both falling and blowing, within the limitations established for the airplane; and

(2) Idle for 30 minutes on the ground with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature of 29°F and has a liquid water content of 0.6 grams per cubic meter in the form of drops having a mean effective diameter of 40 microns, followed by a momentary operation at takeoff power or thrust.

19. Section 25.1183 is amended by amending the heading and paragraph (a) to read as follows:

§ 25.1183 Flammable fluid-carrying components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions, and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 20 quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

* * * * *

20. Section 25.1305 is amended by adding new paragraphs (c)(5) through (8) to read as follows:

§ 25.1305 Powerplant instruments.

* * * * *

(c) For turbine engine powered airplanes.

* * * * *

(5) An indicator to indicate the functioning of the powerplant ice protection system for each engine.

(6) An indicator for the fuel strainer or filter required by § 25.997 to indicate the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 25.997(d).

(7) A warning means for the oil strainer or filter required by § 25.1019, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter screen before it reaches the capacity established in accordance with § 25.1019(a)(2).

(8) An indicator to indicate the proper functioning of any heater used to prevent ice clogging of fuel system components.

* * * * *

PART 27—AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

21. Section 27.951 is amended by adding a new paragraph (c) to read as follows:

§ 27.951 General.

* * * * *

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F. and having 0.75cc of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

22. Section 27.997 is amended to read as follows:

§ 27.997 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself; and

(d) Have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in Part 33 of this Chapter.

23. Section 27.1013 is amended by revoking paragraph (b) and marking it "reserved," and by amending paragraph (c) to read as follows:

§ 27.1013 Oil tanks.

* * * * *

(b) [Reserved]

(c) Where used with a reciprocating engine, it has an expansion space of not less than the greater of 10 percent of the tank capacity or 0.5 gallon, and where used with a turbine engine, it has

an expansion space of not less than 10 percent of the tank capacity.

* * * * *

24. A new § 27.1015 is added to read as follows:

§ 27.1015 Oil tank tests.

Each oil tank must be designed and installed so that it can withstand, without leakage, an internal pressure of 5 p.s.i., except that each pressurized oil tank used with a turbine engine must be designed and installed so that it can withstand, without leakage, an internal pressure of 5 p.s.i., plus the maximum operating pressure of the tank.

25. Section 27.1019 is amended to read as follows:

§ 27.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under Part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination of the screen before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 27.1305(r).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

26. Section 27.1093 is amended by amending paragraph (b) to read as follows:

§ 27.1093 Induction system icing protection.

* * * * *

(b) *Turbine engines.* Each turbine engine must—

(1) Operate throughout its flight power range (including idling) without adverse effect on engine operation or serious loss of power or thrust, under the icing conditions specified in Appendix C of Part 25 of this chapter, and in snow, both falling and blowing, within the limitations established for the rotorcraft; and

(2) Idle for 30 minutes on the ground with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature of 29°F and has a liquid water content of 0.6 grams per cubic meter in the form of drops having a mean effective diameter of 40 microns, followed by a momentary operation at takeoff power or thrust.

27. Section 27.1183 is amended by amending the heading and paragraph (a) to read as follows:

§ 27.1183 Flammable fluid-carrying components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions must be fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 20 quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

* * * * *

28. Section 27.1305 is amended by adding new paragraphs (p), (q), (r), and (s) to read as follows:

§ 27.1305 Powerplant instruments.

* * * * *

(p) For each turbine engine, an indicator to indicate the functioning of the powerplant ice protection system.

(q) For each turbine engine an indicator for the fuel strainer or filter required by § 27.997 to indicate the occurrence of contamination of the strainer of filter before it reaches the capacity established in accordance with § 27.997 (d).

(r) For each turbine engine, a warning means for the oil strainer or filter required by § 27.1019, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 27.1019(a)(2).

(s) An indicator to indicate the proper functioning of any heater used to prevent ice clogging of fuel system components.

PART 29—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

29. Section 29.951 is amended by adding a new paragraph (c) to read as follows:

§ 29.951 General.

* * * * *

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F and having 0.75cc of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

30. Section 29.997 is amended to read as follows:

§ 29.997 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain, except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself; and

(d) Have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in Part 33 of this Chapter.

31. Section 29.1013 is amended by deleting the second sentence in paragraph (a) and by amending paragraph (b)(1) and paragraph (e) to read as follows:

§ 29.1013 Oil tanks.

* * * * *

(b) * * *

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent of the tank capacity or 0.5 gallon, and each oil tank used with a turbine engine has an expansion space of not less than 10 percent of the tank capacity;

* * * * *

(e) *Outlet.* There must be means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. No oil tank outlet may be enclosed by a screen or guard that would reduce the flow of oil below a safe value at any operating temperature. There must be a shutoff valve at the outlet of each oil tank used with a turbine engine unless the external portion of the oil system (including oil tank supports) is fireproof.

* * * * *

32. Section 29.1015 is amended by amending paragraph (b) to read as follows:

§ 29.1015 Oil tank tests.

* * * * *

(b) It meets the requirements of § 29.965, except that instead of the pressure specified in § 29.965(b)—

(1) For pressurized tanks used with a turbine engine, the test pressure may not be less than 5 p.s.i. plus the maximum operating pressure of the tank; and

(2) For all other tanks, the test pressure may not be less than 5 p.s.i.

33. Section 29.1019 is amended to read as follows:

§ 29.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under Part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination of the screen before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 29.1305(a)(18).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

34. Section 29.1093 is amended by amending paragraph (b) to read as follows:

§ 29.1093 Induction system icing protection.

* * * * *

(b) *Turbine engines.* Each turbine engine must—

(1) Operate throughout its flight power range (including idling), without adverse effect on engine operation or serious loss of power or thrust, under the icing conditions specified in Appendix C of Part 25 of this chapter, and in snow, both falling and blowing, within the limitations established for the rotorcraft; and

(2) Idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect in an atmosphere that is at a temperature of 29°F and has a liquid water content of 0.6 grams per cubic meter in the form of drops having a mean effective diameter of 40 microns, followed by a momentary operation at takeoff power or thrust.

