

Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Engine Harmonization Working Group

Task 16 – Electrical and Electronic Engine Control

Task Assignment

[Federal Register: October 20, 1998 (Volume 63, Number 202)]
[Notices]
[Page 56059-56060]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and
Engine Issues--New Tasks

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignments for the Aviation Rulemaking
Advisory Committee (ARAC).

SUMMARY: Notice is given of new tasks assigned to and accepted by the
Aviation Rulemaking Advisory Committee (ARAC). This notice informs the
public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT:

Stewart R. Miller, Transport Standards Staff (ANM-110), Federal
Aviation Administration, 1601 Lind Avenue, SW., Renton, WA 98055-4056;
phone (425) 227-1255; fax (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** has established an Aviation Rulemaking Advisory Committee
to provide advice and recommendations to the **FAA** Administrator, through
the Associate Administrator for Regulation and Certification, on the
full range of the **FAA**'s rulemaking activities with respect to aviation-
related issues. This includes obtaining advice and recommendations on
the **FAA**'s commitment to harmonize its Federal Aviation Regulations
(FAR) and practices with its trading partners in Europe and Canada.

One area ARAC deals with is Transport Airplane and Engine Issues.
These issues involve the airworthiness standards for transport category
airplanes and engines in 14 CFR parts 25, 33, and 35 and parallel
provisions in 14 CFR parts 121 and 135.

The Tasks

This notice is to inform the public that the **FAA** has asked ARAC to
provide advice and recommendation on the following harmonization tasks:

Task 11: Safety and Failure Analysis

1. JAR-E requires a summary listing of all failures which result in
major or hazardous effects and an estimate of the probability of

occurrence of these major and hazardous effects. Part 33 requires an assessment of failures which lead to four specified hazards.

2. JAR requires a list of assumptions and the substantiation of those assumptions. Most of the JAR-E assumptions are covered by other Part 33 paragraphs.

3. JAR-E includes a unique hazard, ``toxic bleed air''.

4. While both regulations require analysis to examine malfunctions and single and multiple failures. Part 33 also requires an examination of improper operation.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by January 31, 2000.

[[Page 56060]]

Task 12: Endurance Test Requirements Study

Review and evaluate the feasibility and adequacy of harmonizing: (1) FAR 33.87 and JAR-E 740 endurance test requirements, including thrust reverser operation during endurance testing, in consideration of changes in engine technology; and (2) FAR 33.88 and JAR-E 700 overtemperature/excess operating conditions. The Aviation Rulemaking Advisory Committee (ARAC) is specifically tasked to study these issues and document findings in the form of a report.

The **FAA** expects ARAC to submit the report by December 31, 1999.

The report must include industry-provided data for an **FAA** economic analysis. This data should include the effects on small operators and small businesses. The report also should include industry-provided data regarding the record-keeping burden on the public.

Task 13: Fatigue Pressure Test/Analysis

JAR-E 640(b)(2) requires fatigue pressure testing of major engine casings. The FAR's do not have a specific requirement for fatigue pressure tests of major engine casings.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by January 31, 1999.

Task 14: Overtorque

JAR-E 820 requires testing at maximum over-torque in combination with maximum turbine-entry and the most critical oil-inlet temperatures for the power turbine to validate transient overtorque values. The **FAA** does not have a specific requirement. Note: The 33.87 endurance test includes requirements that can be used to satisfy JAR-E requirements.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by January 31, 1999.

Task 15: Compressor/Fan and Turbine Shafts

1. JAR-E 850 establishes probability limits for shaft failures based on the consequences of the failure. If the consequences of a shaft failure are not readily predictable, a test is required to determine the consequences. FAR 33.27(c)(2)(vi) requires all shaft failures, regardless of failure probability, to be considered when determining rotor integrity requirements.

2. ACJ E 850 provides guidance to determine the likelihood of a failure at a given location on a shaft and also provides guidance for

conducting tests to determine the dynamic characteristics and fatigue capability of the shaft. The FAR's do not provide any guidance material.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by January 31, 2000.

Task 16: Electrical and Electronic Engine Control Systems

1. Advisory material exists for JAR-E (AMJ 20X-1). Advisory material does not exist for Part 33, which has caused difficulty during certification programs.

2. AMJ 20X-1 clearly defines the engine/airframe substantiation responsibilities, while FAR material does not define these requirements.

3. JAR-E states that an electronic control system ``should provide for the aircraft at least the equivalent safety, and the related reliability level, as achieved by Engines/Propellers equipped with hydromechanical control and protection systems.'' Part 33 does not state a desired reliability level. Part 33 states that failures must not result in unsafe conditions.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by January 31, 2000.

For the above tasks the working group is to review airworthiness, safety, cost, and other relevant factors related to the specified difference, and reach consensus on harmonization of current Part 33/ JAR-E regulations and guidance material.

The **FAA** requests that ARAC draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations. If the resulting recommendation(s) are one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.

Working Group Activity

The Engine Harmonization Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the tasks, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider transport airplane and engine issues held following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with the work stated in item 3 below.

3. Draft appropriate regulatory documents with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such recommendations. If the resulting recommendation is one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.

4. Provide a status report at each meeting of ARAC held to consider transport airplane and engine issues.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of ARAC will be open to the public. Meetings of the Engine Harmonization Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on October 13, 1998.

Joseph A. Hawkins,
Executive Director, Aviation Rulemaking Advisory Committee.
[FR Doc. 98-28038 Filed 10-19-98; 8:45 am]
BILLING CODE 4910-13-M

Recommendation Letter

Pratt & Whitney
400 Main Street
East Hartford, CT 06108



Pratt & Whitney
A United Technologies Company

1/12/01

January 2, 2001

Federal Aviation Administration
800 Independence Avenue SW
Washington, DC 20595

Attention: Mr. Anthony Fazio, Office of Rulemaking, ARM-1

Reference: Tasking to ARAC, 59 FR 42323, August 1994

Dear Tony,

In accordance with the reference tasking, the Transport Airplane and Engine Issues Group is pleased to submit the attached NPRM and AC (FAR 33.28 Electronic Engine Control Systems) to the FAA for formal economic and legal review. These documents have been prepared by the Engine Harmonization Working Group.

Sincerely yours,

C. R. Bolt

C. R. Bolt
Assistant Chair TAEIG

Copy: Effie Upshaw – FAA-Washington, DC
Jerry McRoberts – RR
Marc Bouthillier – FAA-NER
Judith Watson – FAA-NER
Kris Carpenter – NAA-NWR

Acknowledgement Letter



U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

MAR 16 2001

Mr. Craig Bolt
Assistant Chair, Transport Airplanes
and Engines Issues Group
400 Main Street
East Hartford, CT 06108

Dear Mr. Bolt:

We have received your January 2 request for formal legal review of the draft advisory circulars (AC) and formal legal and economic reviews of the draft rulemaking addressing electronic engine control systems.

Operating procedures for the Aviation Rulemaking Advisory Committee (ARAC) specify that the FAA will conduct its review of ARAC tasks within 120 days of receipt of the request. Our rulemaking resources, however, are limited, and we are finding it more difficult to meet these commitments. We are looking at available options, including revising the operating procedures, to assure effective, efficient use of information received from industry through the ARAC process.

Your request has been forwarded to the agency's Rulemaking Management Council for review. The Council should render a decision within the next few months.

As always, we appreciate the support you continue to provide to our aviation rulemaking program.

Sincerely,

Anthony F. Fazio
Executive Director, Aviation Rulemaking
Advisory Committee

engine issue

Recommendation

Draft

NPRM VERSION 17---September 26, 2000

Note: *Bundle II (ANE-99-016-A): Includes compressors Fan & Turbine Shafts (33.27) & Safety & Failure Analysis (33.75). This will not be published until all these associated sections are also ready to be published.*

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts xx,xx,xx

[Docket No. XXXXX; Notice No. XXXXXX]

RIN 2120-XXXX

Airworthiness Standards; Electronic Engine Control System Requirements.....

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This notice proposes to amend Title 14 of the Code of Federal Regulations (CFR) part 33 (14 CFR 33), Aircraft Engines, § 33.28 Electrical and electronic engine control systems and associated sections §33.5, §33.7, §33.27, §33.29, §33.53, §33.67 and §33.91. This proposal harmonizes the requirements being drafted in conjunction with the Joint Aviation Authorities (JAA) of Europe as part of the Aviation Rulemaking Advisory Committee (ARAC) harmonization activities. The proposed changes if adopted would establish uniform standards for all engine control systems, including electrical and electronic engine control system standards for aircraft engines certified in the United States under 14 CFR part 33 and in the JAA countries under Joint Aviation Requirements-Engines (JAR-E), simplifying airworthiness approvals for import and export.

DATES: Comments to be submitted on or before [TBD date 90 days after the date of publication in the Federal Register].

ADDRESSES: Comments on this notice should be mailed, in duplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC-10), Docket No. , 800 Independence Avenue, SW., Washington, DC 20591. Comments submitted must be marked: "Docket No. ." Comments may be inspected in Room 915G weekdays between 9:00 a.m. and 5:00 p.m. Comments may also be sent electronically to the following internet address: nprmcmts@mail.hq.faa.gov.

FOR FURTHER INFORMATION CONTACT: Cosimo Bosco, Engine and Propeller Standards Staff, ANE-110, Engine and Propeller Directorate, Aircraft Certification Service, FAA, New England Region, 12 New England Executive Park, Burlington, Massachusetts 01803-5299; telephone (781) 238-7118, fax (781) 238-7199.

SUPPLEMENTARY INFORMATION:

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File :\\ehwg\\finaldoc\\toTAEIG\\nprm_17.doc dated September 26, _2000.

Draft NPRM VERSION 17---September 26, 2000

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Comments Invited

Interested persons are invited to submit written data, views, or arguments on this proposed rule. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this notice are also invited. Substantive comments should be accompanied by cost estimates. Comments should identify the regulatory docket number and should be submitted in duplicate to the Rules Docket address specified above.

All comments received on or before the closing date for comments specified will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received.

All comments received will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons. A report summarizing each substantive public contact with Federal Aviation Administration (FAA) personnel concerned with this rulemaking will be filed in the docket.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this notice must include a preaddressed, stamped postcard on which the following statement is made: "Comments to Docket No. ." The postcard will be date stamped and mailed to the commenter.

Availability of NPRMs

Any person may obtain a copy of this NPRM by submitting a request to the Federal Aviation Administration, Office of Public Affairs, Attention: Public Inquiry Center, APA-200, 800 Independence Avenue, SW., Washington, DC 20591, or by calling (202) 267-3484. Communications must identify the Notice Number of this NPRM.

Persons interested in being placed on the mailing list for future NPRMs should request from the above office, a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Background

The FAA was committed to undertake and support harmonization of the Code of Federal Regulations (CFR) part 33 (14 CFR part 33) with the Joint Aviation Requirements-Engines (JAR-E). As a result of that commitment, the FAA, in cooperation with the JAA, established an engine certification study group to compare part 33 with JAR-E. The original part 33/JAR-E Authorities Engine

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Group was composed of five members, representing airworthiness authorities of the following countries: France, Canada, Germany, the United Kingdom, and the United States.

The initial task of the group was to compare JAR-E with part 33, using part 33, Amendment 11, and JAR-E, Change 7, as the basis for the comparison. The group focused only on gas turbine engines for the initial effort and produced a comparison that noted those JAR-E requirements that appeared to be more restrictive than part 33. The identified differences were grouped into two categories, referred to as List 1 and List 2. List 1 comparison contained those requirements where the differences appeared to be significant, to which the JAA applies additional requirements to the United States manufacturers seeking JAA certification. List 2 comparison contained those requirements that may be considered equivalent based on current FAA practice and interpretations of part 33. Twenty items were classified as List 1, and twenty-four items were classified as List 2.

In August 1989, the FAA and JAA participated in a joint meeting between industry and the airworthiness authorities as requested by the Aerospace Industries Association of America (AIA), and the Association European des Constructeurs de Material d'Aerospatial (AECMA). The purpose of the meeting was to establish a process for resolving List 1 comparison issues.

At the June 1992 FAA/JAA management meeting in Toronto, Canada, seven engine Harmonization Terms of Reference (TOR) items were introduced. These TOR identified potential harmonization projects and four of these TOR were added to the original List 1 of twenty items. Six of the seven TOR have since been selected as Aviation Rulemaking Advisory Committee (ARAC) projects.

Electronic engine controls was one of these TOR contained in List 1 and in August 1994, the FAA tasked ARAC to further evaluate the proposal(59 FR 42323). This task was assigned to the Engine Harmonization Working Group (EHWG) of ARAC.

The EHWG task group, referred to as the Electronic Engine Control Task Group (EECTG), consisting of authorities from the FAA, JAA, Transport Canada (TCA) and industry representatives from the US and JAA countries has been organized. The task group had been assigned the task of harmonizing §33.28, Aircraft Engines Electrical and Electronic Control Systems with JAR-E 50 Controls and associated JAR-E sections. The first meeting of the EECTG was

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held on July 22-23, 1997 at the Direction Generale de l'Aviation Civile (DGAC) offices in Paris, France.

Representatives from the Propeller and Auxiliary Power Unit (APU) harmonization committees were represented on the committee in order to provide an exchange of information between the harmonization task groups to promote commonality.

The FAA has an on-going effort with the reciprocating engine control community to develop policy and advisory material for reciprocating engine controls for general aviation aircraft applications. Outside of the current harmonization effort, AC 33.38-1 is being modified to create a separate advisory circular, AC 33.28-2, that specifically addresses reciprocating engine control systems. Feedback from this effort is being used in the development of harmonized regulations that are applicable to all engine controls including those for reciprocating engines. However, the specific advisory material for reciprocating engines that defines the method of compliance with the harmonized regulations are not sufficiently developed to be included in AC 33.28-1A at this time. The development of guidance material and the harmonization effort for reciprocating engine control systems will be continued after the current harmonization effort is completed if this becomes necessary. Also, separate guidance material will be issued if required.

On [insert date], the EHWG reported their recommendations to the ARAC, which recommended that FAA proceed with rulemaking. This NPRM reflects the ARAC recommendations. A corresponding Notice of Proposed Amendment (NPA) is being published by the JAA.

Statement of the Problem

The existing part 33 and JAR-E regulations for Electronic Engine Controls differ in a number of areas, such as requirements for analysis, software, high intensity radiated fields (HIRF), fire, and lightning. In some cases the JAR-E advisory material is stated as mandatory under § 33.28 requirements, and in other cases, the FAA advisory material is stated as mandatory under the JAR-E requirements. The JAA has published advisory material for electronic engine control systems, while comprehensive FAA advisory material has not been published yet.

In addition, JAR-E requirements address all controls including hydromechanical control (HMC) systems as well as electronic control systems while the current § 33.28 is specific with regard to EEC systems. Therefore, it is

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beneficial to both the regulatory authorities and industry to harmonize the engine control regulations and advisory material. A number of other sections of part 33 were relevant to the certification of engine control systems and were therefore affected by this harmonization effort.

Discussion of the Proposals

The following discussions have been a result of harmonization with the JAR:

Section 33.5

The proposal would amend § 33.5 by adding new paragraphs (a)(4), (a)(5), (a)(6) and (b)(4). These proposed new paragraphs would require installation information to be included in the instructions for installation. The new requirements being proposed in §§ 33.5 (a)(4), (a)(5) and (b)(4) are currently prescribed under the existing § 33.28(a) as part of the control system description. § 33.5(a)(4), § 33.5(a)(5) and § 33.5(b)(4) are harmonized with JAR-E-20(d), JAR-E-30(b) and JAR-E-20(d) respectively.

Proposed new § 33.5(a)(6) would be added to harmonize the requirements of part 33 with the new proposed JAR-E 60(b)(formerly JAR-E 60(c)). The current part 33 does not address a similar requirement that specifies installation information. The proposed new § 33.5(a)(6) would require that the installation instructions must contain the list of instruments necessary for satisfactory control of the engine. Additionally, the overall limits of accuracy and transient response required for satisfactory engine operation must be stated so that the suitability of the instruments as installed can be assessed.

Section 33.7

The proposal would amend § 33.7 by adding a new paragraph (d). This paragraph is added to harmonize part 33 requirements with the last sentence of the current JAR-E 60(c), Provision for Instrumentation. As part of the harmonization effort, the last sentence of JAR-E 60(c) has been redesignated to a more appropriate section in JAR-E 40(g). The proposed new paragraph (d) would require that the overall limits of accuracy of the engine control system and the necessary instruments as defined in § 33.5(a)(6), be considered when determining the engine performance and operating limitations.

Section 33.27

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The existing § 33.27(b) would be redesignated as proposed new § 33.28(b)(3)(i), where it would be more accurately located since the requirement relates to an engine control function.

A new proposed § 33.27(b) would prescribe requirements for methods other than engine control methods for protecting rotor structural integrity during overspeed conditions. These methods, for example, would include protection methods such as blade shedding which are currently regulated under the JAR, but not definitively identified under part 33.

Section 33.28

The current title of § 33.28 is "Electrical and electronic engine control systems". The proposal would revise the title to read "Engine control systems" and would add an "Applicability" paragraph. Currently, § 33.28 only applies to electrical and electronic engine control systems, while JAR-E 50 and associated requirements apply to all types of engine control systems, including hydromechanical and reciprocating engine controls. The proposal would include all types of engine control systems and devices under § 33.28. When harmonizing the engine control requirements, it was necessary to change the title to better reflect the regulatory language that covers all engine control systems.

The existing § 33.28(a) would be revised and redesignated as §33.5, since the prescription of installation requirements are more properly organized into the section dedicated to installation requirements. The proposed requirements for § 33.28(a) would replace the existing requirements, and provide a single section that prescribes the top level requirements for validation of the engine control system. The new proposed format of §33.28(a) would consist of new subparagraphs (a)(1)(i), (a)(1)(ii), and (a)(2).

The proposed new § 33.28(a)(1)(i) would add a requirement that it be demonstrated through engine tests, rig tests, analysis or combinations of these that the engine control system, in its normal and alternative operating modes, perform the intended functions throughout the declared operating conditions and flight envelope. Currently, this is generally required under various paragraphs of part 33, (e.g., §§33.7 and 33.65). Compliance with these engine requirements depends on engine control functions but are not prescribed specifically as engine control system requirements. In addition, this requirement prescribes that the engine control system must perform its intended functions under the declared operating conditions that includes environmental conditions. The proposed new paragraph

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would harmonize the requirements with JAR-E 50 and various engine sections in part 33 that address engine performance and operability requirements.

The proposed new § 33.28(a)(1)(ii) would clarify what is required of fault accommodation implemented through alternate modes, as required in proposed revisions of § 33.28(b) (formerly § 33.28(c)) and § 33.28(d) (formally § 33.28(b)). In addition, the proposed new requirement would clarify the need for crew notification if their action is required as part of the fault accommodation.

The existing § 33.28(d) that addresses environmental limits and transients caused by lightning strikes would be revised and redesignated as proposed new § 33.28(a)(2). The proposed new § 33.28(a)(2) would clarify environmental testing requirements including those for high intensity radiated fields (HIRF), lightning and electromagnetic interference (EMI) for the engine control system. Engine control system environmental limitations are required to be documented in the instructions for installation as required in proposed revision § 33.5. The certification test limits would define the installation limitations for the system.

Proposed revision of existing § 33.28(b), § 33.28(c) and § 33.28(e) would address requirements for aircraft-supplied power and data, system integrity, and software. Although, the intent of these requirements remain unchanged, the text has been clarified and redesignated for harmonization purposes.

The existing § 33.28(c) would be revised and redesignated as new § 33.28(b) and would harmonize with the new proposed JAR-E 50(b). The proposed new § 33.28(b) would clarify the integrity requirements of the engine control system, which is only addressed generally in the existing § 33.28(c). The proposed new § 33.28(b) would consist of four paragraphs. § 33.28(b)(1) would propose regulatory language to address integrity requirements, such as LOTC requirements consistent with the intended application, accommodation of single failures with respect to LOTC and hazardous engine effect, foreseeable failures or malfunctions in the intended aircraft installation (i.e., local events), and failure or malfunctions of shared engine or propeller data or signals.

§ 33.28(b)(2) would propose the requirement for a System Safety Assessment, and § 33.28(b)(3) would propose the requirements for protective functions preserving the integrity of rotors. It is proposed that the existing requirement to protect the integrity of rotors that is currently promulgated under § 33.27(b) be moved to be under the paragraph titled, protective functions, and be redesignated as § 33.28(b)(3). The proposed new § 33.27(b) has been added to harmonize with JAR-E requirements and promulgates that other rotor protection means may be provided, such as blade shedding. The proposed new paragraph §

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33.28(b)(4) would propose requirements for protective functions such as the interlock that inhibits increased thrust until the thrust reverser doors have opened.

The existing § 33.28(e) prescribes the software requirements for the engine control system. Existing section § 33.28(e) would be revised to prescribe that the software be consistent with the criticality of performed functions to harmonize with JAR E-50(c) and redesignated as § 33.28(c).

The existing § 33.28(b) prescribes requirements in the event of failure of aircraft-supplied power or data. The existing segment of § 33.28(b) that prescribes requirements for any failure of aircraft-supplied data would be revised to provide clarified requirements. In addition it would be revised to exempt single engine applications and thrust or power command signals from the aircraft. This segment of § 33.28(b) would be redesignated as § 33.28(d).

The existing segment of § 33.28(b) which prescribes requirements for the loss of aircraft-supplied power would be revised to clarify this requirement and to make it applicable for all electrical power supplied to the engine control system, including that supplied from the aircraft power system and that from the dedicated power source, if required. Requirements for the response of the control system to loss or interruption of electrical power supplied from the aircraft have been clarified. Requirements which have been normal practice but unwritten in the rules have been added. These are: 1) a requirement to define the power characteristics of any power supplied from the aircraft to the engine control system in the instructions for installation; 2) a requirement to define in the instruction for installation, the engine control and engine responses to low voltage transients outside the declared power supply voltage limitations. A requirement is added for the dedicated power source for the control system, if required, to provide sufficient capacity to power the functions provided by the control system below idle, such as for the auto-relight function. The loss of some control functions that have traditionally been dependent on power supplied from the aircraft continue to be acceptable. These continue to be noted in the advisory material. Examples of these control functions are :

- Functions without safety significance that are primarily performance enhancement functions so that, if inoperative, do not affect the safe operation of the engine.
- Engine start and ignition
- Thrust Reverser deployment
- Anti-Icing (engine probe heat)

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- Fuel Shut-Off
- Overspeed Protection Systems

This segment of § 33.28(b) would be redesignated as § 33.28(e).

The proposed new §33.28(f) would add requirements for air pressure signals used in the engine control to harmonize with requirements of the new proposed JAR E50(f)(formerly JAR-E 560(h)). The proposed addition would prescribe that design precautions must be taken to minimize the malfunctioning of the system as a result of the ingress of foreign matter or blockage of the signal lines by foreign matter or ice.

It is proposed that the existing rule 33.67(d) that prescribes requirements for engines with One Engine Inoperative (OEI) capability be moved and be redesignated as 33.28(g). This rule prescribes a control function that more properly is located under § 33.28.

The proposed new §33.28(h) would add requirements for programmable logic devices(PLD) that include Application Specific Integrated Circuits (ASIC) and programmable gates arrays. It was decided to propose a new requirement separate from software requirements, although the requirements are similar, because PLD are a combination of software and complex hardware. The proposed rule would prescribe that the development of the devices and the associated encoded logic used in the design and implementation of these devices be at a level commensurate with the hazard level of the functions performed through the devices.

Minority Positions

One member of the EHWG committee has filed minority positions for the proposed harmonized new § 33.28(d)(1), § 33.28(e) and § 33.28(h). The three minority positions are listed below followed by the FAA response to each minority position.

