COMMENT RESPONSE DOCUMENT (CRD) TO NOTICE OF PROPOSED AMENDMENT (NPA) 2011-13

for amending the Executive Director Decision No. 2003/2/RM of 17 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes (« CS-25 »)

'Large Aeroplanes protection against fuel low level and fuel exhaustion'

Reactions to this CRD should be submitted via the CRT by clicking the '*add a general reaction*' button.

Please indicate clearly the applicable paragraph.

Executive Summary

Large Aeroplane incidents and accidents have occurred because of fuel tank low level situations, or fuel starvation situations resulting in one or several engine(s) flame-out.

Based on the analysis and lessons learnt from those events, it has been proposed through NPA 2011-03 to introduce new CS-25 fuel indication system(s) standards (CS 25.1305(a)(2) and a corresponding AMC). In addition to the primary function of indicating usable fuel quantity on board, those systems provide, as early as possible, alerts and information to the flight crew to assist them in the task of managing the available fuel quantity and managing fuel system condition(s) that, if not corrected, present a risk of engine fuel starvation with potential unsafe condition(s).

The Agency reviewed the comments received about the proposed CS-25 amendment. The responses are provided here after.

As a result, there is no change in the principle or in the substantial content of the proposed CS-25 text. However, the following improvements have been made:

- a change in the structure of the proposed rule and AMC to better reflect the principle of the new rule;

- improvement of some terms used in the original text and adding of some clarifications when required;

- editorial and wording improvements.

Explanatory Note

I. General

1. The purpose of the Notice of Proposed Amendment (NPA) 2011-13, dated 22 July 2011 was to propose an amendment to Decision 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large aeroplanes (« CS-25 »)[1].

II. Consultation

2. The draft Executive Director Decision amending Decision N° 2003/02/RM was published on the web site (http://www.easa.europa.eu) on 22 July 2011.

   By the closing date of 24 October 2011, the European Aviation Safety Agency ('the Agency') had received 30 comments from 13 National Aviation Authorities, professional organisations and private companies.

III. Publication of the CRD

3. All comments received have been acknowledged and incorporated into this Comment Response Document (CRD) with the responses of the Agency.

4. In responding to comments, a standard terminology has been applied to attest the Agency's acceptance of the comment. This terminology is as follows:

   - **Accepted** – The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially Accepted** – Either the comment is only agreed in part by the Agency, or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** – The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not Accepted** - The comment or proposed amendment is not shared by the Agency

   The resulting text highlights the changes as compared to the current rule.

5. The Executive Director Decision on amendment to Decision 2003/2/RM will be issued at least two months after the publication of this CRD to allow for any possible reactions of stakeholders regarding possible misunderstandings of the comments received and answers provided.

6. Such reactions should be received by the Agency not later than **27 March 2012** and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt.

7. Changes compared to the NPA proposed CS-25 amendment.

   The updated text is available below in chapter V 'Resulting text'.

   In addition to some editorial and wording improvements, the main changes are the following ones.

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[1] ED Decision 2003/2/RM as last amended by ED Decision 2011/004/R of 27 June 2011 (CS-25 Amendment 11).

The structure of the proposed rule and AMC have been modified to better reflect the principle of the new rule. Flight crew must be informed or alerted as soon as practical of any failure or abnormal configuration in the fuel system(s), so that they are able to take corrective action and execute any required operational procedure before reaching a low fuel level situation. The fuel low level alert has to be considered as the last chance alert to make the flight crew aware of the seriousness of the situation. Therefore, paragraphs CS 25.1305(a)(2)(iii) and (iv) have been inverted. The same structure has been changed in the AMC as well.

In CS 25.1305(a)(2)(i), 'Permanently display(s)' is replaced by 'Provide(s) to the flight crew a full-time display'. The term 'permanently display' could be understood as a perpetual availability condition instead of the usual standard and unchanging display condition. Moreover, the term 'full-time display' is already used and defined in AMC 25-11 ('Electronic Flight deck Displays'); the definition provided is 'A dedicated continuous information display'. The AMC 25.1305(a)(2) has also been updated consistently.

In CS 25.1305(a)(2)(iii), now CS 25.1305(a)(2)(iv), the term 'same single failure' is used instead of the proposed 'same failure'. The term 'same failure' could be understood as including the combination of various single failures leading to a failure case, such as complete loss of aircraft electrical power supply. This was not the intent of the proposal, therefore the rule is changed to clarify that single failures must be considered. The same correction is made in the AMC text.

In AMC 25.1305(a)(2), we added a reference to AMC 25-11 Electronic Flight Deck Displays which should be considered concurrently when complying to CS 25.1305(a)(2).

In chapter 7 now chapter 6 ('Fuel leaks') of the AMC, the term 'as early as practical' has been added in the first sentence to make it clear that the objective is not waiting for the time when sufficient fuel has been lost to question the capacity of the aeroplane to reach its destination or an alternate airport. On the opposite, pilots must be informed or alerted in an early phase, so that they have time for taking corrective actions. Also, a new sentence is added to explain that fuel leak may be detected by using and comparing adequate fuel system data or information; it is not required to place sensors everywhere on the fuel system to monitor fuel pipes or hoses.

In chapter 4 now chapter 7 ('Low fuel level alert') of the AMC, paragraph b., a sentence is added to further explain that the 30 minutes cruise conditions should be defined using the mission profile for which the aeroplane has been designed and optimised.

