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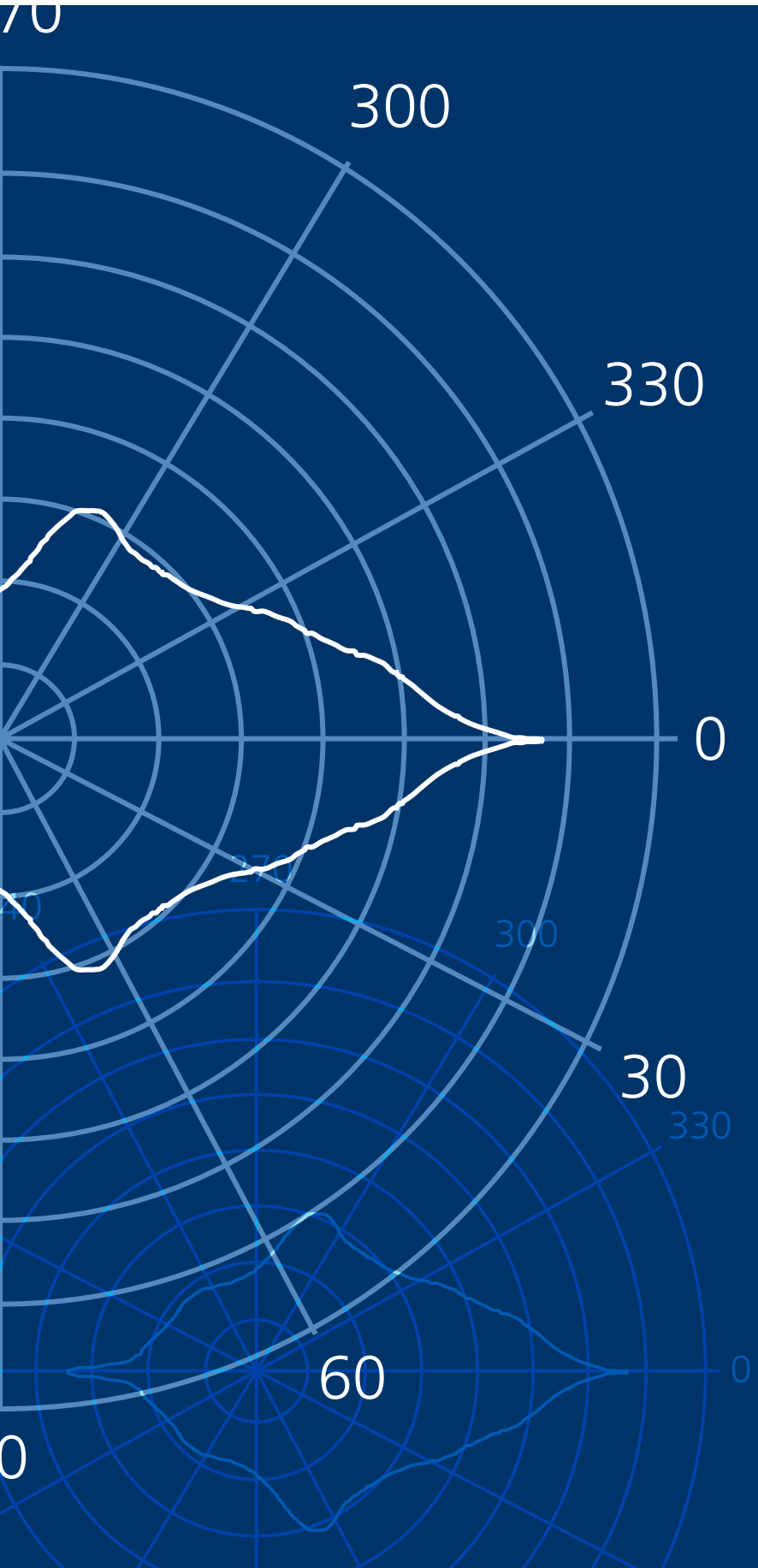

EI 1570

Handbook on electronic sensors for the detection of particulate matter and/or free water during aircraft refuelling

EI 1570

HANDBOOK ON ELECTRONIC SENSORS FOR THE DETECTION OF PARTICULATE MATTER AND/OR FREE WATER DURING AIRCRAFT REFUELLING

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Foreword

This publication has been prepared by members of the EI Contamination Monitoring Working Group, with input from Gary Bessee (Southwest Research Institute) and Vic Hughes (Vic Hughes Associates, Ltd), at the direction of the EI Aviation Committee.

