Designation: D8004 – 15

Standard Test Method for Fuel Dilution of In-Service Lubricants Using Surface Acoustic Wave Sensing[1]

This standard is issued under the fixed designation D8004; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a means for determining the amount of fuel dilution present in an in-service lubricant. This is achieved by drawing into a surface acoustic wave (SAW) sensor vapor from the lubricant. Fuel vapor will be absorbed by the SAW sensor's polymer coating. The amount of absorbance is then related to fuel content in the lubricant.

1.2 The range of fuel dilution capable of being measured by the test method is from 0.1 % to 10.0 % by mass fuel dilution.

1.3 This test method is specifically tailored to determining the fuel dilution of in-service lubricants, including newly utilized lubricants. The method is applicable to contamination with diesel, gasoline, and jet fuels.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*See Section 9.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E456 Terminology Relating to Quality and Statistics

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material

D7235 Guide for Establishing a Linear Correlation Relationship Between Analyzer and Primary Test Method Results Using Relevant ASTM Standard Practices

D7593 Test Method for Determination of Fuel Dilution for In-Service Engine Oils by Gas Chromatography

D7669 Guide for Practical Lubricant Condition Data Trend Analysis

D7720 Guide for Statistically Evaluating Measurand Alarm Limits when Using Oil Analysis to Monitor Equipment and Oil for Fitness and Contamination

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fuel dilution sample holder, n*—a bottle that contains the lubricant to be analyzed. For example, this may be a standard 125 mL bottle (see Fig. 1, example configuration A) or a standard 30 mL laboratory vial (see Fig. 2, example configuration B).

3.1.2 *fuel dilution sample inlet, n*—a tube that connects the sample to the SAW sensor.

3.1.3 *fuel dilution sample stand, n*—mechanical device for holding the bottle of lubricant in the SAW fuel dilution apparatus in a way such that the headspace from the bottle is directly fed into the SAW element.

3.1.4 *fuel dilution seal, n*—a mechanism that seals the fuel dilution sample holder to the vapor path leading to the SAW sensor.

3.1.5 *SAW fuel dilution apparatus, n*—a device that measures fuel dilution using surface acoustic wave (SAW) technology. This is achieved by drawing vapor from the lubricant into a surface acoustic wave (SAW) sensor. The fuel dilution apparatus measures the concentration of contaminating fuel vapor present in the air "headspace" over the lubricant. The fuel dilution apparatus assumes that this headspace fuel vapor concentration is directly proportional to the fuel present in the oil. This relationship is based on Henry's Law. As fuel contamination builds up, a vapor concentration will be established in the headspace that is directly proportional to the concentration dissolved in the oil. The fuel dilution apparatus uses a SAW sensor to make these measurements.

3.1.6 *SAW sensor, n*—consists of a piezoelectric substrate that has an interdigitated electrode lithographically patterned on its surface. The surface of the SAW sensor has a polymer