Minority Position for the Harmonized New § 33.28(d)(1)

The minority position filed for 33.28(d)(1) is stated as follows:

"We object to a new rule being introduced through the advisory material. The rules are currently (see change 10, JAR-E 50, (a)(4):-For turbine engines, the engine control system including a thrust reverser control, if applicable, shall be designed to---Retain the ability to control the engine safely under the appropriate failure conditions determined from the Failure Analysis), and (see FAR 33.28(d):--

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-Each control system which relies on electrical and electronic means for normal operation must: (b) Be designed and constructed so that any failure of aircraft-supplied power or data will not result in an unacceptable change in power or thrust, or prevent continued safe operation of the engine.). The advisory material is currently (See JAR-E, change 10, AMJ 20X-1, section 4.5.5: -Data exchanged with the aircraft, (a) Aircraft must be protected from unacceptable effects of faults due to a single cause, simultaneously affecting more than one engine/propeller. In particular, the following cases should be considered.....(i)Erroneous data received from the aircraft by the engine/propeller control system if the data is common to more than one engine/propeller (e.g. air data sources, auto throttle synchronizing),...and...).

The proposed advisory material defines what is "unacceptable" as a loss of more than 3% requirement of the aircraft (as in the current regulation). The proposed advisory material introduces a "new" requirement, which is a restriction on the design."

FAA Response to the Minority Position for the Harmonized New § 33.28(d)(1)

The minority position claims that the 3% requirement amounts to a new rule introduced through advisory material. The FAA disagrees. The FAA does not intend that this guidance material establish the 3% level as a binding norm. The FAA views an unacceptable change in power or thrust to be one which has a significant affect on the performance margins of the aircraft. The FAA choose, however, not to include a definition of the phrase in the rule, but to offer guidance in this AC. That guidance provides that the FAA will generally not view a change of less than 3% as significant. Changes of 3% or greater will initially be viewed as significant unless the applicant demonstrates otherwise, particularly for engines intended to be installed on aircraft whose designs are certificated under Part 25 rules. The 3% level is similar to the guidance provided for the rain and hail rule.

Therefore, the FAA will proceed with the harmonized new 33.28(d)(1) as proposed.

Minority Position for Harmonized New FAR 33.28(e)

"We object to the introduction of the implied required to comply mandating of a dedicated engine electrical power system. To comply with the existing JARs:--- [change 10 JAR-E 50(a)(4) (For turbine engines, the engine control system including a thrust reverser control if applicable, shall be designed to:---Retain the ability to control the engine safely under the appropriate failure conditions

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determined from the Failure Analysis) and AMJ 20-X 4.5.4, (Aircraft electrical power supply. If the aircraft electrical system supplies power to the engine/propeller electronic control system at any time, the power supply quality, including transients or failures, must not lead to a situation identified by the engine manufacturer, which is considered by the aircraft to be a hazard to the aircraft)], it is possible for the control system to solely use aircraft power if the loss/corruption does not lead to as situation considered by the aircraft manufacturer to be a hazard to the aircraft. The "harmonized" rule defines what is intolerable for the engine whereas in our opinion, it should be what is intolerable for the aircraft (as per the current regulations). The proposed advisory material introduces a "new" requirement, which is a restriction on the design.

AMJ 20X 4.2 says that the objective is "The introduction of electronic control systems should provide for the aircraft at least the equivalent safety, and the related reliability level, as achieved by engines/propellers equipped with hydromechanical control and protection system". The objective is not stated as providing a particular level of independence of the engine control system from the aircraft, which is what this "new" regulation is doing."

FAA Response to Minority Position for Harmonized New § 33.28(e)

The commenter states that this rule is a "new" requirement when referred to JAR E-50(a)(4) and AMJ 20X-1. However, this requirement exists in the current § 33.28(b) and is not new. An analysis of an aircraft power bus system may conclude that there is adequate reliability, because redundant systems do allow individual paths to have somewhat poor reliability. However, it has been the experience of the FAA that complete power losses do occur on aircraft within the life of a given fleet. This is because the analysis may not consider all the potential failure modes to which the power bus and power source are exposed.

Consequently, the FAA has required that the engine continue to operate with the loss of aircraft-supplied power. The ARAC harmonization process is intended to bring the FAR and JAR into agreement. In some cases the FAR has been changed to agree with the JAR. In this case the JAR has been changed to agree with the FAR because the EECTG committee agreed that this provided the better safety objective.

Minority Position for Harmonized New § 33.28(h)

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"We object to the introduction of this topic via the harmonization activity. We agree that the topic needs to be addressed through regulations but the harmonization activity is not the appropriate method to introduce new regulations. Currently a draft FAA issue paper and JAA CRI on this subject are being prepared. It is being written by experts in the field and it is the intention for this to be considered as a new regulation."

FAA Response to the Minority Position for Harmonized New § 33.28(h)

The draft PLD generic issue paper provided by the FAA has been the basis of issue papers written on current certification programs. The draft JAA CRI is similar to the FAA drafted generic issue paper. In addition, RTCA/DO-254 Design Assurance Guidance For Airborne Electronic Hardware that addresses acceptance of PLDs in certification programs was issued on April 19, 2000. It is anticipated that the FAA and JAA will both accept this document as an AC that will provide guidance for the acceptance of PLDs. Methodology described in these documents can be used to demonstrate compliance with § 33.28(h);.

In addition, the authority for the acceptance of the software for PLDs currently is promulgated in existing § 33.28(e). However, it is more appropriate to prescribe a requirement for PLDs considered as complex hardware using methodology similar to that used for software to demonstrate compliance. The harmonization activity provides an opportune time to prescribe harmonized requirements for acceptance of PLDs rather than to continue the use of issue papers or policy memorandums.

Therefore, the FAA disagrees with the commenter's minority position and will move forward with the § 33.28(h).

Section 33.29

The proposed revision of § 33.29, would add new paragraphs (d) through (f) to harmonize the part 33 requirements with JAR-E 60 Provision for Instruments.

The proposed addition of § 33.29(d) would harmonize the requirements of part 33 with JAR-E 60(a), since the current part 33 does not provide for a similar requirement. The proposed revision would prescribe that provision be made for instrumentation necessary to ensure operation in compliance with the engine operating limitations. When the instrumentation is necessary for compliance with

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the engine requirements, the instrumentation must be specified in the instructions for installation and included as part of the engine type design.

The proposed new § 33.29(e) would harmonize the requirements of part 33 and the new JAR-E 110(e). The existing § 33.29(a) requirement addresses the prevention of incorrect connections of instruments only, and the new § 33.29(d) would harmonize with the JAR by requiring a means be provided to minimize the possibility of incorrect fitting of instruments, sensors and connectors.

The proposed new § 33.29(f) would harmonize the requirements of part 33 and the existing JAR-E 60(c). Currently, the part 33 does not address requirements for sensors and associated wiring and signal conditioning segregation. The proposed new requirement would reduce the probability of faults propagating from the instrumentation and monitoring functions to the control functions, or vice versa, by prescribing that the probability of propagation of faults be consistent with the criticality of the function performed.

Section 33.53

The existing title of § 33.53 is “Engine component tests”, and the proposal would revise the title to read “Engine system and component tests”. The proposed revision to the title would better identify reciprocating engine control system tests that may be conducted under this paragraph. System validation testing, for example, may be required under this paragraph.

Section 33.67

The existing § 33.67(d) would be redesignated as proposed new §33.28(g), where it would be more accurately located since the requirement relates to an engine control function. The existing § 33.67(d) had recently been changed as part of the Part 33/JAR-E harmonization effort for the OEI requirements. There is no change in the text of the rule being redesignated.

Section 33.91

The existing title of § 33.91 is “Engine component tests”, and the proposal would revise the title to read “Engine system and component tests”. The proposed revision to the title would better identify engine control system tests that may be conducted under this paragraph. System validation testing, for example, may be required under this paragraph.

The proposal would revise § 33.91(a) to provide for systems tests if required.

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Advisory material that defines environmental tests typically conducted for EEC systems is provided in a policy memorandum that will subsequently be integrated into AC33.2B Aircraft Engine Type Certification Handbook .

Paperwork Reduction Act

TBD

Regulatory Evaluation Summary

TBD

International Trade Impact Analysis

TBD

Regulatory Flexibility Determination

TBD

Federalism Implications

TBD

The Proposed Amendments

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 33 of Title 14, Code of Federal Regulations as follows:

PART 33-AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

1. The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701-44702, 44704.

2. Section 33.5 is amended by adding new paragraphs (a)(4),(a)(5), (a)(6), and (b)(4), to read as follows:

(a) * * *

(3) * * *

(4) A definition of the physical interfaces with the aircraft and aircraft equipment, including the propeller when applicable.

(5) Where a system certified with the engine relies on components which are not part of the engine type design, the system and interface requirements upon which engine type certification is based must be specified in the engine instructions for installation directly, or by reference to appropriate documentation, available to the aircraft installer, containing these requirements.

(6) A list of the instruments necessary for control of the engine, including the overall limits of accuracy and transient response required of such instruments to control operation of the engine.

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(b) * * *

(3) * * *

(4) A description of the operational modes, including limitations, of the engine control system and its functional interface with the aircraft systems, including the propeller when applicable.

3. Section 33.7 is amended by adding new paragraph (d) to read as follows:

(c) * * *

(d) In determining the engine performance and operating limitations, the overall limits of accuracy of the engine control system and of the necessary instrumentation as defined in §33.5(a)(6) will be taken into account.

4. Section 33.27 is amended by revising the existing paragraph (b) to read as follows:

(a) * * *

(b) The design and functioning of engine systems, instruments, and other methods, not covered under 33.28 of this part, must give reasonable assurance that those engine operating limitations that affect turbine, compressor, fan, and turbosupercharger rotor structural integrity will not be exceeded in service.

5. Section 33.28 is amended by revising the title of § 33.28, introductory text and revising and redesignating paragraphs (a), (b), (c), (d) and (e), and adding new paragraphs (a)(1), (a)(2), (b)(1), (b)(2), (b)(3), (b)(4), d(2), e(2), e(3), e(4), (f), (f)(1),(f)(2), (g), and (h).

Section 33.28 Engine control systems.

Applicability: These requirements are applicable to any system or device, that is part of engine type design, that controls, limits or monitors engine operation, and is necessary for continued airworthiness of the engine.

(a) Validation.

(1) Functional Aspects.

(i) Control Modes. It must be substantiated by engine tests, rig tests, analysis or a combination thereof, that the engine control system performs the intended functions throughout the declared operating conditions and flight envelope in a manner which;

1. allows the engine to be controlled within its operating limits,

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2. complies with the operability requirements of § 33.51, §33.65 and §33.73, under all likely system inputs and allowable engine power or thrust demands, unless it can be demonstrated that this is not required in the intended application, and
3. allows modulation of engine power or thrust with adequate sensitivity over the required range of engine operating conditions, and
4. does not create unacceptable power or thrust oscillations.

FAR 33.28(a)(1) applies to the primary control mode and to those alternative or back-up control modes, as described under § 33.5(b)(4) for which the applicant wishes to take LOTC credit, and are necessary for compliance with § 33.28(a)(1)(i). Data obtained from any FAR 33 certification test may be used to substantiate control mode requirements.

(ii) Control Mode Transitions. It must be demonstrated that, when fault accommodation results in a control mode change, the transition occurs so that;

1. the engine does not exceed any of its operating limitations, and
2. the engine does not surge, stall or experience unacceptable thrust or power oscillations or other detrimental characteristics, and
3. the magnitude of any change in thrust or power and the associated transition time are identified and described in the engine instructions for installation and operation.

In addition, if a flight crew action is required in the mode change, provision for a means to alert the crew must be provided and the crew action must be defined in the engine instructions for installation and operation.

(2) Environmental Limits. It must be demonstrated, when complying with § 33.53 or § 33.91, that the engine control system functionality will not be adversely affected by declared environmental conditions, including electromagnetic interference (EMI), HIRF and lightning. The limits to which the system has been qualified shall be documented in the engine instructions for installation.

(b)(1) The control system must be designed and constructed so that:

- (i) a rate for Loss of Thrust (or power) Control (LOTC) events consistent with the intended application can be achieved, and
- (ii) in the full-up configuration, the engine control system is essentially single fault tolerant for electrical or electronic failures with respect to LOTC events, and

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(iii) single failures of an electrical or electronic components shall not result in a hazardous engine effect as defined in §33.75, and

(iv) foreseeable failures or malfunctions in the intended aircraft installation which might affect elements of the engine control system, such as fire, overheat, or failures leading to damage to engine control system components do not result in a hazardous engine effect as defined in §33.75 due to engine control system failures or malfunctions, and

(v) if applicable, the failure or corruption of engine or propeller data or signals shared between engines do not cause an unacceptable change in thrust or power.

2) An System Safety Assessment that demonstrates compliance with FAR 33.28 is required. This assessment must identify faults that result in a change in thrust or power, a transmission of erroneous data, or an effect on engine operability. The analysis must contain the predicted frequency of occurrence of these faults.

(3) Overspeed Protection Function.

(i) The design and functioning of the engine control devices, systems, together with the engine instruments and operating and maintenance instructions, must provide reasonable assurance that those engine operating limitations that affect turbine, compressor, fan, and turbosupercharger rotor structural integrity will not be exceeded in service.

(ii) When electronic overspeed protection systems are provided for compliance with 33.28 (b)(3)(i), the design must include a means for testing, at least once per engine start/stop cycle, to ensure the availability of the protection function. If the test is not fully automatic, the requirement for this periodic manual test must be contained in the engine instructions for operation.

(4) The predicted failure rate of protective functions provided by the engine control system must be consistent with the safety analysis associated with those functions.

(c) For electronic engine control systems, all associated software must be designed, implemented and verified to minimize the existence of errors by using a method, approved by the Administrator, that is consistent with the criticality of the performed functions.

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- (d) For engines intended to be installed in a multi-engine aircraft,
- (1) Engine control systems which use aircraft-supplied data must be designed to accommodate circumstances where some or all of the data are lost, corrupted or failed in any manner. The accommodation strategy must not result in an unacceptable change in thrust or power, a hazardous engine effect as defined in §33.75, or an unacceptable change in engine operating characteristics. The effect of the failure of aircraft-supplied data on the engine's output power or thrust characteristics throughout the flight envelope shall be evaluated and documented. This requirement does not apply to thrust or power command signals from the aircraft, unless these signals produce a hazardous engine effect.
 - (2) For engines intended for single engine applications, the effects of loss, corruption or failure of aircraft supplied data must be included in the engine control system's safety and LOTC analyses required under § 33.28 (b).
- (e) *Electrical power.*
- (1) The engine control system must be designed so that, after the engine is started and operating at idle or above, the loss or interruption of electrical power supplied from the aircraft to the engine control system will not result;
 - (i) in a hazardous engine effect or,
 - (ii) an unacceptable effect in thrust or power, or any effect on engine operating characteristics as required by §33.51, §33.65 and §33.73, as applicable or
 - (iii) the transmission of erroneous data.
 - (1) When an engine dedicated power source is required for compliance with the §33.28(e)(1), its capacity should provide sufficient margin to account for engine operation below idle where the control is designed and expected to recover engine operation automatically.
 - (2) The need for, and the characteristics of, any electrical power supplied from the aircraft to the engine control system for starting and operating the engine, including transient and steady state voltage limits, must be identified and declared in the engine instructions for installation.
 - (1) Low voltage transients outside of the power supply voltage limitations declared in §33.28(e)(3), must not result in a permanent loss of function or an inappropriate operation of the engine control system which could cause the

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engine to exceed any operational limitation, result in a hazardous engine effect as defined in § 33.75, or cause the transmission of erroneous data. The engine control system must resume normal operation when aircraft-supplied power returns to within the declared limits.

(f) Where an air pressure signal is used by the engine control system and could affect engine operation, design precautions must be taken to minimize:

- (1) Malfunctioning of the system as a result of the ingress of foreign matter, and
- (2) Blockage of the signal lines by foreign matter or ice.

(g) Engines having a 30-Second OEI Power rating must incorporate means or provision for means for automatic availability and automatic control of the 30-Second OEI power within its operating limitations.

(h) The development of programmed devices using digital logic or other complex design technologies must provide a level of assurance for the encoded logic which is commensurate with the hazard associated with the failure or malfunction of the systems in which the devices are located. All associated logic must be designed, implemented and verified to minimize the existence of errors by using a method approved by the Administrator, that is consistent with the criticality of the performed function.

6. Section 33.29 is amended adding new paragraphs (d) through (e) to read as follows:

(a) * * *

(b) * * *

(c) * * *

(d) Provision must be made for the installation of instrumentation necessary to ensure operation in compliance with engine operating limitations. When presenting the failure analysis, or complying with any other requirement, if dependence is placed on instrumentation which is not otherwise mandatory in the assumed aircraft installation, then this instrumentation must be specified in the engine instructions for installation and declared mandatory in the engine approval documentation.

(e) Means must be provided to minimize the possibility of incorrect fitting of instruments, sensors and connectors.

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(f) The sensors, together with associated wiring and signal conditioning, must be segregated, both electrically and physically, to the extent necessary to ensure that the probability of faults propagating from instrumentation and monitoring functions to control functions or vice versa is consistent with the criticality of the performed functions.

7. Section 33.53 is amended by revising the title and paragraph (a) as follows:

§ 33.53 Engine system and component tests.

(a) For those systems and components which cannot be adequately substantiated by endurance testing of FAR 33.49, additional tests must be conducted to demonstrate that systems or components are able to perform the intended functions in all declared environmental and operating conditions.

8. Section 33.67(d) is deleted from this section and added to amended Section 33.28 as § 33.28(g).

9. Section 33.91 is amended by revising the title and paragraph (a) as follows:

§ 33.91 Engine system and component tests.

(a) For those systems or components which cannot be adequately substantiated in accordance with endurance testing of § 33.87, additional tests must be conducted to demonstrate that the systems or components are able to perform the intended functions in all declared environmental and operating conditions.

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**US Department
of Transportation
Federal Aviation
Administration**

Memorandum

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Subject: **ACTION:** Advisory Material for FAR 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91 Affected by the Engine Harmonization Working Group (EHWG) Harmonization Effort.

Date: Sept. 26, 2000

From: Manager, Engine and Propeller Standards Staff,
ANE-110

Reply Cosimo Bosco
to ANE-110
Attn. (781) 238-7118
of:

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File PM_r6a.doc dated 10 Oct 2000.

To: Manager, Aircraft Engineering Division, AIR-100
Manager, Aircraft Manufacturing Division, AIR-200
Manager, Brussels Aircraft Certification Staff, AEU-100
Manager, Engine Certification Office, ANE-140
Manager, Engine Certification Branch, ANE-141
Manager, Engine Certification Branch, ANE-142
Manager, Boston Aircraft Certification Office, ANE-150
Manager, New York Aircraft Certification Office, ANE-170
Manager, Airframe and Propulsion Branch, ANE-171
Manager, Rotorcraft Directorate, ASW-100
Manager, Rotorcraft Standards Staff, ASW-110
Manager, Airplane Certification Office, ASW-150
Manager, Rotorcraft Certification Office, ASW-170
Manager, Special Certification Office, ASW-190
Manager, Small Airplane Directorate, ACE-100
Manager, Small Airplane Standards Office, ACE-110
Manager, Atlanta Aircraft Certification Office, ACE-115A
Manager, Propulsion Branch, ACE-140A
Manager, Chicago Aircraft Certification Office, ACE-115C
Manager, Propulsion Branch, ACE-118C
Manager, Wichita Aircraft Certification Office, ACE-115W
Manager, Propulsion Branch, ACE-140W
Manager, Anchorage Aircraft Certification Office, ACE-115N
Manager, Transport Airplane Directorate, ANM-100
Manager, Transport Standards Staff, ANM-110
Manager, Airframe and Propulsion Branch, ANM-112
Manager, Seattle Aircraft Certification Office, ANM-100S
Manager, Propulsion Branch, ANM-140S
Manager, Denver Aircraft Certification Office, ANM-100D
Manager, Los Angeles Aircraft Certification Office, ANM-100L
Manager, Propulsion Branch, ANM-140L
Deputy Director, Flight Standards Service, AFS-2
Manager, Air Transportation Division, AFS-200
Manager, Aircraft Maintenance Division, AFS-300
Manager, Flight Standards National Field Office, AFS-500
Manager, Aircraft Evaluation Group, Boston-AEG
Manager, Aircraft Evaluation Group, Ft Worth-AEG
Manager, Aircraft Evaluation Group, Missouri-Kansas City-AEG
Manager, Aircraft Evaluation Group, Long Beach, California-AEG
Manager, Aircraft Evaluation Group, Seattle-AEG

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The purpose of this Program Memorandum is to provide advisory material for FAR paragraphs 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91 that have been modified because of the ARAC-Engine Harmonization Working Group (EHWG) harmonization effort for engine control systems. Subsequently, the FAA plan is to integrate this guidance material into AC 33-2B, Aircraft Engine Type Certification Handbook at its next update.

The Electronic Engine Control Task Group (EECTG) has been tasked by the Engine Harmonization Working Group (EHWG) to harmonize FAR 33.28 and JAR-E 50. Terms of Reference (TOR) have been issued that define the task to harmonize FAR 33.28 and JAR-E 50 for engine control systems. The FAR paragraphs for which this advisory material is provided have been modified as a result of the basic harmonization task for FAR 33.28 and JAR-E 50, although these FAR paragraphs are not noted in the TOR.

Advisory material for electronic engine controls (EEC) is provided by AC 33.28-1A that has been harmonized with AMJ-20X1. However, AC 33.28-1A is limited to electronic engine controls. The harmonization effort affected other paragraphs for which advisory material is required. This program memorandum is issued to provide guidance material for the paragraphs affected by engine control system harmonization effort and not covered under AC 33.28-1A.

Advisory material, referenced to paragraphs in AC 33-2B, is provided for the harmonized sections of the FAR as follows:

1. FAR 33.5 (Paragraph 17 of AC 33-2B) Instruction manual for installing and operating the engine.

a. Under (a) Installation Instructions, add paragraphs, as follows:

- (1)
- (2)
- (3)
- (4) A definition of the physical interfaces with the aircraft and aircraft equipment, including the propeller when applicable.
- (5) Where a system certified with the engine relies on components which are not part of the engine type design, the system and interface requirements upon which engine type certification is based, or a reference to appropriate documentation containing these requirements, which is available to the installer.
- (6) A list of the instruments needed for control of the engine, including the overall limits of accuracy and transient response required of such instruments to control operation of the engine.

b. Under (b) Operation Instructions, add the following paragraph, as follows:

- (1)....

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(2)....

(3)....

(4) A description of the operational modes of the engine control system and its functional interface with the aircraft systems, including the propeller when applicable.

c. Under Guidance, add the following paragraphs:

a.....

d.....

e. The engine instructions for installation should include or make reference to installation interface descriptions, limitations, and requirements of the engine control system. For example, the electronic engine control (EEC) power requirements and quality, including interrupt limitations, should be clearly defined for the installer. Another example is that the impedance and buffering limitations for the signals provided by the EEC system for display and instrumentation, or signals used by the EEC, such as air data information, should be specified.

f. The trend toward system integration may lead to EEC systems that:

- (1) have other control functions integrated within the engine control system, such as an integrated engine and propeller control system or,
- (2) depend on aircraft resources that form part of the engine certification basis.

Examples of these aircraft supplied resources include, recording of rotorcraft One Engine Inoperative (OEI) data and aircraft central computers that perform some or all of the engine control functions.

