CS-ENGINES AMENDMENT 1 - CHANGE INFORMATION

Certification Specifications (CS) are used for establishing the certification basis for applications made after the date of entry into force of a CS including any amendments. Since the complete text of a CS, including any amendments to it, is relevant for establishing the certification basis, the Agency has decided to enact and publish all amendments to CS's as consolidated documents instead of enacting and publishing only the amended text.

Consequently, except for a note [Amdt. No.:E/1] under the amended paragraph, the consolidated text of CS-Engines does not allow readers to see the detailed changes introduced by the new amendment. To allow readers to also see these detailed changes this document has been created. The same format as for publication of Notices of Proposed Amendments has been used to show the changes.

1. text not affected by the new amendment remains the same: unchanged
2. deleted text is shown with a strike through: ~~deleted~~
3. new text is highlighted with grey shading: new
4. ....
   Indicates that remaining text is unchanged in front of or following the reflected amendment.
   ....

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SUBPART A – GENERAL

CS-E 10 Applicability

(a) This CS-E contains airworthiness specifications for the issue of type certificates, and changes to those certificates, for Engines, in accordance with Part 21.

(b) CS-E contains the specifications for the approval for use of the Engine with a thrust reverser, if fitted. If compliance is shown, the specific thrust reverser approved for use will be noted in the Engine certification documentation. Otherwise, the documentation will be endorsed to indicate that the use of a thrust reverser is prohibited. (See AMC E 10 (b))

(c) The specifications of subparts A, B and C apply to Piston Engines. Any necessary variations of the specifications of subparts B and C for Piston Engines intended for use in rotorcraft will be decided in accordance with 21A.16.

(d) The specifications of subparts A, D, E and F apply to Turbine Engines.

CS-E 15 Terminology

(a) …

…

~~(e) Terms associated with the Engine Control System~~

~~Alternate Mode~~	~~means any Control Mode, including Back up Modes that are not the Primary Mode used for controlling the Engine.~~
~~Back up Mode~~	~~means the Control Mode of the Back up System.~~
~~Back up System~~	~~means a part of the Engine Control System where the operating characteristics or capabilities of the Engine control are sufficiently different from the Primary System that the operating characteristics or capabilities of the aircraft, crew workload, or what constitutes appropriate crew procedures may be significantly impacted or changed.~~
~~Engine Control System~~	~~means any system or device which is part of the Engine type design, which controls, limits or monitors Engine operation and is necessary for continued airworthiness of the Engine.~~
~~Primary System~~	~~means the part of the Engine Control System used for controlling the Engine under normal operation.~~

~~Control Mode~~	~~means each defined operational state of the Engine Control System where satisfactory Engine control can be exercised by the crew.~~
~~Primary Mode~~	~~means the mode that is intended to be used for controlling the Engine under normal operation. This is often referred to as the 'normal mode'.~~
~~Aircraft Supplied Data~~	~~means all data which are supplied by or via aircraft systems and is used by the Engine Control System.~~
~~Electronic Engine Control System (EECS)~~	~~means an Engine Control System in which the primary functions are provided using electronics. It includes all the components (e.g. electrical, electronic, hydromechanical and pneumatic) necessary for the control of the power or thrust output of the Engine, within the flight envelope and operating limitations.~~
~~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.~~
~~Fault or Failure Accommodation~~	~~means the capability to mitigate, either wholly or in part, the Fault or Failure.~~
~~Full up Configuration~~	~~means an EECS that has no known Faults or Failures present.~~
~~Loss of Thrust Control (LOTC) or Loss of Power Control (LOPC)~~	~~means the loss of ability to modulate power or thrust between given values, or unacceptable thrust or power oscillations. These values are determined by the exact application.~~
~~Programmed Logic Device (PLD)~~	~~means a component that is purchased as an electronic component and altered to perform an application specific function. PLDs include, but are not limited to, programmable array logic components (PAL), programmable logic array components, general array logic components (GAL), field programmable gate array components, and erasable programmable logic devices.~~

(e~~f~~) …

CS-E 20 Engine Configuration and Interfaces
(See AMC E 20)

(a) …

(f) For Engines having one or more OEI Ratings, data must be provided on Engine performance characteristics and variability to enable the aircraft manufacturer to establish power assurance procedures. (See AMC E 20 (f))

CS-E 25 Instructions for Continued Airworthiness
(See AMC E 25)

…

CS-E 30 Assumptions
(See AMC E 30)

…

CS-E 40 Ratings
(See AMC E 40)

(a) Power ratings must be established for Take-off Power and/or Thrust and for Maximum Continuous Power and/or Thrust, for all Engines.

(b) Other ratings may also be established as –

(1) Piston Engines -

(i) Maximum Recommended Cruising Power.

(ii) Maximum Best Economy Cruising Power.

(2) Turbine Engines for Multi-Engine Aeroplanes

(i) 2 1/2-Minute OEI Power or Thrust

(ii) Continuous OEI Power or Thrust

(3) Turbine Engines for Multi-Engine Rotorcraft (See AMC E 40 (b)(3)):

(i) 30-Second OEI Power

(ii) 2-Minute OEI Power

(iii) 2 1/2-Minute OEI Power

(iv) 30-Minute OEI Power

(v) Continuous OEI Power

(c) The Engine thrust and/or power ratings will be based on standard atmospheric conditions, with no air bleed for aircraft services and with only those accessories installed which are essential for Engine functioning, including controls, unless otherwise declared in the Engine Type certificate data sheet.

(d) Operating limitations appropriate to the intended operating conditions for the Engine must be established. (See AMC E 40 (d))

(e) The Engine's rated Powers/Thrusts and any operating limitations established under this CS-E 40 which must be respected by the crew of an aircraft must be listed in the Engine Type certificate data sheet specified in 21A.41. The Engine Type certificate data sheet must also identify, or make reference to, all other information found necessary for the safe operation of the Engine.

(f) The ratings established under this CS-E 40 must be defined for the lowest power/thrust that all Engines of the same type may be expected to produce under the conditions used to determine these ratings. The minimum testing must be defined, together with associated conditions, necessary for ensuring that the Engines will comply with this objective.

(g) 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 CS-E 60 (b) must be taken into account.

(h) For Piston Engines, each declared rating must be defined in terms of the power produced at a given power setting and Engine rotational speed.

CS-E 50 Engine Control System
(See AMC E 50)

(a) …

(e) *Protection Systems.* (See AMC E 50 (e))

(1) When electronic over-speed protection systems are provided, the design must include a means for testing the system 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 specification for a manual test must be contained in the Engine instructions for operation.

(2) When over-speed protection is provided through hydromechanical or mechanical means, it must be demonstrated by test or other acceptable means that the over-speed function remains available between inspection and maintenance periods.

(f) *Software and Programmable~~Programmed~~ Logic Devices*. All associated software and encoded logic must be designed, implemented and verified to minimise the existence of errors by using an approved method consistent with the criticality of the performed functions.

…

(j) 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. (See AMC E 50 (j))

(k) Means for shutting down the Engine rapidly must be provided.

CS-E 60 Provision for Instruments
(See AMC E 60)

(a) …

…

(d) Rotorcraft turbine Engines having 30-Second and 2-Minute OEI Power Ratings must (See AMC E 60 (d)):

…

CS-E 70 Materials and Manufacturing Methods
(See AMC E 70)

…

CS-E 80 Equipment
(See AMC E 80)

…

CS-E 130 Fire Protection
(See AMC E 130)

(a) …

~~(g) Any components, modules, equipment and accessories which are susceptible to or are potential sources of static discharges or electrical Fault currents must be designed and constructed so as to be grounded to the Engine reference in order to minimise the risk of ignition in external areas where flammable fluids or vapours could be present.~~

(g~~h~~) Those features of the Engine which form part of the mounting structure or Engine attachment points must be Fireproof, either by construction or by protection, unless not required for the particular aircraft installation and so declared in accordance with CS-E 30.

CS-E 135 Electrical Bonding
(See AMC E 135)

Any components, modules, equipment and accessories that are susceptible to or are potential sources of static discharges or currents from electrical Faults, must be designed and constructed so as to be grounded to the main Engine earth, as necessary to minimise the accumulation of electro-static or electrical charge that would cause:

- Injury from electrical shock,
- Unintentional ignition in areas where flammable fluids or vapours could be present,
- Unacceptable interference with electrical or electronic equipment.

CS-E 140 Tests - Engine Configuration
(See AMC E 140)

…

CS-E 150 Tests - General Conduct of Tests

(a) The fuel and oil used for all tests must normally be chosen from those specified by the Applicant, but, where it may have relevance to the results of any particular test, the actual fuel and oil to be used (including any additives) must be justified. (See AMC E 150 (a))

…

CS-E 170 Engine Systems and Component Verification
(See AMC E 170)

…

CS-E 180 Propeller Functioning Tests
(See AMC E 180)

(a) …

(b) …

(1) …

(2) 10 feathering cycles. In addition, for turbine Engines, where the oil tank is to be approved as part of the Engine, the ability to complete one cycle (i.e. one feather and unfeather) when the supply of oil has been reduced to the feathering reserve oil (see CS-E 570 (f)(3)(i)~~(b)(6)~~) must be demonstrated.

(3) …

…

CS-E 210 Failure Analysis
(See AMC E 210)

…

CS-E 240 Ignition

All spark-ignition Engines shall comply with the following:

(a) …

(b) If the design of the ignition system includes redundancy :

(1) The maximum power reduction resulting from loss of redundancy shall be declared in the appropriate manual(s).