35. Section 29.1183 is amended by amending the heading and paragraph (a) to read as follows:

§ 29.1183 Flammable fluid-carrying components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 20 quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

* * * * *

36. Section 29.1305(a) is amended by deleting the word "and" at the end of paragraph (14), by changing the period to a semicolon at the end of paragraph (15), and by adding new paragraphs (16), (17), (18), and (19) to read as follows:

§ 29.1305 Powerplant instruments.

(a) For each rotorcraft—

* * * * *

(16) For each turbine engine, an indicator to indicate the functioning of the powerplant ice protection system;

(17) An indicator for the fuel strainer or filter required by § 29.997 to indicate the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 29.997(d);

(18) For each turbine engine, a warning means for the oil strainer or filter required by § 29.1019, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 29.1019(a)(2); and

(19) An indicator to indicate the proper functioning of any heater used to prevent ice clogging of fuel system components.

PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

37. Section 33.5 is amended to read as follows:

§ 33.5 Instructions.

Each applicant must prepare and make available to the Administrator prior to the issuance of the type certificate and to the owner at the time of delivery of the engine, instructions for installing, operating, servicing, and maintaining the engine. The instructions must include at least the following:

(a) *Installation instructions.* (1) The location of engine mounting attachments, the method of attaching the engine to the aircraft, and the maximum allowable load for the mounting attachments and related structure.

(2) The location and description of engine connections to be attached to accessories, pipes, wires, cables, ducts, and cowling.

(3) An outline drawing of the engine including overall dimensions.

(b) *Operation instructions.* (1) The operating limitations established by the Administrator.

(2) The power or thrust ratings and procedures for correcting for nonstandard atmosphere.

(3) The recommended procedures, under normal and extreme ambient conditions for—

(i) Starting;

(ii) Operating on the ground; and

(iii) Operating during flight.

(c) *Service instructions.* (1) The techniques and methods of service.

(2) The frequency of service.

(3) The fuel, lubricant, and hydraulic fluid that may be used in the engine.

(d) *Maintenance and inspection instructions.* (1) The techniques and methods for performing inspections.

(2) The frequency of checking, cleaning, lubricating, and adjusting.

(e) *Overhaul and replacement instructions.* (1) The frequency of the overhauls.

(2) The life limits of components requiring replacement.

(3) The techniques and methods of replacing components which have life limits.

(4) The techniques and methods of disassembly and reassembly.

(5) The fits and clearances of each component.

(6) The techniques for testing each component after overhaul or replacement of the component.

38. Section 33.7 is amended to read as follows:

§ 33.7 Engine ratings and operating limitations.

(a) Engine ratings and operating limitations are established by the Administrator and included in the engine certificate data sheet specified in § 21.41 of this chapter, including ratings and limitations based on the operating conditions and information specified in this section, as applicable, and any other information found necessary for safe operation of the engine.

(b) For reciprocating engines, ratings and operating limitations are established relating to the following:

(1) Horsepower or torque, r.p.m., manifold pressure, and time at critical pressure altitude and sea level pressure altitude for—

(i) Rated maximum continuous power (relating to unsupercharged operation or to operation in each supercharger mode as applicable); and

(ii) Rated takeoff power (relating to unsupercharged operation or to operation in each supercharger mode as applicable).
(2) Fuel grade or specification.
(3) Oil grade or specification.
(4) Temperature of the—
(i) Cylinder;
(ii) Oil at the oil inlet; and
(iii) Turbosupercharger turbine wheel inlet gas.
(5) Pressure of—
(i) Fuel at the fuel inlet; and
(ii) Oil at the main oil gallery.
(6) Accessory drive torque and overhang moment.
(7) Component life.
(8) Turbosupercharger turbine wheel r.p.m.
(c) For turbine engines, ratings and operating limitations are established relating to the following:
(1) Horsepower, torque, or thrust, r.p.m., gas temperature, and time for—
(i) Rated maximum continuous power or thrust (augmented);
(ii) Rated maximum continuous power or thrust (unaugmented);
(iii) Rated takeoff power or thrust (augmented);
(iv) Rated takeoff power or thrust (unaugmented);
(v) Rated 30 minute power; and
(vi) Rated 2½ minute power.
(2) Fuel designation or specification.
(3) Oil grade or specification.
(4) Hydraulic fluid specification.
(5) Temperature of—
(i) Oil at the oil inlet;
(ii) Induction air at the inlet face of a supersonic engine, including steady state operation and transient over-temperature and time allowed;
(iii) Hydraulic fluid of a supersonic engine;
(iv) Fuel at a location on a supersonic engine that is specified by the applicant; and
(v) External surfaces of the engine, if specified by the applicant.
(6) Pressure of—
(i) Fuel at the fuel inlet;
(ii) Oil at the main oil gallery;
(iii) Induction air at the inlet face of a supersonic engine, including steady state operation and transient overpressure and time allowed; and
(iv) Hydraulic fluid.
(7) Accessory drive torque and overhang moment.
(8) Component life.
(9) Fuel filtration.
(10) Oil filtration.
(11) Bleed air.
(12) The number of start-stop stress cycles approved for each rotor disc and spacer.
(13) Inlet air distortion at the engine inlet.
(14) Transient rotor shaft overspeed r.p.m., and number of overspeed occurrences.
(15) Transient gas overtemperature, and number of overtemperature occurrences.
(16) Engine rotor windmilling rotational r.p.m.
(17) Time for first overhaul.

§ 33.13 [Revoked]

39. Section 33.13 is revoked and marked "reserved."

40. A new § 33.14 is added to read as follows:

§ 33.14 Start-stop cyclic stress (low-cycle fatigue).