The engine applicant is responsible for specifying the requirements for the EEC system for these aircraft supplied resources in the engine instructions for installation and substantiating the adequacy of those requirements. However, responsibility for complying with the specified requirements lies with the installer.

g. The engine instructions for installation should include a description of all operational modes of the engine control system and its functional interface with the aircraft systems including backups or alternate modes whether dispatchable or not, and including the propeller when applicable.

2. FAR 33.7 (Paragraph 18 of AC 33-2B) Engine Ratings and Operating Limitations.

No additional guidance is required to address the addition of §33.7(d), because the regulatory language is sufficiently explicit.

3. FAR 33.27 (Paragraph 27 of AC 33-2B) Turbine, compressor, fan and turbosupercharger rotors.

The harmonization effort affects paragraph 27 in two ways. The regulatory language to require a protection means to preserve the structural integrity of the rotors is under two paragraphs as follows:

- a.) 33.28(b)(3)(a), if provided by the engine control system, and,
- b.) 33.27(b), if provided by other means.

The regulatory language of §33.27(b) has been modified to harmonize with the JAR requirements that provide other means of preserving the structural integrity of rotors, such as blade shedding and rotor interference means.

Paragraph 27 is changed as follows:

- a.) Change the “Guidance” paragraph to be:

“The INTENT of this section is to assure engine rotor structural integrity, by design and functioning *of a protection means that may include blade shedding or rotor interference techniques*, to inhibit exceedances.....without cracking. Protection means provided by the engine control system are addressed under §33.28(b)(3)(a).”

4. FAR 33.28 (This is a new paragraph for AC 33.2B.), Engine Control Systems
Section 33.28 Engine control systems:

Guidance. The intent of this section is to provide guidance for engine control systems implemented in technologies other than electrical/electronic technology. Guidance for electronic engine controls (EEC) systems is provided by AC 33.28-1A. The modification to AC 33.28-1 is a result of the harmonization effort conducted to harmonize of §33.28 and JAR E-50. This harmonization effort resulted in §33.28 being changed to apply to all engine controls, including hydromechanical controls or controls of other technology. The advisory material provided in AC 33.28-1A only applies to EEC systems although the rule has been changed to apply to all engine controls. Therefore, additional guidance material that applies to controls of other technology is provided in this policy memorandum and will subsequently be included in updated AC 33.2B.

(a) Applicability

§33.28 is applicable to all types of engine control systems. For instance, these might be hydromechanical control systems or hydromechanical control with a limited authority electronic supervisor control, single channel full authority engine control with hydromechanical back-up, dual channel full authority electronic engine control with no back-up, or any other combination. The electronic technology can be analog or digital.

The engine control system includes any system or device that controls, limits or monitors engine operation and is necessary for continued airworthiness standards of the engine. This covers all equipment that is necessary for controlling the engine and ensuring safe operation of the engine within its limits as specified in §33.28(a). This implies consideration of all control system components including the electronic control unit(s), fuel metering unit(s), variable-geometry actuators, cables, wires, sensors, etc.. The main engine fuel pump, which is usually engine-mounted and often physically integrated with the fuel metering unit, is not usually considered part of the engine control system.

These requirements cover the main engine control system as well as protection systems, for example, overspeed, over-torque or over-temperature.

When blade shedding or engine build related means is used for overspeed protection, this would not be considered under §33.28 as being part of the control system, as this protection is purely mechanical and will automatically work without influence from the engine control system. This type of protection is addressed under the requirements of §33.27(b).

Engine monitoring systems are covered by this section when they are physically or functionally integrated with the control system and they perform functions that affect engine safety or are used to effect continued-operation or return-to-service decisions. For instance, low cycle fatigue (LCF) cycle-counters for critical parts would be included but most trend monitors and propulsion multiplexers (PMUX) devices would not.

(b). Objective

For electronic engine control systems, AC33.28-1A, AC33-2B and this FAA Policy Memorandum provide additional and detailed interpretation of §33.28 with special consideration to interfaces with the aircraft, and the propeller when applicable.

The purpose of FAR-33.28 is to set objectives for the general design and functioning of the engine control system and these requirements are not intended to replace or supersede other requirements, such as §33.67 for the fuel system. Therefore, individual components of the control system, such as alternators, sensors, actuators, should be covered, in addition, under other part 33 paragraphs such as §33.53 and §33.91, as appropriate.

(c) Environmental Effects

The objective of §33.28(a)(2), in conjunction with §33.53 and §33.91, is to demonstrate that the engine control system can perform its intended function in its installed environment. Advisory material for HIRF, lightning and electromagnetic effects can be found in AC33.28-1A. Advisory material for environmental effects other than HIRF,

lightning and electromagnetic can be found in this program memorandum under advisory material for §33.91.

In particular, electronic engine control systems are sensitive to lightning and other electromagnetic interference and these conditions can be common to more than one engine.

For compliance with §33.28(a)(2), the functional integrity of the engine control system should be maintained when subjected to designated levels of electric or electromagnetic induction, including effects from external radiation and lightning. The environment, including radiated and conducted emissions, to which the engine control system and its components are qualified should be entered into the engine instructions for installation, and is considered to be an installation limitation for the installer. For aircraft certification, the aircraft manufacturer should substantiate that these levels are compatible with the installation.

When the installer specifies the environmental conditions of the installation, compliance with this requirement can be demonstrated by meeting the specified installation requirements.

When the installation requirements are not specified or not known, environmental conditions of a typical installation may be assumed.

It should be established by analysis or test that all components of the engine control system, including all electronics units, sensors, harnesses, hydromechanical elements, and any other relevant elements or units, operate properly in their declared environment. The environmental limits are not imposed by the rules, but should be representative of the environments that are expected to be encountered in the engine installation.

(d) Integrity

The intent of §33.28(b) is to establish engine control system integrity requirements consistent with operational requirements of the various applications. In particular, the introduction of electronic control systems should provide at least an equivalent level of safety and reliability for the engine as achieved by engines equipped with hydromechanical control and protection systems, and magneto systems. An analysis that demonstrates compliance with the requirements of §33.28(b) is required.

Mechanical and hydromechanical engine control systems rely on mechanical inspection intervals and "soft failure characteristics" to ensure control system integrity and airworthy operation between control system maintenance intervals.

The hardware of electronic control systems, however, tends to be characterised by random failures and does not lend itself to inspection for component wear. It is recognised that in order to achieve an upper limit on the LOTC rate consistent with the application,

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electronic engine control systems should use redundancy and fault accommodation techniques to ensure safe and reliable control system operation following failure of electrical or electronic components. Paragraph (8) of AC33.28-1A provides additional material for electronic engine control systems.

§33.28(b) defines requirements for overspeed protection systems for the engine control system. Overspeed protection is normally provided in hydromechanical controls by flyball mechanisms. Although the functionality of these systems can not be assured by test before or after each flight, as are systems implemented by electronic means, it is still required that these overspeed systems be functional for each flight. This can be demonstrated through a test program that establishes the inspection or overhaul period that will ensure that the overspeed protection system will remain functional between the declared inspection or overhaul periods.

(e) Electrical Power

Engine control systems implemented in hydromechanical technology or technology other than electrical and electronic technology should inherently be compliant with §33.28(e). However, if the system has functions implemented electrically or electronically that depend on aircraft-supplied electrical power, the system should be evaluated for compliance with this rule (see paragraph 13 of AC33.28-1A for relevant interpretation).

(f) Air Pressure Signals

§33.28(f) covers cases of ingress of foreign matter (e.g. sand, dust, water, or insects) which could result in blockage of the lines and result in an adverse effect on engine operation. For example, the experience has shown that lines used for measuring the static pressure in the compressor of turbine engines could be blocked by frozen water, leading to a loss of power. Precautions should therefore be taken, such as use of protected openings, filters, drains for water, heating of the lines to prevent freezing of condensed water. Corrosion effects should also be addressed.

It is required to minimize the effect because it is not possible to totally eliminate the threat. This should be done in light of the integrity requirements of §33.28(b), with due consideration to the fact that this could be an effect common to more than one engine on the same aircraft.

References

- 1.
- 2.
- 3.

5. FAR 33.29 (Paragraph 28 of AC 33.2B Instrument Connection).

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- a. Under **Paragraph 28, Section 33.29 Instrument connection** add paragraphs (d), (e) and (f) as follows:

(a.).....

(b.).....

(c.).....

(d.) Provision must be made for the installation of instrumentation necessary to ensure operation in compliance with engine operating limitations. When presenting the failure analysis, or complying with any other requirement, if dependence is placed on instrumentation which is not otherwise mandatory in the assumed aircraft installation, then this instrumentation must be specified in the engine instructions for installation and declared in the engine approval documentation.

(e) Means must be provided to minimize the possibility of incorrect fitting of instruments, sensors and connectors.

(f) The sensors, together with associated wiring and signal conditioning, must be segregated, electrically and physically, to the extent necessary to ensure that the probability of faults propagating vice versa, or from control functions to instrumentation and monitoring functions, is consistent with the criticality of the performed functions

- b. Under **Guidance change to read as follows:**

The INTENT of this section is to prevent misconnections of engine-required instrumentation, and to provide a drawing location for rotor unbalance sensing. Additional guidance is provided for (d) and (f):

(d) Under the requirements of 33.29(d), the engine manufacturer should define the instrumentation which is necessary for engine operation within its limitations and also make provision for installation of this instrumentation.

(1) Paragraph 1305 of FAR 23, 25, 27 or 29 contains lists of powerplant instrumentation required for aircraft certification compliance. In addition, the engine failure analysis might show the need for specific instrumentation providing information to the flight crew or maintenance personnel for taking the appropriate actions in order to prevent the occurrence of a failure or to mitigate any associated consequences.

(2) Care should be exercised to ensure that the information (i.e., sensors and display system) provided to the flight crew is sufficiently representative, accurate and responsive for its intended function.

(3) If the safety analysis is dependent on instrumentation, assumptions regarding failure rates in any associated subsystems or elements, which are not part of the engine type design, should be specified (see FAR 33.75(d)).

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(4) Care should also be exercised in selecting the position on the engine at which a particular parameter, such as oil pressure, is sensed in order to ensure that the indication is appropriate for the intended protection of relevant components.

(f) The intent of section 33.29 (f) is to provide for segregation of sensors, together with associated wiring and signal conditioning, to basically ensure that faults could not affect at the same time the monitoring functions and the engine control functions.

For example, if the inadvertent deployment of a reverser in-flight is critical to the aircraft, the thrust reverser position control and position indicating systems should be separate, such that failures which could effect the thrust reverser position control system are not allowed to cause loss of the correct flight deck indication of reverser position.

An example of a non-critical function in a multi-engine installation is the control of engine thrust or power. If the same sensor is used for engine control and indication, a malfunction of that sensor will affect both the indication and control of engine power or thrust. However, at the aircraft level, the power or thrust of one engine is not considered a critical function.

The level of segregation, and the associated probability of common fault, is dependent on the criticality of the considered functions.

6, FAR 33.53 (Paragraph 39 of AC 33.2B) Engine Component Tests.

Paragraph 39 is changed as follows:

- a) Change the paragraph title and the bold section title from "Engine Component Tests" to "Engine System and Component Tests".
- b) Change paragraph (a) of the rule to read as follows:
 - (a) For those systems or components which cannot be adequately substantiated by the endurance testing of FAR 33.49, additional tests or analyses must be conducted to demonstrate that the systems or components are able to perform the intended functions in all declared environmental and operating conditions.
- c) Change "Guidance" to be as follows:

The intent of FAR 33.53 is to define the additional tests or analysis which would be necessary for those systems or components which are not necessarily tested during the endurance test of FAR 33.49.

(a) It is also recognized that the other requirements of FAR 33 do not always provide sufficient testing to cover all the conditions (pressure, temperature, vibration, etc. ...) which could affect the airworthiness of a piece of equipment throughout the declared flight envelope and within all the declared installation conditions.

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(b) Other reasons for testing under 33.53 include, but are not limited to, the following examples:

- When testing is required in support of 33.28(a) validation throughout the declared flight envelope and within all the declared installation conditions.
- When a pressure relief valve in a turbo-supercharger is untested during the scheduled test of FAR 33.49.
- When an engine electronic control system has a mechanical back-up which is not normally used during the endurance test.
- When demonstration that a failure indicating system, on which dependence is placed in the engine safety analysis, will function satisfactorily when required.

(c) The Engine manufacturer should define, in agreement with the Authority, all necessary testing and / or analysis for those accessories or systems that need specific substantiation, in addition to the certification tests performed on a complete Engine, with attention paid to their location and operating conditions. Unless it is necessary to test the functioning of a system itself, substantiation of individual components can be made separately from the system they are part of.

5. FAR 33.91 (Paragraph 62 of AC 33.2B) Engine System and Component Tests.

Section 33.91 Engine system and component tests.

The following changes are made to paragraph 62;

- a) Change the section title in both places to be "Engine System and Component Tests"
- b) Change the rule to read as follows:

33.91 Engine Systems and Components Tests

- (a) For those systems or components which cannot be adequately substantiated by the endurance testing of FAR 33.87, additional tests or analyses must be conducted to demonstrate that the systems or components are able to perform the intended functions in all declared environmental and operating conditions.
- c) Change "Guidance" to be as follows:

The intent of FAR 33.91 is to define the additional tests or analysis, which would be necessary for those systems or components which are not necessarily tested during the endurance test of §33.87.

- (1) It is also recognized that the other requirements of FAR 33 do not always provide sufficient testing to cover all the conditions (pressure, temperature, vibration, etc....) which

could affect the airworthiness of a piece of equipment throughout the declared flight envelope and within all the declared installation conditions.

Other reasons for testing under 33.91 include but are not limited to the following examples:

- When testing is required in support of 33.28(a) validation throughout the declared flight envelope and within all the declared installation conditions.
- When, for example, an overspeed protection system (or a torque limiter) is unlikely to be tested during the scheduled tests of FAR 33.87.
- When an engine electronic control system has a mechanical back-up which is not normally used during the endurance test.
- When demonstration that a failure indicating system, on which dependence is placed in the engine safety analysis, will function satisfactorily when required.

The Applicant should define, in agreement with the Authority prior to the start of testing, all necessary testing and / or analysis for those accessories or systems that need specific substantiation, in addition to the certification tests performed on a complete Engine, with attention paid to their location and operating conditions. Unless it is necessary to test the functioning of a system itself, substantiation of individual components can be made separately from the system they are part of.

The Applicant should define, in agreement with the Authority prior to the start of testing, all necessary conformity for both the hardware and the test setups. Conformity should be documented as part of the Certification Report. Differences between the test hardware and the type design hardware should be reviewed and approved by the Authority prior to the start of testing and included as part of the reconciliation in the Certification Report.

(2) The manufacturer should consider the applicability of the items listed in the Tables 1 to 4 below which are considered as being a guide. Additional guidance for EMI, HIRF and lightning is provided in AC 33.28 for all electrical/electronic components or components with electrical/electronic sub-components.

Consideration of general conditions such as those of RTCA DO 160 allows certification of components in a consistent manner, independently from any installation consideration. Nevertheless, the considered conditions must be shown to encompass the particular conditions specific to the declared installation. Documents that provide acceptable test procedures for each item are referenced in the same table. Other acceptable appropriate test and analysis procedures may be defined by the applicant. Compliance is normally demonstrated by test or analysis unless the component is shown to be sufficiently similar to and operates in an environment which is the same or less severe than previously certified components for which similarity is claimed.

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The intent and applicability of each item of Tables 1 to 4 are also specified after each table.

The following list of applicable requirements and the associated tests or procedures (or their equivalent) has been accepted for evaluating component airworthiness. FAA approval of these environmental test plans should be obtained prior to commencing the tests.

(a) General Environmental Conditions

The following environmental conditions should be considered for all components.

Table 1

	ENVIRONMENTAL CONDITIONS	ACCEPTABLE TESTS/PROCEDURES
1	High Temperature Demonstration	EUROCAE ED-14 / RTCA DO-160, section 4 or Mil-E-5007 paragraph 4.6.2.2.5
2	Low Temperature Demonstration	EUROCAE ED-14 / RTCA DO-160, section 4 or Mil-E-5007 paragraph 4.6.2.2.7
3	Room Temperature Demonstration	EUROCAE ED-14 / RTCA DO-160, section 4 or Mil-E-5007 paragraph 4.6.2.2.6
4	Contaminated Fluids	As a reminder. See FAR requirements 33.67, 33.71, 33.66 for fuel/oil/air requirements. Mil-E-5007 paragraph 4.6.2.2.6 (fuel test only)
5	Vibration	EUROCAE ED-14 / RTCA DO-160, Section 8
6	Impact	EUROCAE ED-14 / RTCA DO-160, Section 7
7	Sustained Acceleration	EUROCAE ED-14 / RTCA DO-160, Section 7 or MIL-STD-810E, Method 513
8	Sand and Dust	EUROCAE ED-14 / RTCA DO-160, Section 12, Category D or MIL-STD-810
9	Fluid Susceptibility	EUROCAE ED-14 / RTCA DO-160, Section 11, Category F

10	Salt Spray	EUROCAE ED-14 / RTCA DO-160, Section 14, Category S / MIL-STD-810
11	Fuel System Icing	As a reminder. See FAR 33.67
12	Induction Icing	As a reminder. See FAR 33.68 & 33.35
13	Fungus	EUROCAE ED-14 / RTCA DO-160, Section 13, Category F
14	Temperature and Altitude	EUROCAE ED-14 / RTCA DO-160, Section 4

High Temperature Demonstration :

The high temperature demonstration is to verify that the component can function properly in its maximum temperature environment and to identify any damage caused by exposure to maximum temperature that could lead to component failure. Maximum conditions must take into account both ambient and external and internal fluids to which the component is exposed. Historical requirements can be found in MIL-E-5007 Paragraph 4.6.2.2.5. For electrical components with no mechanical elements (EUROCAE ED-14 /RTCA DO-160 Section 4) tests have been used to show compliance.

Low Temperature Demonstration :

The low temperature demonstration is to verify that the component can function properly in its minimum temperature environment and identify any damage caused by exposure to minimum temperature that could lead to component failure. Minimum conditions must take into account both ambient and external and internal fluids to which the component is exposed. Historical requirements can be found in MIL-E-5007 Paragraph 4.6.2.2.7. For electrical components with no mechanical elements (EUROCAE ED-14 /RTCA DO-160 Section 4) tests have been used to show compliance.

Room Temperature Demonstration :

The room temperature demonstration is to identify any damage caused by extended operation at room temperature that could lead to component failure. EUROCAE ED-14 / RTCA DO-160, section 4 tests have been used to show compliance. Historical requirements can be also be found in MIL-E-5007 Paragraph 4.6.2.2.6. This test may be combined with the contaminated fluids test, if applicable.

Contaminated Fluids:

The contaminated fluids requirement is to verify that the engine systems can function properly in a contaminated fluid environment. This can be achieved either by system testing or individual component test/analysis. Refer to the applicable FAR 33 requirements, such as Far 33.67 for fuel, FAR 33.71 for oil, and FAR 33.66 for air, for more details. Testing may be combined with room temperature demonstration.

Vibration :

The vibration requirement is to verify that exposure to the declared vibration environment does not cause structural failures and to verify that the component functions properly when exposed to that vibration. This can be addressed by either a specific unbalanced engine test or by component test. The component may not be required to be operational during component testing if the applicant can demonstrate by other means that the component operates satisfactorily or does not adversely impact system operation when

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subjected to the declared vibration environment. EUROCAE ED-14 / RTCA DO-160, Section 8 tests are appropriate if the component vibration environment can be correlated to the DO 160 standards.

Impact :

The impact requirement is to verify that exposure to a specified level of impact does not cause structural failure. EUROCAE ED-14 / RTCA DO-160, Section 7 tests are appropriate. It may be possible to demonstrate compliance with an installation environment requiring operational shocks and crash safety testing through other tests conducted on the engine, such as blade-out tests, for example.

Sustained Acceleration :

The sustained acceleration requirement is to verify that exposure to sustained acceleration experienced during aircraft operations do not cause structural failure and verify that the component functions properly during and after exposure to sustained acceleration. EUROCAE ED-14 / RTCA DO-160, Section 7 are appropriate.

Sand and Dust :

The sand and dust requirement is applicable to all components that are not environmentally sealed. Testing should be performed according to EUROCAE ED-14 / RTCA DO-160 section 12, category D.

Fluid Susceptibility :

The fluid susceptibility requirement is to verify that the component can function properly after exposure to specified fluids and identify any damage caused by such exposure that could lead to component failure. Normally the fluids to be considered are those likely to be encountered in service, such as fuel, oil, hydraulic fluids, cleaning solvents, etc. Component testing may follow the procedures defined in EUROCAE ED-14 / RTCA DO-160 section 11, category F, paragraph 11.4.1 (Spray Test). At the conclusion of the test, the unit under test should be opened and inspected for entry of the test fluid. If evidence of fluid entry is detected the applicant should provide the rationale for accepting the test results based on the criticality of the quantity and location of the fluid entry point.

Salt Spray :

The salt spray requirement is to verify proper component operation after exposure to a salt spray environment. For environmentally sealed components, the requirement may be substantiated by an analysis that shows that the component external materials are immune to a salt spray environment. Testing may be performed according to EUROCAE ED-14 / RTCA DO-160 sections 14, category S.

Fuel System Icing :

Fuel system components normally substantiate their capability to operate in icing environment through system test or analysis.

Induction Icing :

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Components exposed to engine gas path or bleed system icing normally substantiate their capability to operate in icing environment through an engine test or analysis.

Fungus :

The fungus requirement is substantiated by test or an analysis which shows that no materials which support the growth of fungus are used in the component. Testing may be performed as defined in EUROCAE ED-14 / RTCA DO-160, section 13.0, category F, (Fungus Resistance).

Temperature and Altitude:

The purpose is to verify by test or an analysis that the component operates per design intent through out the engine flight envelope. Testing may be performed as defined in EUROCAE ED-14 / RTCA DO-160, section 4.0,

(b) General Environmental Conditions for Electrical /Electronic Components.

The following environmental conditions should be considered for all electrical/electronic components or components with electrical/electronic sub-components. Additional advisory material on EMI, HIRF and lightning may be found in AC 33.28-1A.

Table 2

	ENVIRONMENTAL CONDITIONS	ACCEPTABLE TESTS/PROCEDURES
15	Thermal Cycle	EUROCAE ED-14 / RTCA DO-160, Section 5
16	Explosion Proofness	EUROCAE ED-14 / RTCA DO-160, Section 9
17	Humidity	EUROCAE ED-14 / RTCA DO-160, Section 6 / MIL-STD-810
18	Waterproofness	EUROCAE ED-14 / RTCA DO-160, Section 10 / MIL-STD-810 (RAIN)
19	EMI, HIRF & lightning	See AC 33.28-1A
20	Power Input	EUROCAE ED-14 / RTCA DO-160, Section 16 and 17/ MIL-STD-704

Thermal Cycle :

The thermal cycle requirement is to demonstrate that a component will continue to operate and not fail or be damaged when exposed to temperature cycles and thermal transients consistent with the declared temperature environment. Component testing may

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follow the procedures defined in EUROCAE ED-14 / RTCA DO-160, Section 5. Unless other substantiating data is provided, a minimum of 10 thermal cycles should be considered for temperature variation. If the component has electrical sub-components, testing of the sub-components only may be acceptable.

Explosion Proofness:

The explosion proof requirement is to verify that a component cannot cause an explosion of flammable fluids or vapors. If applicable, explosion proof testing may be performed as defined in EUROCAE ED-14 / RTCA DO-160, section 9 (Explosion Proofness). Section 9 of DO-160 is applicable for demonstrating compliance with §33.28 and §33.91.

Environment I defines equipment mounted in fuel tanks or within fuel systems.