(2~~1~~) Provision shall be made to establish the serviceability of the ignition system. The associated procedures and required inspection intervals shall be specified in the appropriate manual(s).

CS-E 250 Fuel System

(a) ...

(b) Any characteristic of fuel conforming to the specification(s) to be approved which is likely to adversely affect Engine functioning or durability, must be identified so that, where necessary, Engine or rig testing using appropriate fuel may be conducted.

…

CS-E 300 Conditions Applicable to All Tests

…

(f) *Torque Measurement* - For testing requiring the measurement of Engine power, an acceptable method of establishing the torque of the Engine shall be defined. (See AMC E 300 (f))

CS-E 320 Performance Correction
(See AMC E 320)

…

CS-E 340 Vibration Tests
(See AMC E 340)

…

CS-E 350 Calibration Tests
(See AMC E 350)

…

CS-E 360 Detonation Tests

For spark ignition Engines:

(a) …

(b) During the test of CS-E 360 (a), the Engine shall be operated throughout the range from the lowest Engine rotational speed intended to be used for cruising, to the declared maximum Engine rotational speed, at the conditions of power setting, mixture setting (if applicable), oil temperature, coolant or cylinder-head temperatures, and manifold air pressure and air temperature, most likely to cause detonation. An agreed method shall be used to determine the degree of detonation.

CS-E 380 Low Temperature Starting Tests
(See AMC E 380)

…

CS-E 440 Endurance Test

(a) …

(b) …

(1)
…

(3) *Schedule for Engine Incorporating a Turbocharger*. (See AMC E 440 (b)(3)). For Engines incorporating a turbocharger, the Schedule of CS-E 440 (b)(1) will apply, except that:
(i) …

…

CS-E 470 Contaminated Fuel
(See AMC E 470)

…

CS-E 500 Functioning
(See AMC E 500)

…

CS-E 510 Safety Analysis

(See AMC E 510)

…

CS-E 515 Engine Critical Parts
(See AMC E 515)

…

CS-E 520 Strength

(a) The major rotating components of the Engine must have adequate strength to withstand both the thermal and dynamic conditions of normal operation and any excessive thermal or dynamic conditions that may result from abnormal speeds, abnormal temperatures or abnormal vibration loads. In assessing the abnormal conditions to be considered, account must be taken of the Failure analysis prescribed in CS-E 510. (See AMC E 520 (a))

(b) …

(c) (1) The strength of the Engine must be such that the shedding of compressor or turbine blades, either singly or in likely combinations, will not result in a Hazardous Engine Effect (e.g. as a long term effect in respect of those Failures which would not be detected by the declared instrumentation, such as vibration detectors~~)~~ and within the likely shutdown time for those which would be detected, and during any continued rotation after shutdown). (See AMC E 520 (c)(1))

…

CS-E 525 Continued Rotation
(See AMC E 525)

…

CS-E 540 Strike and Ingestion of Foreign Matter
(See AMC E 540)

…

CS-E 560 Fuel System
(See AMC E 560)

…

CS-E 570 Oil System
(See AMC E 570)

…

CS-E 580 Air Systems ~~and Compressor and Turbine Bleeds~~

~~(a)~~ Where bleed air is used to cool or to pressurise areas of the Engine, the functions of which could be detrimentally affected by the ingress of foreign matter (e.g. sand or dust), the design must be such that the passage of foreign matter of unacceptable quantity or unacceptable size is precluded.

~~(b) Air ducts external to the Engine must be so designed, routed or arranged that Failure of a duct will not cause an unsafe Engine condition (e.g. by excessive bleed or by secondary damage) before the Engine can be shut down, unless it can be shown that Failure of the duct is Extremely Remote.~~

CS-E 600 Tests – General

(a) …

…

(e) Engines for Rotorcraft. All tests must normally be made with the Engine mounted in the attitude in which it will be installed. (See AMC E 600 (e))

CS-E 620 Performance Correction
(See AMC E 620)

…

CS-E 640 Pressure Loads
(See AMC E 640)

…

CS-E 650 Vibration Surveys
(See AMC E 650)

…

CS-E 660 Fuel Pressure and Temperature
(See AMC E 660)

…

CS-E 670 Contaminated Fuel
(See AMC E 670)

…

CS-E 680 Inclination and Gyroscopic Load Effects
(See AMC E 680)

…

CS-E 690 Engine Bleed
(See AMC E 690)

…

CS-E 700 Excess Operating Conditions
(See AMC E 700)

…

CS-E 710 Rotor Locking Tests
(See AMC E 710)

…

CS-E 720 Continuous Ignition

(a) Where approval of an Engine is sought which permits or requires the use of a continuously-operated ignition system, the specifications of CS-E 720 (b) together with either CS-E 720 (c) or (d) must be met. (See AMC E 720 (a))

(b) …

…

CS-E 730 Engine Calibration Test
(See AMC E 730)

…

CS-E 740 Endurance Tests

(a) …

…

(c) …

(1) …

…

(3) For Engines with 30-Second and 2-Minute OEI Power ratings (See AMC E 740 (c)(3)),

…

…

(f) …

(1) The characteristics of multi-spool Engines may be such that it is not possible to obtain the maximum rotational speed of each spool simultaneously at sea-level test bed conditions, without making the Engine unacceptably non-standard, or running it in a non-representative manner. In such circumstances, the endurance test must be run at the turbine entry temperatures for which approval is sought, and evidence from supplementary endurance testing, to a schedule acceptable to the Agency, must be provided to substantiate the approval of any higher rotational speed limitations desired. (See AMC E 740 (f)(1))

(2) …

…

(g) *Incremental Periods.*

(1) If a significant peak blade vibration is found to exist at any condition within the operating range of the Engine (not prohibited under CS-E 650 (d)), not less than 10 hours, but not exceeding 50%, of the incremental periods of Part 4 of the endurance test must be run with the rotational speed varied continuously over the range for which vibrations of the largest amplitude were disclosed by the vibration survey; if there are other ranges of rotational speed within the operational range of the Engine where approximately the same amplitude exists, a further 10 hours must be run in the same way for each such range. The speed variation must be effected by automatic means using a method acceptable to the Agency. (See AMC E 740 (g)(1))

(2) …

…

(h) *Inspection Checks*

(1) …

(2) Engines with 30-Second and 2-Minute OEI Power ratings must be subjected to a full strip inspection after completing the additional endurance test of CS-E 740 (c)(3)(iii). (See AMC E 740 (h)(2))

(i) …

…

CS-E 745 Engine Acceleration
(See AMC E 745)

…

CS-E 750 Starting Tests

(a) …

(b) Ten False Starts, each followed by a normal start immediately on expiry of the declared drainage period, must be made at evenly distributed intervals throughout the endurance test. Failure to start must be simulated on these occasions by rendering the ignition circuit inoperative. Following each False Start, the combustion chambers, air casings, etc., may be drained, by the normal means provided, of any fuel which may have accumulated. (See AMC E 750 (b))

…

CS-E 770 Low Temperature Starting Tests
(See AMC E 770)

…

CS-E 780 Tests In Ice-Forming Conditions
(See AMC E 780)

…

CS-E 790 Ingestion of Rain and Hail
(See AMC E 790)

(a) *All Engines*

(1) …

(2) In addition to complying with CS-E 790 (a)(1) and except as provided in CS-E 790 (b), it must be shown that each Engine is capable of acceptable operation throughout its specified operating envelope when subjected to sudden encounters with the certification standard concentrations of rain and hail as defined in Appendix A to CS-E. Acceptable Engine operation precludes, during any 3-minute continuous period in rain and during any 30-second continuous period in hail, the occurrence of flameout, rundown, continued or non recoverable surge or stall, or loss of acceleration and deceleration capability. It must also be shown after the ingestion that there is no unacceptable mechanical damage, unacceptable power or thrust loss, or other adverse Engine anomalies. (See AMC E 790 (a)(2))

…

CS-E 800 Bird Strike and Ingestion
(See AMC E 800)

(a) *Objective.*

…

(c) …

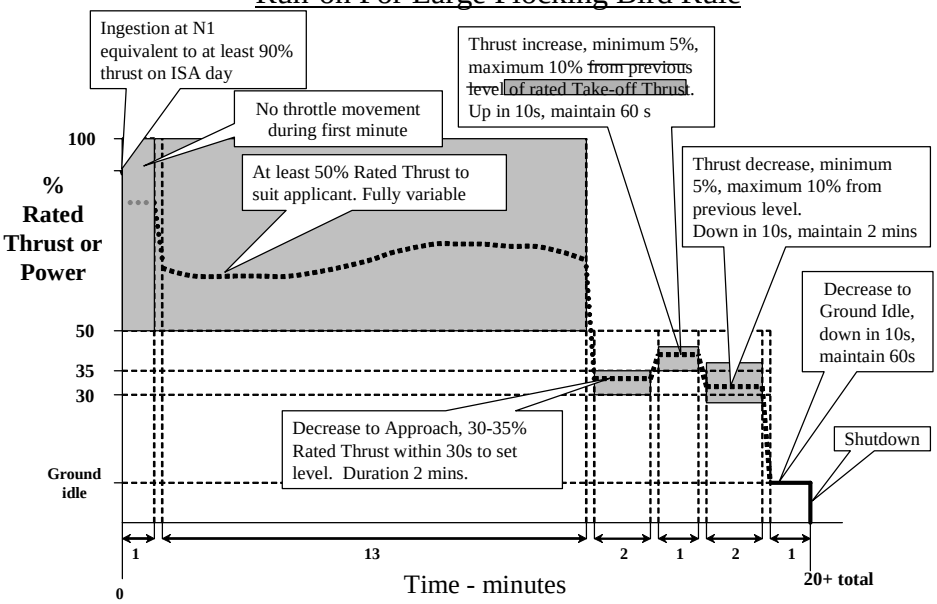
(1) *Test conditions.*

(i) …

...