IV. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*10* comment by: *Luftfahrt-Bundesamt* The LBA has no comments on NPA 2011-13.
response	Noted

comment	*11* comment by: *UK CAA* Please be advised that the UK CAA do not have any comments on NPA 2011-13: Large Aeroplanes protection against fuel low level and fuel exhaustion.
response	Noted

comment	*28* comment by: *FAA* Attachment #1 FAA COMMENTS TO EASA NPA #2011-13 The United States Department of Transportation, Federal Aviation Administration would like to commend the European Aviation Safety Agency (EASA) for undertaking this important safety initiative. We agree there is a need for such regulatory action and strongly support the overall stated objectives and, for the most part, the resulting proposal. We would like to thank EASA for the opportunity to participate on the EASA rulemaking team and for this opportunity to comment on the resulting NPA. **CS 25.1305(a)(2)(i)&(ii) & Associated AMC Material** The FAA supports these amendments aimed at clarifying the expectations for the display of total fuel quantity and individual fuel tank quantities. We suggest that EASA consider taking advantage of this opportunity to also publish fuel quantity accuracy and reliability guidance as part of the proposed AMC. Should EASA decide to take advantage of this opportunity, the FAA would like to work with EASA to facilitate harmonization. **CS 25.1305(a)(2)(iii) & Associated AMC Material** The proposed CS 25.1305(a)(2)(iii) is effectively the same as that proposed by the FAA in Notice of Proposed Rulemaking 87-3 that we ultimately elected not to adopt because it would provide limited value to any aircraft operating over 30 minutes from its first opportunity for a safe landing. EASA states in its NPA that the FAA's minority position in this regard was due to our concern that non-extended operations (non- ETOPS) airplanes can operate up to 60 minutes from a suitable alternate; however, we are also interested in applying this standard to airplanes that can operate up to 180 minutes from a suitable alternate airport under commuter or on-demand operations per Title 14 Code of Federal Regulations (14 CFR) part 135 without having to meet the ETOPS regulations. In the U.S., ETOPS-approved airplanes not only have to meet 14 CFR 25.1309(c), but also Section K25.1.4(a)(3) of 14 CFR part 25, Appendix K. Section K25.1.4(a)(3) requires that: ***"An alert must be displayed to the flightcrew when the quantity of fuel***

available to the engines falls below the level required to fly to the destination. The alert must be given when there is enough fuel remaining to safely complete a diversion. This alert must account for abnormal fuel management or transfer between tanks, and possible loss of fuel. This paragraph does not apply to airplanes with a required flight engineer."

We propose replacing or supplementing the proposed CS 25.1305(a)(2)(iii) with a provision similar to that contained in Section K25.1.4 (a)(3) of 14 CFR part 25, Appendix K. Doing so would have the dual benefit of creating a low fuel alert requirement that meets EASA's objective for this rulemaking, and that is harmonized with an existing FAA requirement.

While the EASA NPA states that compliance with CS 25.1309(c) must take into account any unsafe system operating condition that would lead to catastrophic fuel starvation, it goes on to specify that EASA will not require "*appropriate indication whenever the fuel available for engine feed is below that required to safely complete the flight with the required fuel reserves, and early enough to assure a safe diversion with the required fuel reserves"* because such an *"automatic waypoint system"* is deemed to be impractical. As evidenced by our adoption of 14 CFR K25.1.4(a)(3) in 2007, the FAA does not agree that such a requirement is impractical. The FAA has found an acceptable means of compliance with the ETOPS low fuel alert requirement for two recent airplane programs, which is essentially the same requirement that EASA deems impractical. Although an automatic waypoint system would be the most direct means of compliance with this requirement, the FAA accepted means of compliance for these two programs that utilize a combination of alerts in lieu of a single alert based on an automated waypoint system.

Current technology allows for sufficient onboard intelligence to support an automated waypoint type decision support system that provides conditional alerting so that the crew is made aware of most impending fuel starvation conditions in time to avoid an accident. The argument that: "*this function is not available on aircraft that are not equipped with* [flight management system (FMS)]*, which is currently not required for CS-25 certification*" is not compelling since:

1. Few, if any, new transport category airplane designs do not include an FMS. As a practical matter, airspace navigation requirements such as RNAV and RNP make an FMS a practical necessity for transport airplanes which will become more widespread in the future; and

2. This will be a new rule subject to the applicability and exceptions of the Changed Product Rule of CS 21.101. Therefore, if the proposed rule is truly impractical to apply to modifications of existing designs, there are provisions in the Changed Product Rule to exclude the proposed requirement from the certification basis of the changed product.

As for the valid concern about providing fault independence between the gauging system and any low fuel warning feature, compliance with the provisions of CS 25.1309(b) will provide adequate reliability, fault tolerance, and fault independence.

If EASA determines to retain the current 30 minute alert proposal in the final rule, the intent of the terms "optimum cruise conditions" and "the same failure" should be more fully defined in order to avoid confusion or

misinterpretation.

CS 25.1305(a)(2)(iv) & Associated AMC Material
The FAA supports the CS 25.1305(a)(2)(iv) related proposals aimed at providing early detection and accommodation of the most common causes of fuel starvation; however, we propose the following minor editorial changes:
- the term "*uncorrected*" should read "*not corrected*"
- the term "fuel supplied" should read "fuel being supplied"
- add the phrase "*but is not necessarily limited to*" after the word "*includes*".

Also, the description of "*abnormal fuel transfer*" within the associated AMC may be too specific with regard to the associated hazards and causes. We suggest changing the guidance to read as follows:

"*Abnormal fuel transfer between tanks is a fuel transfer that - if no corrective action is taken - can lead to no fuel being available to an engine, fuel imbalance, and/or any other hazard to the airplane. This may result from a failure or inappropriate flight crew action."*

response

Partially accepted

1) CS 25.1305(a)(2)(i)&(ii) and associated AMC: Proposal to publish fuel quantity accuracy and reliability guidance as part of the proposed AMC:

Response: This item was discussed by the Group and finally it was decided not to address it in this task because it is out of the Terms of Reference. Additionally, the review of accidents and incidents did not reveal that fuel indication accuracy is part of the causal factors.