An operating limitation must be established that specifies as a service life the number of start-stop stress cycles for each rotor disc and each rotor spacer of the compressor and the turbine. A start-stop stress cycle consists of starting the engine, accelerating it to its maximum rated power or thrust and maintaining the power setting until the disc and spacer temperatures are stabilized, after which the engine is stopped and disc and spacer temperatures are again stabilized or reduced to a value which can be shown to produce the same stress range as stabilization. The number of start-stop stress cycles initially established as an operating limitation for any spacer or disc may not exceed one-third of the number of cycles determined to be the maximum number of cycles that can be sustained without failure for that disc or spacer. The initial limitation may be increased for any disc or spacer by testing at least three samples of that disc or spacer, that have been operated through the limiting number of cycles in actual service, through an additional number of cycles equal to at least twice the number of cycles comprising the increase in the limit.

41. Section 33.17 is amended to read as follows:

§ 33.17 Fire prevention.

(a) The design and construction of the engine and the materials used must minimize the probability of the occurrence and spread of fire.

(b) Except as provided in paragraphs (c), (d), and (e) of this section, each external line, fitting, and other component, which contains or conveys flammable fluid must be fire resistant. Components must be shielded or located to safeguard against the ignition of leaking flammable fluid.

(c) Flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. For a reciprocating engine having an integral oil sump of less than 20-quart capacity, the oil sump need not be fireproof nor be enclosed by fireproof shield.

(d) For turbine engines type certificated for use in supersonic aircraft, each external component which conveys or contains flammable fluid must be fireproof.

(e) Unwanted accumulation of flammable fluid and vapor must be prevented by draining and venting.

42. Section 33.25 is amended to read as follows:

§ 33.25 Accessory attachments.

The engine must operate properly with the accessory drive and mounting attachments loaded. Each accessory drive and mounting attachment used only for an aircraft service must be loaded with the limit load specified by the applicant for the engine drive or attachment point during rated maximum continuous power and higher output. Each engine accessory drive and mounting attachment must be sealed to prevent contamination of or leakage from the engine interior. A drive and mounting attachment requiring lubrication of external drive splines or coupling by engine oil must be sealed to prevent loss of oil and to prevent contamination from sources outside the chamber enclosing the drive connection. The design of the engine must allow for the examination, adjustment, or removal of each accessory required for engine operation.

43. Section 33.27 is amended to read as follows:

§ 33.27 Turbine, compressor, and turbosupercharger rotors.

(a) Turbine, compressor, and turbosupercharger rotors must have sufficient strength to withstand the rotor speed, temperature, and vibration test conditions specified in paragraph (c) of this section.

(b) The design and functioning of engine control devices, systems, and instruments must give reasonable assurance that those engine operating limitations that affect turbine, compressor, and turbosupercharger rotor structural integrity will not be exceeded in service.

(c) The turbine rotor, the compressor rotor, and the turbosupercharger rotor sustaining the highest operating stress at the maximum limiting r.p.m., of all such rotors, respectively, in an engine or turborsupercharger, must each be tested—
(1) At its maximum operating temperature, except as provided in paragraph (c)(3)(v) of this section;
(2) For a period of 5 minutes; and
(3) At a speed of—
(i) 120 percent of its maximum limiting r.p.m. if on a rig and the rotor disc is equipped with either blades or blade weights;
(ii) 115 percent of its maximum limiting r.p.m. if on an engine;
(iii) Maximum limiting r.p.m. if on an engine and the rotor disc section is thinner than specified in the type design so that the operating stress induced at maximum limiting r.p.m. is the same as for a rotor conforming to type design at 115 percent of its maximum limiting r.p.m.;
(iv) 115 percent of its maximum limiting r.p.m. if on a turbosupercharger driven by a hot gas supply from a special burner rig; or
(v) 120 percent of the r.p.m. at which, while cold spinning, the disc is subject to the same operating stresses that are induced at the maximum limiting temperature and r.p.m.: *Provided, That* disc temperature survey data from operating engines and data on hot strength properties

of the disc material establish the effect of temperature on stress.

Following the test, each rotor must be within the dimensional limits allowed by the type design for installation in an engine and may not be cracked.

44. A new § 33.29(a) is added to read as follows:

§ 33.29 Instrument connection.

(a) Unless it is constructed to prevent its connection to an incorrect instrument, each connection provided for powerplant instruments required by aircraft airworthiness regulations or necessary to insure operation of the engine in compliance with any engine limitation must be marked to identify it with its corresponding instrument.

* * * * *

45. A new § 33.42 is added to read as follows:

§ 33.42 General.

Before each endurance test required by this subpart, the adjustment setting and functioning characteristic of each component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must be established and recorded.

46. Section 33.43 is amended to read as follows:

§ 33.43 Vibration test.

(a) Each engine must undergo a vibration survey to establish the torsional and bending vibration characteristics of the crankshaft and the propeller shaft or other output shaft, over the range of crankshaft speed and engine power, under steady state and transient conditions, from idling speed to either 110 percent of the desired maximum continuous speed rating or 103 percent of the maximum desired takeoff speed rating, whichever is higher. The survey must be repeated with that cylinder not firing that has the most adverse vibration effect, except that the speed range need be only from idle to the maximum desired takeoff speed rating. The survey must be conducted using, for airplane engines, the same configuration of the propeller type which is used for the endurance test, and using, for other engines, the same configuration of the loading device type which is used for the endurance test.

(b) The torsional and bending vibration stresses of the crankshaft and the propeller shaft or other output shaft may not exceed the endurance limit stress of the material from which the shaft is made. If the maximum stress in the shaft cannot be shown to be below the endurance limit by measurement, the vibration frequency and amplitude must be measured. The peak amplitude must be shown to produce a stress below the endurance limit; if not, the engine must be run at the condition producing the peak amplitude until, for steel shafts, 10 million stress reversals have been sustained without fatigue failure and, for other shafts, until it is shown that fatigue will not occur within the endurance limit stress of the material.

(c) Each accessory drive and mounting attachment must be loaded, with the loads imposed by each accessory used only for an aircraft service being the limit load specified by the applicant for the drive or attachment point.