(v) The following test schedule must be used:
Step 1 - …
…
Step 6 - At least 1 minute at ground idle followed by Engine shut down.
Each specified step duration is time at the defined step conditions. Power lever movement between each step will be 10 seconds or less, except that power lever movement for setting conditions of step 3 will be 30 seconds or less. Within step 2, power lever movements are allowed and are not limited.

Run-on For Large Flocking Bird Rule



(2) …
…

CS-E 810 Compressor and Turbine Blade Failure
(See AMC E 810)

…

CS-E 820 Over-torque Test

(a) …
(1) …
(2) On conclusion of such tests, the stripped condition of the Engine or individual groups of components must be satisfactory for continued running. (See AMC E 820 (a)(2))
(b) …
…

CS-E 830 Maximum Engine Over-speed

(a) …
…
(c) On conclusion of such tests, the stripped condition of the Engine must be satisfactory for continued running. (See AMC E 830 (c))
(d) …

CS-E 840 Rotor Integrity

(See AMC E 840)

…

CS-E 850 Compressor, Fan and Turbine Shafts
(See AMC E 850)

…

CS-E 870 Exhaust Gas Over-temperature Test

(a) *General*
(1) …
…
(3) On conclusion of the tests, the stripped condition of the Engine must be satisfactory for continued running. (See AMC E 870 (a)(3)

(b) …

CS-E 890 Thrust Reverser Tests
(See AMC E 890)

…

CS-E 920 Over-temperature Test
(See AMC E 920)

…

CS-E 1000 General
(See AMC E 1000)

…

CS-E 1020 Engine Emissions
(See AMC E 1020)

…

CS-E 1030 Time Limited Dispatch
(See AMC E 1030)

~~If time limited dispatch is requested, any dispatchable configuration of the Engine, including its control system, must comply with the applicable specifications of CS-E. The length of time allowed prior to rectification of a Fault resulting in degraded operation must be justified as part of the system safety assessment of CS-E 50 (d) or the safety analysis of CS-E 510 and documented as part of the MMEL of the aircraft in which the Engine is installed.~~

(a) If approval is sought for dispatch with Faults present in an Electronic Engine Control System (EECS), a time limited dispatch (TLD) analysis of the EECS must be carried out to determine the dispatch and maintenance intervals.

(b) For each dispatchable configuration it must be shown by test or analysis that:

(1) The Engine remains capable of meeting all CS-E specifications for:

(i) The operability aspects covered by CS-E 500 (a), CS-E 750 and CS-E 745;

(ii) Re-light in flight covered by CS-E 910.

(2) The ability to control the Engine within limits is maintained;

(3) Protection is maintained against Hazardous Engine Effects, if provided solely by the EECS and shown to be necessary by the safety analyses required under CS-E 510 and CS-E 50;

(4) A means is maintained to provide necessary signals to identify EECS Faults;

(5) A further single Failure in the EECS will not produce a Hazardous Engine Effect;

(6) The Engine continues to meet its certification specifications for external threats;

(7) The proposed dispatch interval is justified.

(c) The time-weighted-average of the Full-up Configuration and all allowable dispatch configurations with Faults, must meet the Loss of Thrust Control / Loss of Power Control (LOTC/LOPC) rate for the intended application(s).

(d) The periods of time allowed prior to rectification of Faults must be documented in the appropriate manual(s).

(e) Provision must be made for any no-dispatch configuration to be indicated to the flight crew.

~~If time limited dispatch is requested, any dispatchable configuration of the Engine, including its control system, must comply with the applicable specifications of CS-E. The length of time allowed prior to rectification of a Fault resulting in degraded operation must be justified as part of the system safety assessment of CS-E 50 (d) or the safety analysis of CS-E 510 and documented as part of the MMEL of the aircraft in which the Engine is installed.~~

AMC ~~to CS-~~E 10 (~~c~~b)
Thrust Reversers

…

AMC ~~to CS-~~E 20
Engine Configuration and Interfaces

…

AMC ~~to CS-~~E 20 (f)
Power assurance data for engines with one or more OEI power ratings

…

AMC ~~to CS-~~E 25
Instructions for continued airworthiness

(1) …

…

(4) …

(a) For Engines with 30-Second and 2-Minute OEI Power ratings, the airworthiness limitations section of the instructions for continued airworthiness are required to prescribe the mandatory post-flight inspections and maintenance actions which are applicable following the use of either of these two ratings, or both, prior to next flight.

If the 2-Minute OEI Power rating time period is extended to 2 1/2 minutes, as described in paragraph (5) of AMC ~~to CS-~~E 40 (b), the additional 30 seconds period is considered as a de-rated 30-Second OEI Power rating and the maintenance actions prescribed for the 30-Second OEI rating should be used. Alternatively, the applicant may seek approval for prescribing a different set of inspections and maintenance actions for time exceedence of Engine operation at the 2-Minute OEI Power rating if this is appropriately justified and validated. For instance, if the Engine is essentially the same as one which has a 2 1/2-Minute OEI rating equivalent to the new 2-Minute OEI rating, then the maintenance considerations of the 2 1/2-Minute OEI rating might also be applicable after use of the 2-Minute OEI rating for up to 2.5 minutes.

If only the accumulated usage time is recorded under CS-E 60 (d)(2), the inspection and maintenance action prescribed as required by CS-E 25 (b)(2) should be based on the total recorded time duration regardless of the number of applications at the ratings used in one flight.

(b) …

…

AMC ~~to CS-~~E 30
Assumptions

The details required by CS-E 30 concerning assumptions should normally include information on, at least, the items listed in Table 1.

TABLE 1

Specifications/References	*Assumptions*
ALL ENGINES	
Interfaces CS-E 20	Applicable aircraft specifications Flight and ground loads Aircraft components and equipment not included in the Engine definition Attitudes Negative g duration Physical and functional interfaces with the aircraft Mount flexibility
Engine Control System CS-E 50	Type of aircraft installation Conditions on the interfaces with the aircraft or the Propeller Environmental conditions
Instrumentation CS-E 60	Instrumentation required and statement of accuracy. For engines with 30-Second / 2-Minute OEI ratings, conditions imposed to the usage recording system
Strength CS-E 100 CS-E 520, E 640	Ultimate and limit loads – Out of balance loads – Operating envelope
Fire precautions CS-E 130	Reliance placed on installation fire-zone partitioning for any part of the mounting structure or Engine attachment points that are not Fireproof.
Electrical bonding CS-E 135	Reliance placed on aircraft provisions for electrical bonding of the Engine.
Propeller functioning tests CS-E 180	Propeller system Levels of the Propeller vibrations
Failure Analysis CS-E 210, E 510	Installation aspects and the assumptions made with respect to any safety system that is required for the Engine and which is outside the applicant's control.
Low temperature starting tests, CS-E 380, E 770	Minimum and maximum starting torque.
TURBINE ENGINES	
Freedom from surge CS-E 500	Operating envelope, i.e. altitude, temperature, aircraft speed. Permissible intake distortion.
Low cycle fatigue CS-E 515	Engine Flight Cycle
Continued rotation CS-E 525	Aircraft conditions such as airspeed, flight duration and ambient conditions.
~~Fire precautions~~ ~~CS-E 530~~	~~Reliance placed on installation fire-zone partitioning for any part of the mounting structure or Engine attachment points that are not fireproof.~~

~~Electrical bonding CS-E 530~~	~~Reliance placed on aircraft provisions for electrical bonding of Engine components and for their protection against lightning strikes.~~
Fuel system CS-E 560	Fuel Specifications approved for use. Need for aircraft fuel anti-ice means or fuel with anti-ice additives. Assumptions made with respect to the maximum levels of contamination in the fuel supplied to the Engine.
Oil System CS-E 570	Oil(s) approved for use.
Starter system CS-E 570	Reliance placed on aircraft provisions for any safety system that is outside the applicant's control.
Vibration Survey CS-E 650	Intake conditions, exhaust conditions. Propeller or thrust reverser effects.
Contaminated fuel CS-E 670	Duration of flight with contaminated fuel following indication of impending filter blockage, and critical temperature for test of AMC ~~to CS-E 670 Paragraph 2.~~
Inclination and gyroscopic loads effects CS-E 680	Flight manoeuvres.
Excess operating conditions CS-E 700	Operating envelope.
Rotor locking test CS-E 710	Maximum torque from continued flight.
Thrust or power response CS-E 745	Minimum ground idle Minimum flight idle Flight envelope
Test in ice forming conditions CS-E 780	Intake conditions and configuration. Aircraft speeds and appropriate Engine powers.
Ingestion of rain and hail CS-E 790	Aircraft speeds, Engine speeds and altitudes. Intake throat area – Intake configuration.
Bird strikes CS-E 800	Aircraft speeds, Engine speeds and altitudes. Intake throat area – Intake configuration.
Re-light in flight CS-E 910	Flight re-light envelope
PISTON ENGINES	
De-icing and anti-icing CS-E 230	Temperature rise provided.

