EI 1598 *Design, functional requirements and laboratory testing protocols for electronic sensors to monitor free water and/or particulate matter in aviation fuel*, 2nd edition

Addendum 12 June 2019

Page 10: Amend existing 3.1.1 to read

'3.1.1 Any part of the equipment that comes into contact with fuel shall not be adversely affected by the fuel[3] (including any approved aviation fuel additive~~, see also Table C.1~~) and shall also preserve the integrity of the fuel. Manufacturers shall provide a list of all materials used in any part of the equipment that comes into contact with fuel. ~~For details of testing that is typically required to be undertaken to demonstrate compatibility of materials and fuel, see Annex C.~~ Material compatibility with fuel shall be demonstrated by testing in accordance with, and meeting the requirements of, EI 1589. For further details see Annex C.'

Page 10: Amend existing 3.3.1 to read

'3.3.1 The equipment shall operate in fuel handling systems with flow rates up to at least 4 500 lpm (1 190 gpm) and linear velocities up to 12 m/s. Note: Pipe diameters may be up to ~~400 mm (8 in.)~~ 150 mm (6 in.). A different flow range may be agreed between the customer and the manufacturer.'

Page 11: Amend 3.3.2 to read

'3.3.2 The equipment ~~should~~ shall be suitable for use at pressures stated in Table 1. The equipment should also operate during transient pressure surge conditions including that caused by a two second shut down of fuel flow from maximum flow rate[4]. Testing on any component or part of the equipment that is exposed to fuel flow, to demonstrate compliance with selected requirements of this clause shall be undertaken in accordance with Annex B. (See also Annex C.)'

Page 11: Amend 3.4.5 to read

'3.4.5 The equipment shall be designed so that it does not trap contaminants and should be self-cleaning or easily cleanable *in situ* without excessive dismantling (which would require equipment recalibration). Manufacturers ~~should~~ shall provide recommendations for inspection checks and their frequency.'

Page 14: Add new 5.3

'If the sensor incorporates a probe that inserts into pipework the manufacturer shall state how it is to be orientated (e.g. whether it can be installed in horizontal or vertical pipe) and the required positioning of the sensing head (e.g. at right angles to the fuel flow path).'

Renumber existing 5.3, 5.4 and 5.5 as 5.4, 5.5 and 5.6 respectively.

Page 17: Amend 7.2 to read

'The system shall incorporate self-checking functionality, and fault diagnosis. In the event of incorrect functioning, it is critical that the system shall shut down and alert the operator to its condition. Testing in accordance with Annex D shall be undertaken.'

Page 20: Amend second paragraph in A.1 to read

The performance testing detailed in this annex shall be undertaken and reported. A suitably qualified and competent person shall witness on behalf of the purchaser/user the testing. A manufacturer wishing to claim that its electronic sensor meets the requirements of, or is compliant with, EI 1598 shall be able to provide evidence of having met the requirements of this annex (in addition to the sensor meeting the design and functional requirements).

Page 21: Amend the fifth paragraph in A.2.2 to read

'For the dirt injection tests the test dust shall be injected as a slurry in test fuel at a point as close as possible to the inlet side of the main pump to produce the necessary dispersion without the use of surfactants. Alternatively, the dirt slurry can be injected close to the outlet side of the pump, which also results in the necessary dispersion of the test dust. The slurry injection point shall not be less than 10 pipe diameters from the test bench. The slurry injection velocity shall be greater or equal to 1,0 m/sec (3,3 ft/sec) with a Reynolds Number >2 500. The slurry shall be prepared using a recirculation system as shown in either option of Figure A.2.'

Page 21: Amend A.2.3 to read

'Upstream facing, chamfered probe-type sampling devices shall be provided in a section of straight pipe for the purposes of carrying out representative sampling for supportive measurements, e.g. gravimetric or free water assays. Such a probe is shown schematically in Figure A.3. ~~There shall be no internal protrusions within five pipe diameters of the candidate instrument.~~ One sample point is required for each type of supporting measurement, i.e. one for dirt tests, one for free-water concentration tests. The sampling probes shall be positioned downstream of ~~as close to~~ the candidate equipment as closely as possible to it and within a maximum of five pipe diameters, whether in-line or on-line. ~~and t~~There shall be no other internal protrusions ~~(with the exception of the sensor)~~ within five pipe diameters of these sampling probes. Sample pipe layout and size shall be designed to preclude particle settlement in areas upstream of the sampling point.'