Environment II is an atmosphere in which flammable mixtures can be expected to occur as the result of a "fault causing spillage or leakage".

For installations in a Fire zone, the Fire zone will have extinguishing provisions, so that the explosion proof test given by Environment II of DO-160, section 9 is adequate. However, Flammable Fluid Leakage (FFL) areas may not have fire extinguishing provisions or any of the other safety requirements associated with Fire zones based on the assumption that there are no ignition sources in these areas. In these cases the explosion proof test given by **Environment I** of DO-160, section 9 may be required for aircraft installation. The applicant should note in the installation for instructions which environmental test has been conducted. Unless Environmental I testing has been conducted, the applicant should alert the installer in the installation for instructions that the equipment may be an ignition source.

Humidity :

The humidity requirement is to demonstrate that the component is not adversely effected, operationally or structurally, by ingress of moisture. Testing may be performed according to EUROCAE ED-14 / RTCA DO-160 section 6,

Waterproofness :

The water requirement is to verify that the component can function properly after exposure to water and identify any damage caused by water exposure that could lead to component failure. Water testing may be performed according to EUROCAE ED-14 / RTCA DO-160 section 10, Category S. Following the test, the unit under test should be opened and inspected for entry of water. If evidence of water entry is detected, the applicant should provide the rationale for accepting the test results based on the criticality of the quantity and location of the water entry point.

Power Input :

The power input requirement applies only to electrical/electronic components or components with electrical/electronic sub-components that receive power directly from the aircraft (e.g., EEC, HMU fuel shutoff solenoid). The purpose of this test is to demonstrate that such components can accommodate the full range of power inputs

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declared for the installation. For applicable components, requirement may be substantiated by the test defined in EUROCAE ED-14 / RTCA DO-160, section 16.

(c) Mechanical Components

Other requirements of FAR 33 may affect some components as follows.

Table 3

	SUBJECT	ACCEPTABLE TESTS/PROCEDURES
21	Proof Pressure	FAR 33.18
22	Burst Pressure	FAR 33.18
23	Pressure Cycling Test	FAR 33.18
24	Fire	FAR 33.17 [Note: The engine control system must comply with 33.17(e)]

The related AC 33.17-1 and AC 33.18-1 are therefore relevant.

(d) Specialized Component Testing

Table 4

Specialized Component Testing	SUBJECT	ACCEPTABLE TESTS/PROCEDURE
25 Engine electronic control systems	Overheat	FAR 33.28 (b)(1)(iii)

Overheat:

The purpose of this test or analysis is to verify that the electrical/electronic portions of the engine control system, when subjected to an overheat condition leading to failure, will not cause a hazardous engine effect. See also AC 33.28-1A. If an overheat test/analysis is not completed, this must be declared as an installation limitation in the engine installation instructions and the consequences of an overheat should be addressed at aircraft certification.

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U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

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**Subject: COMPLIANCE CRITERIA FOR 14 CFR
§33.28, AIRCRAFT ENGINES, ELECTRONIC
ENGINE CONTROL SYSTEMS.**

**Date: October 10, 2000
Initiated By:
Cosimo Bosco,
ANE-110**

**AC No: 33.28
Change: Rev. 1A
Version 9b**

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AC33.28-1A supercedes AC33.28-1.

AC33.28-1A has been harmonized with revised AMJ 20X-1 (Certification of Aircraft Propulsion Systems Equipped with Electronic Engine Control Systems) as part of the terms of reference (TOR) issued by the Engine Harmonization Working Group (EHWG) to the Electronic Engine Control Task Group (EECTG) to harmonize FAR33.28 and JAR E-50. This activity is part of the overall ARAC effort to harmonize the JARs and FARs..

Harmonization of §33.28 and JAR E-50 resulted in a change in §33.28 to apply the rule to all types of engine controls, including hydromechanical controls. Because both AC33.28-1 and AMJ 20X-1 provide advisory material dedicated to electronic engine control systems, it was decided to keep these documents dedicated to electronic engine control systems and to provide additional guidance material applicable to engine control systems implemented in other than electronic technologies. This additional advisory material is provided in an FAA policy memorandum that subsequently will be included in AC33.2B, Aircraft Engine Type Certification Handbook at the next update of this advisory circular.. The policy memorandum is harmonized with the corresponding ACJ advisory material from the JAR.

This document does not represent Final Agency Action on this matter, and shall not be viewed as a
promise that any final action will follow in this or any other form.

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1. **PURPOSE.** This Advisory Circular (AC) provides guidance and acceptable methods, but not the only methods, that may be used to demonstrate compliance with the regulations of Title 14 of the Code of Federal Regulations (14 CFR), part 33 section 33.28. Like all AC material, this AC is not, in itself, mandatory and does not constitute a regulation. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration (FAA) and industry experience in determining compliance with the pertinent regulations.

The existing regulations for engine certification may require specific interpretation for engines equipped with electronic control systems with special regard to interface with the certification of the aircraft, and propeller when applicable. Because of the nature of this technology it has been considered useful to prepare advisory material specifically addressing the certification of these control systems.

This document discusses the compliance tasks relating to the engine, propeller and aircraft certification processes and indicates how these tasks could be allocated between the engine, propeller and aircraft manufacturers. It does not, however, seek to define or to interfere with the contractual arrangements made between the engine, propeller and aircraft manufacturers for the provision of any particular data.

2. **SCOPE.** This advisory material provides guidance on the interpretation and means of compliance with the relevant engine certification requirements for electronic engine control (EEC) systems, whether implemented in electrical and electronic, analog or digital technology. Additional guidance material is provided in interim policy memorandum , Advisory Material for FAR 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91 Affected by the Engine Harmonization Working Group (EHWG) Harmonization Effort dated [insert date] that will be integrated into the forthcoming update to AC33.2B.

It gives guidance on the precautions to be taken for the use of electronic technology for engine control and protection, limiting, and monitoring functions, and, where applicable, for integration of functions specific to an aircraft or a propeller. In the latter cases, this document is applicable to such functions integrated into the EEC system, but only to the extent that these functions affect compliance with FAR requirements.

Precautions have to be adapted to the criticality of the functions. These precautions may be affected by the degree of authority of the system, the phase of flight and the availability of a back-up system as defined in Section (7) of this AC.

3. RELEVANT REGULATIONS (CFR) AND REFERENCE DOCUMENTS.

a. **Relevant Regulations (CFR).** Sections 21.16, 33.4, 33.5, 33.17, 33.19, 33.27, 33.29, 33.49, 33.53, 33.75, 33.91(a), Appendix A of part 33, 23.901, 23.903, 23.1309, 25.901, 25.903, 25.939, 25.1181, 25.1309, 27.901, 27.903, 27.1309, 29.901, 29.903, 29.1309

b. **Reference Documents (Advisory Circulars, Notices and Policy Letters/Memoranda).**

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(1) AC 20-115B, RTCA, Inc. Document RTCA/DO-178B, dated January 11, 1993 (AMJ 20-115B) RTCA Document RTCA/DO-178B/EUROCAE ED-12B).

(2) AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning, dated 3 May 1990 (SAE-AE4L 87-3 REV B dated October 1989).

(3) AC 20-53A, Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning, dated April 22, 1991.

(4) Federal Aviation Administration (FAA) Notice N8110.71, Guidance For The Certification of Aircraft Operating in High Intensity Radiated Field (HIRF) Environments, dated April 2, 1998.

(5) AC No. 21-16C (RTCA Document No. DO-160C) Environmental Conditions and Test Procedures For Airborne Equipment, dated February 14, 1990, and AC No. 21-16D (RTCA DO-160D/EUROCAE ED-14D) Environmental Conditions and Test Procedures for Airborne Equipment, dated July 21, 1998.

(6) Policy Memorandum, FAA Engine and Propeller Directorate Policy Regarding Time Limited Dispatch (TLD) Of Engines Fitted With Full Authority Digital Engine Control (FADEC) Systems, dated October 28, 1993.

(7) AC 33.2B Aircraft Engine Type Certification Handbook, dated June 30, 1993.

c. Industry Documents

(1) RTCA . DO-160D/EUROCAE ED14D, Environmental Conditions and Test procedures for Airborne Equipment, dated July 29, 1997.

(2) RTCA . DO-178B/EUROCAE ED12D, Software Considerations in Airborne Systems and Equipment Certification, dated December 1, 1992.

(3) SAE ARP 5107; Guidelines for Time-Limited-Dispatch for Electronic Engine Control Systems issued June 1997.

(4) SAE ARP 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems issued November 1996.

(5) SAE ARP 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems issued December 1996.

(6) SAE ARP 926A/B Fault/Failure Analysis Procedure.

(7) SAE ARP 1834/A Fault/Failure Analysis for Digital Systems.

(8) RTCA DO-254/ EUROCAE ED-80 dated April 19, 2000.

d. Military Specifications

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(1) MIL-STD-461D, Requirements For the Control of Electromagnetic Interference Emissions and Susceptibility, dated January 11, 1993.

(2) MIL-STD-462D, Measurement of Electromagnetic Interference Characteristics, Test Standard For, dated February 5, 1996.

(3) MIL-STD-810E, Environmental Test Methods and Engineering Guidelines, dated July 31, 1995.

(4) MIL-HDBK-217F, Reliability Prediction of Electronic Equipment, dated February 28, 1995

(5) MIL-E-5007D Engines, Aircraft, Turbojet and Turbofan, General Specification For, dated October 15, 1973

4. PRECAUTIONS. The introduction of electronic technology can entail the following:

a. A greater dependence of the engine on the aircraft owing to the use of electrical power or data supplied from the aircraft,

b. A risk of significant failures common to more than one engine of the aircraft which might, for example, occur as a result of:

(i) Insufficient protection from electromagnetic disturbance (lightning, internal or external radiation effects), [see §33.28(a)(2)]

(ii) Insufficient integrity of the aircraft electrical power supply, [see §33.28(e)]

(iii) Insufficient integrity of data supplied from the aircraft, [see §33.28(d)]

(iv) Hidden design faults or discrepancies contained within the design of the propulsion system control software [see §33.28(c)], or

(v) Omissions or errors in the system/software specification. [see §33.28(c)]

Special design and integration precautions should therefore be taken to minimize these risks. One basic objective behind the rules of §33.28 is to keep the same independence of the engine from the aircraft as was provided with purely hydromechanical control systems for not aggravating an aircraft situation by adding a wrong behavior of the engine.

5. DEFINITIONS. The following definitions apply in the context of engine control systems for use of this AC.

Aircraft-supplied data means information which is generated in the aircraft systems and is used by the engine control system but whose source is not controlled under the

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design authority of the engine certification applicant. This does not include inputs from those sensors which are used by, and normally dedicated to, the engine control system but which may be mounted in the airframe.

Alternate Control Mode means one mode where the operating characteristics or capabilities of the engine control are sufficiently different from the “primary mode” that the operating characteristics or capabilities of the aircraft, crew workload, or what constitutes appropriate crew procedures may be significantly impacted or changed.

Back-up system means a different type of system which is used as a stand by or alternate control mode to the primary or normal control mode or system.

Commercial and Industrial Grade Electronic Parts means commercial and industrial grade parts not manufactured to military standards.

Electronic Engine Control (EECS) System means the complete system which includes all the components necessary for the control of the power or thrust output of the engine, within the flight envelope and operating limitations.

Electronic Engine Control (EEC) Unit means the main electronic unit(s) of an electronic engine control system that usually includes the computing elements.

Fault or Failure means an occurrence which affects the operation of a component, part, or element such that it can no longer function as intended (this includes both loss of function and malfunction). Errors may cause failures, but are not considered to be failures.

Fault or Failure Condition means a condition having an effect on the airplane and/or its occupants, either direct or consequential, which is caused or contributed to by one or more failures or errors, considering flight phase and relevant adverse operational or environmental conditions, or external events.

Fault or Failure Detection means the discovery of a fault or failure or the resulting condition.

Fault or Failure Accommodation means the capability of the engine control system or flight crew to mitigate, either wholly or in-part, the fault or failure.

Full Authority Digital Engine Control (FADEC) means an engine control system in which the primary functions are provided using digital electronics and wherein the electronic engine control (EEC) unit has full-range authority over the engine power or thrust.

Full-up System or Configuration means an EECS that has no faults or failures present, detected or undetected, which affect the control of engine power or thrust, engine

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protection systems, indication of critical engine operating parameters or other safety features of the engine control system.

Loss of Thrust or Power Control (LOTC) means a condition where the control has lost the capability, due to control system failures or malfunctions, of governing the engine within the bounds contained in paragraph 8 of this AC.

Per hour means "per engine flight hour."

Primary Mode The mode of operation that is intended to be used for controlling the engine. This is often referred to as the "normal mode".

Programmed Logic Device means custom micro-coded components, such as Application Specific Integrated Circuits (ASIC) and Programmable Logic Devices (PLDs).

Uncovered Fault means a fault or failure for which either no detection mechanism exists or, if detected, no accommodation exists.

6. GENERAL. One of the objectives for the engine manufacturer in an engine certification program is to show that the certificated engine should be "installable" in a particular aircraft or aircraft type. It is recognized that the determination of compliance of the engine control system with applicable aircraft certification regulations will only be made during aircraft certification. . In the case where the application is unknown at the time of engine certification, the engine manufacturer should make reasonable installation and operational assumptions for the target application. Any installation limitations or operational issues will be noted in the instructions for installation or operation, and/or the Type Certification Data Sheet (TCDS).

When possible, co-ordination between the engine and the aircraft manufacturers is recommended in association with the relevant authorities as discussed under paragraph (16) of this AC.

7. SYSTEM DESIGN AND VALIDATION

(a) Control Modes

Under FAR 33(a)(1)(i) the applicant must perform all necessary testing and analysis to ensure that all control modes, including those which occur as a result of control fault accommodation strategies, are implemented as required.

All control modes, including alternative or back-up modes, should be capable of performing their intended functions in the environmental conditions, including HIRF and Lightning, declared in the engine instructions for installation. . "Performing their intended functions" means that the system functions within its specified limits throughout the declared operating conditions and flight envelope. It is assumed that the specified limits will result in a system that complies with Part 33 requirements. In some cases the agreed test plan(s) may allow for some transitory perturbations which are within the requirements for compliance with Part 33.

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In addition the requirement states that the system must comply with the specified operability requirements "...under all likely system inputs and allowable engine power or thrust demands...". This phrase means that the system should not limit the pilot inputs in order to comply with the operability requirements.

These rules and advisory material are not specifically intended to apply to any crew training modes. These modes are usually application, and possibly operator, specific and need to be negotiated on a case-by-case basis. However training modes should be described in the engine instructions for operation. Also precautions should be taken in the design of the control and its crew interfaces to prevent inadvertent entry into any training modes.

The need to provide protective functions, such as overspeed protection, for all control modes, including any alternative or backup modes, should be reviewed under the requirements of 33.28(b)(3) and 33.75.

For rotorcraft propulsion control systems with power turbine speed governing the requirement for modulation of engine power should be interpreted as the ability to progressively apply power as required to maintain power turbine speed within specified limits.

Any uncommanded power oscillations should be of such a magnitude as not to impact aircraft controllability in the intended application. In general, power oscillations less than 5% of normal maximum rated power at the flight condition may be considered acceptable. Regardless of the levels discussed herein, if the flight crew has to shutdown an engine because of unacceptable thrust or power oscillations, such an event would be deemed an in-service LOTC event.

§33.28(a)(1) primarily applies to the engine control system operating in its normal full-up configuration and to those alternative or back-up control modes for which the applicant wishes to take credit in his LOTC analysis for compliance with FAR 33.28(b). The engine control may have fault accommodation configurations or other operating modes that are safe, but transfer of operation into these modes or configurations would be normally classified as an LOTC event. Moreover, the applicant should provide assurance that operation in any such configurations will not result in an engine hazardous event, as defined in §33.75. All such configurations should be defined in the engine instructions for operation.

For control configurations where the applicant seeks to take credit in his LOTC analysis, but which are not intended to be dispatchable configurations, it may be acceptable to have specific operating limitations. In addition, compliance with 33.28(a)(1)(i) does not imply strict compliance with the operability requirements of §33.51, §33.65 and §33.73 in these non-dispatchable configurations, if it can be demonstrated that, in the intended application, no likely pilot control system inputs will result in engine surge, stall, flame-out or unmanageable delay in power recovery.

For example, in a twin-engined rotorcraft, a rudimentary back-up control may be adequate since frequent and rapid changes in power setting with the back-up control may not be necessary.

In addition to these operability considerations, other factors which should be considered in assessing the acceptability of such reduced-capability back-up control modes include :-

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- The installed operating characteristics of the back-up mode and the differences from the primary mode. Consideration should be given to the likely impact on pilot workload, if the application is known, of any alternative control modes.
- The rate of transfer from the primary to the back-up mode (i.e. the reliability of the primary mode). Transfer rates of less than 1 per 20,000 hours have been considered acceptable.

Any limitations on operations in alternative or back-up modes should be clearly stated in the engine instructions for operation.

Descriptions of the functioning of the engine control system operating in its primary and any alternative modes should be provided in the engine instructions for installation and operation.

Early coordination between the engine manufacturer and the airframe manufacturer is recommended in order to ensure that the requirements for compliance with the appropriate airworthiness standards of CFR 14 Subchapter C are understood.

Performing some portion of the engine certification testing in the alternate or back-up mode(s), including transition between modes, can be used as part of the system validation required under §33.28(a)(1). However, analyses are generally required to substantiate that operating in the alternative or back-up modes has no effect on engine durability or endurance. As with the primary mode, demonstration of the durability and reliability of the control system in all modes is primarily addressed by the system or component testing of §33.91.

Engine Test Considerations - If the engine certification tests defined in FAR 33 are performed using only the primary full-up control system, it should be demonstrated, by analysis and/or test, that the engine can meet the defined test-success criteria when operating in any alternative or back-up control mode, if the alternate or back-up mode is considered dispatchable. This would be applicable to test requirements such as operability, blade-off, rain, hail, bird ingestion etc..

There may be some control modes which are not intended to be dispatchable, but for which LOTC credit is being sought, in which such capability may be lost. This may be acceptable provided that the safety assessment and the installation instructions reflect this loss of capability

Availability - If the applicant seeks to take credit in his LOTC analysis for a back-up control mode which is not normally exercised, then, in addition to meeting the above criteria, the availability of the back-up should be established by routine testing or monitoring to ensure that the back-up will be available when needed. The frequency of the testing should be approved by the certifying authority and documented in the instructions for installing and operating the engine.

(b) Control Mode Transitions

The intent of §33.28 (a)(1)(ii) is to ensure that any control mode changes, which occur as a result of control fault accommodation strategies, are implemented in an acceptable manner.

"Unacceptable thrust or power oscillations" are defined in Section 7(a), above. "Other detrimental characteristics" as required in the rule include flameout, over temperature or over speed, for example, in addition to preventing surge and stall.

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In general, transition to the alternative mode should be accomplished automatically by the engine control system. However, systems wherein pilot action is required to engage the back-up mode may also be acceptable. For instance, a fault in the primary system may result in a “failed-fixed” fuel flow (constant power output) and some action is required by the pilot to engage the back-up system in order to modulate engine power.

The transient change in power or thrust associated with transfer to the alternate mode should be reviewed with the cognizant authority for compliance with 33.28(a)(1)(ii). Input from the installer should be considered. Although this is not to be considered a complete list, some of the items that should be considered when reviewing the acceptability of control mode transitions are:

- The frequency of occurrence of transfers to any alternate control mode and the capability of the alternate mode. Computed frequency-of-transfer rates should be supported with data from endurance or reliability testing, in-service experience on similar equipment, or other appropriate data.
- The magnitude of the power, thrust, rotor or propeller speed transients.
- Successful demonstration, by simulation or other means, of the ability of the engine control system to control the engine safely during the transition. In some cases, particularly those involving rotorcraft, it may not be possible to make a determination that the mode transition provides a safe system based solely on analytical or simulation data. Therefore, it may be advantageous to the applicant to propose a flight test program to support the data.
- For compliance with 33.28(a)(1)(ii), an analysis should be provided to identify those faults that cause control mode transitions either automatically or through pilot action.
- For helicopter or propeller applications, the transition should not result in excessive overspeed or underspeed of the rotor or propeller which could cause emergency shutdown, loss of electrical generator power or the setting-off of warning devices.

The power or thrust change associated with the transition should be declared in the instructions for installing the engine.

Time Delays - Any observable time delays associated with control mode transitions or in re-establishing the pilot’s ability to modulate engine thrust or power should be identified in the engine instructions for operation. These delays would be assessed during aircraft certification.

Annunciation to the Flight Crew – If annunciation is required, the type of annunciation to the flight crew should be commensurate with the nature of the transition. For instance, reversion to a “supervisory” mode of control where the transition is automatic and the only observable changes in operation of the engine are different thrust control schedules, would require a very different form of annunciation to that required if timely action by the pilot is required in order to maintain control of the aircraft.

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The intent and purpose of the cockpit annunciation should be clearly stated in the engine instructions for installation. Early coordination between the engine manufacturer and the airframe manufacturer is recommended in order to ensure that the requirements are understood and that suitable provision is made in the airframe design.

(c) HIRF, lightning, and electromagnetic interference (EMI) system tests.

("Advisory Material for FAR 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91 Affected by the Engine Harmonization Working Group (EHWG) Harmonization Effort" dated 2000 is the program memorandum associated with this harmonization effort. It provides guidance for other environmental tests under the section dedicated to §33.91. The program memorandum will be integrated into AC33.2B, Aircraft Engine Type Certification Handbook at its next update. Environmental tests in accordance with MIL-STD-810E may be accepted in lieu of DO-160 tests where the MIL-STD-810E tests are equal to or more rigorous than those defined in DO-160.))

(i) Declared levels

When the installation is known, the engine control system during the engine type certification program should be tested at levels that have been determined and agreed by the engine and aircraft manufacturers. It is assumed that, by this agreement, the installation can meet the aircraft certification requirements. Successful completion of the testing to the agreed upon levels would be accepted for engine type certification. This, however, may make engine installability dependent on a specific aircraft installation.

If the aircraft application is not known or defined at the time of the engine certification, in order to determine the levels to be declared for the engine certification, the engine manufacturer may use the general threat defined at the aircraft level and use assumptions on installation attenuation effects.

If none of the conditions defined above is available, it is recommended that minimum default levels for system laboratory HIRF tests be as follows :

- For frequencies from 10 kHz to 700 MHz, a minimum test level should be 100 volts per meter average.
- For frequencies from 700 MHz to 18 GHz, the minimum test level should be 200 volts per meter average.
- For rotorcraft applications, the minimum test level should be 200 volts per meter average over the entire frequency range from 10 kHz to 18 GHz.

(ii) Test procedures.

(A) General

The installed engine controls system, including representative engine-aircraft interface cables, should be the basis for certification testing.

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EMI tests procedures and test levels conducted in accordance with MIL-STD-461/462 or DO-160 have been considered acceptable. However, when using MIL-STD-461/462, if the two test procedures differ for a particular test case, the applicant should provide the rationale for conducting the test using the MIL-STD procedure rather than that of DO-160.

The applicant should use the HIRF test guidelines provided in Section 20 of RTCA / DO-160 / EUROCAE ED-14D or equivalent. However, it should be recognized that the tests defined in DO-160 are applicable at a component test level, requiring the applicant to adapt these test procedures to a system level HIRF test to demonstrate compliance with §33.28 (a)(2).

For lightning tests, the guidelines of AC 20-136 and Section 22 of DO-160 would be applicable. Pin Injection Tests (PIT) are normally conducted on the EEC unit and other system components as required. PIT levels are selected as appropriate from the tables of Section 22 of DO-160.