Filters CS-E 260	Provision to be made in installation.
Vibration tests CS-E 340	Propeller used.
Water Spray tests CS-E 430	Installation details.

AMC ~~to CS-~~E 40
Ratings

…

AMC ~~to CS-~~E 40 (b)(3)
30-Second OEI and 2-Minute OEI Ratings

(1) …

…

(3) While the 30-Second and 2-Minute OEI power ratings were originally conceived as high power ratings, using the available margins in the Engine design, and followed by a mandatory Engine overhaul, the experience has shown that the manufacturers provide engines with differing capabilities and different margins. Therefore some flexibility is possible in defining the mandatory maintenance actions, provided they are appropriately validated during certification. (See also AMC ~~to CS-~~E 25)

(4) …

(5) In some circumstances, the highest power used during a 2.5 minute duration OEI event might be lower than the 30-second OEI power band but still inside the certified power band of the 2-Minute OEI power rating. In this case, it is permissible to extend the use of the 2-Minute OEI power rating to a total duration of 2.5 minutes. However, that additional 30 seconds period will be considered as a de-rated 30-Second OEI power rating. For the required mandatory maintenance actions, see CS-E 25 (b)(2) and AMC ~~to CS-~~E 25.

(6) …

AMC ~~to CS-~~E 40 (d)
Operating Limitations

The Operating limitations established under CS-40 (d) should normally include those items listed below.

(1) General

(a) Environmental conditions. (Flight envelope)

(b) Maximum declared Engine conditions for Reversible~~reverse p~~ Pitch Propeller operations. (If applicable)

(c) …

…

AMC ~~to CS-~~E 50
Engine Control System

(1) …

(2) Objective

The purpose of CS-E 50 is to set objectives for the general design and functioning of the Engine Control System and these specifications are not intended to replace or supersede other specifications, such as CS-E 560 for the fuel system. Therefore, individual components of the Engine Control System, such as alternators, sensors, actuators, should be covered, in addition, under other CS-E paragraphs such as CS-E 80 or CS-E 170, as appropriate.

For EECS, AMC 20-1 and AMC 20-3 provide~~s~~ additional and detailed interpretation of CS-E 50 with special consideration to interfaces with the aircraft, and the Propeller when applicable.

(3) Rotorcraft Engines

For rotorcraft Engine Control Systems that have a power turbine speed governing mode, the specification of CS-50(a)(3) for modulation of Engine power should be interpreted as the ability to manage power as required to maintain power turbine speed within specified limits.

(4~~3~~) Integrity

The intent of CS-E 50 (c) is to establish Engine Control System integrity specifications consistent with operational specifications of the various applications. In particular, the introduction of Electronic Engine 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.

(5~~4~~) Aircraft Supplied Power

Engine Control Systems implemented in hydromechanical technology or technology other than electrical and electronic technology should inherently be compliant with CS-E 50 (h). 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 AMC 20-1 and AMC 20-3 for relevant interpretation).

(6~~5~~) Air Signal Lines

CS-E 50 (i) 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.

AMC ~~to CS-~~E 50 (e)
Rotor integrity

…

AMC ~~to CS-~~E 50 (j)
Controls - Engines having a 30-Second OEI Power Rating

(1) …

(2) The means required by CS-E 50 (j) should not prevent the Engine from reaching and maintaining its rated 30-Second OEI Power. See also paragraph (5) of AMC ~~to CS-~~E 20 (f).

AMC ~~to CS-~~E 60
Provision for instruments

…

AMC ~~to CS-~~E 60 (d)
Provision for instruments

(1) …

(2) The required means, provided by the applicant or by the rotorcraft manufacturer, are intended to automatically record the entry into, and the subsequent usage of, the defined power levels, and to enable the pilot to be automatically alerted of the entry into the power levels and the corresponding impending time expiration and the time expiration point. The automatic recording should be compatible with the maintenance instructions prescribed for these ratings. In particular, it should record the number of usages and time of each usage or accumulated time, including any exceedence of 30-Second OEI and/or 2-Minute OEI operating limitations or relevant time limitations. It should also provide a means to alert the maintenance personnel that usage and/or exceedence of 30-Second and/or 2-Minute OEI power have taken place. See also paragraph (5) of AMC ~~to CS-~~E 40 (b) regarding exceedence of the 2 minute time limitation at 2-Minute OEI power.

…

(5) An Engine can be approved with 30-Second/2-Minute OEI Power Ratings and any combination of Maximum Engine Over-torque, Maximum Engine Over-speed and Maximum Exhaust Gas Over-Temperature in compliance with CS-E 820, 830, and 870. In such a case, Engine operation above the Take-off Rating limits but within the limits established under CS-E 820, 830, and 870 need not be considered as usage of 30-Second/2-Minute OEI Power Ratings if the event was a true over-torque, over-speed or over-temperature event and it can be demonstrated that the recording system is able to distinguish between;

(i) an Engine over-speed, over-torque or over-temperature with all Engines operating, and

(ii) use of the 30 Second/2 Minute OEI Power Ratings with one Engine inoperative.

AMC ~~to CS-~~E 70
Castings, Forgings, Welded Structures and Welded Components

…

AMC ~~to CS-~~E 80

Equipment

(1) …

(2) …

(a) …

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

The following environmental conditions should be considered for all electrical / electronic equipment or equipment with electrical / electronic sub-components. Additional advisory material on EMI, HIRF and lightning strikes may be found in AMC 20-1 and AMC 20-3.

Table 2

Electrical General	ENVIRONMENTAL CONDITIONS	ACCEPTABLE TESTS/PROCEDURES
14	Thermal Cycle	EUROCAE ED-14 / RTCA/DO-160, Section 5
15	Explosion Proofness	EUROCAE ED-14 / RTCA/DO-160, Section 9
16	Humidity	EUROCAE ED-14 / RTCA/DO-160, Section 6 or MIL-STD-810
17	Waterproofness	EUROCAE ED-14 / RTCA/DO-160, Section 10 or MIL-STD-810 (RAIN)
18	EMI, HIRF & lightning	See AMC 20-1 and AMC 20-3
19	Power Input	EUROCAE ED-14 / RTCA/DO-160, Section 16 and 17 or MIL-STD-704

…

Table 3

	SUBJECT	ACCEPTABLE TESTS/PROCEDURES
20	Proof Pressure	CS-E 640 (a)(1)
21	Burst Pressure	CS-E 640 (a)(2)
22	Pressure Cycling	~~CS-E 640 (b)~~ AMC E 515 (3)(e)
23	Fire	CS-E 130 (note : the Engine Control System should also comply with CS-E 130 (e))

The related AMC ~~to CS-~~E 130 and AMC ~~to CS-~~E 640 are therefore relevant.

(d) Specialised Equipment Testing

Table 4

	SUBJECT	ACCEPTABLE TESTS/PROCEDURE
24	Overheat for Engine electronic control systems	AMC 20-1 and AMC 20-3

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 AMC 20-1 and AMC 20-3. If an overheat test/analysis is not completed, this should be declared as an installation limitation in the Engine instructions for installation and the possibility of an overheat should be addressed at aircraft certification.

(3) …

…

AMC ~~to CS-~~E 130
Fire protection

(1) Definitions

(a) …

…

(d) Fire-resistant, Fireproof: the definitions of "Fire-resistant" and "Fireproof" are given in CS-Definitions~~CS-E 15~~; they imply that the functioning of the part under fire condition should not hazard the aircraft.

(e) …

…

(5) ~~Fire tests~~ Flammable fluid tank fire test

~~(a) Flammable fluid tank fire test~~

In the absence of …

(6~~b~~) Drain and Vent Systems

…

~~(c) Electrical Bonding~~

~~The overall intent of CS-E 130 (g) is to show that an electrical current path exists between certain components that are mounted externally to the Engine and the Engine carcass.~~

~~These components are those which, with respect to fire protection, are susceptible to or are potential sources of static discharge or electrical Fault current. To comply with this specification, the applicant should show that the modules, assemblies, components and accessories installed in or on the Engine are electrically grounded to the Engine reference.~~

~~This may be accomplished by examination of the type design drawings, electrical continuity check, or actual inspection of an Engine. The type design should provide protection for probable Failure cases.~~

(7~~d~~) Air Sources

…

(8~~e~~) Firewall

…

(9f) Shielding

…

AMC E 135
Electrical Bonding

Electrical bonding is a means to protect against the effects of electro-static discharges and currents from electrical Faults. The overall intent of CS-E 135 is to ensure that:

(i) a main Engine earth is provided. This is generally achieved by showing that all the elements of the Engine carcass are electrically bonded together.

(ii) a current path for electrical bonding exists between certain components that are mounted externally to the Engine and the main Engine earth.

With respect to the accumulation of electro-static or electrical charge, the applicant should show that the modules, assemblies, components and accessories installed in or on the Engine are electrically bonded to the main Engine earth. This may be accomplished by examination of the type design drawings, electrical continuity checks, or actual inspection of a representative Engine.