2) CS 25.1305(a)(2)(iii) & associated AMC:

Response: The Agency takes note of the FAA position and concludes that FAA and the Agency intends to reach the same goals in different ways.
The Agency highlights the importance of early detection of fuel system failures such as fuel leak where the crew shall not wait until an indication is given that the flight to the destination or alternate cannot be made anymore. Large quantities of fuel may already have been lost when the alert is given. Also it is not known in advance how a fuel leak would evolve in flight.
The non-applicability to aircraft with flight engineer on board is not supported by the Agency.
Automated waypoint system can be a practical help to crews, however considering the range of designs within CS-25, the Agency has concluded on the basis of review of incidents and accidents that such an automated waypoint system is a useful tool to assist the crew, but is not required for safety.

Proposal to better define 'optimum cruise conditions':

Response: This question was already discussed within the working group. Because the ways manufacturers are defining optimum cruise conditions is not uniform and depends on the category of aircraft as well as the way it will be operated, the group decided not to specify a method that would not leave room for interpretation. Instead, it has been proposed that the applicant will come up with a definition of the optimum cruise for a given product, and based on this, the alert will be set to meet the 30 minutes time requirement. The definition of the 30 minutes fuel low level alert under optimum cruise conditions will consider the mission profile for which the aircraft is designed.

	Proposal to better explain 'the same failure': Response: We clarified the rule and the AMC by adding the word 'single'. 3) CS 25.1305(a)(2)(iv) & associated AMC Material: - the term '*uncorrected*' should read '*not corrected*': Response: Accepted - the term 'fuel supplied' should read 'fuel being supplied': Response: Accepted - add the phrase '*but is not necessarily limited to*' after the word '*includes*': Response: Not accepted; the term 'this includes' already suggests that the following list of items may not be exhaustive.

TITLE PAGE p. 1

comment	*2* comment by: *ASD* Rolls-Royce fully support the proposal.
response	Noted

comment	*12* comment by: *Swiss International Airlines / Bruno Pfister* SWISS Intl. Air Lines supports the NPA 2011-13.
response	Noted

A. Explanatory Note - I. General p. 4

comment	*7* comment by: *European Cockpit Association* ECA fully supports the need for enhanced fuel (leak/trap/unbalance) system state awareness in a response to modern increased fuel system complexity and agrees that related warnings can help to identify hazards.
response	Noted

A. Explanatory Note - IV. Content of the draft Opinion / Decision - 11. Review of events and lessons learnt p. 5-7

comment	*4* comment by: *Bombardier Aerospace* While there is a historical justification for independent indicating and alerting systems, the referenced accidents and incidents mostly occurred on older aircraft. The lesson learned should not be the need to use a specific system design architecture of proven reliability, but the need for the applicant to demonstrate acceptable levels of reliability for the fuel quantity indicating and alerting systems.
response	Partially accepted Events happened and recommendations have been made for relatively recent

certificated aircraft. The proposed rule does not impose a specific system architecture.

A. Explanatory Note - IV. Content of the draft Opinion / Decision - 14. Proposed new fuel indication system(s) standards - Fuel leaks p. 11

comment

13 comment by: *GE Aviation*

There are a very large number of fuel components and connections on a typical engine. A fuel leak at a connection can be anywhere in the range of being within maintenance manual limits (a few drops a minute) to very large, so that airplane range is affected. Larger leaks are easier to detect.

The rule and AC do not bound the magnitude of fuel leak which is to be addressed, so there is potential for wide variation in interpretation. We suggest that the magnitude of fuel leaks to be detected should be bounded. Since airplanes generally carry more fuel than required to reach their destination, the fuel leak might be related to using up that fuel margin. An appropriate limit might be a leak which would over the course of a typical flight, use 30 minutes worth of fuel with the engines operating at cruise power.

response

Not accepted.

It is not our intent to specify the magnitude of leakage that shall be detectable. The proposed specification does not require a system with capability to monitor every inch of the fuel system pipes or hoses. The objective is being able to detect and alert when a leak, that has the potential to eventually result in a hazard for the aircraft, exists somewhere in the system. This may be performed by monitoring and comparing several sources of information like fuel flows, fuel used computation, usable fuel quantities per tank(s), total usable fuel on board before take-off. In case of small leak, it may be detected after a relatively long time, for instance a time sufficient to highlight an inconsistency between the fuel used and the remaining usable fuel; a large leak should be identified quickly and more easily.
A new paragraph has been added to the AMC chapter 6 for clarification.

A. Explanatory Note - IV. Content of the draft Opinion / Decision - 14. Proposed new fuel indication system(s) standards - Low fuel level alert p. 11

comment

1 comment by: *Nigel WEBSTER*

OPS1.375 is already vague enough - particularly 2(i) - to encourage the unscrupulous or careless to start an approach with very low fuel levels.
During multiple approaches/go-arounds, fuel for '30 min with the aircraft operated in optimum cruise conditions' is an almost irrelevant figure, and could be misleading.
The common thread in most of the accidents analysed is poor airmanship/decision-making. The proposed warning is unlikely to have changed the crews' minds to continue their approaches.
In the event when the crew know that their fuel situation is perilous, the proposed warning would add to the stress and confusion without helping them.
Far better to improve the poor wording of OPS1.375.

response

Not accepted

The 30 minutes cruise fuel low level alert is to be considered as the last chance alert to make the crew aware that the fuel quantity situation is serious and that a diversion must be performed if not already on-going. It is expected that the combination of on-time alerting of the crew by aircraft systems about failures (such as fuel leaks, fuel imbalance, trapped fuel…) and correct application of operational rules would allow the crew to identify a problem early enough in the flight so that they are able to plan appropriate corrective actions and diversion.
The general principle of the proposed CS 25.1305 amendment is not waiting for a stressful situation when destination or alternate airport cannot be reached, but rather informing and alerting as early as possible.

comment

5 comment by: *Bombardier Aerospace*

Incidents and accidents have also demonstrated that it is important that this fu el low level alert is not adversely affected by any failure of the fuel quantity indication. Therefore, the alert shall be designed such that no failure of the FQIS (including total loss of FQIS power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert not being correctly triggered.