(B) Open loop versus Closed loop

HIRF, lightning, and EMI tests should be conducted as system tests on closed loop or open loop laboratory set-ups. The closed loop set-up is usually provided with hydraulic pressure to move actuators to close the inner actuating loops. A simplified engine simulation may be used to close the outer engine loop. Testing should be conducted with the engine control system controlling at the most sensitive operating point, as selected by the applicant. The system should be exposed to the HIRF, lightning, and EMI environmental threats while operating at the selected condition. There may be a different operating point for HIRF, lightning, and EMI environmental threats.

If the applicant elects to conduct tests in open loop set-ups, the following factors should also be considered :

- If special EEC test software is used, that software should be developed and implemented by guidelines defined for software levels of at least Level 2 in DO-178A, Level C in DO-178B, or equivalent. In some cases, the application code is modified to include the required test code features.
- The system test set-up should be instrumented to monitor both the output drive signals and the input signals.
- Anomalies observed on inputs or outputs should be duplicated on the engine simulation to determine whether the resulting power or thrust perturbations comply with the pass/fail criteria.

(iii) Pass/Fail Criteria

The pass / fail criteria for HIRF and lightning is that there should be "no adverse effect" on the functionality of the system.

The following are considered adverse effects :

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- A greater than +/- 2 percent (+/- 10% for Small General Aviation applications) change of rated power or thrust change from the normal control governing capability for a period of more than one second.
- Transfers to alternate channels, backup systems, or reversionary modes.
- Component damage.
- Significant fault codes recorded in the fault memory.
- False fault annunciation to the crew which could cause unnecessary or inappropriate crew action.
- Erroneous operation of overspeed or thrust reverser circuits.

(iv) **Component and Software Design Changes**

Hardware or Software design changes implemented after initial qualification should be evaluated for their effects with respect to the EMI/HIRF and lightning environment. Appropriate testing and/or analysis should be defined to ensure that the original basis for certification is maintained. Component level testing may be acceptable for such purposes.

(v) **Maintenance Actions**

§33.4 requires that the applicant prepare Instructions for Continued Airworthiness (ICA). This includes a maintenance plan. Therefore, for any protection system that is part of the type design of the engine control system and is required by the system to meet the qualified levels of HIRF and lightning, a maintenance plan should be provided to ensure the continued airworthiness for the parts of the installed system which are supplied by the engine manufacturer.

The maintenance actions to be considered include periodic inspections or tests for required structural shielding, wire shields, connectors, and equipment protection components. The applicant should provide the engineering validation and substantiation of these maintenance actions.

(vi) **Time Limited Dispatch (TLD) Environmental Tests**

Although TLD is not a requirement for certification, HIRF and lightning tests for TLD are usually conducted together with tests conducted for certification. In order to gain approval for the use of TLD, applicants should demonstrate that dispatchable EEC configurations continue to meet the environmental requirements of the certification basis. For example, in some cases a single channel dispatch configuration is the worst case dispatch configuration and HIRF and lightning tests should be conducted on such a configuration to demonstrate compliance.

8. INTEGRITY OF THE CONTROL SYSTEM.

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The intent of 33.28(b) is to establish engine control system integrity requirements consistent with operational requirements of the various applications. In particular, the introduction of electronic control systems should provide at least an equivalent level of safety and reliability for the engine - as achieved by engines equipped with hydromechanical control and protection systems, and magneto systems.

Mechanical and hydromechanical engine control systems rely on mechanical inspection intervals and "soft failure characteristics" to ensure control system integrity and airworthy operation between control system maintenance intervals.

The hardware of electronic control systems, however, tends to be characterized by random failures and does not lend itself to inspection for component wear. It is recognized that in order to achieve an upper limit on the LOTC rate consistent with the application, electronic engine control systems should use redundancy and fault accommodation techniques to ensure safe and reliable control system operation following failure of electrical or electronic components

1. Engine Control Design and Construction:

A. General LOTC Guidance:

The LOTC rate is the predicted number of LOTC events per engine flight hour. This predicted rate includes all single and combinations of control system failures or malfunctions that lead to LOTC events.

(1) Definition of LOTC events and guidance on LOTC rates:

(a) The following guidance is applicable to engine controls for FAA/JAA Part 23 installations complying with Part 25 propulsion requirements and Part 25 transport aircraft applications. For engines used in these applications, the electronic engine control (EEC) system should not cause more than one LOTC event per 100,000 engine flight hours. For these applications, an LOTC event is defined as one where:

- (i) the engine control system has lost the capability of modulating thrust or power between flight idle and 90% of maximum rated power or thrust at the operating condition, or**
- (ii) the control system suffers a fault which results in a thrust or power oscillation greater than the levels given in Section 7 of this AC.**
- (iii) the control has lost the capability to govern the engine in a manner which allows compliance with the operability requirements given in 33.65 and 33.73.**

(b) The following guidance applies to engine control systems intended for applications other than those defined in A.(1)(a) above:

- (i) Unless another LOTC rate is agreed (see paragraph (ii) below), the 1 per 100,000 hour LOTC rate defined above is still considered to be applicable, For these applications an LOTC event is as defined in paragraph 1.A.(1)(a) above; with the exception that the inability to meet the operability requirements of FAR 33.65 and 33.73 in the alternate or backup modes may not be included as LOTC events.**

Examples of engines in this category include turbine engines intended for rotorcraft applications. In general, the 100,000 LOTC rate is considered applicable for these engines, but the inability to meet the operability requirements of 33.67 and 33.73 in the alternate or backup mode(s) may not be part of the LOTC event definition. The following guidance applies to these applications:

- **Single turbine engine rotorcraft:** Single engine rotorcraft may be required to meet the operability requirements of 33.65 and 33.73 in the alternate or backup mode(s), unless the lack of this capability is demonstrated to be acceptable at the aircraft level. In general, if (1) the control transitions to the alternate or backup mode more frequently than the 100,000 LOTC rate, and (2) normal flight crew activity requires rapid changes in power to safely fly the aircraft, then engine operability in the alternate or backup mode(s) is considered a necessity.
- **Multi-turbine engined rotorcraft:** For multi-engined rotorcraft, the LOTC definition may not need to include the inability to meet the operability requirements of 33.65 and 33.73 in the alternate or backup mode(s). This may be considered acceptable because when one engine control transitions to an alternate or backup mode that does not have robust operability, that engine can be left at a reasonably fixed or slowly modulated power condition. The engine(s) with the normally operating control(s) can change power – as necessary – to complete aircraft maneuvers and safely land the aircraft. Demonstration of the acceptability of this type of operation is considered aircraft certification issue.

- (ii) The applicant may propose an LOTC criteria other than; (1) a 1 per 100,000 hour LOTC rate, or (2) the acceptability of not being compliant with the thrust or power oscillation levels given in AC 33.28(a)(1), or (3) the acceptability of not meeting the operability requirements of 33.65 and 33.73 in the alternate or backup mode, or any combination thereof, as the LOTC criteria for control system reliability and operability requirements. Such a proposal should be substantiated. The substantiation data should evaluate the criticality of the engine and control system relative to the intended application.

Examples of engines in this category are engines intended for small general aviation aircraft (i.e., less than 6,000 lbs. max takeoff gross weight): Based on an analysis of the current small general aviation aircraft fleet, it is considered acceptable to define an LOTC event as the inability of modulating thrust or power between flight idle and 85% of maximum rated power or thrust at all operating conditions, and an LOTC rate of 1 per 40,000 engine operating hours has been shown to represent an acceptable level of system reliability and safety.

The FAA will review applicant proposals and supporting data for using different acceptance criteria for the definition of an LOTC event and make

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determinations of the acceptability of such proposals on a case-by-case basis. The intent is to show equivalence of the LOTC rate to existing systems in comparable applications. (For additional information, see 33.28(a)(1).)

(2) Control System LOTC Analysis:

A system reliability analysis should be submitted to substantiate the agreed LOTC rate for the control system.. A numerical analysis such as a Markov model analysis, fault tree analysis or equivalent analytical approach is expected.

The following guidance applies to LOTC analyses:

- (a) The analysis should address all components in the system that can contribute to LOTC events. This includes all electrical, mechanical, hydromechanical, and pneumatic elements of the system. This should also include aircraft signals or data used by the engine control when the failure or malfunction of those signals or data can contribute to LOTC events. As discussed below, the analysis should also include failures and malfunctions which contribute to the transmission of incorrect information in the case where that incorrect information would lead to a flight crew initiated engine shutdown or thrust reduction to a level within the agreed LOTC definition. The fuel pump is generally not included. It is usually considered part of the fuel delivery system. As discussed in sub-paragraph (c)(1) of the advisory material for 33.28(d), the system definition includes those sensors or elements which may not be part of the engine type design, but which are dedicated to the system and contribute to LOTC events. An example of this is the throttle or power lever transducer, which is usually supplied by the installer. The reliability and interface requirements for these other than engine type design elements should be contained in the engine instructions for installation.
 - (b) The LOTC analysis should consider all fault types. This includes both covered and uncovered faults.
 - (c) Any periodic maintenance actions needed to find and repair both covered and uncovered fault conditions in order to meet the LOTC rate, should be contained in airworthiness limitations section of the engine Instructions for Continued Airworthiness.
- (3) Guidance for the Failure Rates Used in the LOTC Analysis for any Commercial and/or Industrial Grade Electronic Components Used in the Control System:**
The applicant should have in place plans for procurement, quality assurance, and process control for the vendor-supplied commercial and industrial grade electrical/electronic parts to ensure that the control system of the type design will continue to be provided at the reliability level which was considered during the engine certification and the component failure rates used in control system's LOTC analysis. When available and agreed by the authorities, the International Electrotechnical Commission Quality Assessment System for Electronic Components (IECQ) "Avionics Industry: Guide for Component Management" may be used for additional guidance.

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Commercial and industrial grade parts have typical operating ranges of 0 degrees to +70 degrees Celsius and -40 degrees to +85 degrees Celsius, respectively. (Military grade parts are typically rated at -54 degrees to 125 degrees Celsius.) Commercial and industrial grade parts are typically defined in these temperature ranges in vendor parts catalogs. If the declared temperature environment for the engine control system exceeds the stated capability of the commercial or industrial grade electronic components, the applicant should substantiate that

- (a) the proposed extended range of the specified components is suitable for the application, and
- (b) the failure rates used for those components in the LOTC analysis are appropriately adjusted for the extended temperature environment.

When any electrical or electronic components are changed, the SSA and LOTC analyzes should be reviewed with regard to the impact of any changes in component reliability. Component, subassembly or assembly level testing may be required by the Authorities to substantiate that a change that introduces a commercial or industrial part(s) does not change the certification basis of the engine control system.

In some applications, it may be acceptable to use components classified as Automotive Parts. The guidance provided above is applicable to these parts as well.

B. Effects of Single Electrical/Electronic Component Failures on the LOTC Rate:

Compliance with the single fault requirements of 33.28(b)(1)(ii) may be substantiated by a combination of tests and analyses. The intent of 33.28(b)(1)(ii) is that the engine control system be "essentially" single fault tolerant of electrical/electrical component failures.

It is recognized that to achieve complete single fault tolerance could require a triplicated design approach or a design approach with 100% fault detection. Currently, systems have been designed with dual, redundant channels or with backup systems that provide what has been called "essentially single fault tolerant". Although these systems may have some faults that are not covered, they have demonstrated excellent in-service safety and reliability, and have proven to be acceptable.

The objective, of course, is to have all the faults covered, and the dual channel or backup system configurations do cover the vast majority of potential electrical and electronic faults. However, on a case-by-case basis it may be appropriate for the applicant to omit some coverage because detection or accommodation of some electrical/electronic faults may not be practical. In these cases, the certification authorities recognize that single, simple electrical or electronic components or circuits can be employed in a reliable manner, and that requiring redundancy in some situations may not be appropriate. In these circumstances, failures in some single electrical or electronic components, elements or circuits may result in an LOTC event. This is what is meant by the use of the term "essentially", and such a system may be acceptable.

Single electrical and electronic faults that result in LOTC events should be identified and reviewed with the authority.

- C. Contribution of Single Electrical/Electronic Component Failures to Hazardous Events: Compliance with the single fault requirements of 33.28(b)(1)(iii) may be substantiated by a combination of tests and analyses. The intent of 33.28(b)(1)(iii) is that single electrical/electronic component failures in the engine control system should not result in a hazardous engine event as defined in FAR 33.75. In addition, the aircraft should not be dispatched if it is known that an engine control system protective feature is not available, such that a single electrical or electronic failure in the control system could result in a hazardous engine event.

D. Local Events

When the installation environment is more severe than the declared environmental limits, the LOTC requirements of 33.28(b)(1)(i) are not applicable. The applicable requirement for operation in a severe environment is that control system failures shall not result in a hazardous engine effect, as defined in FAR 33.75. Occurrence of severe environmental events would normally be limited to one engine and are referred to herein as "local events". A local event is not usually considered to be a common mode event, and common mode threats, such as HIRF, lightning and rain are not considered local events. (There may be installations where multiple engines are affected by the same local event. Such installations should be given consideration by the engine manufacturer and will be reviewed at aircraft certification.)

(1) Examples of local events:

- (a) Fluid leaks or mechanical disruptions which could lead to damage to control system electrical harnesses, connectors, or the control unit(s),
- (b) Fires, and
- (c) Overheat conditions, for example, those resulting from hot air duct bursts.

(2) Consideration of Local Events.

- (a) Whatever the local event, the behavior of the electronic engine control (EEC) system should not cause a hazardous engine effect, as defined in FAR 33.75.
- (b) When demonstration that there is no hazardous engine condition is based on the assumption that there exists another function to afford the necessary protection, it should be shown that this function is not rendered inoperative by the same local event on the engine (including destruction of wires, ducts, power supplies).
- (c) For the purposes of the rule, it is considered that an overheat condition exists when the temperature of the system components is greater than the maximum design operating temperature for the components - as declared by the engine manufacturer in the engine instructions for installation. The electronic portions of the control system should not cause a hazardous engine condition when the electronic components or units of the system are exposed to a continuous overheat or over-temperature condition. Specific design features or analysis

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methods may be used to show compliance with respect to the prevention of hazardous effects. Where this is not possible, for example, due to the variability or the complexity of the failure sequence, then testing may be required.

(d) The electronic engine control system, including the electrical/electronic and mechanical parts of the system, must comply with the fire requirements of FAR 33.17 and the interpretative material of AC 33.17 is relevant. This rule applies to the elements of the engine control system which are installed in designated fire zones.

(e) There is no probability associated with 33.28 (b)(1)(iv). Hence, all foreseeable local events should be considered. It is recognized, however, that it is difficult to address all possible local events in the intended aircraft installation at the time of engine certification. Therefore, sound engineering judgement should be applied in order to identify the reasonably foreseeable local events.

Each wire interfacing with the electronic control unit should be tested or analyzed with respect to wiring faults. These faults should include opens and shorts to ground, and the test or analysis should show that the fault results in an identified and non-hazardous engine response.

Engine control unit aircraft interface wiring should be tested or analyzed for shorts to aircraft power, and these "hot" shorts should result in an identified and non-hazardous effect, as well. Where aircraft interface wiring is involved, the installer should be informed of the potential effects of wiring faults on aircraft interface wiring in the engine instructions for installation. It is the installer's responsibility to ensure that there are no wiring faults which could affect more than one engine, and if practical, more than one FADEC channel of a single engine by isolation/separation of the relevant wiring/conductors.

Where physical separation of conductors is not practical, coordination between the engine manufacturer and the installer should ensure that the potential for common mode faults between engine controls is eliminated, and between channels on one engine is minimized.

(f) The applicant should assess by analysis or test the effects of hydraulic or lubricating leaks impinging on components of the electronic engine control system. Such conditions should not result in a hazardous engine effect, nor should the fluids be allowed to impinge on circuitry or printed circuit boards and result in a potential latent failure condition. Refer to the Advisory Material for FAR 33.91 for test procedures with regard to fluid susceptibility.

E. Engine Control System Shared Signals:

The failure or corruption of data or signals originating within an engine control system and shared across engines should not cause an unacceptable change in thrust or power. This subject is discussed in the Safety Assessment advisory material in section 2 below.

9. SYSTEM SAFETY ASSESSMENT

The system safety assessment (SSA) required under FAR 33.28 (b) (2) should address all operating modes, and the data used in the SSA should be substantiated.

The SSA should consider faults and their effects on the engine control system and the engine itself. The intent is to primarily address the faults or malfunctions which only affect one engine control system, and therefore only one engine. However, faults in aircraft signals in a multi-engined installation that could affect more than one engine should also be included in the SSA. These types of faults are addressed under 33.28(d).

The engine control SSA and LOTC analyses should identify the applicable assumptions, installation requirements and any control system limitations. The assumptions, installation requirements, and any limitations relating to control system operation should be stated in the engine instructions for installation, and if necessary, the limitations should be contained in the airworthiness limitations section of the instructions for continued airworthiness. This should include any periodic inspections and repair requirements for control system components.

A. Scope of the Assessment:

The SSA should address all Hazardous and Major effects identified under FAR 33.75 and also should include, but not necessarily be limited to, the following events caused by engine control system malfunctions:

- (1) Failures affecting power or thrust and resulting in LOTC events (i.e., the LOTC analysis)
- (2) Failures which result in the engine's inability to meet the operability requirements of 33.65 and 33.73. (If these are not LOTC events, document the expected frequency of occurrence for these events. The acceptability of the frequency of occurrence for these events – along with any aircraft flight deck indications deemed necessary to inform the flight crew of such a condition - will be determined at aircraft certification.)
- (3) Transmission of erroneous parameters which could lead to thrust or power changes greater than 10% (e.g., false high indication of the thrust or power setting parameter) or to engine shutdown (e.g., high EGT or turbine temperatures or low oil pressure).
- (4) Failures affecting functions included in the control system, which may be considered aircraft functions. Examples of these include, propeller control, TLD, thrust reverser control, etc.

The SSA should also consider all signals used by the control, including any cross-engine-control signals.

B. Pass/Fail Considerations:

Guidelines for the pass/fail criteria with respect to reliability requirements for the system safety assessment are as follows:

- (1) Compliance with 33.75

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- (2) Failures leading to LOTC events: For control system failures or malfunctions leading to LOTC events, the control system has to have an average LOTC rate that is less than or equal to the agreed LOTC rate for the intended application. See paragraph 1.(A) of this AC.
- (3) Failures affecting engine operability: If engine operability is included in the definition of LOTC events, then failures or malfunctions resulting in the engine's non-compliance with 33.65 and 33.73 should be contained in the LOTC analysis and need to be accounted in the agreed LOTC rate. If engine operability is not part of the LOTC definition, then the total frequency of occurrence of failures that result in engine response that is non-compliant with 33.65 and 33.73 requirements should be contained in the SSA and the acceptability of the frequency for these events – along with any aircraft flight deck indications deemed necessary to inform the flight crew of such a condition - will be determined at aircraft certification.
- (4) Transmission of faulty parameters: The consequence of the transmission of a faulty parameter by the control system should be identified and included, as appropriate, in the LOTC analysis. Any information necessary to mitigate the consequence of a faulty parameter transmission should be contained in the engine operating instructions. For example, the engine's Operating Instructions may indicate that a display of zero oil pressure can be ignored in-flight if the oil quantity and temperature displays appear normal. In this situation, failure to transmit oil pressure or transmitting a zero oil pressure signal should not lead to an engine shutdown or LOTC events. Admittedly, flight crew initiated shutdowns have occurred in-service during such conditions. In this regard, if the engine operating instructions provide information to mitigate the condition, then control system faults or malfunctions leading to the condition do not have to be included in the LOTC analysis. In such a situation, the loss of multiple functions should be included in the LOTC analysis. For example, if the display of zero oil pressure and zero oil quantity (or high oil temperature) would result in a crew initiated shutdown, then those conditions should be included on the systems LOTC analysis.
- (5) The criticality of functions included in the control system for aircraft level functions needs to be defined by the aircraft manufacturer.

C. Malfunctions or Faults Affecting Thrust or Power:

The engine control SSA should consider both undetected and detect faults and their effects on the control system and the engine.

Concerning the flight crews' capabilities for "detecting and reporting fault conditions" which result in engine power or thrust differences in a multi-engined aircraft: It is generally accepted that the flight crews may not note the engine operating differences when the difference is less than (approximately) 5% in thrust or power. For this reason thrust changes less than approximately 5% are generally considered undetectable by the flight crews. If a greater than 5% thrust difference occurs during a takeoff, the flight crews are likely to note the condition and may elect to abort the takeoff. Takeoff aborts at

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low aircraft speeds are generally not considered a flight safety related event, but they certainly are undesirable.

The following guidance applies to undetected and detected malfunctions or faults which affect thrust or power. This guidance is particularly applicable to installations designed to meet Part 25 requirements. In some applications, the applicant may propose to the FAA other levels for some or all of the guidance provided below. The applicant should present substantiation why the proposed alternate levels are appropriate to the application being certificated.

(1) Undetected faults :

- (a) When operating in the takeoff envelope, undetected or uncovered faults in the engine control system, which result in a thrust or power change of less than 3%, are generally considered acceptable.) However, this does not detract from the applicant's obligation to ensure that the full-up system is capable of providing the declared minimum rated thrust or power (i.e. such faults should be random in nature and detectable and correctable during routine inspections, overhauls or power-checks).
- (b) When operating in the takeoff envelope, the frequency of undetected or uncovered faults or malfunctions that result in a thrust or power change greater than 3%, but less than the change defined as an LOTC event, should be contained in the SSA documentation. There are no firm requirements relating to this class of faults or malfunctions for engine certification, however the rate of occurrence of these types of faults should be reasonably low, like 10^{-4} events per engine hour or less. These faults may be required to be included in aircraft certification analysis.
- (c) Signals sent from one engine control to another in an airplane application, such as signals used for ATTCS, , synchrophasing, etc., should be authority limited by the receiving control, so that undetected faults do not result in an unacceptable change in thrust or power on the engines using those signals.
- (d) It is recognized that signals sent from one engine control to another in a rotorcraft application, such as load sharing and one engine inoperative (OEI)signals, can have a much greater impact on engine power when those signals fail. These failure effects should be contained in the SSA.

(2) Detected faults :

- (a) When operating in the takeoff envelope, detected faults in the engine control system which result in a thrust or power change of up to 10%, may be acceptable if the total frequency of occurrence for these types of failures is relatively low. . The frequency of occurrence for this category of faults should be contained in SSA documentation. It should be noted that requirements for the allowable frequency of occurrence for this category of faults and any need for a flight deck indication of these conditions should be determined during aircraft certification. A total frequency of occurrence of less than 10^{-4} events per engine hour may be acceptable.

- (b) Detected faults in signals exchanged between engine controls should be accommodated so as not to result in an unacceptable thrust or power change on the engine using the cross-engine signals. For example, synchronizers should be limited in thrust or power authority.