AMC ~~to CS-~~E 140
Test- Engine configuration

…

AMC ~~to CS-~~E 150 (a)
Tests - General conduct of tests

…

~~**AMC to CS-E 150 (f)**~~
~~**Endurance tests - Inspection checks and calibration tests**~~

~~(1) If relevant, the level of Engine disassembly, component cleaning and replacement prior to rebuild for the additional endurance test sequence should be agreed with the Agency (See CS-E 150 (f)(3)(ii)). It should be shown that any cleaning or replacement of consumable parts during the strip examination or replacement of consumable parts will not enhance the Engine's ability to meet the specifications of the additional endurance test of CS-E 740 (c)(3)(iii).~~

~~(2) For complying with the structural integrity specification of CS-E 150 (f)(3)(iii), the applicant should show that no Failure of any significant Engine component occurs during test or during shutdown, or becomes evident during the subsequent tear-down inspection. In the event that any Failure becomes evident, this should be analysed and corrective actions taken, or certain limitations imposed on the Engine as appropriate. For the purpose of this specification, the Engine parts deemed significant are those that can affect the structural integrity, including but not limited to mountings, casings, bearing supports, shafts and rotors.~~

~~(3) The Engine condition exhibited after the additional endurance test required by CS-E 740 (c)(3)(iii) may be used to validate the mandatory maintenance actions after use of 30-Second and 2-Minute OEI ratings as required by CS-E 25 (b)(2) and described in the associated AMC material.~~

~~(4) For components which are distressed beyond serviceable limits during the test of CS-E 740 (c)(3)(iii), it should be shown that the inspections and mandatory maintenance actions for these components, as specified in the Instruction for Continued Airworthiness, are adequate. The instructions should include means for proper identification of these component conditions, and appropriately defined maintenance actions.~~

~~The component deterioration as it affects performance during the test, and the component condition after test, should be determined. The distress seen as a result of the 2-hour test should not create a potentially hazardous condition. In addition to visible physical damage, non-visible damage should be assessed. Such damage may include but not necessarily be limited to the effects of creep, stress rupture, metallurgical effects, life usage, etc. This overall evaluation should then be considered when defining and justifying the inspections and mandatory maintenance actions for instructions for continued airworthiness.~~

AMC ~~to CS-~~E 170
Engine systems and component verification

The intent of CS-E 170 is …

…

The objective of CS-E 50 (a), in conjunction with CS-E 80 or CS-E 170, is to demonstrate that the Engine Control System can perform its intended function in its installed environment. 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. Advisory material for environmental effects other than lightning and electromagnetic effects can be found in AMC ~~to CS-~~E 80.

If, for compliance with CS-E 170, high intensity radiated fields (HIRF)/Lightning tests are carried out on anything other than a representative complete Engine, the test results may depend on the validity of the assumed electrical bonding between those elements of the Engine that are tested and the main Engine earth. In such cases, the applicant should demonstrate that these electrical bonding assumptions are valid. This may be accomplished by examination of the type design drawings, electrical continuity checks, or actual inspection of a representative Engine.

For compliance with CS-E 170, …

...

Additional means may be found in AMC ~~to CS-~~E 80 or in AMC 20-1 and AMC 20-3 for Electronic Engine Control Systems.

In meeting the above environmental concerns, due consideration should be given to dispatching in each approved degraded state.

See AMC ~~to CS-~~E 80 for additional specific means.

AMC ~~to CS-~~E 180
Propeller Functioning Tests

…

AMC ~~to CS-~~E 210
Failure Analysis

…

AMC ~~to CS-~~E 300 (f)
Conditions Applicable to all Tests - Torque Measurement

…

AMC ~~to CS-~~E 320
Performance correction

…

AMC ~~to CS-~~E 340
Vibration Tests

…

AMC ~~to CS-~~E 350
Calibration Tests

…

AMC ~~to CS-~~E 380
Low Temperature Starting Tests

…

AMC ~~to CS-~~E 440 (b)(3)
Endurance Test – Schedule for Engine Incorporating a Turbocharger

…

AMC ~~to CS-~~E 470
Contaminated Fuel

….

AMC ~~to CS-~~E 500
Functioning – Control of Engines (Turbine Engines for Aeroplanes)

…

(3) The Engine is shown to be safe in the event of inadvertent opening of the throttle to its maximum travel in an emergency situation (see also AMC ~~to CS-~~E 700 paragraph 3).

AMC ~~to CS-~~E 510
Safety analysis

(1) …

…

(3) Specific means.

(a) …

…

(c) Typical installation

The reference to "typical installation" in CS-E 510 (a)(1)(i) does not imply that the aircraft-level effects are known, but that assumptions of typical aircraft devices and procedures, such as fire-extinguishing equipment, annunciation devices, etc., are clearly stated in the analysis.

CS-E 510 (a)(1)(i)~~(f)~~ requires the applicant to take account of aircraft-level devices ~~include~~ in the Engine safety analysis ~~consideration of some aircraft components~~. For example, the effects on the Engine of failure of aircraft air ducts might be considered.

…

…

AMC ~~to CS~~ E 515
Engine Critical Parts

(1) …

…

(3) …

(a) …

…

(d) …

(i) …

…

(v) *Damage Tolerance assessment.*

…

Anomaly size and frequency distributions.

A key input in the damage tolerance assessment is the size and rate of occurrence of the anomalies. This type of information may be statistical in nature and can be presented in a form that plots number of ~~inclusions~~anomalies that exceed a particular size in a specified amount of material. Anomalies should be treated as sharp propagating cracks from the first stress cycle unless there is sufficient data to indicate otherwise.

…

…

AMC ~~to CS~~ E 520 (a)
Strength – High Cycle Fatigue

…

AMC ~~to CS~~ E 520 (c)(1)
Strength – Shedding of Blades

…

AMC ~~to CS-~~E 525
Continued rotation

…

AMC ~~to CS-~~E 540
Strike and ingestion of foreign matter

…

AMC ~~to CS-~~E 560
Fuel system

…

AMC ~~to CS-~~E 570
Oil system

(1) …

…

(5) "Hazardous quantities", as referred to in CS-E 570 (e)(1), is defined in AMC ~~to CS-~~E 130.

AMC ~~to CS-~~E 600 (e)
Test - General

…

AMC ~~to CS-~~E 620
Performance : Formulae

…

AMC ~~to CS-~~E 640
~~Static~~ Pressure Loads~~and Fatigue Tests~~

…

AMC ~~to CS-~~E 650
Vibration Surveys

(1) Definitions. The following are defined for the purpose of this AMC:

…

Corrected rotational speed (Nc).	The rotational speed of a rotor system corrected by normalising the compressor inlet conditions to a standard condition of air at 15°C. The correction values are empirically determined and are applied by the formula: $Nc = Nr/(T_{inlet}/288)^{e}$ ~~exponent~~ Where T_{inlet} is the compressor inlet temperature in Kelvin and the exponent e is determined empirically but has a typical value of 0.5.

…

AMC ~~to CS-~~E 660
Fuel Pump Tests (Turbine Engines for Aeroplanes)

…

AMC ~~to CS-~~E 670
Contaminated Fuel Testing

(1) …

(a) …

…

(c) The point at which impending filter blockage will be indicated to the flight crew should also be established and the fuel system should be shown to be capable of continuing to operate without causing Engine malfunction for a further period equal to at least half the maximum flight duration of the aircraft in which it is likely to be installed. Once this has been established, it is permissible to clean or replace filter(s) as frequently as necessary for the remainder of the test. If blockage has not occurred by the time the total quantity of contaminant has reached the level specified in paragraph (d) below, the objective of this paragraph (c) may be considered to have been met.

(d) …

…

AMC ~~to CS-~~E 680
Inclination and Gyroscopic Load Effects

…

AMC ~~to CS-~~E 690
Engine bleed

For reducing test complexity, and for improved flexibility needed to attain the key parameters (speed, temperature and torque) during the 2-hour test of CS-E 740 (c)(3)(iii), maximum air bleed for Engine and aircraft services need not be used if the applicant can show by test or analysis based on test that the Engine's ability to meet the ~~tear-down inspection~~ strip examination specifications of CS-E 740 (h)(2) ~~150 (f)(3)(iii)~~ is not enhanced. The analysis should include

…

AMC ~~to CS-~~E 700
Excess Operating Conditions (Turbine Engines for Aeroplanes)

(1) …

(3) Case of 'Throttle Slam'.

The Engine should be rapidly accelerated from minimum flight idle conditions in simulation of throttle slam (i.e. opening the throttle as rapidly as is physically possible) and then run for two minutes to cover the excess conditions (e.g. rpm, pressure, thrust, temperature), which result from operating the Engine with the power control lever in the maximum forward position under the most critical ambient conditions likely to exist within the range of aerodrome altitudes for which performance is scheduled. If desired, the 2 minutes test may be made up of separate tests, each of not less than one-minute duration. At the end of the test the condition of the Engine should be such as to enable it to complete a flight in which such circumstances have occurred. This may be shown by demonstrating that the Engine will run satisfactorily at typical cruising conditions for a continuous period of 30 minutes (see also AMC ~~to CS-~~E 500 paragraph 3).

(4) …

AMC ~~to CS-~~E 710
Rotor locking tests

…

AMC ~~to CS-~~E 720 (a)
Continuous Ignition

…

AMC ~~to CS-~~E 730
Calibration Tests

…

AMC ~~to CS-~~E 740 (c)(3)
Endurance tests

(1) Two procedures for running the tests required under CS-E 740 (c)(3) are acceptable :

(a) After the basic 150-hour endurance test the Engine may be subject to a strip inspection in accordance with CS-E 740 (h)(1)~~CS-E 150 (f)(2)~~.