The definition of "no failure of the FQIS" should be clarified. For example, we do not see a safety issue with using the same fuel level sensors for the indicating and alerting systems as the failure probability of these components is typically very low and multiple sensors are used for each fuel tank. Failure of one of these sensors would be detected by the alerting system but would not affect alert triggering. Replacement of a fuel level sensor typically requires recalibrating of the FQIS and alerting system, avoiding any errors that may happen with gauge replacement. We would like to confirm that such a system relying on some common components would be acceptable.

response

Partially accepted

We have clarified the rule and its AMC to make it clear that a same ‘single’ failure shall not affect the fuel low level alert and the fuel quantity indication.

comment

15 comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

The statement "...*the alert shall be designed such that no failure of the FQIS (including total loss of FQIS power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert not being correctly triggered*....", does not allow common failures with FQIS that cause the low level alert to be triggered at a level different that the design low level alert point, whichever this point is lower or higher the design point.
In case the low level alert being triggered in a level below the design point, this statement contributes to aircraft safety.

However, in the case the low level alert being triggered above the design point, the crew shall take the low level alert procedures. This is because there is no means for the crew to make sure the FQIS is operating properly if the low level alert is activated when the FQIS is indicating a quantity above the low level alert point, as latent failures such as misleading may have happened.

	Based on the exposed, avoiding common failures of the FQIS that cause the low level alert to be triggered at a level higher that the design low level alert point does not increase the aircraft safety level. Then, Embraer suggests changing the requirement statement as follow: "*...the alert shall be designed such that no failure of the FQIS (including total loss of FQIS power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert* ***not being triggered or being triggered below the fuel low level alert design level...".***
response	Not accepted. The principle is that the fuel low level alert and the fuel quantity indication shall not be adversely affected by the same single failure. Alerting below or above the design point is not acceptable. If the system is susceptible to alert triggering above the design point, there is a risk of nuisance warnings being created and loss of confidence from the flight crew in the alerting system. This may also result in flight crew deciding to perform an emergency landing (eventually on a non-prepared runway) that is not necessary.

A. Explanatory Note - V. Regulatory Impact Assessment - 6. Analysis of the impacts p. 15-30

comment	*17* comment by: *Cessna Aircraft Company* Cessna suggests that for clarification in accident/incident table and summary statements to replace column label 'Could the event have been prevented by the proposed Option 1 rule?' with 'Could compliance with the Option 1 rule have provided additional alert indication during the event?' Cessna feels that many of the events examined involved deliberate or inadvertent violation of published operational rules, it is not clear that the presence of additional alert information would necessarily have prevented the event in each of the 24 accidents and 25 incidents for which benefit was concluded.
response	Not accepted. While the Agency agrees that many events involved deliberate or inadvertent violation of published operational rules, pertinent and adequate alerts or information are deemed useful to warn the crew of an aggravating fuel situation, the last chance alert being the fuel low level alert. The principle is to inform or alert the crew clearly and as early as possible so that they are early aware of what is wrong and can take actions to ensure a safe flight to destination or diversion airport. The text could then be: 'Could compliance with proposed option 1 rule have prevented the event?'. We have to assume that crews work professionally but might sometimes be distracted or focused on other tasks due to workloads. Then, a well-designed information and alerting system is expected to attract their attention on-time, and this shall be associated with the availability of efficient operational procedures.

A. B. Draft CS-25 Decision - CS-25 Book 1 SUBPART F - EQUIPMENT - Amend CS 25.1305(a)(2) p. 36

comment	*6* comment by: *Bombardier Aerospace* The time to annunciate a low fuel level alert should be defined in the operating rules, as it has been pointed out in the NPA that different operating conditions can lead to different "critical fuel levels". 25.1305(2)(iii)(1) should require a capability to annunciate a low fuel level alert with this in mind, with a minimum cruise endurance of 30 minutes. It has been previously mentioned how the design requirements should not prescribe the system architecture. While we agree that the alerting system should be independent from components like fuel totalizers and gauges, the reliability of certain components in the FQIS like the fuel level sensors does not warrant the total elimination of all common components between systems. Accordingly, 25.1305(2)(iii)(2) should be changed to reflect this. System reliability should be determined through CS 25.1309, with guidance material indicating recommended system design practices to achieve that level of reliability.
response	Partially accepted. The operational regulation is not be used to prescribe aircraft design specifications. Moreover, various incidents and accidents investigations concluded and recommended that new certifications specifications be developed, and the Agency made a proposal in this direction. The 30 minutes threshold is considered the requirement that must be present on all new CS-25 types of aircraft; nevertheless, this does not prevent manufacturers and authorities to develop additional alerts adapted to some operations, for instance ETOPS operation. We have clarified the rule and its AMC to make it clear that a same 'single' failure shall not affect the fuel low level alert and the fuel quantity indication.

comment	*8* comment by: *European Cockpit Association* ECA requests to increase the insight in trapped fuel in a low fuel state. Is the 30 minute of minimum fuel indeed 30 minutes in high pitch / bank attitudes?
response	Noted. The alert indicates a quantity of fuel that is usable throughout the aeroplane operating envelope, including high pitch and bank attitudes.