47. Section 33.45 is amended by deleting the final period and adding to the last sentence of the present rule the words "with only those accessories installed which are essential for engine functioning."; by designating the present rule as amended as paragraph (a); and by adding a new paragraph (b) to read as follows:

§ 33.45 Calibration tests.

* * * * *

(b) A power check at sea level conditions must be accomplished on the endurance test engine after the endurance test. Any change in power characteristics which occurs during the endurance test must be determined. Measurements taken during the final portion of the endurance test may be used in showing compliance with the requirements of this paragraph.

48. Section 33.49, paragraph (a) and the headings and lead-in sentences of paragraphs (b) and (c) are amended, and a new paragraph (e) is added, to read as follows:

§ 33.49 Endurance test.

(a) *General.* Each engine must be subjected to an endurance test that includes a total of 150 hours of operation (except as provided in paragraph (e)(1)(iii) of this section) and, depending upon the type and contemplated use of the engine, consists of one of the series of runs specified in paragraphs (b) through (e) of this section, as applicable. The runs must be made in the order found appropriate by the Administrator for the particular engine being tested. During the endurance test the engine power and the crankshaft rotational speed must be kept within ±3 percent of the rated values. During the runs at rated takeoff power and for at least 35 hours at rated maximum continuous power, one cylinder must be operated at not less than the limiting temperature, the other cylinders must be operated at a temperature not lower than 50 degrees F below the limiting temperature, and the oil inlet temperature must be maintained within ±10 degrees F of the limiting temperature. An engine that is equipped with a propeller shaft must be fitted for the endurance test with a propeller that thrust-loads the engine to the maximum thrust which the engine is designed to resist at each applicable operating condition specified in this section. Each accessory drive and mounting attachment must be loaded. During operation at rated takeoff power and rated maximum continuous power, the load imposed by each accessory used only for an aircraft service must be the limit load specified by the applicant for the engine drive or attachment point.

(b) *Unsupercharged engines and engines incorporating a gear-driven single-speed supercharger.* For engines not incorporating a supercharger and for engines incorporating a gear-driven single-speed supercharger the applicant must conduct the following runs: * * *

(c) *Engines incorporating a gear-driven two-speed supercharger.* For engines incorporating a gear-driven two-speed supercharger the applicant must conduct the following runs: * * *

* * * * *

(e) *Turbosupercharged engines.* For engines incorporating a turbosupercharger the following apply except that altitude testing may be simulated provided the applicant shows that the engine and supercharger are being subjected to mechanical loads and operating temperatures no less severe than if run at actual altitude conditions:

(1) For engines used in airplanes the applicant must conduct the runs specified in paragraph (b) of this section, except—

(i) The entire run specified in paragraph (b)(1) of this section must be made at sea level altitude pressure;

(ii) The portions of the runs specified in paragraphs (b) (2) through (7) of this section at rated maximum continuous power must be made at critical altitude pressure and the portions of the runs at other power must be made at critical altitude pressure and the portions of the runs at other power must be made at 8,000 feet altitude pressure; and

(iii) The turbosupercharger used during the 150-hour endurance test must be run on the bench for an additional 50 hours at the limiting turbine wheel inlet gas temperature and rotational speed for rated maximum continuous power operation unless the limiting temperature and speed are maintained during 50 hours of the rated maximum continuous power operation.

(2) For engines used in helicopters the applicant must conduct the runs specified in paragraph (d) of this section, except—

(i) The entire run specified in paragraph (d)(1) of this section must be made at critical altitude pressure;

(ii) The portions of the runs specified in paragraphs (d) (2) and (3) of this section at rated maximum continuous power must be made at critical altitude pressure and the portions of the runs at other power must be made at 8,000 feet altitude pressure;

(iii) The entire run specified in paragraph (d)(4) of this section must be made at 8,000 feet altitude pressure;

(iv) The portion of the runs specified in paragraph (d)(5) of this section at 80 percent of rated maximum continuous power must be made at 8,000 feet altitude pressure and the portions of the runs at other power must be made at critical altitude pressure;

(v) The entire run specified in paragraph (d)(6) of this section must be made at critical altitude pressure; and

(vi) The turbosupercharger used during the endurance test must be run on

the bench for 50 hours at the limiting turbine wheel inlet gas temperature and rotational speed for rated maximum continuous power operation unless the limiting temperature and speed are maintained during 50 hours of the rated maximum continuous power operation.

49. Section 33.55 is amended to read as follows:

§ 33.55 Teardown inspection.

After completing the endurance test—

(a) Each engine must be completely disassembled;

(b) Each component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must retain each setting and functioning characteristic within the limits that were established and recorded at the beginning of the test; and

(c) Each engine component must conform to the type design and be eligible for incorporation into an engine for continued operation, in accordance with information submitted in compliance with § 33.5(e).

50. Section 33.57 is amended by amending paragraph (b) to read as follows:

§ 33.57 General conduct of block tests.

* * * * *

(b) The applicant may service and make minor repairs to the engine during the block tests in accordance with the service and maintenance instructions submitted in compliance with § 33.5. If the frequency of the service is excessive, or the number of stops due to engine malfunction is excessive, or a major repair, or replacement of a part is found necessary during the block tests or as the result of findings from the teardown inspection, the engine or its parts may be subjected to any additional test the Administrator finds necessary.

51. A new § 33.62 is added to read as follows:

§ 33.62 Stress analysis.

A stress analysis must be performed on each turbine engine showing the design safety margin of each turbine engine rotor, spacer, and rotor shaft.

52. Section 33.65 is amended to read as follows:

§ 33.65 Surge and stall characteristics.

When the engine is operated in accordance with operating instructions required by § 33.5(b), starting, a change of power or thrust, power or thrust augmentation, limiting inlet air distortion, or inlet air temperature may not cause surge or stall to the extent that flameout, structural failure, overtemperature, or failure of the engine to recover power or thrust will occur at any point in the operating envelope.