The Engine is then reassembled using the same parts used for the 150-hour endurance test except as otherwise allowed by CS-E 740 (h)(2)(ii)~~CS-E 150 (f)(3)(ii)~~ and the additional 2-hour endurance test is run to CS-E 740 (c)(3)(iii).

Completion of the additional 2-hour endurance test would be followed by compliance with the strip inspection specifications of CS-E 740 (h)(2)(iii)~~CS-E 150 (f)(3)(iii)~~; or

(b) The 2-hour additional endurance test of CS-E 740 (c)(3)(iii) may be run immediately after the basic 150-hour endurance test without Engine disassembly.

The strip inspection standards that will be applied after completion of the additional 2-hour endurance test will be those prescribed in CS-E 740 (h)(2)~~CS-E 150 (f)(2)~~.

(2) …

…

AMC ~~to CS-~~E 740 (f)(1)
Multi-spool Engines

…

AMC ~~to CS-~~E 740 (g)(1)
Endurance Tests – Incremental Periods

As an alternative to revising the incremental running as indicated in CS-E 740 (g)(1), separate Engine running of appropriate severity may be completed (see also AMC ~~to CS-~~E 650 paragraph 8).

AMC E 740 (h)(2)
Endurance tests - Inspection checks

(1) If relevant, the level of Engine disassembly, component cleaning and replacement prior to rebuild for the additional endurance test sequence should be agreed with the Agency (See CS-E 150 (b)). It should

be shown that any cleaning or replacement of consumable parts during the strip examination or replacement of consumable parts will not enhance the Engine's ability to meet the specifications of the additional endurance test of CS-E 740 (c)(3)(iii).

(2) For complying with the structural integrity specification of CS-E 740 (h)(2)(iii), the applicant should show that no Failure of any significant Engine component occurs during test or during shutdown, or becomes evident during the subsequent strip examination. In the event that any Failure becomes evident, this should be analysed and corrective actions taken, or certain limitations imposed on the Engine as appropriate. For the purpose of this specification, the Engine parts deemed significant are those that can affect the structural integrity, including but not limited to mountings, casings, bearing supports, shafts and rotors.

(3) The Engine condition exhibited after the additional endurance test required by CS-E 740 (c)(3)(iii) may be used to validate the mandatory maintenance actions after use of 30-Second and 2-Minute OEI ratings as required by CS-E 25 (b)(2) and described in the associated AMC material.

(4) For components which are distressed beyond serviceable limits during the test of CS-E 740 (c)(3)(iii), it should be shown that the inspections and mandatory maintenance actions for these components, as specified in the Instruction for Continued Airworthiness, are adequate. The instructions should include means for proper identification of these component conditions, and appropriately defined maintenance actions.

The component deterioration as it affects performance during the test, and the component condition after test, should be determined. The distress seen as a result of the 2-hour test should not create a potentially hazardous condition. In addition to visible physical damage, non-visible damage should be assessed. Such damage may include but not necessarily be limited to the effects of creep, stress rupture, metallurgical effects, life usage, etc. This overall evaluation should then be considered when defining and justifying the inspections and mandatory maintenance actions for instructions for continued airworthiness.

AMC ~~to CS-~~E 745
Engine Acceleration

…

AMC ~~to CS-~~E 750 (b)
Starting tests

…

AMC ~~to CS-~~E 770
Low Temperature Starting Tests

…

AMC ~~to CS-~~E 780
Tests in Ice-Forming Conditions (Engines for Aeroplanes)

Non-altitude testing is permissible where appropriate justification can be presented, but this could involve modification of other test conditions of this paragraph.

(1) Because Engine behaviour cannot easily be divorced from the effects of the intake and Propeller, where appropriate, it is recommended that the tests be conducted on an Engine complete with representative intake and Propeller (or those parts of the Propeller which affect the Engine air intake). Separate assessment and/or testing of the intake and Propeller are not excluded, but in such circumstances the details of the actual intake and Propeller used in the Engine tests will be defined in the Engine approval

documents. It would then finally be the responsibility of the aeroplane constructor to show that the Engine tests would still be valid for his particular installation, taking into account –

- Intake distortion as a result of, for example, incidence or ice formation on the intake and Propeller,
- The shedding of ice from the intake and Propeller into the Engine, or
- The icing of any Engine sensing devices, other subsidiary intakes or equipment contained in the intake.

See also, in CS-25, AMC ~~to CS-~~25.1093 (b) and/or CS-25.929 (a).

(2) …

AMC ~~to CS-~~E 790
Rain and Hail Ingestion

(1) For the purposes of interpreting the words ‘unacceptable mechanical damage’ and ‘unacceptable power or thrust loss' in CS-E 790 (a)(1), (a)(2), (b) and (c), see paragraphs (5)(c)(vi), (5)(c)(vi)(A) and (B) in AMC ~~to CS-~~E 790 (a)(2).

(2) For the purposes of interpreting the words ‘flameout, rundown, continued or non-recoverable surge or stall’ in CS-E 790 (a)(2) and (b), see paragraphs (1) and (5)(c)(vi) in AMC ~~to CS-~~E 790 (a)(2).

(3) For the purposes of interpreting the words ‘sudden encounter’ in CS-E 790 (a)(2) and the words ‘suddenly commencing’ in CS-E 790 (b), see paragraphs (5)(c)(iv)(D) and (G) in AMC ~~to CS-~~E 790 (a)(2).

(4) …

(5) …

AMC ~~to CS-~~E 790 (a)(2)
Rain and Hail Ingestion – Turbine Engine Power/Thrust Loss and Instability in Extreme Conditions of Rain and Hail

…

AMC ~~to CS-~~E 800
Bird Strike and Ingestion

…

AMC ~~to CS-~~E 810
Compressor and Turbine Blade Failure

(1) General

(2) Containment

(a) …

(b) Test Conditions. Separate tests on each compressor and turbine stage adjudged to be most critical from the point of view of blade containment (account being taken of blade size, material, radius of rotation, Rotational Speed and the relative strength of the adjacent Engine casing under operating temperature and pressure conditions) should be carried out in accordance with the conditions of (~~a~~i) and (~~b~~ii).

NOTE: Where the Engine design is such that potentially Engine Critical Parts overlie the compressor or turbine casing (e.g. by-pass Engines, or reverse flow Engines where the combustion systems may be outside the rotors) consideration should also be given to possible hazardous internal damage caused by blades penetrating the rotor casings, even though they are contained within the external geometry of the Engine. Consideration should also be given to AMC ~~to CS-~~E 520 (c)(2).

…

…

AMC E 820 (a)(2)
Over-torque Test

In order to comply with CS-E 820 (a)(2), it should be shown that an over-torque event does not compromise the ability of the Engine to reach its Rated 30-Second/2-Minute OEI Power.

AMC E 830 (c)
Maximum Engine Over-speed

In order to comply with CS-E 830 (c), it should be shown that an over-speed event does not compromise the ability of the Engine to reach its Rated 30-Second/2-Minute OEI Power.

AMC ~~to CS-~~E 840
Rotor integrity

…

AMC ~~to CS-~~E 850
Compressor, Fan and Turbine Shafts

…

AMC E 870 (a)(3)
Exhaust Gas Over-temperature Test

In order to comply with CS-E 870 (a)(3), it should be shown that an over-temperature event does not compromise the ability of the Engine to reach its Rated 30-Second/2-Minute OEI Power.

AMC ~~to CS-~~E 890
Thrust reverser tests

…

AMC ~~to CS-~~E 920
Over-temperature test

…

AMC ~~to CS-~~E 1000
Environmental and Operational Design Specifications - General

…

AMC ~~to CS-~~E 1020
Engine emissions

(1) The following format should be used for the note referred to in CS-E 1000 ~~(c)~~.

Note x : Engine emissions
Engine (type/model) complies with CS-34 amendment (number).

(2) …

AMC E 1030
Time limited dispatch

(1) Guidance

This AMC provides guidance for obtaining type design approval of engines with EECS in a degraded condition with respect to redundancy when these systems are to be dispatched with Faults present for limited time intervals before maintenance actions are required. This is commonly referred to as time limited dispatch (TLD).

The objective of TLD is to allow dispatch with certain EECS Faults present but without them compromising the prescribed fleet-wide average LOTC/LOPC rates and Hazardous Engine Effects rates.

TLD methodology is one way of managing dispatch with EECS Faults. Faults in systems or equipment other than EECS or EECS Faults other than loss of redundancy are typically addressed through the Master Minimum Equipment List (MMEL). Figure 2 illustrates the various ways of managing dispatch with engine faults.

TLD operations have been applied to EECS equipped engines used in multi-engine Aircraft applications, particularly those engines used in large transport Aeroplanes (certified under CS-25). The TLD requirements and limitations for those multi-engine Aircraft discussed in this advisory material should be acceptable in single engine Aircraft applications. However, the criteria used to establish acceptable TLD operations may need to be reviewed for those other applications. This assessment of control system reliability and availability requirements for single engine Aircraft applies to both piston and turbine engines.