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

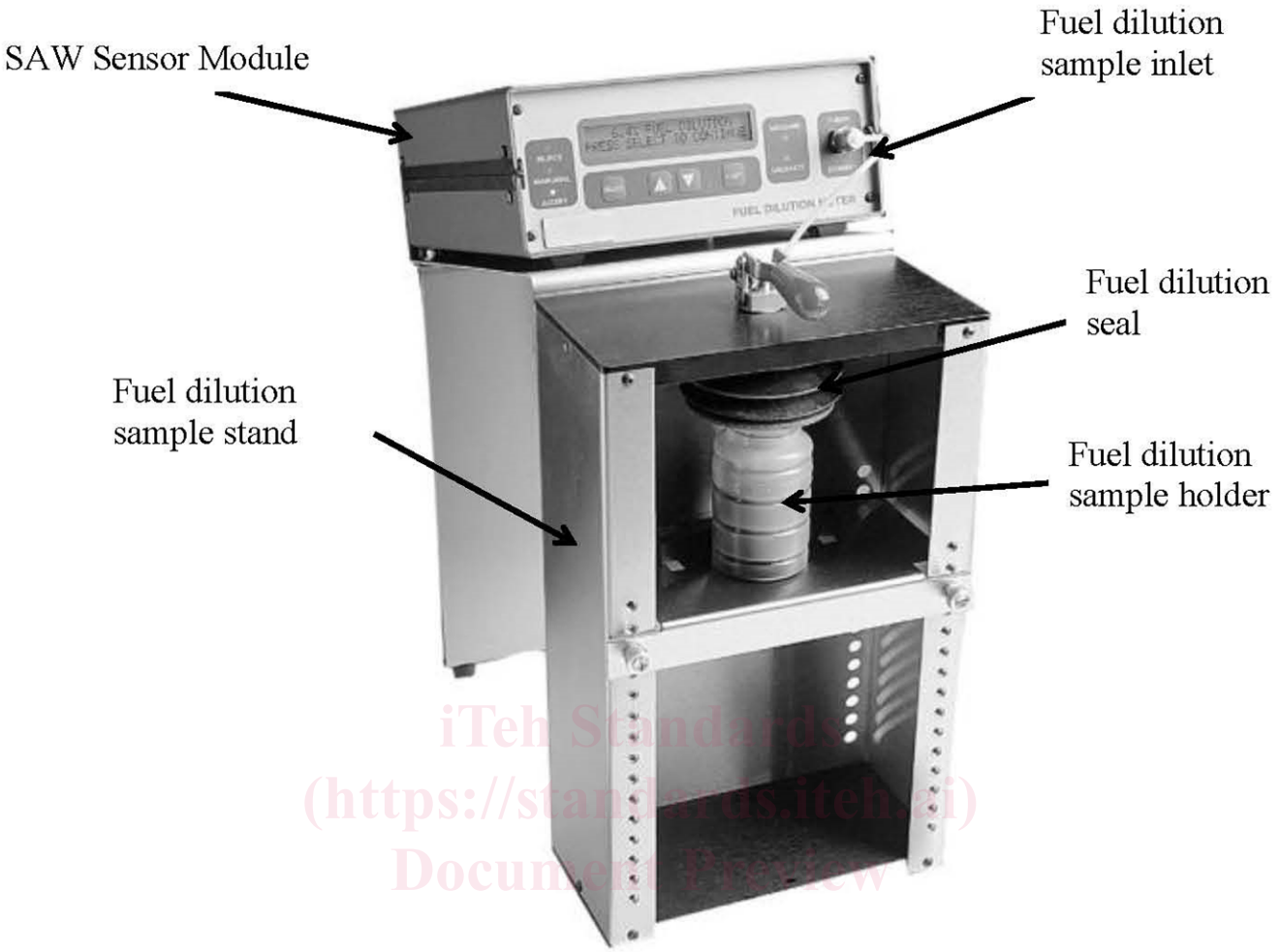

FIG. 1 Example SAW Fuel Dilution Apparatus—Configuration A

coating that is chosen to offer specific solubility to fuel vapors. The mechanism of detection is a reversible absorption of the fuel component into the polymer. When this device is excited by external RF (radio frequency) voltage, a synchronous Rayleigh wave is generated on the surface of the device. When fuel contamination comes in contact with the SAW sensor surface, it will absorb into the polymer coating. This absorption into the polymer causes a mass change, which produces a corresponding change in the amplitude and velocity of the surface wave. When used in a self-resonant oscillator circuit, the change in Rayleigh wave velocity resulting from vapor absorption into the polymer coating causes a corresponding change in oscillator frequency. This change in frequency is the basis of detection of the fuel dilution apparatus.

3.1.7 *surface acoustic wave (SAW), n*—a mechanical deformation travelling on the surface of a material; such a deformation may be converted into electrical signals using a piezoelectric material, which generates a voltage in response to a mechanical deformation.

4. Summary of Test Method

4.1 A liquid sample is placed into the fuel dilution sample holder (see Figs. 1 and 2) of the SAW fuel dilution apparatus and fuel dilution (percent by mass) is determined.

4.2 The vapor headspace of the sample, equilibrated at room temperature, is drawn into the SAW sensor by means of a diaphragm pump, which draws the vapor into the chamber of the SAW sensor.

4.3 The SAW sensor registers the buildup of mass on its polymer absorbent coating over a period of approximately one minute.

4.4 Based on this mass buildup and a calibration, fuel dilution (percent by mass) for the sample is determined.

5. Significance and Use

5.1 This test method provides a means for a reliable field determination of fuel dilution that is quick and preparation-free. Results are obtained in approximately 1 min. Such a