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Standard Method of Testing DEUTERIUM OXIDE¹

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1. Scope

1.1 This method covers the measurement of the isotopic composition of hydrogen in deuterium oxide (heavy water) which is nominally 99.75 atom percent deuterium (D), equal to $D/(D + H) \times 100$. The primary use of the heavy water is as a moderator in production, power, or research reactors in which a fissionable nuclide is consumed. In such reactors the percentage of deuterium in the heavy water usually exceeds 95 %.

2. Applicable Documents

2.1 ASTM Standards:

- D 1129 Definitions of Terms Relating to Water²
- D 1192 Specification for Equipment for Complying Water and Steam²
- D 1193 Specification for Reagent Water²
- D 1217 Test for Density and Specific Gravity²
- E 1 Specification for Thermometers³
- E 137 Evaluation of Mass Spectrometers⁴

3. Summary of Method

3.1 There are numerous physical properties of heavy water that are different in value from the corresponding value for natural water. These properties form the basis of several instrumental methods of analysis of heavy water. The accepted value for the specific gravity of heavy water is $S_{25}^{25} = 1.10775 \pm 0.00003$ which is roughly 11 % greater than the specific gravity of natural water. Measurement of the specific gravity of heavy water is the most precise and accurate method of determining the isotopic concentration of heavy water. The uncertainty of 30 mg/L in S_{25}^{25} permits determination of atom percent deuterium to no better than ± 0.03 atom percent deuterium.

4. Terminology

4.1 *Definitions*—Certain terms in this method are defined in accordance with Definitions D 1129, as follows:

4.2 *Descriptions of Terms Specific to This Method:*

4.2.1 *normal abundance of an isotope*—the abundance in atom percent of the isotopes of an element as it is found in nature.

4.2.2 *atom percent of an isotope*—the atom fraction of the isotope expressed in percent.

4.2.3 *atom fraction of an isotope*—the number of atoms of the isotope divided by the total number of atoms of that element in the sample; this ratio is analogous to mol fraction. For example, using the isotopes of oxygen, the atom fraction of ^{18}O is $^{18}\text{O}/(^{16}\text{O} + ^{17}\text{O} + ^{18}\text{O})$.

5. Interferences

5.1 One or more of the processes for producing heavy water may increase its oxygen-18 content. A change in the concentration of either deuterium or oxygen-18 changes the specific gravity of the water in a nearly linear manner. The heavy water that is sold commercially by the Atomic Energy Commission usually contains oxygen-18 at about 0.4 atom percent or roughly twice normal abundance. This increase in concentration results from the distillation process because water that contains oxygen-18 has a lower volatility than water that contains oxygen-16.

¹ This method is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D19.04 on Methods of Radiochemical Analysis.

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² Annual Book of ASTM Standards, Part 31.

³ Annual Book of ASTM Standards, Parts 25 and 44.

⁴ Annual Book of ASTM Standards, Part 23.