(2) Definitions

Definitions may be found in CS-Definitions, CS-E 15 and AMC 20-3. For the purpose of this AMC E 1030 the following additional definitions apply:

"**Average fault exposure time**" means the average period of time between the Fault occurring and that Fault being repaired. It applies when the periodic inspection/repair maintenance approach is used. In this case the time of occurrence of the Fault may not be known. One-half of the periodic inspection interval will be used in the TLD analysis since the Fault could have occurred at any time during the interval. This assumes that the Fault rate of occurrence is constant throughout the interval. If the Fault rate is not constant throughout the interval, the average exposure time should be adjusted accordingly.

"**Dispatch interval**" means the maximum time interval approved for dispatch with Faults present in the system before corrective maintenance is required.

"**MEL maintenance approach**" means that the presence of a detected TLD approved fault in the EECS will be annunciated in the cockpit and that in the presence of the fault indication dispatch will be allowed by including the indication in the MMEL. The operator can then keep the indication listed within their approved MEL and disposition the indication as they do any other MEL items.

"**Inspection/Repair maintenance approach**" means that a periodic inspection and repair strategy has been approved to manage FADEC system faults. Within this approach, the presence of a detected TLD approved fault in the EECS need not be annunciated to the flight crew. The FADEC system must be interrogated by maintenance for the presence of faults during periodic inspections, and the faults found must be repaired within a specified time period or interval, so that the average exposure time of a fault in a particular category does not exceed the maximum average allowed exposure time for that category.

(3) Referenced Documents

ARP 5107 revB, Time-Limited-Dispatch (TLD) Analysis for Electronic Engine Control Systems, dated November 2006.

SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

(4) Time Limited Dispatch Analysis

The factors and limitations used throughout this AMC, and in Tables 2 and 3 in particular, are examples and are used for illustrative purposes only. However, where supporting data and analysis are not available, the values quoted may be used as default values.

The TLD analysis should establish the dispatchable configurations. The TLD report should define the dispatchable configurations in terms of the Faults and their associated dispatch intervals. The TLD analysis, typically a Markov analysis or Fault tree analysis, should show that the fleet-wide average reliability or "average LOTC/LOPC rate," which includes full-up as well as degraded system dispatches (including those resulting from Uncovered Faults), meets the required LOTC/LOPC rate for the assumed installation (see also AMC 20-3).

The TLD analysis that substantiates compliance with the required LOTC/LOPC rate should be summarised in a graph. An example of such a graph is shown in Figure 1. The ordinates of the graph should be the estimate of fleet-wide average LOTC/LOPC rate of the EECS versus the dispatch interval(s) (in hours) for the EECS Faults.

If dispatchable EECS Faults have been grouped into two categories, a short-time dispatch (or repair) category and a long time dispatch (or repair) category (see paragraph (6) below), the ordinate of the graph should show a long time dispatch interval of at least twice the length of time of the dispatch interval being requested. When calculating the LOTC/LOPC rate as a function of the long time dispatch interval, the assumed short-time dispatch interval should be twice the requested short-time dispatch interval. This factor of two is used to cover uncertainties in the analysis itself.

In the TLD analysis, all Uncovered Faults should be assumed to lead to LOTC/LOPC unless it can be shown that they do not directly result in an LOTC/LOPC. The TLD analysis should provide the rationale and substantiation for the Failure rates used for Uncovered Faults.

(5) Certification specifications for all dispatchable configurations.

(a) CS-E 1030 (b) and (c) prescribes the requirements for all dispatchable configurations.

(b) CS-E 1030 (b)(3) is directed at protection systems within the EECS that provide the sole means of mitigation from Hazardous Engine Effects. There may be some cases that have a degree of protection from other sources. Such cases may best be addressed through the MMEL rather than the TLD.

(c) CS-E 1030 (b)(5) stipulates that when dispatching with single or multiple Faults, there can be no further single Failure in the Engine Control System that would create a Hazardous Engine Effect.

For example, it is necessary to ensure that the over-speed protection system function is operational at dispatch to guard against a Hazardous Engine Effect resulting from a single additional Fault driving fuel flow upwards.

(d) CS-E 1030 (b)(6) requires that the applicant shows that the Engine, in all dispatchable configurations, continues to operate satisfactorily in the external threat levels for the system and remain compliant with the corresponding certification specifications. The Engine in each permitted TLD configuration should maintain the capability of operating through the external threats considered during Engine certification e.g. icing, rain, hail, birds, EMI, HIRF and lightning.

Relative to HIRF and lightning, compliance is typically, but not always, addressed by conducting the tests in the worst-case dispatchable configuration. This worst case is often represented by single channel operation. The other external threats are typically addressed by analysis.

(e) In showing compliance with CS-E 1030 (b)(7), justification of the proposed dispatch intervals should be based on a reliability analysis. The reliability analysis is typically the result of a model of the EECS, like a Markov Model or a Fault Tree Analysis, and is based largely on electronic component databases for failure rates.

A Summary Report of the Engine Control System time-limited-dispatch analysis should be prepared and made available to the installer. This report should contain the list of the non-dispatchable and time limited dispatch configurations.

A means to monitor the in-service LOTC/LOPC rate should be established. This should compare service experience of component Failures with the modes, effects, rates, and exposure times predicted in the TLD analysis. The data collected by this means may be used to support applications for changing dispatch intervals and may be incorporated into the system required by Part 21A.3.

Entry level and mature level EECSs are differentiated to consider factors not included in a reliability analysis.

A mature level system is an EECS that has achieved a stable in-service LOTC/LOPC rate that meets the required LOTC/LOPC rate for the intended application and is consistent with the analysis on which TLD approval is based. For engines installed in large transport aeroplanes this might not be achieved until 250,000 Engine flight hours in-service operation have been accumulated.

An EECS is classified as an entry-level system if it is not a mature level system.

The applicant may request alleviation from entry level classification if it has sufficiently similar systems operating in the field that have accumulated enough flight hours to establish stable behaviour over time. Such applications will be reviewed on a case-by-case basis.

A reliability analysis is typically based on electronic component databases. These databases consider components to be mature and, hence, only random Failures are considered. Failures due to design, manufacturing, quality and operating environment of the EECS, as well as maintenance errors, are not included.

Since such failures due to design, manufacturing, quality and operating environment of the EECS, as well as maintenance errors, are not covered by the reliability analysis, and because these Faults tend to be exposed and corrected only as in-service time is accumulated, the EECS is classified as an entry-level system and appropriate limitations are applied as shown in Table 2. Thus, more conservative criteria for dispatch intervals for entry-level systems are applied compared to mature level systems, even though the reliability analysis may support dispatch for a longer dispatch interval for entry-level systems.

The TLD analysis report should include a tabulation of the various proposed dispatch configurations and provide: (1) the expected frequency of occurrence of the Faults leading to those dispatchable configurations; and (2) the LOTC/LOPC rate of the system when operating in those configurations.

The report should tabulate the chosen category described in paragraph (6) for each Fault covered in the analysis. The report should also show that the exposure time chosen for the short and long time Fault categories allows the EECS to continue to meet its reliability requirements.

(6) Dispatch Categories

The dispatch intervals determined in compliance with CS-E 1030 (b)(7) and (c) are usually grouped into dispatch categories.

The following are typical dispatch categories:

(a) **No Dispatch**. Configurations that do not comply with CS-E 1030 (b) and/or (c) or do not qualify for another category should be categorised as No Dispatch.

(b) **Short Time Dispatch**. Configurations that comply with CS-E 1030 (b) and/or (c) and satisfy the following condition should be categorised as Short Time Dispatch: the computed LOTC/LOPC rate with the Fault(s) present is less than or equal to an upper limit that has been set at 10 times the fleet-wide average reliability criteria or "average LOTC/LOPC rate" for the installation. (The LOTC/LOPC rates for different installations may be found in AMC 20-3.)

However, even if the Long Time Dispatch LOTC/LOPC rate is met, configurations where the EECS has reverted to essentially single channel operation or has lost a significant degree of redundancy should be categorised as Short Time.

(c) **Long Time Dispatch**. Configurations that comply with CS-E 1030 (b) and/or (c) and satisfy the following condition should be categorised as Long Time Dispatch: the computed LOTC/LOPC rate with the Fault(s) present is less than or equal to 75 percent of an upper limit that has been set at 10 times the fleet-wide average reliability criteria or "average LOTC/LOPC rate" for the installation. (The LOTC/LOPC rates for different installations may be found in AMC 20-3.)

(d) **Applicant defined dispatch**. This category is for Faults that do not have an impact on the LOTC/LOPC rate. These Faults do not have to be included in the LOTC/LOPC analysis. It should be substantiated that these Fault conditions do not have an impact on the LOTC/LOPC rate. These configurations should be included in the TLD summary report to enable an appropriate maintenance programme to be developed.

(7) TLD Operations Associated with the "MEL Maintenance Approach" and with the "Inspection/Repair Maintenance Approach."

The dispatch intervals for Short Time and Long Time dispatch will also depend upon the approach used in the maintenance programme. Where a "MEL Maintenance Approach" is used, and hence the time of initial occurrence of the Fault is known, the dispatch interval starts from the point in time when the MEL procedures identify the presence of the fault. In the "Inspection/Repair maintenance approach", the Fault is assumed to have occurred half-way through the inspection interval and the dispatch interval is therefore assumed to have started accordingly from this mid-point. In each case, the analysis should support the dispatch interval(s). Table 3 shows an example of operating times for TLD Operations Associated with the "MEL Maintenance Approach" and with the "Inspection/Repair Maintenance Approach."