Page 22: Amend A.2.6 to read

‘The test facility shall be capable of being configured to deliver a slug of water test. A tank for water needs to be available of sufficient size to deliver the required volume of water (a minimum of 50 litres is required if testing at 200 lpm to ensure displacement of fuel for the 15 second test duration, see A.8.7), and be configured with an arrangement of valves such that water can substitute the flow of jet fuel completely for the duration of the test without the pump running dry at any point. The injection point for the water slug should be as close as possible to the test bench, downstream of the pump.’

Page 25: Amend A.5 to read

Candidate instruments shall be calibrated prior to testing. Each candidate instrument being tested shall be installed in the test bench ~~and no modification of the installation made during the tests A to H described in A.8.2 - A.8.7. The candidate instrument shall be installed~~ as recommended by the instrument manufacturer with a visible readout so that the instrument response can be recorded at the time points indicated in the following test protocols. The visible read-out can be part of an electronic data capture system, or a standalone visual indicator.

Due consideration should be given to all safety aspects during installation as required by local legislation or specific explosive atmosphere zoning requirements.

Once installed ~~to the standard required by the manufacturer~~, no further changes (including, but not limited to, electrical, mechanical, ~~and~~ calibration changes or output signal) ~~should~~ shall be made to the candidate instrument during ~~testing~~ the tests A to H described in A.8.2 - A.8.7.

If electronic data capture is used, data ~~must~~ shall be collected at a frequency appropriate to the candidate instrument’s fastest response time (as limited by the units of measurement, e.g. minimum volumes needed to collect ISO 4406:1999 particle counts) and recorded electronically such that it can be reviewed later. ~~Instruments shall be calibrated prior to testing, and no further changes shall be made to the calibration or output signal during testing.~~

Data for the candidate instrument responses and the supplementary tests as specified in the following test protocols shall be recorded in a copy of Table A.1. A populated copy of that table serves as the recorded test result for the candidate instrument.’

Page 27: Amend A.8.1 third paragraph to read

‘Candidate instruments ~~with~~ that provide continuous ~~read-outs~~ measurement (defined as providing a data point every second or quicker) ~~can~~ shall supply a chart of the instrument response throughout the test sequence to supplement the manually recorded values. This chart can be of a format of the candidate instrument manufacturer’s choosing but should record the candidate instrument response as well as the injected contaminant concentration profile (Figure A.4) and the values recorded for supplementary tests specified with each test condition[16].’

Page 27: Amend A.8.1 fourth paragraph to read

‘The test slurry ~~should~~ shall be prepared in advance for injection and the volumetric injection of test dust slurry and injection of water ~~should~~ shall be calibrated in advance so that the ramping up and running down of the injected contaminant concentration at the start and end of each test period ~~should be~~ is completed in <1 minute.’

Page 27: Amend A.8.2 Step 3 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) and gravimetric particulate concentration (ASTM D2276) three times during the test condition. Record the three values of each in the test sheet.'

Page 28: Amend A.8.3 Test B, Step 3 and Test C, Step 2 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) and gravimetric particulate concentration (ASTM D2276) three times during the test condition. Record the three values of each in the test sheet.'

Page 28: Amend A.8.4 Step 3 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) and gravimetric particulate concentration (ASTM D2276) three times during the test condition. Record the three values of each in the test sheet.'

Page 29: Amend A.8.5 Step 3 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) and gravimetric particulate concentration (ASTM D2276) three times during the test condition. Record the three values of each in the test sheet.'

Page 29: Amend A.8.5 Test F, Step 2 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) ~~and gravimetric particulate concentration (ASTM D2276)~~ three times during the test condition. Record the three values in the test sheet.'

Page 29: Amend A.8.6 Step 2 to read

'Take samples of flowing fuel from the rig to measure ~~and record~~ the free water concentration (ASTM D3240) ~~and gravimetric particulate concentration (ASTM D2276)~~ three times during the test condition. Record the three values in the test sheet.'