comment	*9* comment by: *European Cockpit Association* ECA requests a more accurate fuel quantity indication over the full range (eg with fuel transfer from tail to wingtanks or vice versa there may be quite some strange fuel quantity indications during a considerable amount of time - this can obscure abnormal fuel consumption).
response	Not accepted. The Terms of Reference of this rulemaking task did not allow us to include the fuel quantity indication accuracy in this rulemaking task.

comment	*18* comment by: *Cessna Aircraft Company*

	CS 25.1305(2)(i) Cessna suggests replacing “Permanently display(s)” with either “display(s) full time” (which is a term/concept used in AMC 25-11, 7.h), “normally display(s)” or “display(s) during normal operation”. The term “permanently” implies perpetual availability, not just the standard and unchanging display condition.
response	Accepted. ‘Permanently display(s)’ is replaced by ‘provide(s) to the flight crew a full-time display’.

comment	*19* comment by: *Cessna Aircraft Company* CS 25.1305(2)(iii) Cessna suggests harmonization with CS 23.1305(c)(4) and 14CFR 23.1305(c)(4), which read, “A fuel low level warning means for any fuel tank that should not be depleted of fuel in normal operations.”
response	Not accepted. It is up to the CS 25.1322 analysis to determine the appropriate alert hierarchy and suitable attention-getting cues, therefore it was decided to use the non-prescriptive term ‘alert’. Concerning the term ‘in normal operations’, it has not been retained because a low fuel level situation can happen in normal or abnormal operations, however an alert shall be available and triggered anyway.

comment	*20* comment by: *Cessna Aircraft Company* CS 25.1305(2)(iii)(1) Cessna suggests replacing ‘30 minutes’ with ‘approximately 30 minutes’ due to the variability of cruise conditions caused by atmospheric properties and operational variables.
response	Not accepted. A rule requiring “approximately 30 minutes” would be vague and subject to interpretation. The proposed AMC further explains what is expected: the quantity required to operate an engine for 30 minutes with the aircraft operated in optimum cruise conditions. It is accepted that the way the optimum cruise conditions are specified may vary from one aircraft to another one, and the actual flight time available in a real flight would vary around the 30 minutes threshold because not all flights are operated exactly in the conditions corresponding to the designed optimum cruise. The 30 minutes alert level indicates a fuel quantity equivalent to operations at optimum cruise thrust/power. This in turn will most likely provide a considerably longer time of operation due to the fact that during descent and approach fuel flow is considerably less than in cruise. However, it was deemed necessary to provide a common objective for all manufacturers. The working group also envisaged providing detailed conditions to make the assessment, but it was agreed that this would be too prescriptive and it would also be nearly impossible to propose a generic method suitable for the whole range of CS-25 aeroplanes.

comment	*21* comment by: *Cessna Aircraft Company*

	CS 25.1305(2)(iii)(2) Cessna suggests replacing “may not be adversely affected by the same failure” with “may not be adversely affected by any single failure.” It is understood that the intent is to eliminate single failures that might result in a loss of both features, and to ensure independence of the two measurement systems. However, total loss of aircraft power could be considered a “failure” even though this would require multiple single failures to occur.
response	Accepted. We have added the word ‘single’ in the rule and AMC.

comment	*22* comment by: *Cessna Aircraft Company* CS 25.1305(2)(iv) Cessna suggests rewording this subparagraph as follows: (iv) Provide(s) alert information and necessary AFM procedures to prevent an inadvertent total loss of fuel supply to one or more engine(s). The phrase “Provide(s) fuel quantity and availability information to the flight crew” is redundant to the requirements of subparagraphs (i) through (iii). The inclusiveness of the phrase “any fuel system condition” mandates indication of conditions for which detection is impractical. Fuel leaks can vary considerably in their flow rates yet may or may not, if uncorrected, result in a fuel exhaustion event. This depends upon the evolving nature of the leak, its exact location, as well as the duration of the flight and many other contributing factors. Such high resolution of the location and nature of a leak, such as exactly which access panel, fastener, or tube, would require extraordinarily complex leak detect systems that are impractical due to the weight, cost, and negative safety consequences of adding potential ignition sources near flammable fluid leakage sites. It is suggested that the two primary concerns would be preventing excessive fuel imbalance and preventing fuel exhaustion to one or more engines. This differs from the listed three conditions because normally commanded transfer can result in undesirable situations as well as abnormal transfer, trapped fuel is already indicated by unchanging fuel quantity displays, and while not all leaks can be pinpointed, the resulting fuel quantity discrepancies or imbalances can be detected. One cited example was that of a leak scenario where the pilot commanded transfer of fuel to the leaking tank, thereby losing additional fuel. However, it must also be acknowledged that the pilot is required to avoid exceeding the fuel imbalance limitations and therefore may be forced to transfer fuel into a leaking tank to achieve this and maintain control authority. This situation is much more foreseeable in smaller Part 25 aircraft.
response	Not accepted. The NPA proposed CS 25.1305(2)(iv) is focused on other kind of information and alert than the one specified under CS 25.1305(2)(i) through (iii). Moreover it is not a mandated function of the Fuel indication system(s) to provide AFM procedures. The proposed specification does not require a system with capability to monitor every inch of the fuel system pipes or hoses. The objective is being able to detect and alert when a leak, that has the potential to eventually result in a hazard for the aircraft, exists somewhere in the system. This may be performed by monitoring and comparing several sources of information like