It is intended as a source of information on the technologies that may be viable for use in electronic sensors for the detection of particulate matter and/or free water during aviation fuelling.

This publication is intended to facilitate the understanding of potential users of such sensors, to enable them to make informed choices about which technologies may be best suited for their applications.

The information provided in this handbook is intended to be applicable internationally.

Although this handbook has been written primarily for those involved in the fuelling of commercial aircraft, the overview of detection technologies is equally applicable to military applications. However, military applications have not been specifically considered in the preparation of the information contained herein.

Although it is anticipated that following this publication may assist those involved in the supply of fuel to aircraft, the information contained in this publication is provided for information only. While every reasonable care has been taken to ensure the accuracy of its contents, the EI, and the technical representatives listed in the acknowledgements, cannot accept any responsibility for any action taken, or not taken, on the basis of this information. The EI shall not be liable to any person for any loss or damage which may arise from the use of any of the information contained in any of its publications.

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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Project co-ordination and editing was undertaken by Martin Hunnybun (EI). Layout and formatting was undertaken by Symmone Cupidore (EI).

Chapter 1

Introduction

This chapter describes the interest in electronic fuel cleanliness sensors within the aviation fuel handling operation at airports. In other industries there are several technologies in regular use for fluid cleanliness assurance, but there is limited experience of their use in aviation fuel handling applications. This informative handbook is provided to help bridge this gap in sensor knowledge.

Why the interest in electronic sensors?

For an in-depth account of fuel cleanliness control see EI 1550 *Handbook on equipment used for the maintenance and delivery of clean aviation fuel*

Aviation fuel handling systems rely on the use of strict fuel quality control procedures coupled with highly specified filtration and water separation technologies to ensure that fuel delivered to aircraft is fit-for-purpose.

As a possible additional layer of protection, the international aviation fuel supply industry is assessing the use of electronic sensors for the detection of particulate matter (dirt) and/or free water in aviation fuel during aircraft refuelling. Such devices may enable continuous, rather than periodic, fuel cleanliness monitoring, and potentially highlight failures in the cleanliness assurance system.

It is important for operators to only consider sensors as one part of the comprehensive system to protect fuel quality/cleanliness. As with other quality assurance steps, they cannot be regarded as being fail-safe devices.

The use of sensors may be able to provide industry with a means of 'condition monitoring' – the on-going appraisal of the cleanliness of a fuel delivery system.

The three aspects:

- procedures (current quality assurance);
- filtration/water separation and absorption, and
- sensors

seek to provide the industry with fuel cleanliness assurance in which there is improved contingency – reducing the reliance on any single process. It is important to note that it is not intended that sensors will replace current procedures or filtration.

The interest in electronic sensors is perhaps greatest for the hydrant servicer application, where experience has shown failure in the quality assurance (QA) system may lead to bulk water contamination in hydrants. However, the application of sensor technology downstream of mobile filtration (the filter systems used on hydrant servicers, refuellers or carts), is technically challenging.

What do I need an electronic sensor to do?

An electronic sensor can be thought of in two ways, described below as 'Philosophy A and B'. Although the distinction between the two philosophies appears subtle, it has far-reaching consequences for global into-plane fuelling operations:

Philosophy A – considering an electronic sensor as an alarm to indicate a breakdown in the effectiveness of the mobile filtration system and other fuel cleanliness assurance steps.

Philosophy B – considering an electronic sensor as a means of continuously monitoring fuel for trace levels of dirt or water downstream of mobile filtration, to confirm they remain below industry-accepted levels during each aircraft fuelling.

Key points for philosophy A

- Into-plane operations relying on the robust QA procedures currently adopted have proved highly effective in mitigating the risk of fuel containing unacceptable levels of dirt/water being uplifted to aircraft, so enhanced cleanliness monitoring is not critical to the maintenance of current into-plane fuel cleanliness levels.
- The sensor is applied as an electronic 'equivalent' of current water detection/ gravimetric assessment methods.
- Monitoring can be achieved throughout a fuelling rather than periodically (after each uplift, daily, weekly, monthly etc).
- An alarm condition should only be an extremely rare event.
- An additional safeguard/layer of protection to those already implemented to ensure filtration remains effective, e.g. monitoring of differential pressure, sump draining etc.

Key points for philosophy B

- This would be a new operating condition for into-plane fuelling companies.
- There are inherent challenges with analysis of the massive quantity of data generated during a refuelling.
- There are risks of sensor outputs reading too high or too low.
- There would be the benefit of demonstrable QA for each fuelling.
- Analysis of a sensor output trend over time would be more robust than responding to absolute values.
- Such use of a sensor may lead to enhanced knowledge of in-service filtration efficacy.
- Such devices would still need to be used in conjunction with mobile filtration.