Page 29: Amend start of A.8.7 Note to read

'Note: The use of downstream FWS may not be capable of removing the 50 L ~~(190 gal)~~ (11 gal) of water during the slug of water test …'

Page 30: Amend 1st paragraph of A.9 read

'Many instruments under consideration for this application have the ability to produce at a higher frequency than that shown in Figure A.4. Where ~~such a facility exists~~ instruments provide continuous measurement (defined as providing a data point every second or quicker), ~~it is recommended that~~ in addition to Table A.1, the data ~~are~~ shall be reported in a suitable graphical format. The exact format is not mandated by this publication as many instruments operate with different units of measurement. A recommended format is shown in Figure A.5.'

Page 34: Amend B.1 to read

'The testing procedures of B.2 to B.4 shall be undertaken on any component or part of the equipment that is exposed to fuel flow, to demonstrate compliance with selected requirements of section 3.3. A record of the testing shall be provided by the manufacturer. A suitably qualified and competent person shall witness on behalf of the purchaser/user the testing. Testing may be on a different rig to that used for performance assessment in accordance with Annex A. As a minimum, the four sensors that are exposed to EI 1589 test fluids shall each be tested in accordance with B.2 to B.4 after their 336 hour soak periods.'

Pages 34-35: Replace Annex C with

'SEQUENCE OF SENSOR TESTING

Baseline responses to a 15ppm water challenge (Test run E) and water slug challenge (Test run H) shall be established for each of four sensors before they are subjected to EI 1589 testing and pressure/vacuum resistance testing (B.2 to B.4), and then again after pressure/vacuum resistance testing (B.2 to B.4), as follows:

1. Position five sensors in series in the test rig (with a minimum of 200 lpm flow capability).
2. Subject them to a dispersed water Run E (15 ppm, no dirt injection), ensuring system stability before the test condition commences.
3. Record responses from each of the sensors.
4. After completion of Run E, subject the sensors in series to the Run H water slug test.
5. Record responses from each of the sensors.
6. Remove four of the sensors and use them for EI 1589 testing.
   Note: Steps 1 to 6 do not need to be performed in the presence of a user/purchaser's representative.

7. The user/purchaser's representative shall observe the sensors being removed from the four EI 1589 test fluids after the sensors have been exposure to them for 336 hours.
8. Each of the five sensors (four from EI 1589 test fluids and the baseline one from Run E that was not subjected to an EI 1589 test fluid) to be subjected to each mechanical integrity test, described in B.2 to B.4.
9. Reinstate each of the five sensors in series in the test rig in the same position that they were installed in Step 1 and subject them to dispersed water Run E.
10. Record responses from each of the sensors.
11. After completion of Run E, subject the sensors to a Run H water slug.
12. Record responses from each of the sensors.
13. Report all results.
    Note: Steps 9 to 13 shall be performed in the presence of a user/purchaser's representative.

Page 37: Add new Annex D

TESTING TO CONFIRM SYSTEM FAULT RESPONSE CAPABILITY

The test procedure in this Annex shall be performed in the presence of a user/purchaser's representative to demonstrate one of the required self-checking capabilities of a sensor.

1. Place the detection head of the candidate sensor in a beaker or glass jar containing jet fuel.

2. Using a rod of an opaque/non-reflecting material, block the optical path of the candidate sensor or ensure that the reflection does not reach the receiver or emitter.

3. Confirm that Step 3 results in a signal (namur or other) from the candidate sensor that indicates its malfunction.

4. Confirm that immediately the rod is removed the signal from the candidate sensor ceases.

Page 37: Change existing Annex D to Annex E and add

EI 1589 *Materials compatibility testing for aviation fuel filter elements and fuel sensing devices*

Page 38: Change existing Annex E to Annex F and renumber sub-clause E.1 and E.2 to F.1 and F.2 respectively.

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2nd edition

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2nd edition

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CONTENTS

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FOREWORD

This publication has been prepared by the Energy Institute's Aviation Committee. It is intended to provide design and functional requirements, and laboratory testing protocols for electronic sensors for the detection of particulate matter and/or free water, which may be appropriate for use in aviation fuel distribution systems.