10 PROTECTIVE FUNCTIONS

A. Rotor Overspeed Protection.

The intent of 33.28(b)(3) is to protect the rotating parts of the engine by providing “reasonable assurance” that the engine rotor speed limits will not be exceeded in service. Compliance with the “reasonable assurance” requirement of the rule is achieved by providing an independent overspeed protection system, such that it requires two independent faults or malfunctions (as described in 3.A.(1) below) to result in an uncontrolled overspeed. The following guidance applies if the rotor overspeed protection is provided by an engine control system function:

- (1) In all dispatchable configurations, the overall engine system (i.e., the engine and overspeed protection system) must be at least two independent faults removed from an uncontrolled overspeed event. Hence, a potential rotor overspeed burst should only be possible as a result of a first fault causing an overspeed and an independent fault preventing the overspeed protection sub-system from operating properly.
- (2) The SSA should show that the probability per engine flight hour of an uncontrolled overspeed condition from any cause in combination with a failure of the overspeed protection system to function is less than one event per hundred million hours (a failure rate of 10^{-8} events per hour). The applicant should be aware that due to the severity of an uncontained engine failure in some installations, the hourly rate for this combined event may have to be shown to be less than one event per billion hours (10^{-9}) for certification of the aircraft.
- (3) The overspeed protection system would be expected to have a failure rate consistent with recent industry experience which is better than 10^{-4} failures per operating hour to comply with the overall objective.
- (4) A self-test of the overspeed protection system to ensure its functionality prior to each engine start/stop cycle is normally necessary for achieving the objectives. Verifying the functionality of the overspeed protection system at engine shutdown of the previous flight is considered acceptable.
- (5) With multiple path overspeed protection systems, there will always be uncertainty that all paths are functional at any given time. Where multiple paths can invoke the overspeed protection system, a test of a different path may be performed each engine cycle. As a means to achieve a reasonable assurance of availability of the function, the objective is that a complete test of the overspeed system is achieved in a minimum number of engine cycles. It is recommended that the control system should

not be considered dispatchable if the overspeed protection system has an instantaneous failure rate greater than 10^{-4} failures per operating hour.

(6) The applicant may provide data that demonstrates that the mechanical parts of the overspeed protection system can operate without failure between stated periods, and a periodic inspection may be established for those parts. This data may be considered in lieu of testing the mechanical parts of the sub-system each engine cycle. When this approach is used, the test conducted each engine cycle may be limited to the electrical and electronic components of the overspeed protection system.

(7) When the overspeed control function is implemented via mechanical or hydromechanical means only, such as a fly-ball governor system, a periodic inspection or test interval is acceptable for compliance with the requirement for "continued system availability". The periodic inspection or test interval should be based on test or in-service data that demonstrates that the system operates without failure between intervals.

4. Other Protective Functions.

The engine control system may perform other protective functions. Some of these may be engine functions, but others may be aircraft or propeller functions. Engine functions should be considered under the guidelines of this Advisory Material, AC33.28-1A. The integrity of other protective functions provided by the engine control should be consistent with a hazard assessment associated with those functions, but if those functions are not concerned with the engine or engine systems, they may not be a part of engine certification.

As engine controls become increasingly integrated into the aircraft and propeller systems, they are incorporating protective functions that were previously provided by the aircraft or propeller systems. Examples are:

- reducing the engine to idle thrust if a thrust reverser inadvertently deploys, and
- providing the auto-feather function for the propeller when an engine fails.

The reliability and availability associated with these functions should be consistent with the aircraft level hazard assessment of conditions involving these functions. This will be completed during the aircraft certification.

Hence, if for example, an engine failure with loss of the auto-feather function is catastrophic at the aircraft level - and the auto-feather function is incorporated into the engine control system - the applicant will have to show for Part 25 or Part 23 applications certified to Part 25 requirements that an engine failure with loss of the auto-feather function cannot result from a single control system failure, and that combinations of control system failures, or engine and control system failures, which lead to a significant engine loss of thrust or power with an associated loss of the autofeather function may be required to have an extremely improbable event rate (i.e., $10E-09$ events per hour).

Although these functions await evaluation at the aircraft level, it is strongly recommended that if practicable, the aircraft level hazard assessment involving these functions be available at the time

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of the engine control system certification. This will facilitate discussions and coordination between the engine and aircraft certification offices under the conditions outlined in paragraph 16 of this AC. It is recognized that this coordination may not occur for various reasons. Because of this, the applicant should recognize that although the engine may be certified, it may not be installable at the aircraft level.

11 SOFTWARE DESIGN AND IMPLEMENTATION

(a) Objective

For engine control systems that use software, the objective of §33.28(c) is to prevent as far as possible software errors that would result in an unacceptable effect on power or thrust, or other unsafe condition.

It is understood that it may be impossible to establish with certainty that the software has been designed without errors. However, if the applicant uses the software level appropriate for the criticality of the performed functions and uses an approved software development method, the Authorities would consider the software to be compliant with the requirement to minimize errors. In multiple engine installations, the possibility of software errors common to more than one engine control system may determine the criticality level of the software.

(b) Approved Methods

Methods for developing software, compliant with the guidelines of RTCA documents DO-178A/EUROCAE ED-12A and DO-178B/EUROCAE ED-12B, hereafter referred to as DO-178A and DO-178B, respectively, are acceptable methods. Alternative methods for developing software may be proposed by the applicant and are subject to approval by the authorities.

Software which is not developed using DO 178B is referred to as legacy software. In general, software changes made to legacy systems applicable to its original installation are assured in the same manner as the original certification. When legacy software is used in a new aircraft installation that requires DO-178B, the original approval of the legacy software is still valid, assuming equivalence to the required software level can be ascertained. If the software equivalence is acceptable to the authorities, the legacy software can be used in the new installation that requires DO-178B software. If equivalence cannot be substantiated, all the software changes should be assured using DO-178B.

(c) Level of software design assurance

In multiple engine installations, the design, implementation, and verification of the software in accordance with Level 1 (DO-178A) or Level A (DO-178B) is normally needed to achieve the certification objectives for independence of engines for aircraft to be type certificated under Part 25 transport, Part 23 Commuter, and Part 27, Category A and Part 29, Category A.

The criticality of functions on other aircraft may be different, and therefore, a different level of software design assurance may be acceptable.

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Determination of the appropriate software assurance level may depend on the failure modes and consequences of those failures. For example, it may be the case that failures resulting in significant thrust or power increases or oscillations may be more severe than an engine shutdown, and therefore, the possibility of these types of failures should be considered when selecting a given software assurance level.

It may be possible to partition non-critical software from the critical software and design and implement the non-critical software to a lower level as defined by the RTCA documents. The adequacy of the partitioning method should be demonstrated. This demonstration should consider whether the partitioned lower software levels are appropriate for any anticipated installations. Should the criticality level be higher in subsequent installations, it would be difficult to raise the software level.

(d) Architectural Protection

As it is not possible to be certain that there are no software errors, the need for additional system protection, beyond reliance on a high level of discipline in the software development and certification methodology, in order to preclude an unsafe condition, should be derived from the system safety analysis required under §33.28(b).

(e) On-Board or Field Software Loading and Part Number Marking

The following guidelines should be followed when on-board or field loading of Electronic Engine Control software and associated Electronic Part Marking (EPM) is implemented.

For software changes, the software to be loaded should have been documented by an approved design change and released with an approved service bulletin.

Software loading procedures and loading equipment should have been previously approved.

The verification test program should demonstrate that the new software version is compatible with the loading system(s).

For those EEC Units having separate part numbers for hardware and software, the software part numbers need not be displayed on the unit as long as the software part number is embedded in the loaded software and can be verified by electronic means. When new software is loaded into the unit, the same verification requirement applies and the proper software part number should be verified before the unit is returned to service.

For those EEC Units having only one part number, which represents a combination of a software and hardware build, the unit part number on the nameplate should be changed when the new software is loaded. The software build or version number should be verified before the unit is returned to service.

The configuration control system for electronic engine control system that will be onboard/field loaded and using electronic part marking should be approved. The drawing system should provide a compatibility table that tabulates the combinations of hardware part numbers and

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software versions that have been approved by the authorities. The compatibility table may either be combined with one of the hardware or software Line Replaceable Unit (LRU) drawings or it may be a separate drawing. The top-level compatibility table should be under configuration control, and it should be updated for each change that affects hardware/software combinations. The applicable service bulletin should define the hardware configurations with which the new software version is compatible.

The loading system should be in compliance with the guidelines of DO-178B, Section 2.5.

If the applicant proposes more than one source for loading, (e.g., diskette, mass storage, etc.), all sources should comply with these guidelines.

The service bulletin should require verification that the correct software version has been loaded after installation on the aircraft.

(f) Software Change Category

The processes and methods used to change software should not affect the design assurance level of that software. Per current policy, there is no minor change category for DO 178A Level 1 or DO 178B Level A software. Consequently, all changes to Level 1 or A software are considered "Major" and require that they be processed as a "Major Change to the Type Design".

(g) Software Changes By Other than the TC Holder

There are two types of potential software changes that could be implemented by someone other than the original TC holder:

- option-selectable software or
- user modifiable software (UMS).

Option selectable changes would have to be pre-certified logic utilizing a method of selection which has been shown not to be capable of causing a control malfunction.

UMS is software intended for modification by the aircraft operator without review by the certification authority, the airframe manufacturer, or the equipment vendor. If this is the case, the aircraft operator should demonstrate that the engine and its modified control system continue to meet all FAR-33 requirements for certification. For engine control systems, UMS has generally not been applicable. However, approval of UMS, if required, would be addressed on a case-by-case basis.

The necessary guidance for UMS is contained in DO-178B, paragraph 2.4. In essence, it conveys the position that other than TC holders may modify the software within the modification constraints defined by the TC holder, if the system has been certified with the provision for software user modifications. To certify an electronic engine control system with the provision for software modification by other than the TC holder, the TC holder should (1) provide the necessary information for approval of the design and implementation of a software change, and (2) demonstrate that the necessary precautions have been taken to prevent the user modification

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from affecting engine airworthiness, whether the user modification is correctly implemented or not.

In the case where the software is changed in a manner not pre-allowed by the TC holder as “user modifiable”, the “non-TC holder” applicant will have to follow the process given in FAR 21.

12. AIRCRAFT SUPPLIED DATA

(a) Objective

In case of loss, corruption or failure of aircraft-supplied data, the engine should continue to function in a safe and acceptable manner, without unacceptable effects on thrust or power, hazardous engine effects, or loss of ability to comply with the operating requirements of §33.51, §33.65 and §33.73. This is imposed only to the engines to be installed in a multi-engine installation. For single engine installations, the effects should be reviewed as part of the overall safety and reliability objectives of §33.28(b).

(b) Background

§33.28(d) retains the independence of engines from the aircraft, which has traditionally been the case for aircraft equipped with engines having hydromechanical control systems, while providing sufficient flexibility to accommodate the increasing engine and aircraft integration that accrues from the use of electronic technology.

The intent is for the engine to provide rated thrust using engine sensors and also to protect the aircraft from unacceptable thrust or power changes on more than one engine due to faulty or erroneous aircraft signals.

Thrust and power command signals sent from aircraft are exempt from the requirement of §33.28(d). If the aircraft thrust or power command system is configured to move the engine thrust or power levers or transmit an electronic signal to command a thrust or power change, the engine control system merely responds to the command and changes engine thrust or power as appropriate. The engine control system may have no way of knowing that the sensed throttle or power lever movement was correct or erroneous.

In both the moving throttle (or power lever) and non-moving throttle (or power lever) configurations, it is the installer’s responsibility to show that a proper functional hazard analysis is performed on the aircraft system involved in generating engine thrust or power commands, and that the system meets the appropriate aircraft’s functional hazard assessment safety related requirements. This task is an aircraft certification issue.

(c) Design assessment

The applicant should evaluate the impact of the failure of aircraft-supplied data on the engine’s output power or thrust characteristics throughout the flight envelope. The applicant should prepare a fault accommodation chart that defines the fault accommodation architecture for the aircraft-supplied data.

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There may be elements of the engine control system that are mounted in the aircraft and are not part of the engine type design, but which are dedicated to the engine control system and powered by it, such as a throttle position resolver. In these instances, such elements are considered to be an integral component of the electronic engine control system and are not considered aircraft data.

In the case where the particular failure modes of the aircraft air data may be unknown, the typical failure modes of (a) loss of data, and (b) erroneous data should be assumed. The term "erroneous data" is used herein to describe a condition where the data appears to be valid but is incorrect.

Such assumptions and the results of the evaluation of erroneous aircraft data should be provided to the installer.

(d) Examples of accommodation means

The followings are examples of possible accommodation means.

- Accommodation for loss of all aircraft-supplied data may be accomplished by providing an alternate control mode independent of aircraft-supplied data.
- Dual sources of aircraft-supplied sensor data with local engine sensors provided as voters and alternate data sources.
- Use of synthesized engine parameters as voters. When synthesized parameters are used for control or voting purposes, the analysis should consider the impact of temperature and other environmental effects on those sensors whose data are used in the synthesis. The variability of any data or information necessary to relate the data from the sensors used in the synthesis to the parameters being synthesized should also be assessed.

(e) Effects on the engine

§33.75 defines the hazardous engine effects.

§33.28(d) is primarily intended to address the effects of aircraft signals, such as aircraft air data information, or other signals which could be common to all engine control systems in a multi-engine installation. The control system design should ensure that the full-up system is capable of providing the declared minimum rated thrust or power through out the engine operation envelope.

§ 33.28(d)(1) requires the applicant to provide an analysis of the effect of loss or corruption of aircraft data on engine thrust or power. The following guidance applies to engine control systems for engines intended for applications on aircraft designed to meet Part 25 requirements. For applications other than those that must comply with Part 25 requirements, the engine applicant may justify to the FAA that a different change in power or thrust than those listed below may be acceptable.

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For fixed-wing multi-engined aircraft operating in the engine approved take-off envelope, erroneous data in aircraft signals used by the engine control system, should not be allowed to affect the power or thrust of each engine by more than 3%. When operating outside the engine's takeoff envelope but inside the engine's maximum continuous envelope erroneous aircraft data should not cause a thrust or power change greater than 10%. When operating outside the approved engine maximum continuous envelope, the effects of erroneous aircraft data on engine power or thrust may be allowed to increase with increasing altitude, but erroneous aircraft data should not be allowed to affect the power or thrust of each engine by more than 20%. Thrust or power changes greater than 10% should be included in the control system's LOTC analysis.

For multi-engined rotorcraft the power changes associated with the use of erroneous data should normally be less than 10% of takeoff power. If greater than 10%, they should be agreed with the certification authority.

(f) Validation

Functionality of the fault accommodation logic should be demonstrated by test. All fault accommodation modes for all control modes should be tested and evaluated.

If an alternate control mode independent of aircraft-supplied data has been provided to accommodate the loss of all aircraft-supplied data, sufficient testing should be conducted to demonstrate that the operability requirements have been met. Characteristics of operation in this mode should be included in the instructions for operating the engine.

13. AIRCRAFT SUPPLIED ELECTRICAL POWER

(a) Objective

Prior to the introduction of electrical/electronic technology, engine control systems were almost independent from the aircraft. For example, when dealing with aircraft situations like total electrical power failure, the flight crew did not have to be concerned about engine stability or operability, because the hydromechanical engine control system was independent from aircraft-supplied power. One of the objectives of §33.28 is to maintain this independence as far as practicable.

The engine control system should be designed and constructed so that after the engine is started and operating at or above idle, the engine will continue to function normally and without an "unacceptable effect on power or thrust or engine operating characteristics", in case of loss or interruption of aircraft-supplied electrical power at any point within the declared engine operating envelope.

(b) Analysis of the design architecture

An analysis and review of the design architecture should identify the requirements for dedicated electrical power sources and aircraft supplied power sources. The analysis should include the sources of power and the effects of loss or degradation of these sources. If the engine is

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dependent on aircraft supplied power for any operational functions, the analysis should result in a definition of the requirements for aircraft supplied power.

The capacity of any engine dedicated power source which would be required for complying with §33.28 (e)(1) should provide sufficient margin to maintain confidence that the engine control system will continue to function in all anticipated engine operating conditions where the control system is designed and expected to recover engine operation in-flight. This margin should account for any other anticipated variations in the output of the dedicated power source such as those due to temperature variations, manufacturing tolerances and idle speed variations. The design margin should be substantiated by test and/or analysis and should also take into account any deterioration over the life of the engine.

In the case of rotorcraft, it is recognized that the engine control system may require aircraft power during ground operations.

When compliance with FAR 33.28(e)(1) imposes a dedicated electrical power source, failure of this source should be addressed in the LOTC analysis required under FAR 33.28(b)(1)(i). While no credit is normally given in the LOTC analysis for the use of aircraft-supplied electrical power as a backup power source, aircraft power has typically been provided for the purpose of accommodating the loss of the engine's dedicated power supply. However, LOTC allowance for the use of aircraft power as the power source for an engine control backup system would be reviewed on a case-by-case basis.

When aircraft electrical power is necessary for operation of the engine control system, §33.28(e)(3) requires that the engine instructions for installation contain the engine control system's electrical power supply quality requirements. This should include steady-state and transient under-voltage and over-voltage limits for the equipment. The power input requirements of DO-160 (rev. D), Section 16, are considered to provide an acceptable definition of such requirements. If DO-160 is used, any exceptions to the power quality requirements cited in DO-160 for the particular category of equipment specified, should be stated.

It is recognized that the electronic components of the engine control system may cease to operate during some low voltage aircraft power supply conditions beyond those required to sustain normal operation, but in no case should the operation of the engine control result in a hazardous engine condition as defined §33.75. In addition, low voltage transients outside the control system's declared capability should not cause permanent loss of function of the control system, or result in inappropriate control system operation which could cause the engine to exceed any operational limits, or cause the transmission of erroneous data.

When aircraft power recovers from a low-voltage condition to a condition within which the control is expected to operate normally, the engine control system should resume normal operation. The time interval associated with this recovery should be contained in the engine instructions for installation. It is recognized that aircraft power supply conditions may lead to an engine shutdown or engine condition which is not recoverable automatically. In these cases the engine should be capable of being restarted, and any special flight crew procedures for executing an engine restart during such conditions should be contained in the engine instructions for

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operation. The acceptability of any non-recoverable engine operating conditions - as a result of these aircraft power supply conditions - will be determined at aircraft certification.

If aircraft-supplied battery power is required to meet an "all engine out" restart requirement, the analysis should result in a definition of the requirements for this aircraft-supplied power. In any application where aircraft electrical power is used to operate the engine control system, such as low engine speed in-flight re-starting conditions, the effects of any aircraft electrical bus-switching transients or power transients associated with application of electrical loads, which could cause an interruption in voltage or a decay in voltage below that level required for proper control functioning, should be considered.

In some system architectures, a dedicated power source may not be required and an aircraft-supplied electrical power supply may be acceptable as the sole source of power. An example is a system that consists of a primary electronic single channel and a full capability hydromechanical back-up system that is independent of electrical power. (A full capability hydromechanical control system is one that meets all FAR Part 33 requirements and is not dependent on aircraft power.) In this type of architecture, loss or interruption of aircraft-supplied power is accommodated by transferring control to the hydromechanical system. Such architectures should also consider the effects of aircraft electrical power bus switching and bus power decays on engine control system operation during in-flight engine re-starts as well as other conditions. Transition from the electronic to the hydromechanical control mode is addressed under FAR 33.28(a)(1)(ii).

(c) Electrical power sources:

A dedicated power source is defined herein as an electric power source providing electrical power generated and supplied solely for use by a single engine control system. They usually are alternators, mechanically driven by the engine or the transmission system of rotorcraft.

Batteries are considered an aircraft-supplied electrical power source (see definition in paragraph (5) of this AC) except in the case of engine applications for small general aviation aircraft (i.e., aircraft less than 6000 lbs. maximum takeoff gross weight). For such aircraft, a battery source dedicated solely to the engine control system may be accepted as a dedicated power source. In such installations, appropriate information for the installer should be provided including, for example, health status and maintenance requirements for the dedicated battery system.

(d) Effects on the engine

In the case of loss of aircraft supplied power, an unacceptable change in power or thrust is defined as any decrease or more than a 10% increase in Takeoff power or thrust.

Where loss of aircraft power results in a change in engine control mode, the control mode transition should meet requirements of §33.28(a)(1)(ii).

The loss of some engine control functions that rely upon aircraft-supplied electrical power may be acceptable. Acceptability is based on evaluation of the change in engine operating characteristics, current experience with similar designs, or the accommodation designed into the control system.

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Examples of these are :

- Engine start and ignition
- Thrust Reverser deployment
- Anti-Icing (engine probe heat)
- Fuel Shut-Off
- Overspeed Protection Systems
- Functions without safety significance that are primarily performance enhancement functions which, if inoperative, do not affect the safe operation of the engine.

(e) Validation

The applicant should demonstrate the effects of loss of aircraft-supplied electrical power by engine test, system validation test or bench test or combination thereof.

14. PROGRAMMED LOGIC DEVICES

The devices considered under §33.28 (h) are usually called Programmed Logic Devices. Because of the nature and complexity of systems containing digital logic, the Programmed Logic Devices should be developed using a structured development approach, commensurate with the hazard associated with failure or malfunction of the system in which the device is contained.

Programmed Logic Devices include Application Specific Integrated Circuits (ASIC) and Programmable Logic Devices (PLDs).

An ASIC is defined as any masked programmed integrated circuit that requires physical customization of the device die by an ASIC vendor. Gate array, cell based and custom designs are included as they involve some level of customization of the mask sets used in the fabrication of the devices.

A PLD is defined as any device that is purchased as an electronic part and altered to perform an application specific function. PLDs include, but are not limited to, Programmable Array Logic (PAL) devices, Programmable Logic Array (PLA) devices, General Array Logic (GAL) devices, Field Programmable Gate Array (FPGA) devices, and Electrically or Erasable Programmable Logic Devices (EPLD). Programmable Logic Devices typically require programming using software which is done in-house by the equipment manufacturer.

RTCA DO-254/ EUROCAE ED-80 which provides guidance for the criticality, failure condition categories and design assurance levels associated with Programmed Logic Devices development, is an acceptable means, but not the only means, for showing compliance with §33.28 (h).

For off-the-shelf equipment or modified equipment, service experience may be used in showing compliance to this guidance. This should be acceptable provided the worst case failure or malfunction of the device for the new installation is no more severe than that for the original installation of the same equipment on another application. Consideration should also be given to any significant differences related to environmental, operational or the category of the aircraft where the original system was installed and certified.

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15. SECTION (--) RECIPROCATING ENGINES.**TBD**

(NOTE: The FAA has a SGAE activity that will issue AC33.28-2 dedicated to reciprocating engines because designs are in work and can not wait for this AC or the draft AC33.28-1. Hopefully this subsequently will be harmonized with the JAA activity on reciprocating engines.. However, the intent is to have the harmonized rule address SGAE as well.)

16. ENGINE, PROPELLER AND AIRCRAFT SYSTEMS INTEGRATION AND THE INTER-RELATION BETWEEN ENGINE, PROPELLER AND AIRCRAFT CERTIFICATION ACTIVITIES**(a) Integration Activities****(1) Aircraft Functions Integrated into the Engine Control System**

This involves the integration of aircraft and propeller control functions (i.e., those that have traditionally not been considered engine control functions), into the electronic engine control (EEC) system's hardware and software. Examples of this involve thrust reverser controls, propeller speed governors, which govern speed by varying pitch, and ATTCS systems. Although the aircraft functions incorporated into the EEC system may receive review at engine certification, the acceptability of these functions would be determined at aircraft certification.

The EEC system may be configured to contain only part of the aircraft system's functionality, or it may contain virtually all of it. Thrust reverser control systems are an example where only part of the functionality is included in the EEC system. In such cases, the aircraft is configured to have separate switches and logic (i.e., independent from the EEC system) as part of the thrust reverser control system. This separation of reverser control system elements and logic provides an architectural means to limit the criticality of the functions provided by the EEC system.

However, in some cases the EEC system may be configured to incorporate virtually all of a critical aircraft function. Examples of this "virtually completeness" in aircraft functionality are EEC systems which contain full authority to govern propeller speed in turboprop powered aircraft and ATTCS systems in turbofan power aircraft. The first of these is considered critical because, if an engine fails, the logic in the engine control must be configured to feather the propeller on that engine. Failure to rapidly feather the propeller following an engine failure results in excessive drag on the aircraft, and such a condition can be critical to the aircraft. The second example, that of an ATTCS system, is considered critical because the system is required to increase the thrust

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of the remaining engine(s) following an engine failure during takeoff, and the increased thrust on the remaining engines is necessary to achieve the required aircraft performance.

