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Nuclear fuel technology — Guide to the measurement of the specific surface area of uranium oxide powders by the BET method

Technologie du combustible nucléaire — Principe de la mesure de l'aire massique (surface spécifique) des poudres d'oxyde d'uranium par la méthode BET

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Foreword

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Nuclear fuel technology — Guide to the measurement of the specific surface area of uranium oxide powders by the BET method

1 Scope

This International Standard covers the determination of the specific surface area of as-fabricated uranium dioxide powder by volumetric or gravimetric determination of the amount of nitrogen adsorbed on the powder, and can be applied to other similar materials, e.g. U_3O_8, UO_2-PuO_2 powders, and other bodies with similar surface areas, e.g. powder granules or green pellets, provided that the conditions described are fulfilled. Modifications using other adsorbing gases are included.

2 Principle

2.1 Summary of the method

The method is based on the determination of the amount of gas necessary to cover the surface by a monomolecular layer. This amount is determined from the isothermal adsorption curve of nitrogen at the temperature of liquid nitrogen (77,4 K) according to Brunauer, Emmett and Teller (BET) [1] since the adsorbate N_2 is physically adsorbed on the adsorbent. The amount of N_2 adsorbed at a given pressure is determined by volumetric or gravimetric measurement. In order to remove surface contamination of the adsorbent, the sample has to be evacuated and heated under appropriate conditions before the measurement is performed.

2.2 Isothermal adsorption curves

The isothermal adsorption curve describes the relationship between the mass of the adsorbate m_A (N_2) adsorbed per gram of adsorbent (e.g. UO_2 powder) at an equilibrium pressure of p at constant temperature T:

$$m_A = f(p,T) \tag{1}$$

Generally the relative pressure p/p_0 is introduced instead of the absolute pressure p, where p_0 is the saturation vapour pressure which is 1,013 10^5 Pa for nitrogen at 77,4 K.

Most isothermal adsorption curves can be classified according to Brunauer, Deming L., Deming W. and Teller [2] to be one of the five common types (see Figure 1).

Materials with pure micropores (< 2 nm diameter) result in a type 1 adsorption curve. Most frequently, type 2 and 4 adsorption curves are observed where the adsorption energy of the first layer E_1 is much higher than that of the higher layers E_n. When $E_1 \approx E_n$, type 3 or type 5 adsorption curves result. The BET method can be applied to type 2 and type 4 curves only.