This handbook describes the implications for the 'Philosophy B' approach to adoption of electronic sensors.

Why water and/or dirt?

A sensor may be designed to only detect one type of contaminant – water or dirt. Other sensors may be designed to detect both contaminants.

Fundamental to the successful application of sensors is that devices may not be able to differentiate between dirt or water droplets and produce a signal indicating a higher level of contaminant than occurred.

What is an electronic sensor?

An electronic sensor, as used throughout this handbook, is a device capable of detecting free water and/or particulate matter (dirt) in aviation fuel, and providing an electronic signal/data output.

Various types of technologies may be suitable, and are covered by this broad term.

Where would I use an electronic sensor?

Cleanliness monitoring by electronic sensors may offer benefits to operators at a variety of locations at an airport, including at fixed facilities – into-storage, out-of-storage. However, as described above, this handbook, and EI 1598, describe sensors applied downstream of mobile filtration.

A sensor located downstream of mobile filtration will be monitoring the effective dirt removal/water separation of that filtration system. Such systems are subjected to stringent industry specifications and it is the expectation that sensor detection of fuel cleanliness would only register an anomaly in the rare event of gross failure in the existing cleanliness assurance system.

Why have electronic sensors not been used previously?

Several companies involved in the aviation fuelling industry have previously undertaken technical evaluations of a variety of sensing technologies for this application. At that time companies concluded that the technology was not suitable, primarily due to reliability issues and the challenge of sensors providing false readings.

Following advances in technology, the industry is again investigating the potential use of sensors which may be sufficiently robust and operationally reliable for implementation worldwide.

Key requirements for electronic sensors

For an electronic sensor to be suitable for an aircraft fuelling application, it would have to be:

- able to provide results in real-time, or as close to it as possible;
- installed to receive a representative fuel sample;
- able to provide a timely indication of a significant change in fuel cleanliness;
- sufficiently robust/reliable for field operations;
- fully compliant with applicable safety requirements/legislation, and
- cost effective.

Electronic sensors, particularly those adopting some of the technologies used in other industries for similar reasons, have been identified as providing the aviation fuel handling industry with potential condition-monitoring solutions.

Which electronic sensors can I use?

Into-plane fuel suppliers can currently choose to install and operate any type of electronic sensor they wish for this application, as long as the device meets applicable safety regulations.

EI 1598 *Considerations for electronic sensors to monitor free water and/or particulate matter in aviation fuel,* 1st edition, 2007

However, as for other critical items of equipment used on fuelling vehicles, industry stakeholders have worked with the EI to define key mechanical and material compatibility requirements for sensors, to ensure their safety of use. This work was published by the EI in 2007 as EI 1598. It is recommended that all users consider the requirements of EI 1598 during equipment selection. EI 1598 also outlines some key minimum performance requirements that a sensor will have to be able to meet to be worthy of evaluation for this application.

EI 1598 was also issued to encourage those manufacturers who provide sensors for other applications, to offer their equipment for use in fuel cleanliness monitoring during aircraft fuelling. It was provided to help them understand the operational environment they would be required to address.

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, 2012

A second edition of EI 1598 was published in January 2012. The standard now includes laboratory test protocols to establish the response (or otherwise) of sensors to defined particulate matter and free water contamination events in a flowing jet fuel system (defined as fuel flowing in a pressurised system at the rate that occurs during fuel delivery to aircraft). The test protocols are intended to mimic possible contamination events sensors may encounter in field use. The instrument response to these events is recorded and reported to enable potential users to make an informed decision on the suitability of a sensor for their specific application.

Why the need for this handbook as well as EI 1598?

EI 1570 has been prepared as a means of disseminating to those involved in aviation fuel handling, information on:

- The different mechanisms or technology that an electronic sensor can use to measure particulate matter and/or free water.
- The different ways in which a sample from flowing fuel can be obtained.
- The terminology used by sensor manufacturers to facilitate common understanding between potential users and manufacturers.

When reading this handbook it is important to bear in mind that it is not yet known whether any particular type(s) of electronic sensor will be able to provide the total detection coverage and robustness needed to be successfully incorporated as one of the steps in a comprehensive fuel cleanliness strategy for aircraft refuelling.

Experience with these devices is accumulating (particularly under laboratory conditions) and this handbook includes indications of some of the capabilities and limitations currently established for the different technologies.

How can this handbook help me select a sensor for field trial?

This handbook is intended to inform the user's decision-making process, as outlined graphically in Figure 1.