All of the above examples of integration involve aircraft functionality that would receive significant review during aircraft certification.

(2) **Integration of Engine Control Functions into Aircraft Systems**

The trend toward systems integration may lead to aircraft systems performing functions traditionally considered part of the engine control.

Some limited designs may have functions, traditionally considered part of the engine control system, provided by the aircraft, but the EEC system itself, which is part of the type design, provides all the functionally required to safely operate the engine in accordance with FAR 33, 35 and other applicable regulations. An example of such a "limited design" would be an engine control which receives a torque output demand signal from the aircraft and responds by changing the engine's fuel flow and other variables to meet that demand.

Other designs may use aircraft systems to implement a significant number of the engine control system functions. An example would be the complex integrated flight and engine control systems – integrated in aircraft avionics units - which govern engine speed, rotor speed, rotor pitch angle and rotor tilt angle in tilt-rotor aircraft

In all of these cases, the functions provided by the engine system which is part of the engine type design are certified with the engine and the completed system including both engine and aircraft provided functions are certified with the aircraft. Whenever possible, compliance to aircraft rules will be based on compliance with comparable engine rules. However, this is not always possible and in the end, the "airplane" including the "engine" must meet the "airplane" rules.

In these designs, aircraft systems may be an integral part of engine regulatory compliance. In such cases, the FAA considers the engine applicant to be responsible for specifying the requirements for the EEC system in the instruction for installation and substantiating the adequacy of those requirements. These requirements become part of the engine type design.

(b) Certification Activities

(1) Objective

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To satisfy the aircraft requirements, such as FAR/JAR 25.901, 25.903 and 25.1309, an analysis of the consequences of failures of the engine control system on the aircraft has to be made. The engine manufacturer should, together with the aircraft manufacturer, ensure that the software levels and safety and reliability objectives for the engine electronic control system are consistent with these associated aircraft requirements.

Also, the use of the electronic technology has consistently resulted in greater integration of engine, propeller and aircraft systems. For example, in some applications the engine EEC unit may integrate the control functions for the propeller, or the aircraft computers may integrate the engine control and the propeller control functions.

There must be a clear definition of the respective certification tasks of the various applicants: engine, propeller and aircraft manufacturers, with the associated engine, propeller and aircraft certifying authorities.

(2) **Interface Definition & System Responsibilities**

System responsibilities as well as interface definitions should be identified for the functional and hardware and software aspects between the engine, propeller and the aircraft systems in the appropriate documents. It is recommended that these responsibilities be summarized in the various plans for engine, propeller and aircraft certification.

In particular, the engine/propeller/aircraft documents should cover:

- (i) Functional requirements and criticality (which may be based on engine, propeller and aircraft considerations),
- (ii) Fault accommodation strategies, and
- (iii) Maintenance strategies
- (iv) The software quality level (per function if necessary),
- (v) The reliability objectives for –
--LOTC events
--Transmission of faulty parameters,
- (vi) The environmental requirements including the degree of protection against lightning or other electromagnetic effects (e.g., level of induced voltages that can be supported at the interfaces),

In this example, the propeller functions and characteristics defined by the propeller manufacturer that are to be provided by the engine control system, would normally need to be refined by flight test. However, the propeller manufacturer is responsible for ensuring that these requirements that would be certificated as part of the engine certification program, although not refined by flight test, define an airworthy configuration. Definition of an airworthy configuration, although an unrefined configuration, is required because one of the essential requirements of a certificated engine is that it be airworthy.

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- In addition, any type design changes to the engine control system which could affect the functioning of the propeller must be properly coordinated between the cognizant ACO's, engine, and propeller manufacturers and vice versa, if applicable.

- (ii) Case of an aircraft computer performing the functions for the control of the engine and/or the propeller. This example is not intended to provide a methodology that must be followed by the responsible aircraft and propeller parties involved. The intent is to provide an example of how these complex engine control systems with shared resources may be approached to reach agreement on responsibilities of the various parties involved with the certification process when the traditional approach to engine certification that includes an engine control system is not applicable.

- The aircraft certification would address all general requirements such as software quality assurance procedures, EMI/lightning protection levels.
- The aircraft certification would address the functional aspects for the aircraft functions.
- The engine certification would address the functional aspects for the engine functions (safety analysis, rate for LOTC events, effect of loss of aircraft supplied data, etc.) The fault accommodation logic affecting the control of the engine, for example, would be reviewed at that time.
- The propeller certification would address the functional aspects for the propeller control functions (safety analysis, contribution to LOTC events, effect of loss of aircraft supplied data, etc.) The fault accommodation logic affecting the control of the propeller, for example, would be reviewed at that time.

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- (vii) Engine, propeller and aircraft interface data and characteristics, and
- (viii) Aircraft electrical power supply requirements and characteristics (if relevant).

(3) Distribution of Compliance Tasks

The objective in any engine or propeller certification program should be to provide appropriate data that will provide evidence of compliance for both engine and aircraft requirements that are applicable to the engine control system. If anything done during engine or propeller certification is intended to also directly demonstrate or support compliance with an aircraft regulation, care should be taken that the installation effects and differences between the engine, propeller and aircraft requirements are clearly understood and accounted for. Also, the overall "aircraft certification plan" should clearly identify where this approach is being proposed. This would allow all parties to review and agree with the plan and assure that the necessary airplane information gets to the engine authority to facilitate an informed finding.

The aircraft certification plans should deal with the overall integration of the engine and propeller in compliance with the applicable aircraft requirements.

The engine and propeller certification plans should address the functional aspects of the engine and propeller control systems for compliance with the applicable engine and propeller control system requirements.

Two examples are given below to illustrate this principle.

- (i) Case of an EEC unit performing the functions for the control of the engine and the functions for the control of the propeller:
 - The engine certification would address all general requirements such as software quality assurance procedures, EMI/lightning protection levels, effects of loss of aircraft supplied power.
 - The engine certification would address the functional aspects for the engine functions (safety analysis, rate for LOTC events, effect of loss of aircraft supplied data, etc.). The fault accommodation logic affecting the control of the engine, for example, will be reviewed at that time.
 - The propeller certification would similarly address the functional aspects for the propeller control functions. The fault accommodation logic affecting the control of the propeller, for example, would be reviewed at that time.

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[AE1]

Mr. Ron Priddy
President, Operations
National Air Carrier Association
1100 Wilson Blvd., Suite 1700
Arlington, VA 22209

Dear Mr. Priddy:

The Federal Aviation Administration (FAA) recently completed a regulatory program review. That review focused on prioritizing rulemaking initiatives to more efficiently and effectively use limited industry and regulatory rulemaking resources. The review resulted in an internal Regulation and Certification Rulemaking Priority List that will guide our rulemaking activities, including the tasking of initiatives to the Aviation Rulemaking Advisory Committee (ARAC). Part of the review determined if some rulemaking initiatives could be addressed by other than regulatory means, and considered products of ARAC that have been or are about to be forwarded to us as recommendations.

The Regulatory Agenda will continue to be the vehicle the FAA uses to communicate its rulemaking program to the public and the U.S. government. However, the FAA also wanted to identify for ARAC those ARAC rulemaking initiatives it is considering to handle by alternative actions (see the attached list). At this time, we have not yet determined what those alternative actions may be. We also have not eliminated the possibility that some of these actions in the future could be addressed through rulemaking when resources are available.

If you have any questions, please feel free to contact Gerri Robinson at (202) 267-9678 or gerri.robinson@faa.gov.

Sincerely,

Anthony F. Fazio
Executive Director, Aviation Rulemaking Advisory Committee

Enclosure

cc:

William W. Edmunds, Air Carrier Operation Issues
Sarah MacLeod, Air Carrier/General Aviation Maintenance Issues
James L. Crook, Air Traffic Issues
William H. Schultz, Aircraft Certification Procedures Issues
Ian Redhead, Airport Certification Issues

Billy Glover, Occupant Safety Issues

John Tigue, General Aviation Certification and Operations Issues

David Hilton, Noise Certification Issues

John Swihart, Rotorcraft Issues

Roland B. Liddell, Training and Qualification Issues

Craig Bolt, Transport Airplane and Engine Issues

ARAC Projects that will be handled by Alternative Actions rather than Rulemaking

(Beta) Reverse Thrust and propeller Pitch Setting below the Flight Regime (25.1155)
Fire Protection (33.17)
Rotor Integrity--Overspeed (33.27)
Safety Analysis (33.75)
Rotor Integrity – Over-torque (33.84)
2 Minute/30 Second One Engine Inoperative (OEI) (33.XX)
Bird Strike (25.775, 25.571, 25.631)
Casting Factors (25.621)
Certification of New Propulsion Technologies on Part 23 Airplanes
Electrical and Electronic Engine Control Systems (33.28)
Fast Track Harmonization Project: Engine and APU Loads Conditions (25.361, 25.362)
Fire Protection of Engine Cowling (25.1193(e)(3))
Flight Loads Validation (25.301)
Fuel Vent System Fire Protection (Part 25 and Retrofit Rule for Part 121, 125, and 135)
Ground Gust Conditions (25.415)
Harmonization of Airworthiness Standards Flight Rules, Static Lateral-Directional Stability, and Speed Increase and Recovery Characteristics (25.107(e)(1)(iv), 25.177©, 25.253(a)(3)(4)(50)). Note: 25.107(a)(b)(d) were enveloping tasks also included in this project—They will be included in the enveloping NPRM)
Harmonization of Part 1 Definitions Fireproof and Fire Resistant (25.1)
Jet and High Performance Part 23 Airplanes
Load and Dynamics (Continuous Turbulence Loads) (25.302, 25.305, 25.341 (b), etc.)
Restart Capability (25.903(e))
Standardization of Improved Small Airplane Normal Category Stall Characteristics Requirements (23.777, 23.781, 23.1141, 23.1309, 23.1337, 25.1305)

ATTC (25.904/App I)
Cargo Compartment Fire Extinguishing or Suppression Systems (25.851(b), 25.855, 25.857)
Proof of Structure (25.307)
High Altitude Flight (25.365(d))
Fatigue and Damage Tolerance (25.571)
Material Prosperities (25.604)

Rules and Regulations

Federal Register

Vol. 73, No. 161

Tuesday, August 19, 2008

This section of the FEDERAL REGISTER contains regulatory documents having general applicability and legal effect, most of which are keyed to and codified in the Code of Federal Regulations, which is published under 50 titles pursuant to 44 U.S.C. 1510.

The Code of Federal Regulations is sold by the Superintendent of Documents. Prices of new books are listed in the first FEDERAL REGISTER issue of each week.

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No. FAA-2007-27311, Amendment No. 33-26]

RIN 2120-AI94

Airworthiness Standards; Engine Control System Requirements

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: The FAA is amending type certification standards for aircraft engine control systems. These changes reflect current industry practices and harmonize FAA standards with those recently adopted by the European Aviation Safety Agency (EASA). These changes establish uniform standards for all engine control systems for aircraft engines certificated by both U.S. and European countries and will simplify airworthiness approvals for import and export.

DATES: This amendment becomes effective October 20, 2008.

FOR FURTHER INFORMATION CONTACT: For technical questions concerning this final rule contact Gary Horan, Engine and Propeller Directorate Standards Staff, ANE-111, Federal Aviation Administration, 12 New England Executive Park, Burlington, Massachusetts 01803-5299; telephone (781) 238-7164, fax (781) 238-7199, e-mail gary.horan@faa.gov.

SUPPLEMENTARY INFORMATION:

Authority for This Rulemaking

The FAA's authority to issue rules on aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation

Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, part A, Subpart III, Section 44701, "General requirements." Under that section, the FAA is charged with prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce, including minimum safety standards for aircraft engines. This proposed rule is within the scope of that authority because it updates existing regulations for aircraft engine control systems.

Background

U.S. and European aircraft engine regulations differ in several areas including engine controls. Certifying to a common set of requirements (harmonization) benefits industry and regulators because of the lower costs associated with a single set of regulations.

The FAA, in cooperation with the Joint Aviation Authorities (JAA), the European rulemaking authority before EASA, established an international engine certification study group to compare part 33 with the Joint Aviation Requirements—Engines (JAR-E), the European requirements for engines. As a follow-on, the Aviation Rulemaking Advisory Committee, through its Engine Harmonization Working Group (EHWG), looked at harmonizing the engine control requirements of part 33 and the JAR-E. This final rule reflects the agreed harmonization between the FAA and the JAA that was subsequently adopted by EASA as CS-E (Certification Specifications for Engines) 50.

Summary of the NPRM

A Notice of Proposed Rulemaking (NPRM) was published on April 11, 2007 (72 FR 18148) that proposed changes to §§ 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91. The comment period for the NPRM closed on July 10, 2007. These proposed changes would harmonize FAA and EASA regulations for the referenced sections.

Summary of the Final Rule

This final rule on Engine Control System requirements contains no significant changes from the NPRM published on April 11, 2007. We made minor changes to several sections to ensure clarity and better harmonization

with EASA regulations. This rule harmonizes FAA and EASA regulations for portions of §§ 33.5, 33.7, 33.27, 33.28, 33.29, 33.53, and 33.91.

Summary of Comments

Five commenters, including an aircraft engine manufacturer and a manufacturer of light business jets, responded to the NPRM request for comments. The commenters supported the proposed rule while suggesting minor changes.

The FAA received comments on the following general areas of the proposal:

- Instructions for installing the engine control transitions
- Engine control system failures
- Overspeed protection
- System Safety Assessment (SSA) interfaces between engine and aircraft
- Programmable logic devices
- Instrument connection

Discussion of the Final Rule

Below is a more detailed discussion of the rule as it relates to the comments we received to the proposal.

Instructions for Installing and Operating the Engine

We revised § 33.5, Instruction manual for installing and operating the engine, to require applicants to list in the installation instructions the instruments necessary for satisfactory control of the engine. The new § 33.5 also requires that the limits of accuracy and transient response required for satisfactory engine operation be identified so the suitability of the instruments as installed can be assessed.

General Electric (GE) indicated the definition of the reliability, accuracy, and transient response requirements should not be required in part 33 and would be more appropriate for evaluation as part of compliance with part 25.

During the design, development and certification of an engine, the engine manufacturer must determine the specific information the pilot needs to control the engine. The engine manufacturer must convey this information, which includes necessary measurement data, to the installer. In addition, the FAA notes that the engine manufacturer, rather than the installer, should know the transient capability needed by the display to accurately represent the engine behavior. We did

not change the final rule due to this comment.

In the final rule, we are adding a paragraph (b)(5) that was originally proposed in the NPRM as paragraph (b)(4). We are doing this because another final rule, "Rotorcraft Turbine Engines One-Engine-Inoperative (OEI) Ratings, Type Certification Standards" has already added paragraph (b)(4) to this section.

Engine Ratings and Operating Limitations

The revised § 33.7 requires that the overall limits of accuracy of the engine control system and the necessary instruments, as defined in § 33.5(a)(6), be considered when determining engine performance and operating limitations.

Sino Swearingen, a business jet manufacturer, suggested any assumptions made relative to the accuracy of installer-supplied instruments should be stated as assumptions in the installation manual. The FAA believes this level of detail is excessive for a regulatory requirement. Therefore, we did not change the final rule due to this comment.

GE asserted that defining the accuracy limits for the aircraft-provided instruments should be a task for the airframe manufacturer and should be part of compliance with part 25 not part 33.

We find the engine manufacturer needs to determine the accuracy limits for aircraft-provided instruments and provide this information to the installer. Without this information, it is unclear if it is critical that a given parameter must be measured and displayed with an accuracy of 1% or as much as 20%, which is a significant difference to the installer. We did not change the final rule due to this comment.

None of the above comments to the proposed § 33.7 reflect the complexity of integration encountered during installation of an engine on an aircraft. Sections 33.7 and 33.5(a)(6) require that the engine manufacturer and the installer account for the accuracies and the documentation of these accuracies for the overall system as installed. This is to ensure the engine, as installed, can be operated within its limitations.

Engine Control Systems

We revised the title and contents of § 33.28 to apply to all types of engine control systems, including hydromechanical and reciprocating engine controls. Formerly, § 33.28 applied only to electrical and electronic engine control systems.

Engine Control Systems Validation

The revised § 33.28(b) prescribes requirements for engine control system validation. Section 33.28(b)(1) requires that applicants demonstrate their engine control system performs its intended function in the declared operating conditions, including the environmental conditions and flight envelope. Section 33.28(b)(1)(ii) also requires that the engine control system comply with §§ 33.51, 33.65, and 33.73, as appropriate, under all likely system inputs and allowable engine power or thrust demands.

GE found proposed § 33.28(b)(1)(ii) difficult to understand. GE suggested § 33.28(b)(1)(ii) be revised to read: "Complies with the operability requirements of §§ 33.51, 33.65 and 33.73, as appropriate, under all likely system inputs and allowable engine power or thrust demands, unless it can be demonstrated that failure of the control function results in a non-dispatchable condition in the intended application." The FAA agrees and has revised the final rule to read as the commenter suggested.

Control Transitions

We revised § 33.28(c) to clarify the requirements for control transitions, including crew notification, when fault accommodation is implemented through alternate modes, channel changes, or changes from primary to back-up systems.

GE suggested that revised § 33.28(c)(1)(iii) requires the action of the flight crew be described in the engine operating instructions if the crew must respond to changes in control modes. GE claimed the indication of the mode change to the cockpit crew should be included in the compliance with part 33 but the action required by the crew should be reserved for compliance with part 25. GE also noted § 33.28(c)(2) requires the magnitude of a thrust change associated with a control mode change be described in the engine installation manual. GE believes it is only necessary for this information to be included in the engine installation manual if the flight crew is required to initiate, respond, or be aware of this mode change.

We note the intent of these changes to § 33.28(c) is to ensure the installer is aware of any engine or engine control operational differences and the recommended differences in procedures. We have observed this problem in some previous engine installations. The inclusion of these actions in the operating instructions draws the attention of the installer to

this condition so that the crew action must be evaluated—and be found acceptable—under aircraft certification. This recommended crew action in the engine installation manual is a guideline for the installer and does not replace requirements for crew action that are normally included in the aircraft operations manual. We did not change the final rule due to this comment.

Engine Control System Failures

Revised § 33.28(d) consists of control system failure requirements formerly located in § 33.28(c). Section 33.28(d)(1) addresses integrity requirements, such as Loss of Thrust Control (LOTC)/Loss of Power Control (LOPC) requirements consistent with the intended application.

Section 33.28(d)(2) requires the engine control system be designed and constructed so that in its full-up configuration it is single fault tolerant, as determined by the Administrator, for electrical or electronic failures with respect to LOTC/LOPC events. We received no comments on proposed § 33.28(d)(2).

Sino Swearingen pointed out § 33.28(d)(1) requires the applicant to design a system that will achieve an LOTC rate compatible with intended application. However, Sino Swearingen notes that different aircraft categories (normal, commuter, transport, rotorcraft) have different levels of safety, associated reliability requirements, and software verification and validation requirements. Sino Swearingen asserted the "intended application" should, therefore, be specified in the engine installation instructions.

We do not believe this level of specificity is appropriate for a regulation, but we will provide appropriate LOTC/LOPC rates and levels of reliability in the advisory material that accompanies the rule.

System Safety Assessment

The revised § 33.28(e) requires a System Safety Assessment (SSA) for the engine control system. The SSA must identify faults or failures that would have harmful effects on the engine.

GE expressed concern that the conditions to be analyzed for compliance with § 33.28(e) are not clearly related to safety, as would be implied by the requirement that an SSA be done. The commenter believes the listed conditions would have a minor effect for a typical installation.

We note that under the SSA, in complying with §§ 33.28 and 33.75, applicants are required to identify faults or failures that would cause major,

hazardous and catastrophic engine effects. These types of faults would require an SSA and a reliability assessment. For example, faults that can lead to an LOTC and subsequent high thrust or an uncontrolled overspeed can cause a hazardous engine effect. Faults such as thrust in the wrong direction or excessive drag (propeller airplanes) or 'thrust failed high and not controllable' can produce a catastrophic aircraft effect. We find, therefore, that the conditions to be analyzed for an SSA under § 33.28(e) are clearly related to safety. We did not change the final rule due to this comment.

GE also claimed the phrase "an effect on engine operability" in § 33.28(e) is not "bounded." The commenter felt this phrase should be modified to "an effect on engine operability producing a surge or stall * * *"

The suggested phrasing is clearer and places the appropriate boundaries on the statement. We, therefore, revised § 33.28(e) in the final rule to include the suggested phrase.

GE commented that requiring an SSA addressing every single data element would impose additional costs to applicants. This final rule requires an aggregate SSA, not a separate analysis on every single data element. The SSA must identify faults or failures that would have harmful effects on the engine. It has been used in the certification process for the last several years and is already an existing requirement in Europe. Recent examples include certification of Pratt & Whitney's PW6000, Rolls-Royce's Model 250, and General Electric GENx engines. We find that this manufacturer will not face additional cost from complying with this requirement because it already meets the existing European requirements.

Protection Systems

The new § 33.28(f) requires protective functions, such as overspeed protection systems, that preserve rotor integrity. Section 33.28(f)(2) adds a requirement that the design of electronic overspeed protection systems include a means for testing at least once per engine start/stop cycle to establish the availability of the system's function.

GE commented that the frequency at which the overspeed protection must be tested should be determined based on the application, the possible failure modes, and the potential of those failure modes.

We have found the requirement to test overspeed protection at least once per engine start/stop cycle is appropriate based on safety considerations. We note that if overspeed protection is not

available, then exposure of an engine to a single failure could result in uncontrolled overspeed. We made no changes to the final rule due to this comment. We will, however, clarify in the advisory material that will accompany this rule that testing the overspeed system depends on a number of design and architecture factors. For example, the system architecture may implement a number of protection paths that have to be individually tested to confirm the system's functionality. Thus, while the test frequency is one flight cycle, it may take more than one flight cycle to complete the test of the overspeed protection system.

Aircraft-Supplied Data

The new § 33.28(h) prescribes requirements for single failures leading to loss, interruption, or corruption of aircraft-supplied data or data shared between engines. We modified the former fault accommodation requirement for loss of all aircraft-supplied data to require detection and accommodation for single failures leading to loss, interruption, or corruption of aircraft-supplied data. This accommodation must not result in an unacceptable change in thrust or power or an unacceptable change in engine operating and starting characteristics.

GE suggested the phrase "as part of certification documentation" be added to § 33.28(h)(2) to avoid confusion since other parts of this rule define what needs to be documented in the installation manual. FAA experience with previous engine programs has been that information on the effects of failures on engine power or thrust, engine operability, and starting characteristics is needed in the engine installation instructions to ensure that it is clearly communicated by the applicant to the installer. As a result of this comment, we modified the final rule to clarify that this information must be documented in the engine installation instructions.

Also, Sino Swearingen expressed concern that § 33.28(h)(2) does not define the unacceptable change in thrust or power or "allowable degradation" in engine operating and starting characteristics. We find that including this information in the rule would be overly prescriptive. Unacceptable changes or allowable degradation often depend on the installation. We find, therefore, that it is more appropriate to explain unacceptable changes in thrust, power, or engine operating and starting characteristics in the advisory material that accompanies this rule. We did not

change the final rule due to this comment.

Aircraft-Supplied Electrical Power

The new § 33.28(i) establishes requirements for the response of the engine control system to the loss or interruption of electrical power supplied from the aircraft. Section 33.28(i) applies to all electrical power supplied to the engine control system, including that supplied from the aircraft power system and from the dedicated power source, if required.