	fuel flows, fuel used computation, usable fuel quantities per tank(s), total usable fuel on board before take-off. In case of small leak, it may be detected after a relatively long time, for instance a time sufficient to highlight an inconsistency between the fuel used and the remaining usable fuel; a large leak should be identified quickly and more easily. A new paragraph has been added to the AMC chapter 6 for clarification. The three specified fuel system conditions (Abnormal fuel transfer between tanks, Trapped fuel, Fuel leaks including in the engines) were selected based on the review of service experience showing that these are the main issues that have been faced. Meanwhile, the alerts and information shall not necessarily be limited to those cases; a safety analysis of the fuel system may determine other important cases that need to be informed or alerted. Regarding fuel imbalance situation created by a fuel leak, the design of the aircraft and AFM procedure(s) should isolate the fuel leak as soon as practical and prevent any hazardous controllability situation.
comment	*27* comment by: *Cessna Aircraft Company* CS25.1305(2)(i) Cessna requests clarification (perhaps in the AMC?): in EMER power modes is display of fuel quantity/low level required or not?
response	Noted. Yes, in any emergency power mode the quantity of fuel shall be displayed because it is essential information for continued safe flight and landing.
comment	*29* comment by: *Boeing* ***Affected paragraph and page number*** Page: 36 Paragraph: *CS 25.1305 (2)(iv)* Proposed text: ***CS 25.1305 Powerplant instruments*** ***…*** *(iv) Provide(s) fuel quantity and availability information to the flight crew, including alerts, to indicate any fuel system condition (e.g. misconfiguration or failure) that, if uncorrected, would result in no fuel supplied to one or more engine(s). This includes:* *(1) Abnormal fuel transfer between tanks,* *(2) Trapped fuel,* *(3) Fuel leaks including in the engines.* ***What is your concern and what do you want changed in this paragraph?*** The level of alert required for each message, or with respect to each type of abnormal fuel configuration, is undefined. Boeing requests that EASA clarify the acceptable level of message in the rule, or provide guidance within the AMC to arrive at the appropriate level for each alert.

The philosophy in use today would define an EICAS Advisory as the proper alert level due to the timeliness associated with the crew actions to investigate the potential leak. Other messages occurring late in the flight may warrant the determination of a CAUTION to illicit immediate crew response.

Why is your suggested change justified?

JUSTIFICATION: Consistent guidance on the required levels of alerting is necessary to ensure consistent awareness to flight crews, regardless of airframe. While 25.1322 provides guidance independent of this rule, the absence of any definitive guidance for this specific rule could cause inconsistent messaging philosophies, dependent on the airplane capability and dependent on airframer history. Consistent messaging philosophies would result in consistent crew awareness and response time across models.

response

Noted.

It was discussed and agreed within the working group that the CS 25.1322 analysis will assign a hierarchy to the alerts generated by the fuel indication system(s). We chose not to provide prescriptive requirements.

A. B. Draft CS-25 Decision - CS-25 Book 2 AMC - SUBPART F - Create a new AMC 25.1305(a)(2) p. 37-38

comment

3 comment by: *Sezgin DURAK*

The comment is for bullet#4 "Low fuel level alert".

It is proposed that;

c. The safety analysis in accordance with CS 25.1309 (b) and (c) should at least include the following failure scenarios:
- Erroneous high fuel quantity indication system (FQIS) readings,
- Loss of FQIS gauging information.

"Loss of FQIS gauging information" is sometimes critical, sometimes not. The criticality depends on some factors;
- If the **actual** amount of fuel level is critical **or** not
- If there is an **independent** warning system **or** not

So, there must be critical fuel amount and pilot can not read it on indicator and the warning is not produced.

Therefore, the failure condition below can be considered to cover all factors above;

"**Inability to warn pilot about critical fuel amount**". This failure condition will cover all scenario below;

Scenario.1: The actual amount of fuel level is critical(1) **and** loss of FQIS gauging infomation(2) **and** loss of low level fuel alert(3)
Scenario.2: The actual amount of fuel level is critical(1) **and** erroneous(high) FQIS gauging infomation(4) **and** loss of low level fuel alert(3)

This failure condition shall be CATASTROPHIC.

A procedure can be recommended to mitigate the severity of Scenario.1. It can be;

"**Pilot shall apply land as soon as possible procedure after loss of FQIS gauging infomation**"

A procedure can be recommended to mitigate the probability of Scenario.2. It can be;

"Pilot shall cross check planned fuel figures with actual fuel data from the aircraft."

"Pilot shall cross check fuel level between fuel tanks in every XX ninutes or at every waypoint."

Thank you.

Sezgin DURAK

Aeronautical Engineer
Expert Certification Engineer - Safety/Reliability

response: Noted.

comment: *14* comment by: *GE Aviation*

The advisory material refers to a fuel leaks analysis, which is not mentioned elsewhere. The purpose of the fuel leaks analysis is unclear, in the requirement to identify all foreseeable leakage sources. It may be more appropriate to specify that the fuel leaks analysis is to ensure that leakage from any foreseeable source – greater than a certain magnitude – will be detectable.

response: Not accepted.

It is not our intent to specify the magnitude of leakage that shall be detectable. The proposed specification does not require a system with capability to monitor every inch of the fuel system pipes or hoses. The objective is being able to detect and alert when a leak, that has the potential to eventually result in a hazard for the aircraft, exists somewhere in the system. This may be performed by monitoring and comparing several sources of information like fuel flows, fuel used computation, usable fuel quantities per tank(s), total usable fuel on board before take-off. In case of small leak, it may be detected after a relatively long time, for instance a time sufficient to highlight an inconsistency between the fuel used and the remaining usable fuel; a large leak should be identified quickly and more easily.
A new paragraph has been added to the AMC chapter 6 for clarification.