This publication is intended to encourage manufacturers of electronic sensors that are currently used in other fluid applications, to consider the suitability of their equipment for use in aviation fuel distribution systems.

This is the second edition of this publication, and supersedes the 'Draft Standard' published in 2007. Following the publication of the first edition, several manufacturers offered sensors purported to meet fully all of the requirements of that publication, confirming its validity.

This second edition includes recommended minimum performance verification tests for electronic sensor responses to jet fuel contamination challenges. These are intended for first article testing only. The inclusion of such tests is intended to only provide a means for manufacturers to demonstrate, under controlled laboratory conditions, selected aspects of the performance of their equipment. The tests should in no way be taken as the only aspects of performance that a user should investigate prior to the routine use of such equipment in their operations. An electronic sensor that is subjected to the laboratory performance verification tests should not be represented by a manufacturer as being 'fit-for-purpose' in aviation fuelling operations on the sole basis of such test results. The limitations of laboratory testing should be fully appreciated by manufacturers and users of electronic sensors. It is not possible to replicate exactly in a laboratory the parameters to which an electronic sensor would be exposed when in service in commercial aircraft fuelling applications. For further information see EI 1570 *Handbook on electronic sensors for the detection of particulate matter and/or free water during aircraft refuelling*.

The use of electronic sensors that meet the requirements of EI 1598 alone cannot provide assurance that fuel delivered to aircraft will meet minimum quality requirements. It is envisaged that electronic sensors will be used in conjunction with a recognised means of fuel filtration. Electronic sensors that meet the requirements of EI 1598 are intended to be part of a comprehensive system to protect aviation fuel quality. They cannot be regarded as fail-safe devices on their own. It is not necessarily intended that electronic sensors that meet the design requirements of this publication alone, will be suitable for their intended application. Users are recommended to conduct trials in a low risk application before adopting equipment for widespread use. For further information see EI 1570.

Any manufacturer wishing to offer electronic sensors stated to comply with this publication is responsible for complying with all the mandatory provisions included herein. It is the responsibility of the manufacturer to further define any application and/or performance limitations that affect the serviceability of electronic sensors in aircraft servicing.

Suggested revisions are invited and should be submitted to the Technical Department, Energy Institute, 61 New Cavendish Street, London, W1G 7AR (e: **technical@energyinst.org**).

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1 INTRODUCTION AND SCOPE

1.1 INTRODUCTION

The aviation fuel supply industry operates stringent quality control processes during fuel handling operations to ensure that all aviation fuel supplied to aircraft is within prescribed parameters of cleanliness, in accordance with the relevant fuel specification. Fuel filtration is used extensively to maintain fuel quality, with several different types of filtration system commonly adopted at airports.

This publication provides electronic sensor manufacturers/suppliers and users with a basis for developing a specification for one component of the aviation fuel handling system that can detect free water and/or particulate matter[1].

This publication has been developed to primarily apply to electronic sensors that could be used on mobile into-plane fuelling equipment, in conjunction with filtration equipment. However, some users of this publication may wish to consider extending some of the requirements to electronic sensors that may be considered for use in airport depot fuel systems. Note: Operational conditions are likely to differ in such applications. The units should not be considered as a replacement for filtration.

This publication applies to components that can detect certain levels of particulate matter and/or free water either by one integrated component or by separate components, e.g. one for particulate matter and one for free water detection.

It should be noted that it is the intention that this publication be applicable to any form of detection technology offered for consideration by users.

1.2 SCOPE

This publication is primarily intended to apply to equipment for:

– Commercial/civilian applications[2].
– Applications that may handle fuel containing approved additives.
– Use on vehicles (hydrant servicers/dispensers, carts and refuellers).
– Use with jet fuel or aviation gasoline.

1 Note: Other contaminants such as microbes and surfactants may also occur in aviation fuel handling systems that may or may not be detected.

2 The surfactancy of military additives is known to have an effect on dirt and water dispersions in jet fuel. These effects and the military additives have not been investigated in the development of the test protocols in Annex A.