GE commented the applicant should be able to identify the characteristics of any electrical power supplied from the aircraft to the engine control system for starting and operating the engine in any document that is part of the certification process rather than in the engine instructions for installation, as required by the proposed rule.

The FAA has observed a significant number of problems caused by inadequate communication between the applicant and the installer regarding aircraft-supplied electrical power. We have found it is critical that this level of detail be clearly communicated by the applicant to the installer. The FAA notes also that at the time of engine certification, it is not always clear who the ultimate installer(s) will be. Providing these details, therefore, in the engine instructions for installation will help to ensure the installer has the needed information. We did not change the final rule due to this comment.

Programmable Logic Devices

The new § 33.28(m) establishes safety requirements for programmable logic devices (PLDs) that include application-specific integrated circuits and programmable gate arrays. The rule requires that development of the devices and associated encoded logic used in their design and implementation be at a level equal to the hazard level of the functions performed via the devices.

EASA suggested that the FAA should clarify the rule to ensure it is not the FAA's intent to mandate that the type certificate (TC) holder design and implement PLD logic. EASA argued the TC holder should only be required to provide evidence that these devices have been developed using a method, for example DO-254, that is acceptable to the FAA.

We agree with EASA that the proposed language might be misinterpreted. We, therefore, have revised § 33.28(m) in the final rule to indicate the applicant must provide evidence that PLDs have been developed in accordance with a method approved by the FAA.

Instrument Connection

We revised § 33.29 by adding new paragraphs (e) through (h). The new § 33.29(e) requires that applicants provide instrumentation necessary to ensure engine operation in compliance with the engine operating limitations. The new § 33.29(f) requires that applicants provide a means to minimize the possibility of incorrect fitting of instruments, sensors and connectors. The new § 33.29(g) reduces the probability of faults propagating from the instrumentation and monitoring functions to the control functions, or vice versa, by prescribing that the probability of propagation of faults be consistent with the criticality of the function performed. The new § 33.29(h) adds requirements for instrumentation that enables the flight crew to monitor the functioning of the turbine case cooling system.

Sino Swearingen agreed it is appropriate in § 33.29(f) to specify that the engine design should include means to prevent improper installation or “fit” of instruments, sensors and connectors. Sino Swearingen commented, however, that it is virtually impossible to consider the effects of multiple possible incorrect assembly and installation scenarios within the engine control system’s SSA especially since it must consider airplane-installed instruments to be comprehensive.

The FAA notes the intent of this rule is to achieve an engine design where the fit of the installation will prevent an accidental incorrect assembly. When incorrect fit cannot be ensured, the SSA needs to address the effects of the incorrect assembly. The FAA is not intending to include aircraft-installed instruments in this assessment. We did not change the final rule due to this comment.

Engine Overtemperature Test

We did not propose changes to this section in the NPRM. We are, however, changing a reference in this section in the final rule from § 33.67(d) to § 33.28(k) because this rule eliminates § 33.67(d) and moves its contents to § 33.28(k). We did not make any other changes to § 33.88 by this rule.

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires the FAA consider the impact of paperwork and other information collection burdens imposed on the public. We have determined there is no current or new requirement for information collection associated with this amendment.

An agency may not collect or sponsor the collection of information, nor may it

impose an information collection requirement unless it displays a currently valid Office of Management and Budget (OMB) control number.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has reviewed the corresponding ICAO Standards and Recommended Practices and has identified no differences with these regulations.

Regulatory Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs each Federal agency propose or adopt a regulation only upon a determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act also requires agencies to consider international standards and, where appropriate, use them as the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by private sector, of \$100 million or more annually (adjusted for inflation with base year of 1995). This portion of the preamble summarizes the FAA’s analysis of the economic impacts of this final rule.

Department of Transportation Order DOT 2100.5 prescribes policies and procedures for simplification, analysis, and review of regulations. If the expected cost impact is so minimal that a proposed or final rule does not warrant a full evaluation, this order permits that a statement to that effect, and the basis for it, be included in the preamble if a full regulatory evaluation of the cost and benefits is not prepared. Such a determination has been made for this final rule.

Presently, engine manufacturers must satisfy both United States and European requirements to certify and market part 33 engines in both the United States and in Europe. Meeting two sets of certification requirements raises the cost of developing a new engine often with no increase in safety. In the interest of fostering international trade, lowering the cost of engine development, and making the certification process more efficient, the FAA, EASA, and manufacturers have worked to create to the maximum extent possible a single set of certification requirements accepted in both the United States and Europe. These efforts are referred to as harmonization.

This final rule codifies current industry practices and harmonizes FAA requirements for aircraft engine control systems with similar requirements recently adopted by EASA, thereby simplifying airworthiness approvals for import and export. Similar international requirements reduce duplicative testing which will reduce certification costs. The FAA has not attempted to quantify the cost savings that may accrue due to this specific rule, beyond noting that while they may be minimal they contribute to harmonization savings. In addition, a potential for increased safety lies in having clearer and more explicit regulations. The agency concludes that there is consensus among potentially impacted manufacturers that savings will result, and further analysis is not required. The benefits of this final rule justify the costs and the existing level of safety will be preserved.

Economic Summary

The FAA has determined that the benefits of this final rule justify the costs. It is not a “significant regulatory action” as defined in section 3(f) of Executive Order 12866, and is not “significant” as defined in DOT’s Regulatory Policies and Procedures.

Final Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (Pub. L. 96–354) (RFA) establishes “as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration.” The RFA covers a wide-range of small entities,

including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA.

However, if an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

During the comment period, one individual questioned our determination that the rule would not affect a substantial number of small entities. In the Initial Regulatory Flexibility Determination, we found there would not be a significant economic impact on a substantial number of small entities and used the broadest category, "more than just a few," in determining if a substantial number of small entities were impacted. There were no other comments on the potential effect on small businesses.

Although there are engine manufacturers who qualify as small businesses based on Small Business Administration Size Standards, this rule reduces cost. Our final regulatory flexibility determination is that this final rule will not have a significant economic impact on a substantial number of small entities.

Therefore, as the Acting FAA Administrator, I certify that this final rule will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreements Act of 1979 (Pub. L. 96-39) prohibits Federal agencies from establishing any standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards.

This final rule considers and incorporates an international standard as the basis of an FAA regulation. Thus this final rule complies with The Trade

Agreements Act of 1979 and does not create unnecessary obstacles to international trade.

Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of \$100 million or more (adjusted annually for inflation with the base year 1995) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a "significant regulatory action." The level equivalent of \$100 million in CY 1995, adjusted for inflation to CY 2007 levels by the Consumer Price Index for all Urban Consumers (CPI-U) as published by the Bureau of Labor Statistics, is \$136.1 million.

This final rule does not contain such a mandate. The requirements of Title II do not apply.

Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. We have determined that this action will not have a substantial direct effect on the States, or the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, does not have federalism implications.

Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 312d and involves no extraordinary circumstances.

Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA has analyzed this final rule under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). We have determined that it is not a "significant energy action" under the executive order because it is not a "significant regulatory action" under Executive Order 12866, and it is not likely to have a significant adverse effect

on the supply, distribution, or use of energy.

Availability of Rulemaking Documents

You can get an electronic copy of rulemaking documents using the Internet by—

1. Searching the *Federal eRulemaking Portal* (<http://www.regulations.gov>);
2. Visiting the FAA's Regulations and Policies Web page at http://www.faa.gov/regulations_policies/; or
3. Accessing the Government Printing Office's Web page at <http://www.gpoaccess.gov/fr/index.html>.

You can also get a copy by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue, SW., Washington, DC 20591, or by calling (202) 267-9680. Make sure to identify the amendment number or docket number of this rulemaking.

Anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act statement in the **Federal Register** published on April 11, 2000 (Volume 65, Number 70; Pages 19477-78) or you may visit <http://docketsinfo.dot.gov>.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. If you are a small entity and you have a question regarding this document, you may contact your local FAA official, or the person listed under the **FOR FURTHER INFORMATION CONTACT** heading at the beginning of the preamble. You can find out more about SBREFA on the Internet at http://www.faa.gov/regulations_policies/rulemaking/sbre_act/.

List of Subjects in 14 CFR Part 33

Aircraft, Aviation safety, Life-limited parts, Reporting and recordkeeping requirements.

The Amendment

■ In consideration of the foregoing, the Federal Aviation Administration amends Chapter I of Title 14, Code of Federal Regulations as follows:

**PART 33—AIRWORTHINESS
STANDARDS: AIRCRAFT ENGINES**

■ 1. The authority citation for part 33 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44704

■ 2. Amend § 33.5 by adding new paragraphs (a)(4), (a)(5), (a)(6), and (b)(5), to read as follows:

§ 33.5 Instruction manual for installing and operating the engine.

* * * * *

(a) * * *

(4) A definition of the physical and functional interfaces with the aircraft and aircraft equipment, including the propeller when applicable.

(5) Where an engine system relies on components that are not part of the engine type design, the interface conditions and reliability requirements for those components upon which engine type certification is based must be specified in the engine installation instructions directly or by reference to appropriate documentation.

(6) A list of the instruments necessary for control of the engine, including the overall limits of accuracy and transient response required of such instruments for control of the operation of the engine, must also be stated so that the suitability of the instruments as installed may be assessed.

(b) * * *

(5) A description of the primary and all alternate modes, and any back-up system, together with any associated limitations, of the engine control system and its interface with the aircraft systems, including the propeller when applicable.

* * * * *

■ 3. Amend § 33.7 by adding new paragraph (d) to read as follows:

§ 33.7 Engine ratings and operating limitations.

* * * * *

(d) In determining the engine performance and operating limitations, the overall limits of accuracy of the engine control system and of the necessary instrumentation as defined in § 33.5(a)(6) must be taken into account.

■ 4. Amend § 33.27 by revising paragraph (b) to read as follows:

§ 33.27 Turbine, compressor, fan, and turbosupercharger rotors.

* * * * *

(b) The design and functioning of engine systems, instruments, and other methods, not covered under § 33.28 must give reasonable assurance that those engine operating limitations that affect turbine, compressor, fan, and

turbosupercharger rotor structural integrity will not be exceeded in service.

* * * * *

■ 5. Revise § 33.28 to read as follows:

§ 33.28 Engine control systems.

(a) *Applicability.* These requirements are applicable to any system or device that is part of engine type design, that controls, limits, or monitors engine operation, and is necessary for the continued airworthiness of the engine.

(b) *Validation.*

(1) *Functional aspects.* The applicant must substantiate by tests, analysis, or a combination thereof, that the engine control system performs the intended functions in a manner which:

(i) Enables selected values of relevant control parameters to be maintained and the engine kept within the approved operating limits over changing atmospheric conditions in the declared flight envelope;

(ii) Complies with the operability requirements of §§ 33.51, 33.65 and 33.73, as appropriate, under all likely system inputs and allowable engine power or thrust demands, unless it can be demonstrated that failure of the control function results in a non-dispatchable condition in the intended application;

(iii) Allows modulation of engine power or thrust with adequate sensitivity over the declared range of engine operating conditions; and

(iv) Does not create unacceptable power or thrust oscillations.

(2) *Environmental limits.* The applicant must demonstrate, when complying with §§ 33.53 or 33.91, that the engine control system functionality will not be adversely affected by declared environmental conditions, including electromagnetic interference (EMI), High Intensity Radiated Fields (HIRF), and lightning. The limits to which the system has been qualified must be documented in the engine installation instructions.

(c) *Control transitions.*

(1) The applicant must demonstrate that, when fault or failure results in a change from one control mode to another, from one channel to another, or from the primary system to the back-up system, the change occurs so that:

(i) The engine does not exceed any of its operating limitations;

(ii) The engine does not surge, stall, or experience unacceptable thrust or power changes or oscillations or other unacceptable characteristics; and

(iii) There is a means to alert the flight crew if the crew is required to initiate, respond to, or be aware of the control mode change. The means to alert the

crew must be described in the engine installation instructions, and the crew action must be described in the engine operating instructions;

(2) The magnitude of any change in thrust or power and the associated transition time must be identified and described in the engine installation instructions and the engine operating instructions.

(d) *Engine control system failures.* The applicant must design and construct the engine control system so that:

(1) The rate for Loss of Thrust (or Power) Control (LOTC/LOPC) events, consistent with the safety objective associated with the intended application can be achieved;

(2) In the full-up configuration, the system is single fault tolerant, as determined by the Administrator, for electrical or electronic failures with respect to LOTC/LOPC events;

(3) Single failures of engine control system components do not result in a hazardous engine effect; and

(4) Foreseeable failures or malfunctions leading to local events in the intended aircraft installation, such as fire, overheat, or failures leading to damage to engine control system components, do not result in a hazardous engine effect due to engine control system failures or malfunctions.

(e) *System safety assessment.* When complying with this section and § 33.75, the applicant must complete a System Safety Assessment for the engine control system. This assessment must identify faults or failures that result in a change in thrust or power, transmission of erroneous data, or an effect on engine operability producing a surge or stall together with the predicted frequency of occurrence of these faults or failures.

(f) *Protection systems.*

(1) The design and functioning of engine control devices and systems, together with engine instruments and operating and maintenance instructions, must provide reasonable assurance that those engine operating limitations that affect turbine, compressor, fan, and turbosupercharger rotor structural integrity will not be exceeded in service.

(2) When electronic overspeed protection systems are provided, the design must include a means for testing, at least once per engine start/stop cycle, to establish the availability of the protection function. The means must be such that a complete test of the system can be achieved in the minimum number of cycles. If the test is not fully automatic, the requirement for a manual test must be contained in the engine instructions for operation.

(3) When overspeed protection is provided through hydromechanical or mechanical means, the applicant must demonstrate by test or other acceptable means that the overspeed function remains available between inspection and maintenance periods.

(g) *Software*. The applicant must design, implement, and verify all associated software to minimize the existence of errors by using a method, approved by the FAA, consistent with the criticality of the performed functions.

(h) *Aircraft-supplied data*. Single failures leading to loss, interruption or corruption of aircraft-supplied data (other than thrust or power command signals from the aircraft), or data shared between engines must:

(1) Not result in a hazardous engine effect for any engine; and

(2) Be detected and accommodated. The accommodation strategy must not result in an unacceptable change in thrust or power or an unacceptable change in engine operating and starting characteristics. The applicant must evaluate and document in the engine installation instructions the effects of these failures on engine power or thrust, engine operability, and starting characteristics throughout the flight envelope.

(i) *Aircraft-supplied electrical power*.

(1) The applicant must design the engine control system so that the loss, malfunction, or interruption of electrical power supplied from the aircraft to the engine control system will not result in any of the following:

(i) A hazardous engine effect, or

(ii) The unacceptable transmission of erroneous data.

(2) When an engine dedicated power source is required for compliance with paragraph (i)(1) of this section, its capacity should provide sufficient margin to account for engine operation below idle where the engine control system is designed and expected to recover engine operation automatically.

(3) The applicant must identify and declare the need for, and the characteristics of, any electrical power supplied from the aircraft to the engine control system for starting and operating the engine, including transient and steady state voltage limits, in the engine instructions for installation.

(4) Low voltage transients outside the power supply voltage limitations declared in paragraph (i)(3) of this section must meet the requirements of paragraph (i)(1) of this section. The engine control system must be capable of resuming normal operation when aircraft-supplied power returns to within the declared limits.

(j) *Air pressure signal*. The applicant must consider the effects of blockage or leakage of the signal lines on the engine control system as part of the System Safety Assessment of paragraph (e) of this section and must adopt the appropriate design precautions.

(k) *Automatic availability and control of engine power for 30-second OEI rating*. Rotorcraft engines having a 30-second OEI rating must incorporate a means, or a provision for a means, for automatic availability and automatic control of the 30-second OEI power within its operating limitations.

(l) *Engine shut down means*. Means must be provided for shutting down the engine rapidly.

(m) *Programmable logic devices*. The development of programmable logic devices using digital logic or other complex design technologies must provide a level of assurance for the encoded logic commensurate with the hazard associated with the failure or malfunction of the systems in which the devices are located. The applicant must provide evidence that the development of these devices has been done by using a method, approved by the FAA, that is consistent with the criticality of the performed function.

■ 6. Amend § 33.29 by adding new paragraphs (e) through (h) to read as follows:

§ 33.29 Instrument connection.

* * * * *

(e) The applicant must make provision for the installation of instrumentation necessary to ensure operation in compliance with engine operating limitations. Where, in presenting the safety analysis, or complying with any other requirement, dependence is placed on instrumentation that is not otherwise mandatory in the assumed aircraft installation, then the applicant must specify this instrumentation in the engine installation instructions and declare it mandatory in the engine approval documentation.

(f) As part of the System Safety Assessment of § 33.28(e), the applicant must assess the possibility and subsequent effect of incorrect fit of instruments, sensors, or connectors. Where necessary, the applicant must take design precautions to prevent incorrect configuration of the system.

(g) The sensors, together with associated wiring and signal conditioning, must be segregated, electrically and physically, to the extent necessary to ensure that the probability of a fault propagating from instrumentation and monitoring functions to control functions, or vice

versa, is consistent with the failure effect of the fault.

(h) The applicant must provide instrumentation enabling the flight crew to monitor the functioning of the turbine cooling system unless appropriate inspections are published in the relevant manuals and evidence shows that:

(1) Other existing instrumentation provides adequate warning of failure or impending failure;

(2) Failure of the cooling system would not lead to hazardous engine effects before detection; or

(3) The probability of failure of the cooling system is extremely remote.

■ 7. Amend § 33.53 by revising the section heading and paragraph (a) to read as follows:

§ 33.53 Engine system and component tests.

(a) For those systems and components that cannot be adequately substantiated in accordance with endurance testing of § 33.49, the applicant must conduct additional tests to demonstrate that systems or components are able to perform the intended functions in all declared environmental and operating conditions.

* * * * *

§ 33.67 [Amended]

■ 8. Remove paragraph (d) from § 33.67.

■ 9. Amend § 33.88 by revising paragraph (b) to read as follows:

§ 33.88 Engine overtemperature test.

* * * * *

(b) In addition to the test requirements in paragraph (a) of this section, each engine for which 30-second OEI and 2-minute OEI ratings are desired, that incorporates a means for automatic temperature control within its operating limitations in accordance with § 33.28(k), must run for a period of 4 minutes at the maximum power-on rpm with the gas temperature at least 35 °F (19 °C) higher than the maximum operating limit at 30-second OEI rating. Following this run, the turbine assembly may exhibit distress beyond the limits for an overtemperature condition provided the engine is shown by analysis or test, as found necessary by the FAA, to maintain the integrity of the turbine assembly.

* * * * *

■ 10. Amend § 33.91 by revising the section heading and paragraph (a) to read as follows:

§ 33.91 Engine system and component tests.

(a) For those systems or components that cannot be adequately substantiated in accordance with endurance testing of § 33.87, the applicant must conduct additional tests to demonstrate that the systems or components are able to perform the intended functions in all declared environmental and operating conditions.

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Issued in Washington, DC, on July 2, 2008.

Robert A. Sturgell,

Acting Administrator.

[FR Doc. E8-19048 Filed 8-18-08; 8:45 am]

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DEPARTMENT OF TRANSPORTATION**Federal Aviation Administration****14 CFR Part 39**

[Docket No. FAA-2008-0627; Directorate Identifier 2008-CE-033-AD; Amendment 39-15647; AD 2008-17-09]

RIN 2120-AA64

Airworthiness Directives; EADS SOCATA Model TBM 700 Airplanes

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Final rule.

SUMMARY: We are superseding an existing airworthiness directive (AD) for the products listed above. This AD results from mandatory continuing airworthiness information (MCAI) issued by an aviation authority of another country to identify and correct an unsafe condition on an aviation product. The MCAI describes the unsafe condition as:

A rupture of the alternator and vapour cycle cooling system pulley drive assembly has reportedly been found. Such a failure could lead to the loss of the alternator and vapour cycle cooling systems and could also cause mechanical damage inside the powerplant compartment.

We are issuing this AD to require actions to correct the unsafe condition on these products.

DATES: This AD becomes effective September 23, 2008.

As of September 23, 2008, the Director of the Federal Register approved the incorporation by reference of certain publications listed in this AD.

ADDRESSES: You may examine the AD docket on the Internet at <http://www.regulations.gov> or in person at the Docket Management Facility, U.S.

Department of Transportation, Docket Operations, M-30, West Building Ground Floor, Room W12-140, 1200 New Jersey Avenue, SE., Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT

Albert Mercado, Aerospace Engineer, FAA, Small Airplane Directorate, 901 Locust, Room 301, Kansas City, Missouri 64106; *telephone:* (816) 329-4119; *fax:* (816) 329-4090.

SUPPLEMENTARY INFORMATION:**Discussion**

We issued a notice of proposed rulemaking (NPRM) to amend 14 CFR part 39 to include an AD that would apply to the specified products. That NPRM was published in the **Federal Register** on June 9, 2008 (73 FR 32495), and proposed to supersede AD 2008-10-13, Amendment 39-15520 (73 FR 26318, May 9, 2008). That NPRM proposed to correct an unsafe condition for the specified products. The MCAI states that:

A rupture of the alternator and vapour cycle cooling system pulley drive assembly has reportedly been found. Such a failure could lead to the loss of the alternator and vapour cycle cooling systems and could also cause mechanical damage inside the powerplant compartment.

To address this condition, AD 2008-0063-E had been published to require a check of the pulley drive assembly for leakage and, as an interim action, removal of the compressor drive belt from the assembly, and adoption of a new operational procedure to keep the air-conditioning system deactivated.

This AD retains the requirements of AD 2008-0063-E which is superseded, introduces a mandatory terminating action which consists in replacing the original pulley drive assembly by a new one of an improved design—corresponding to the EADS SOCATA modification MOD 70-0231-21—that permits reinstallation of the compressor drive belt.

Comments

We gave the public the opportunity to participate in developing this AD. We received no comments on the NPRM or on the determination of the cost to the public.

Conclusion

We reviewed the available data and determined that air safety and the public interest require adopting the AD as proposed.

Differences Between This AD and the MCAI or Service Information

We have reviewed the MCAI and related service information and, in general, agree with their substance. But we might have found it necessary to use different words from those in the MCAI to ensure the AD is clear for U.S.

operators and is enforceable. In making these changes, we do not intend to differ substantively from the information provided in the MCAI and related service information.

We might also have required different actions in this AD from those in the MCAI in order to follow FAA policies. Any such differences are highlighted in a NOTE within the AD.

Costs of Compliance

We estimate that this AD will affect 21 products of U.S. registry. We also estimate that it will take about 10 work-hours per product to comply with basic requirements of this AD. The average labor rate is \$80 per work-hour. Required parts will cost about \$2,912 per product.

Based on these figures, we estimate the cost of this AD to the U.S. operators to be \$77,952, or \$3,712 per product.

Authority for This Rulemaking

Title 49 of the United States Code specifies the FAA's authority to issue rules on aviation safety. Subtitle I, section 106, describes the authority of the FAA Administrator. "Subtitle VII: Aviation Programs," describes in more detail the scope of the Agency's authority.

We are issuing this rulemaking under the authority described in "Subtitle VII, Part A, Subpart III, Section 44701: General requirements." Under that section, Congress charges the FAA with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it addresses an unsafe condition that is likely to exist or develop on products identified in this rulemaking action.

Regulatory Findings

We determined that this AD will not have federalism implications under Executive Order 13132. This AD will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

For the reasons discussed above, I certify this AD:

- (1) Is not a "significant regulatory action" under Executive Order 12866;
- (2) Is not a "significant rule" under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979); and
- (3) Will not have a significant economic impact, positive or negative, on a substantial number of small entities