53. A new § 33.66 is added to read as follows:

§ 33.66 Bleed air system.

The engine must supply bleed air without adverse effect on the engine, excluding reduced output, at the discharge flow condition established as a limitation. If bleed air used for engine anti-icing can be controlled, provision must be made for connecting the bleed air system to a means to indicate the functioning of the aircraft powerplant ice protection system.

54. Section 33.67 is amended to read as follows:

§ 33.67 Fuel system.

(a) With fuel supplied to the engine at the flow and pressure specified by the applicant, the engine must function properly under each operating condition required by this Part. Each fuel control adjusting means that may not be manipulated while the fuel control device is mounted on the engine must be secured by a locking device and sealed, or otherwise be inaccessible. All other fuel control adjusting means must be accessible and marked to indicate the function of the adjustment unless the function is obvious. Each fuel system must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80 degrees F and having 0.75cc. of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

(b) There must be a fuel strainer or filter between the engine fuel inlet opening and the inlet of either the fuel metering device or the engine-driven positive displacement pump whichever is nearer the engine fuel inlet. In addition, the following provisions apply to each strainer or filter required by this paragraph (b):

(1) It must be accessible for draining and cleaning and must incorporate a screen or element that is easily removable.

(2) It must have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes.

(3) It must be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter.

(4) It must have the type and degree of fuel filtering specified as necessary for protection of the engine fuel system against foreign particles in the fuel. The applicant must demonstrate that foreign particles passing through the specified filtering means do not impair engine fuel system functioning.

(5) It must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine fuel system functioning is not impaired with fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in paragraph (b)(4) of this section.

(6) Any strainer or filter bypass must be designed and constructed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(7) The fuel system must incorporate means to indicate the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with paragraph (b)(5) of this section.

55. A new § 33.68 is added to read as follows:

§ 33.68 Induction system icing.

Each engine, with all icing protection systems operating, must—

(a) Operate throughout its flight power range (including idling) without the accumulation of ice on the engine components that adversely affects engine operation or that causes a serious loss of power or thrust in continuous maximum and intermittent maximum icing conditions as defined in Appendix C of Part 25 of this chapter; and

(b) Idle for 30 minutes on the ground, with the available air bleed for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature of 29 degrees F and has a liquid water content of 0.6 grams per cubic meter in the form of drops having a mean effective diameter of 40 microns, followed by a momentary operation at takeoff power or thrust.

57. Section 33.69 is amended to read as follows:

§ 33.69 Ignitions system.

Each engine must be equipped with an ignition system for starting the engine on the ground and in flight. An electric ignition system must have at least two igniters and two separate secondary electric circuits, except that only one igniter is required for fuel burning augmentation systems.

57. Section 33.71 is amended to read as follows:

§ 33.71 Lubrication system.

(a) *General.* Each lubrication system must function properly in the flight attitudes and atmospheric conditions in which an aircraft is expected to operate.

(b) *Oil strainer or filter.* There must be an oil strainer or filter through which all of the engine oil flows and there must be a separate strainer or filter ahead of each scavenge pump. In addition:

(1) Each strainer or filter required by this paragraph that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

(2) The type and degree of filtering necessary for protection of the engine oil system against foreign particles in the oil must be specified. The applicant must demonstrate that foreign particles passing through the specified filtering means do not impair engine oil system functioning.

(3) Each strainer or filter required by this paragraph must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine oil system functioning is not impaired with the oil contaminated to a degree (with respect to

particle size and density) that is greater than that established for the engine in paragraph (b)(2) of this section.

(4) The oil system must incorporate means, for each strainer or filter required by this paragraph except the strainer or filter at an oil tank outlet or for a scavenge pump, to indicate contamination of the screen before it reaches the capacity established in accordance with paragraph (b)(3) of this section.

(5) Any filter bypass must be designed and constructed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that the collected contaminants are not in the bypass flow path.

(6) Each strainer or filter required by this paragraph that has no bypass, except the strainer or filter at an oil tank outlet or for a scavenge pump, must have provisions for connection with a warning means to warn the pilot of the occurrence of contamination of the screen before it reaches the capacity established in accordance with paragraph (b)(3) of this section.

(7) Each strainer or filter required by this paragraph must be accessible for draining and cleaning.

(c) *Oil tanks.* (1) Each oil tank must have an expansion space of not less than 10 percent of the tank capacity.

(2) It must be impossible to inadvertently fill the oil tank expansion space.

(3) Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have provision for fitting a drain.

(4) Each oil tank cap must provide an oil-tight seal.

(5) Each oil tank filler must be marked with the word "oil" and the tank capacity.

(6) Each oil tank must be vented from the top part of the expansion space, with the vent so arranged that condensed water vapor that might freeze and obstruct the line cannot accumulate at any point.

(7) There must be means to prevent entrance into the oil tank or into any oil tank outlet, of any object that might obstruct the flow of oil through the system.

(8) There must be a shutoff valve at the outlet of each oil tank, unless the external portion of the oil system (including oil tank supports) is fireproof.

(9) Each unpressurized oil tank may not leak when subjected to maximum operating temperature and an internal pressure of 5 p.s.i., and each pressurized oil tank may not leak when subjected to maximum operating temperature and an internal pressure that is not less than 5 p.s.i. plus the maximum operating pressure of the tank.

(10) Leaked or spilled oil may not accumulate between the tank and the remainder of the engine.

(11) Each oil tank must have an oil quantity indicator.

(d) *Oil drains.* There must be an accessible oil drain that will drain the entire oil system. The drain must have a manual or automatic means for positive locking in the closed position.

(e) *Oil radiators.* Each oil radiator must withstand, without failure, any vibration, inertia, and oil pressure load to which it is subjected during the block tests.

58. A new § 33.72 is added to read as follows:

§ 33.72 Hydraulic actuating systems.

Each hydraulic actuating system must function properly under all conditions in which the engine is expected to operate. Each filter or screen must be accessible for servicing and each tank must meet the design criteria of § 33.71.