comment: *16* comment by: *Embraer - Indústria Brasileira de Aeronáutica - S.A.*

The statement "...*it should be demonstrated that no failure of the FQIS system*

	(including total loss of FQIS system power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert not being correctly triggered....", does not allow common failures with FQIS that cause the low level alert to be triggered at a level different that the design low level alert point, whichever this point is lower or higher the design point. In case the low level alert being triggered in a level below the design point, this statement contributes to aircraft safety. However, in the case the low level alert being triggered above the design point, the crew shall take the low level alert procedures. This is because there is no means for the crew to make sure the FQIS is operating properly if the low level alert is activated when the FQIS is indicating a quantity above the low level alert point, as latent failures such as misleading may have happened. Based on the exposed, avoiding common failures of the FQIS that cause the low level alert to be triggered at a level higher that the design low level alert point does not increase the aircraft safety level. Then, Embraer suggests changing the requirement statement as follow: "...*it should be demonstrated that no failure of the FQIS system (including total loss of FQIS system power supply) or total loss of the primary basic FQIS information would lead to the fuel low level alert* ***not being triggered or being triggered below the fuel low level alert design level...".***
response	Not accepted. See our response to your comment 15 which is identical.

comment	*23* comment by: *Cessna Aircraft Company* AMC 25.1305(a)(2) Cessna suggests that there should be a reference here to AMC 25-11 since it does discuss engine/fuel indications.
response	Accepted. A reference is added at the beginning of the AMC.

comment	*24* comment by: *Cessna Aircraft Company* AMC 25.1305(a)(2), Section 2c Cessna suggests modifying list of minimum indication system alerts to: - - a low fuel level situation - - a fuel imbalance situation Suggest rewording to “For each alert, available corrective actions shall be identified to the flight crew.” This reflects that not every situation requires additional corrective action, and for some there may not be an action necessary at that time.
response	Not accepted. The three specified fuel system conditions (Abnormal fuel transfer between tanks, Trapped fuel, Fuel leaks including in the engines) were selected based on the review of service experience showing that these are the main issues that have been faced. Meanwhile, the alerts and information shall not necessarily be limited to those cases; a safety analysis of the fuel system may

	determine other important cases that need to be informed or alerted. Addressing fuel imbalance is not in the scope of this rulemaking task.
comment	*25* comment by: *Cessna Aircraft Company* AMC 25.1305(a)(2),Section4b Cessna suggests 'approximately 30 minutes' to reflect variability in this time due to atmospheric conditions and operational variables.
response	Not accepted. See our response to comment 20.
comment	*26* comment by: *Cessna Aircraft Company* AMC 25.1305(a)(2),Section7 Cessna suggests revising to "shall provide any available alert and information" Cessna is unclear on the intent and requests clarification of "identify all foreseeable leakage sources." Does this include damage to protected portions of tubing, no matter how unlikely? Does this include all potential wing tank leaks?
response	Not accepted. The proposed specification does not require a system with capability to monitor every inch of the fuel system pipes or hoses. The objective is being able to detect and alert when a leak, that has the potential to eventually result in a hazard for the aircraft, exists somewhere in the system. This may be performed by monitoring and comparing several sources of information like fuel flows, fuel used computation, usable fuel quantities per tank(s), total usable fuel on board before take-off. In case of small leak, it may be detected after a relatively long time, for instance a time sufficient to highlight an inconsistency between the fuel used and the remaining usable fuel; a large leak should be identified quickly and more easily. A new paragraph has been added to the AMC chapter 6 for clarification.
comment	*30* comment by: *Boeing* ***Affected paragraph and page number*** Page: 38 Paragraph: *AMC 25.1305(a)(2) - Item 7* Proposed text: ***"7. Fuel leaks*** *The fuel indication system(s) shall provide any alert and information enabling the crew to identify a fuel leak.* *Fuel leaks may be generated by a loss of integrity of the fuel system (for instance, fuel pipes failures, leakage of connections) and result in fuel being drained overboard the aircraft.* *The fuel leaks analysis shall identify all foreseeable leakage sources from the*

	aircraft fuel tank(s) to the engine fuel nozzles. For the engines, it means that the effects of leaks upstream and downstream of the engine fuel flow meter shall be considered." ***What is your concern and what do you want changed in this paragraph?*** The proposed rule, or AMC, does not provide guidance on the timeliness of the required alert(s). Boeing requests that EASA provide guidance to establish the timeframe in which an alert needs to be provided, considering the airplane's diversion capability. For instance, if an aircraft can continue to conduct a mission/diversion after depleting one of the fuel tanks, the alerting architecture need not indicate at the same point in time as depleting required mission fuel. ***Why is your suggested change justified?*** **JUSTIFICATION:** The specific feed configuration of a given airplane, in concert with the airplane capability, governs the type of alerts that are required. However, exactly when those alerts must be provided is subjective in the currently proposed rule and AMC. Some time is required for the leak to manifest itself to the crew, and additional time for the flightcrew to confirm that a leak actually exists. This time may or may not be critical to continued safe flight and landing. Guidance should be established to determine at what point an alert must be provided.
response	Partially accepted. It is not possible to specify a time when a fuel leak information or alert shall be provided. The principle is that flight crew shall be informed as early as practical so that maximum time is available to take a corrective action and ensure safe flight to destination or a diversion. The Agency does not agree to wait until the remaining usable fuel on-board approaches the quantity required to reach the destination (with applicable fuel reserves) or to make a diversion; because as such a point of time, no one can predict the evolution of a fuel leakage and it may be already too late at this time. We clarified the first sentence of chapter 6 of the AMC to emphasize that alerts and information should be available as early as practical.

V. Resulting text

CS-25 Book 1

SUBPART F - EQUIPMENT

Amend CS 25.1305(a)(2) as follows:

CS 25.1305 Powerplant instruments

…

(a)…

(2) ~~A fuel quantity indicator for each fuel tank~~

Fuel indication system(s) which:

(i) Provide(s) to the flight crew a full-time display of the total quantity of usable fuel on board;

(ii) Is (are) capable of indicating to the flight crew the quantity of usable fuel in each tank in accordance with CS 25.1337(b);

(iii) Provide(s) fuel quantity and availability information to the flight crew, including alerts, to indicate any fuel system condition (e.g. misconfiguration or failure) that, if not corrected, would result in no fuel being supplied to one or more engine(s). This includes:

(A) Abnormal fuel transfer between tanks;
(B) Trapped fuel;
(C) Fuel leaks including in the engines.