(8) Declaration of approved TLD operating limitations

The approved TLD operating limitations should be declared in the manuals specified in CS-E 20 (d) and CS-E 25 (a), whichever is appropriate, and provided to operators as required by Part 21A.61. The approved TLD operating limitations are the times allowed for rectification of Faults. An example of the typical operating limitations for TLD is provided in Table 1. The fact that the Engine has been approved for TLD operations should be recorded in the Engine TCDS (See CS-E 40(d)).

(9) Flight Crew Indication

CS-E 1030 (e) requires provisions for indication to the flight crew for no-dispatch configurations. This does not mean that indication during flight is required. Indication on the ground only is an acceptable means of compliance.

Table 1. Typical Operating Limitations for TLD

<table>
<tr><td colspan="2">This page gives the EASA-approved time limits to operate this engine (identify engine manufacturer and model) with control system Faults present. These limits are also defined in engine report (identify report number and date), the Engine Control System Time-Limited-Dispatch Summary Report.</td></tr>
<tr><td>Fault Category</td><td>Operational Limitation</td></tr>
<tr><td>NO DISPATCH</td><td>DISPATCH NOT ALLOWED WITH THIS CONDITION PRESENT.
Note 1: There must be a flight deck display of the presence of a no dispatch condition</td></tr>
<tr><td>SHORT TIME</td><td>DISPATCH IS ALLOWED WITH SHORT TIME FAULTS PRESENT. THE MAXIMUM (AVERAGE – IF APPLICABLE) EXPOSURE TIME OF THE SYSTEM TO THESE FAULTS MUST BE LIMITED TO (insert XXX) FLIGHT HOURS.

Note 2: All Faults in this short time category must be corrected within a time period, such that (a) each Fault in the group does not have an exposure time greater than (insert XXX) hours, OR (b) the average exposure time for short time Faults does not exceed (insert XXX) hours. Also, it is noted that the time limitations contained herein with respect to short time EECS Faults may only be changed with approval of the agency.

• If an MEL Maintenance Approach is used for this Fault category, there should be an appropriate generic flight deck display of the presence of a short time Fault condition(s).
• If a Periodic Inspection/Repair Maintenance Approach is used, the system should be inspected for short time Faults at an interval, such that if Faults are found, they can be repaired so that the average length of time that a Fault is present in the system (average fault exposure time) does not exceed the specified (insert XXX) hour limitation.

Reference SAE ARP5107 revB for a more complete understanding of these maintenance approaches.</td></tr>
<tr><td>LONG TIME</td><td>DISPATCH IS ALLOWED WITH LONG TIME FAULTS PRESENT. THE MAXIMUM (AVERAGE – IF APPLICABLE) EXPOSURE TIME OF THE SYSTEM TO THESE FAULTS MUST BE LIMITED TO (insert YYY) FLIGHT HOURS.

Note 3: All Faults in this long time category must be corrected within a time period, such that (a) each Fault in the group does not have an exposure time greater than (insert YYY) hours, OR (b) the average exposure time for long time Faults does not exceed (insert YYY) hours. Also, it is noted that the time limitations contained herein with respect to long time Electronic Engine Control System Faults may only be changed with approval of the agency.

• If an MEL Maintenance Approach is used for this Fault category, there should be an appropriate generic flight deck display of the presence of a long time Fault condition(s).

• If a Periodic Inspection/Repair Maintenance Approach is used, the system should be inspected for long time Faults at an interval, such that if Faults are found, they can be repaired so that the average length of time that a Fault is present in the system (i.e., average fault exposure time) does not exceed the specified (insert YYY) hour limitation.</td></tr>
</table>

Table 2. An Example of Operating Times for TLD Operations associated with the MEL maintenance approach.

Limitations on Electronic Engine Control System Operations with Faults Present

Experience Level	No Dispatch Category	Short Time Faults Category - maximum operating time	Long Time Faults Category – maximum operating time	Electronic Engine Control System Faults Not Affecting the LOTC/LOPC Rate
Entry Level	No Flight Allowed	125 Engine flight hours.	250 Engine flight hours.	(2)
Mature Level	No Flight Allowed	(1)	(1)	(2)

Notes:
(1) Times vary depending upon the results of the TLD Analysis.
(2) The time to repair should be included in an appropriate document.

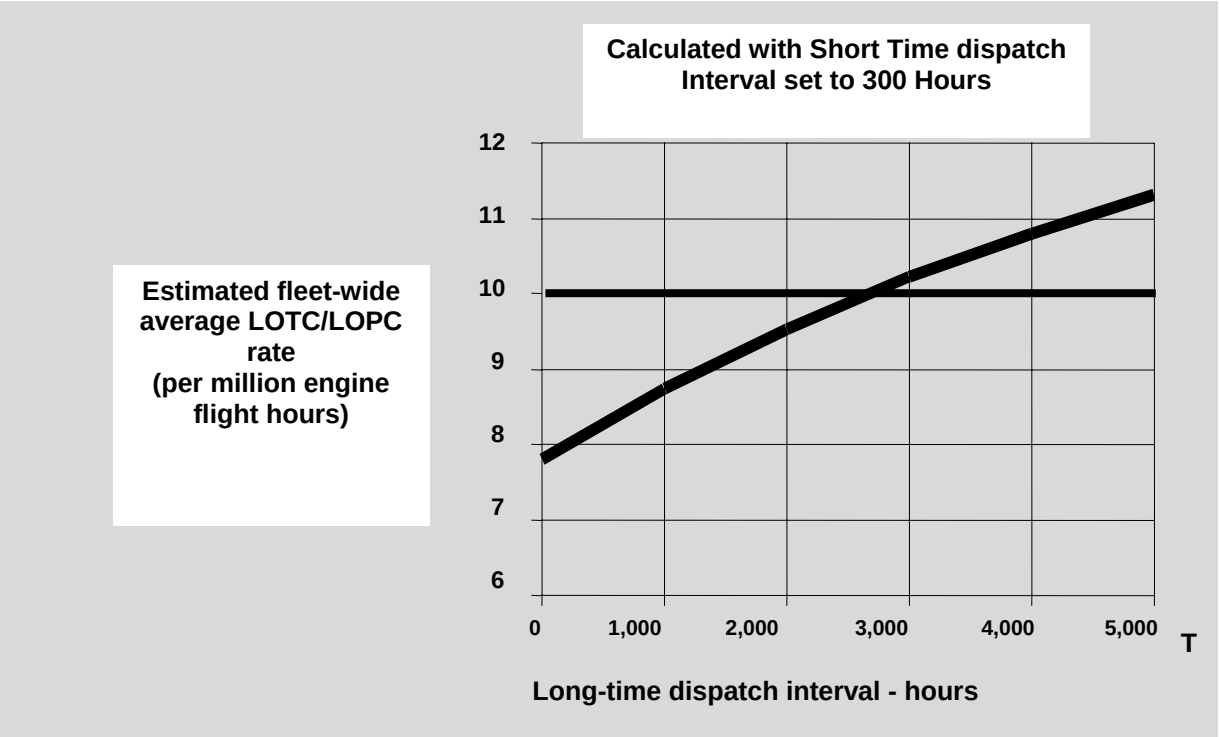
Table 3. Maximum Operating Times for TLD Operations Associated with the “MEL maintenance approach” and “Inspection/Repair maintenance approach.”

Limitations on Electronic Engine Control System Short Time and Long Time Operations with Faults Present

	Short Time Faults		Long Time Faults	
Experience Level	Time of Fault occurrence known and MEL maintenance approach used – max operating time with Fault(s) present	Time of Fault occurrence unknown and Periodic Inspection/ Repair maintenance approach used – max periodic inspection/repair interval	Time of Fault occurrence known and MEL maintenance approach used – max operating time with Fault(s) present	Time of Fault occurrence unknown and Periodic Inspection/ Repair maintenance approach used – max periodic inspection/repair interval
Entry Level	125 engine flight hours.	250 engine flight hours.	250 engine flight hours.	500 engine flight hours.
Mature Level	(1)	(2)	(1)	(2)

Notes:
(1) Times vary depending upon the results of the TLD Analysis.
(2) Should be equal to two times the value of note (1)

Figure 1. Example of the analysis results for a system with both Short Time Dispatch and Long Time Dispatch



In this example,

- The analysis was conducted with the Short Time dispatch interval set to 300 hours based on the assumption that the desired Short Time approval was 150 hours. This ratio is in accordance with paragraph (4)
- The target average LOTC / LOPC rate is 10 per million engine flight hours
- The analysis shows that the target rate is not exceeded with a declared Short Time dispatch interval set to 150 (= 300/2) hours and the Long Time less than 2700 hours. However, the long-time interval would be limited to an operational time of 1,350 hours. Again this ratio is in accordance with paragraph (4).
- In the case of an entry level system the short-time Fault category would be limited to an operational time period of 125 hours, and Faults in the long-time interval would be limited to an operational time of 250 hours. This is in accordance with Table 2.
- If the long-time Faults were to be addressed using the periodic inspection/repair maintenance approach, the inspection/repair interval could not be longer than 500 hours for entry level system and 2,700 hours for a mature level system. This in accordance with Table 3.
- If the short-time Faults were to be addressed using the periodic inspection/repair maintenance approach, the inspection/repair interval could not be longer than 250 hours for entry level system and 300 hours for a mature level system. This in accordance with Table 3.

Figure 2: Different possible ways of managing Dispatch with Engine Faults