59. A new § 33.75 is added to read as follows:

§ 33.75 Safety analysis.

It must be shown by analysis that any probable malfunction or any probable single or multiple failure, or any probable improper operation of the engine will not cause the engine to—

(a) Catch fire;

(b) Burst (penetrate its case);

(c) Generate loads greater than those specified in § 33.23; or

(d) Lose the capability of being shut down.

60. A new § 33.77 is added to read as follows:

§ 33.77 Foreign object ingestion.

(a) Ingestion of a 4-pound bird, a piece of tire tread, or a broken rotor blade, under the conditions set forth in paragraph (f) of this section, may not cause the engine to—

(1) Catch fire;

(2) Burst (penetrate its case);

(3) Generate loads greater than those specified in § 33.23; or

(4) Lose the capability of being shut down.

(b) Ingestion of 3-ounce birds, 1½-pound birds, or mixed gravel and sand, under the conditions set forth in paragraph (f) of this section, may not cause more than a sustained 25 percent power or thrust loss or require the engine to be shut down.

(c) Ingestion of water, ice, or hail, under the conditions set forth in paragraph (f) of this section may not cause a sustained power or thrust loss or require the engine to be shut down.

(d) For an engine that incorporates a protective device, compliance with this section need not be demonstrated with respect to foreign objects sought to be ingested under the conditions set forth in paragraph (f) of this section, if it is shown that—

(1) Such foreign objects are of a size that will not pass through the protective device;

(2) The protective device will withstand the impact of the foreign objects; and

(3) The foreign object or objects stopped by the protective device will not obstruct the flow of induction air into the engine.

(e) In showing compliance with paragraphs (a) and (b) of this section, the engine need be tested by ingesting only that foreign object specified in paragraph (a) of this section which the applicant shows has the most severe effect on the engine and by ingesting the mixed gravel and sand specified in paragraph (b) of this section and either the 3-ounce birds or the 1½-pound birds, as specified in paragraph (f) of this section.

(f) The prescribed foreign object ingestion conditions are as follows:

Foreign object	Test quantity	Speed of foreign object	Engine operation	Ingestion
Birds:				
3-oz size	One for each 50 in² of inlet area or fraction thereof up to a maximum of 16 birds. 3-oz bird ingestion not required if a 1½-lb bird will pass the inlet guide vanes into the rotor blades.	Liftoff speed of typical aircraft.	Takeoff	In rapid sequence to simulate a flock encounter.
1½-lb size	One for the first 300 in² of inlet area, if it can enter the inlet, plus one for each additional 600 in² of inlet area or fraction thereof up to maximum of 8 birds.	Initial climb speed of typical aircraft.	do	Do.
4-lb size	One if it can enter the inlet.	Maximum climb speed.	Maximum cruise	Aimed at critical area.
Ice	Maximum accumulation on inlet cowl and engine face resulting from a 30-second delay in actuating anti-icing system.	Sucked in	do	To simulate an intermittent maximum icing encounter at 25° F.

Foreign object	Test quantity	Speed of foreign object	Engine operation	Ingestion
Hail (0.8 to 0.9 specific gravity).	For subsonic and supersonic engines: With inlet areas of not more than 100 in²: one 1-in hailstone. With inlet area of more than 100 in²: one 1-in and one 2-in. hailstones for each 150 in² of inlet area of fraction thereof.	Rough air flight speed of typical aircraft.	Maximum cruise at 15,000 ft altitude.	In a volley to simulate a hailstone encounter. One half the number of hailstones aimed at random areas over the face of the inlet area and the other half aimed at the critical face area.
	For supersonic engines (in addition): 3 hailstones each having a diameter equal to that in a straight line variation from 1 in at 35,000 ft to ¼ in at 60,000 ft using diameter corresponding to the lowest supersonic cruise altitude expected.	Supersonic cruise velocity. Alternatively use subsonic velocities with larger hailstones to give equivalent kinetic energy.	Maximum cruise	Aimed for critical engine face area.
Water	4 percent of engine airflow by weight.	Sucked in	Takeoff and flight idle.	For 3 minutes at each engine operation condition as spray to simulate rain.
Mixed gravel and sand (one part stones with diameter not less than 3/16—nor more than ¼ in and 7 parts sand.)	1 oz for each 100 in² of inlet area or fraction thereof.	do	Takeoff	Over a 15-minute period.
Broken rotor blade: (The heaviest compressor or turbine blade, broken at the outermost retention groove or member or at least 80 percent of an integral blade.)	1		do	Release from rotor followed by 15-second delay prior to initiating shutdown.[1]
Tire tread (having width and length equal to full width of tread).	do	do	do	

[1] Blade containment must be demonstrated with a complete engine to evaluate secondary effects of blade loss and to determine blade fragment trajectories, except that in fan engines, the fan assembly may be tested separately for blade containment if it is demonstrated that fan blade or vane debris would not enter the compressor after a fan blade failure.

61. A new § 33.79 is added to read as follows:

§ 33.79 Fuel burning thrust augmentor.

Each fuel burning thrust augmentor, including the nozzle, must—

(a) Provide cutoff of the fuel burning thrust augmentor;

(b) Permit on-off cycling;

(c) Be controllable within the intended range of operation;

(d) Upon a failure or malfunction of augmentor combustion, not cause the engine to lose thrust other than that provided by the augmentor; and

(e) Have controls that function compatibly with the other engine controls and automatically shut off augmentor fuel flow if the engine rotor speed drops below the minimum rotational speed at which the augmentor is intended to function.

§ 33.81 [Amended]

62. Section 33.81 is amended by deleting the second sentence of the text.

63. A new § 33.82 is added to read as follows:

§ 33.82 General.

Before each endurance test required by this subpart, the adjustment setting and functioning characteristic of each component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must be established and recorded.

64. Section 33.83 is amended to read as follows:

§ 33.83 Vibration test.