(iv) Provide(s) a low fuel level cockpit alert for any tank and/or collector cell that should not become depleted of fuel.

Each alert is such that:

(A) It is provided to the flight crew when the usable quantity of fuel in the tank concerned reaches the quantity required to operate the engine(s) for 30 minutes at cruise conditions;

(B) The alert and the fuel quantity indication for that tank are not adversely affected by the same single failure.

CS-25 Book 2

AMC - SUBPART F

Create a new AMC 25.1305(a)(2) as follows:

AMC 25.1305(a)(2)

Fuel indication system(s)

0. Related references

AMC 25-11 Electronic Flight Deck Displays

1. Purpose

This AMC provides guidance and means of compliance for demonstrating compliance with CS 25.1305(a)(2) when designing a fuel indication system(s).

2. General objective

a. The primary function of fuel indication system(s) is indicating the usable fuel quantity on board an aircraft. Additionally, the fuel indication system(s) provide(s) any alert and information to the flight crew to assist them in the task of managing the fuel quantity on board.

b. Service experience indicates that scenarios leading to impending fuel starvation of one or more engines have developed into an unsafe system operating condition. Therefore, such scenarios have to be identified and, as required per CS 25.1309(c), appropriate information is provided to the flight crew to enable them taking corrective action.

This information, including alerts, is provided in a timely manner so that any unsafe fuel starvation situation can be avoided.

c. The fuel indication system(s) alerts as a minimum inform the flight crew of:

- any abnormal fuel transfer;
- a trapped fuel situation;
- the existence of a fuel leak;
- a low fuel level situation.

For each alert, corrective actions are made available to the flight crew. This should include for instance:

- procedure(s) to identify and isolate the fuel leak;
- procedure(s) to correct the abnormal fuel transfer and/or to manage the trapped fuel situation;
- diversion procedure or the instruction to land as soon as possible;
- any required procedure to avoid additional hazard (for instance: fuel coming into contact with wheel brakes during landing when a fuel leak is not isolated; exceeding centre of gravity or fuel imbalance limits).

3. Usable fuel quantity

a. The total usable fuel quantity is considered essential information. Operational regulations require the flight crew to regularly check the remaining total usable fuel quantity. This quantity is then evaluated when comparing the actual quantity of fuel used to the planned fuel consumption, and to ensure that sufficient fuel is available to complete the flight with the required fuel reserve. The total usable fuel quantity is therefore displayed full-time and it is easily and directly readable by the flight crew.

b. As required per CS 25.1337(b), there is a means to indicate to the flight crew the usable fuel quantity in each fuel tank. It is considered acceptable that these individual tank quantities be only displayed when required. This may be displayed either at pilot discretion (on demand) or automatically as determined to support operational procedures associated to fuel system alerts.

4. Abnormal fuel transfer between tanks

The fuel indication system(s) provide(s) any alert and information enabling to identify abnormal fuel transfer between tanks.

Abnormal fuel transfer between tanks is a fuel transfer that - if no corrective action is taken - can lead to fuel becoming unavailable to an engine and/or fuel imbalance causing aeroplane control difficulties. It may result either from a fuel management system failure or from inappropriate flight crew action.

5. Trapped fuel

The fuel indication system(s) provide(s) any alert and information enabling to identify trapped fuel situations.

Trapped fuel means any fuel quantity (above the unusable fuel quantity) gauged by the FQIS that cannot be supplied to the engine.

For instance, failure of an isolation valve in an auxiliary tank, failure of a transfer pump, fuel pipe failure inside a tank could result in trapped fuel. Also, inappropriate selection of fuel system configuration by the flight crew has to be considered.

6. Fuel leaks

The fuel indication system(s) provide(s), as early as practical, any alert and information enabling the crew to identify a fuel leak.

Fuel leaks can be caused by a loss of integrity of the fuel system (for instance, fuel pipes failures, leakage of connections) and result in fuel being drained overboard the aircraft.

The fuel leaks analysis will identify all foreseeable leakage sources from the aircraft fuel tank(s) to the engine fuel nozzles. For the engines, it means that the effects of leaks upstream and downstream of the engine fuel flow meter have to be considered.

The leak detection may be performed by monitoring and comparing several sources of information (for instance fuel flows, fuel used computation, usable fuel quantities per tank(s) and total usable fuel on board before take-off).

7. Low fuel level alert

a. The fuel indication system(s) trigger(s) an alert in case of low fuel level. The low fuel level cockpit alert is applicable to any tank or collector cell that is not expected to be depleted in flight because otherwise this situation would lead to an engine fuel starvation. Fuel tanks that may normally be depleted during flight do not require a low fuel level alert.

b. The alert is triggered when the quantity of usable fuel in the tank concerned reaches the quantity required to operate an engine for 30 minutes with the aircraft operated in optimum cruise conditions. When defining the 30 minutes under optimum cruise conditions the applicant will consider the mission profile for which the aircraft is designed.

c. The safety analysis in accordance with CS 25.1309 (b) and (c) includes as a minimum the following failure scenarios:

- Erroneous high fuel quantity indication system (FQIS) readings;
- Loss of FQIS gauging information.

No single failure of the FQIS (including total loss of FQIS power supply) or total loss of the primary basic FQIS information will lead to the fuel low level alert not being correctly triggered.

Appendix A - Attachments

FAA Comments to EASA NPA - 2011-13.pdf
Attachment #1 to comment #28