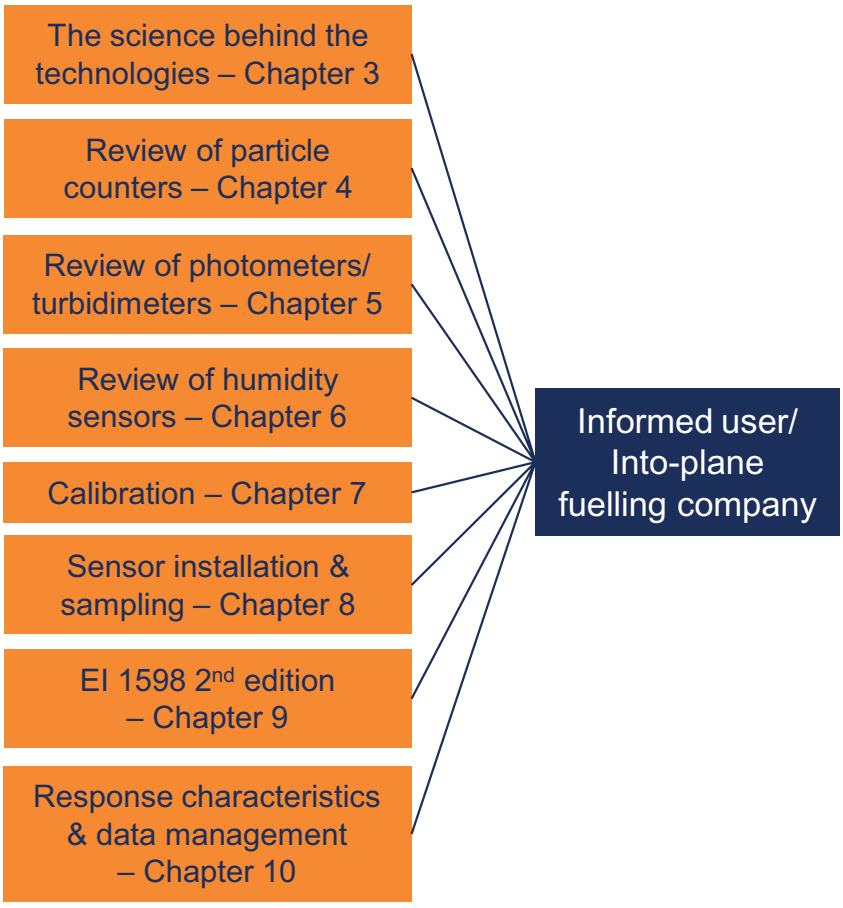
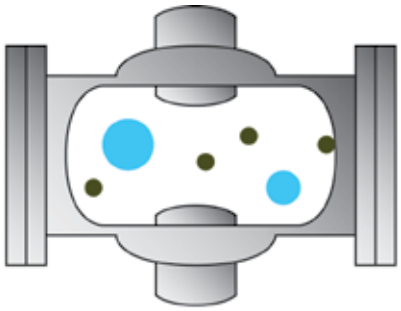


Figure 1: Schematic outline of information provided by this handbook



Chapter 2

Scope

This chapter clarifies the topics covered by this handbook, and those items that are not specifically addressed.

What is covered by this handbook?

This handbook is primarily intended to inform any company or organisation considering the use of electronic sensors about some key concepts worthy of consideration in the procurement, installation and use of electronic sensor equipment.

Specifically, this handbook is relevant to the following:

- Commercial, civilian and military aviation fuel handling applications at airports.
- Applications that may handle fuel containing approved aviation fuel additives. (See chapter 9 for limitations of EI 1598 testing protocols with military fuel grades.)
- Use of sensors for on-line/side-stream or in-line continuous monitoring of fuel on fuelling vehicles (hydrant-servicers/dispensers, refuelling carts and refuellers), downstream of final filtration.
- Use of sensors with jet fuel and aviation gasoline.
- Sensors meeting the minimum requirements of EI 1598.
- Key issues that will need to be addressed for sensor installation to lead to successful cleanliness monitoring.

What is not covered by this handbook?

This publication does not provide information/or good practice regarding:

- Detailed sensor installation, field application/use, or data management. Industry knowledge in these areas was limited at the time of publication.
- Image analysis machines which have been used for the calibration of other simpler electronic sensors, as this type of technology is too complex and expensive for practical use in this application.
- Electronic devices that measure other parameters which are used in operations to assess the effectiveness of filtration systems (e.g. differential pressure across filter vessels).
- Electronic devices that measure fuel density and/or temperature.