(a) Each engine must undergo a vibration survey to establish the vibration characteristics of the rotors, rotor shafts, and rotor and stator blades at the maximum inlet air distortion limit, over the range of rotor shaft speeds and engine power or thrust, under steady state and transient conditions, from idling speed to 103 percent of the maximum desired takeoff speed rating. The survey must be conducted using, for turbopropeller engines, the same configuration of the propeller type which is used for the endurance test, and using, for other engines, the same configuration of the loading device type which is used for the endurance test.

(b) The vibration stresses of the rotors, rotor shafts, and rotor and stator blades may not exceed the endurance limit stress of the material from which these parts are made. If the maximum stress in the shaft cannot be shown to be below the endurance limit by measurement, the vibration frequency and amplitude must be measured. The peak amplitude must be shown to produce a stress below the endurance limit; if not, the engine must be run at the condition producing the peak amplitude until, for steel parts, 10 million stress reversals have been sustained without fatigue failure and, for other parts, until it is shown that fatigue failure will not occur within the endurance limit stress of the material.

(c) Each accessory drive and mounting attachment must be loaded, with the load imposed by each accessory used only for an aircraft service being the limit load specified by the applicant for the engine drive or attachment point.

65. Section 33.85 is amended by deleting the period and adding to the last sentence of paragraph (a) the words "with no airbleed for aircraft services and with only those accessories installed which are essential for engine functioning.", and by amending paragraph (b) to read as follows:

§ 33.85 Calibration tests.

* * * * *

(b) A power check at sea level conditions must be accomplished on the endurance test engine after the endurance test and any change in power characteristics which occurs during the endurance test must be determined. Measurements taken during the final portion of the endurance test may be used in showing compliance with the requirements of this paragraph.

66. Section 33.87 is amended by deleting paragraphs (b)(7), (c)(7), and (d)(3), and by amending paragraph (a) and adding a new paragraph (e) to read as follows:

§ 33.87 Endurance test.

(a) *General.* Each engine must be subjected to an endurance test that includes a total of 150 hours of operation and, depending upon the type and contemplated use of the engine, consists of one of the series of runs specified in paragraphs (b) through (e) of this section, as applicable. The following test requirements apply:

(1) The runs must be made in the order found appropriate by the Administrator for the particular engine being tested.

(2) Any automatic engine control that is part of the engine must control the engine during the endurance test except for operations where automatic control is normally overridden by manual control or where manual control is otherwise specified for a particular test run.

(3) Power or thrust, gas temperature, rotor shaft rotational speed, and, if limited, temperature of external surfaces of the engine must be at least 100 percent of the value associated with the particular engine operation being tested. More than one test may be run if all parameters cannot be held at the 100 percent level simultaneously.

(4) The runs must be made using fuel, lubricants and hydraulic fluid which conform to the specifications specified in complying with § 33.7(c).

(5) Maximum air bleed for engine and aircraft services must be used during at least one-fifth of the runs.

(6) Each accessory drive and mounting attachment must be loaded. The load imposed by each accessory used only for an aircraft service must be the limit load specified by the applicant for the engine drive or attachment point during rated maximum continuous power or thrust and higher output.

(7) During the runs at any rated power or thrust the gas temperature and the oil inlet temperature must be maintained at the limiting temperature except where the test periods are not longer than 5 minutes and do not allow stabilization. At least one run must be made with fuel, oil, and hydraulic fluid at the minimum pressure limit and at least one run must be made with fuel, oil, and hydraulic fluid at the maximum pressure limit with fluid temperature reduced as necessary to allow maximum pressure to be attained.

(8) If the number of occurrences of either transient rotor shaft overspeed or transient gas overtemperature is limited, that number of the accelerations required by paragraphs (b), (c), (d), and (e) of this section must be made at the limiting overspeed or overtemperature. If the number of occurrences is not limited, half the required accelerations must be made at the limiting overspeed or overtemperature.

(9) For each engine type certificated for use on supersonic aircraft the following additional test requirements apply:

(i) To change the thrust setting, the power control lever must be moved from the initial position to the final position in not more than one second except for movements into the fuel burning thrust augmentor augmentation position if additional time to confirm ignition is necessary.

(ii) During the runs at any rated augmented thrust the hydraulic fluid temperature must be maintained at the limiting temperature except where the test periods are not long enough to allow stabilization.

(iii) During the simulated supersonic runs the fuel temperature and induction air temperature may not be less than the limiting temperature.

(iv) The endurance test must be conducted with the fuel burning thrust augmentor installed, with the primary and secondary exhaust nozzles installed, and with the variable area exhaust nozzles operated during each run according to the methods specified in complying with § 33.5(b).

(v) During the runs at thrust settings for maximum continuous thrust and percentages thereof, the engine must be operated with the inlet air distortion at the limit for those thrust settings.

* * * * *

(e) *Supersonic aircraft engines.* For each engine type certificated for use on supersonic aircraft the applicant must conduct the following:

(1) *Subsonic test under sea level ambient atmospheric conditions.* Thirty runs of one hour each must be made, consisting of—

(i) Two periods of 5 minutes at rated takeoff augmented thrust each followed by 5 minutes at idle thrust;

(ii) One period of 5 minutes at rated takeoff thrust followed by 5 minutes at not more than 15 percent of rated takeoff thrust;

(iii) One period of 10 minutes at rated takeoff augmented thrust followed by 2 minutes at idle thrust, except that if rated maximum continuous augmented thrust is lower than rated takeoff augmented thrust, 5 of the 10-minute periods must be at rated maximum continuous augmented thrust; and

(iv) Six periods of 1 minute at rated takeoff augmented thrust each followed by 2 minutes, including acceleration and deceleration time, at idle thrust.

(2) *Simulated supersonic test.* Each run of the simulated supersonic test must be preceded by changing the inlet air temperature and pressure from that attained at subsonic conditions to the temperature and pressure attained at supersonic velocity, and must be followed by a return to the temperature attained at subsonic condition. Thirty runs of 4 hours each must be made, consisting of—

(i) One period of 30 minutes at the thrust obtained with the power control lever set at the position for rated maximum continuous augmented thrust followed by 10 minutes at the thrust obtained with the power control lever set at the position for 90 percent of rated maximum continuous augmented thrust. The end of this period in the first five runs must be made with the induction air temperature at the limiting condition of transient overtemperature, but need not be repeated during the periods specified in paragraphs (e)(2) (ii) through (iv) of this section;

(ii) One period repeating the run specified in subdivision (i) of this subparagraph, except that it must be followed by 10 minutes at the thrust obtained with the power control lever set at the position for 80 percent of rated maximum continuous augmented thrust;

(iii) One period repeating the run specified in subdivision (i) of this subparagraph, except that it must be followed by 10 minutes at the thrust obtained with the power control lever set at the position for 60 percent of rated maximum continuous augmented thrust and then 10 minutes at not more than 15 percent of rated takeoff thrust;

(iv) One period repeating the runs specified in paragraphs (e)(2) (i) and (ii) of this section; and

(v) One period of 30 minutes with 25 of the runs made at the thrust obtained with the power control lever set at the position for rated maximum continuous augmented thrust, each followed by idle thrust and with the remaining 5 runs at the thrust obtained with the power control lever set at the position for rated maximum continuous augmented thrust for 25 minutes each, followed by subsonic operation at not more than 15 percent or rated takeoff thrust and accelerated to rated takeoff thrust for 5 minutes using hot fuel.

(3) *Starts.* One hundred starts must be made, of which 25 starts must be preceded by an engine shutdown of at least 2 hours. There must be at least 10 false engine starts, pausing for the applicant's specified minimum fuel drainage time before attempting a normal start. At least 10 starts must be normal restarts, each made no later than 15 minutes after engine shutdown. The starts may be made at any time, including the period of endurance testing.

67. A new § 33.88 is added to read as follows:

§ 33.88 Rotor tests.

Each engine must be run for 30 minutes at maximum rated r.p.m. and with the gas temperature 75 degrees F. higher than the maximum operating limit. Following the run each rotor must remain within the dimensional limits allowed by the type design and may not be cracked.

68. The present text of § 33.89 is designated as paragraph (a), present paragraphs (a), (b), (c)(1), (c)(2), (c)(3), and (d) are redesignated (1), (2), (3)(i), (3)(ii), (3)(iii) and (4) of paragraph (a) respectively, the references in redesignated paragraph (a)(4) are amended to read "paragraphs (a)(3) (ii) and (iii) of this section," and a new paragraph (b) is added to read as follows:

§ 33.89 Operation test.

* * * * *

(b) The operation test must include all testing found necessary by the Administrator to demonstrate the effect of maximum and minimum operating ambient temperature and maximum operating altitude on the engine. The operation test must include several power changes and the operation of the fuel burning thrust augmentor through several complete cycles from ignition to shutoff.

69. A new § 33.90 is added to read as follows:

§ 33.90 Overhaul test.

Each engine, except engines being type certificated through amendment of an existing type certificate or through supplemental type certification procedures, must undergo a test run simulating the conditions in which the engine is expected to operate in service, including start-stop cycles typical of expected service for the period of time established as the limitation on operation prior to the first overhaul under § 33.7. The test run must be accomplished on an engine which substantially conforms to the final type design.

70. New paragraphs (c) and (d) are added to § 33.91 to read as follows:

§ 33.91 Engine component tests.

* * * * *

(c) Each unpressurized hydraulic fluid tank may not fail or leak when subjected to maximum operating temperature and an internal pressure of 5 p.s.i., and each pressurized hydraulic fluid tank may not fail or leak when subjected to maximum operating temperature and an internal

pressure not less than 5 p.s.i. plus the maximum operating pressure of the tank.

(d) For an engine type certificated for use in supersonic aircraft, the systems, safety devices, and external components that may fail because of operation at maximum and minimum operating temperatures must be identified and tested at maximum and minimum operating temperatures and while temperature and other operating conditions are cycled between maximum and minimum operating values.

71. A new § 33.92 is added to read as follows:

§ 33.92 Windmilling tests.

(a) Unless means are incorporated in the engine to stop rotation of the engine rotors when the engine is shut down in flight, each engine rotor must either seize or be capable of rotation for 3 hours at the limiting windmilling rotational r.p.m. with no oil in the engine system, without the engine—

(1) Catching fire;

(2) Bursting (penetrating the case); or

(3) Generating loads greater than those specified in § 33.23.

(b) A turbojet or turbofan engine incorporating means to stop rotation of the engine rotors when the engine is shut down in flight must be subjected to 25 operations under the following conditions:

(1) Each engine must be shut down while operating at rated maximum continuous thrust.

(2) For engines certificated for use on supersonic aircraft, the temperature of the induction air and the external surfaces of the engine must be held at the maximum limit during the tests required by this paragraph.

72. Section 33.93 is amended to read as follows:

§ 33.93 Teardown inspection.

After completing the endurance test each engine must be completely disassembled, and—

(a) Each component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must retain each setting and functioning characteristic within the limits that were established and recorded at the beginning of the test; and

(b) Each engine component must conform to the type design and be eligible for incorporation into an engine for continued operation, in accordance with information submitted in compliance with § 33.5.

73. Section 33.99 is amended by amending paragraph (b) to read as follows:

§ 33.99 General conduct of block tests.

* * * * *

(b) Each applicant may service and make minor repairs to the engine during the block tests in accordance with the service and maintenance instructions submitted in compliance with § 33.5. If the frequency of the service is excessive, or the number of stops due to engine malfunction is excessive, or a major repair, or replacement of a part is found necessary during the block tests or as the result of findings from the teardown inspection, the engine or its parts must be subjected to any additional tests the Administrator finds necessary.

Issued in Washington, D.C., on September 20, 1974.

JAMES E. DOW,
Acting Administrator.

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