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Iodine charcoal sorbents for nuclear facilities — Method for defining sorption capacity index

Pièges à iode pour installations nucléaires — Méthode pour définir la capacité de rétention



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

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Introduction

Iodine sorbents are extensively used in nuclear facilities to remove radioiodine from gases and air in off-gas cleaning systems and ventilation installations. The sorbents are very important for protection of the members of the public and environment from iodine radionuclides radiation.

In the normal operation of nuclear installations, the main hazard comes from radioactive isotopes of iodine; as examples, for reactors ^{131}I and a minor extent ^{133}I, for fuel processing facilities ^{129}I, etc. Iodine is one of the main contributors of the radiation impact on the environment. Under abnormal and accident conditions, some other isotopes ^{132}I, ^{134}I and ^{135}I have also some significant effects on the total iodine dose (thyroid dose)[3].

The volatile radioiodine forms can occur in the gaseous radioactive wastes as elemental iodine, the simplest organic compound methyl iodide, and some others such as hydrogen iodide under reducing conditions.

Radioactive iodine can create a serious danger to the members of the public and workers in abnormal and accident conditions at nuclear facilities as far as the exposure in these conditions could be much higher than the exposure due to the natural background radiation.

The need to prevent widespread dispersal of gaseous radioiodine from nuclear facilities is a major purpose of iodine sorbents. It is universally recognized that radioactive methyl iodide is the less readily removable radioiodine form. The removal of radioactive iodine from gaseous radioactive wastes at nuclear facilities is almost always performed with the help of impregnated activated charcoals that have become often accepted as the preferred iodine sorbents used in these facilities. Impregnated charcoals require a high efficiency especially from humid gases containing iodine in order to trap all the iodine gaseous compounds.

Two types of tests are considered[2][4]: laboratory and *in situ* tests.

— Laboratory tests are done to establish the performance characteristics of the charcoal to be used in retention systems under specified operating conditions.

— *In situ* tests are done to obtain a measure of the performance of retention systems under appropriate operational conditions.

This document concerns only the laboratory tests. Laboratory tests of representative samples of charcoal (e.g. new charcoal, aged charcoal from iodine absorbers, etc.) are performed to establish their efficiency for a given test agent under specified conditions.

The quality of sorbents and its potential application at nuclear facilities can be estimated by means of a criterion that defines specifically the sorption capacity of the sorbent. Such criterion is called in this document the sorption capacity index.

The index is defined by the result of a laboratory test on the basis of radioiodine activity distribution inside the sorbent. This index characterizes the total kinetic sorption process for established test conditions and show whether the sorbent can be used as iodine filters for nuclear facilities. One example of criteria is given in Annex D.

This document provides a method to determine the quantitative quality of a sorbent and also to compare the performance of different iodine sorbents at the specified conditions. It is useful for users of iodine sorbents (filter or sorbent manufacturers as well as operators).

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Iodine charcoal sorbents for nuclear facilities — Method for defining sorption capacity index

1 Scope

The scope of this document covers

— iodine sorbents for nuclear power plants, nuclear facilities, research and other nuclear reactors,

— iodine sorbents for laboratories, including nuclear medicine, and

— iodine sorbents for sampling equipment on sample lines.

This document applies to iodine sorbents manufacturers and operators in order to measure the actual performance of these sorbents and their sorption capacity for radioiodine.

This document applies to granulated and crushed iodine sorbents based on activated charcoal (hereinafter referred to as "sorbents") used for trapping gaseous radioiodine and its compounds. This document establishes the method and conditions for defining sorption capacity index in a laboratory.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
gaseous radioactive wastes
wastes that contain radioactive material in gas form for which no further use is foreseen and have radionuclides at concentrations or activities greater than clearance levels as established by a regulatory body

3.2
discharge
planned and controlled release of (gas or liquid) radioactive material to the environment

3.3
mass transfer zone
defined zone (range) of sorbent volume in which the phenomena of substance mass transfer from gas to solid phases takes place

3.4
iodine sorbent
sorbent intended for trapping radioiodine in gaseous radioactive wastes

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3.5
free volume
void between grains or crushed grains of the sorbent inside the whole volume containing the sorbent

Note 1 to entry: The free volume can be expressed as in Formula (1):

$$V_{\text{fr}} = \chi \cdot V_{\text{sorb}} \tag{1}$$

where

V_{fr} free volume;

χ fraction free volume in sorbent volume;

V_{sorb} sorbent volume.

3.6
contact time
gas flow transit time through sorbent layer

Note 1 to entry: Contact time τ is expressed using Formula (2):

$$\tau = \frac{V_{\text{fr}}}{Q_{\text{col}}} \tag{2}$$

where

Q_{col} the volumetric gas flow rate in the inlet sectional column.

Note 2 to entry: The contact time defined here does not consider the geometric volume of the sample, but only its free volume.

3.7
bulk density
ρ_{sorb}
ratio between granulated or crushed grains sorbent mass (definite granulation) and the total volume containing the sorbent

3.8
sorption capacity index
ξ
criterion indicating the degree of reduction of gaseous radioiodine in the gas flowing through the sorbent under specified test conditions

Note 1 to entry: The index is valid only for a specific chemical form of the radioactive gas. In this document, the index has been calculated for radioactive methyl iodide. The index can also be calculated with other gaseous species, such as radioactive iodine, but the results cannot be compared with the ones obtained with radioactive methyl iodide.

4 Principles of the method

The main rationale for the method defined in this document are the following:

— radioactive methyl iodide ($CH_3{}^{131}I$) is the most difficult form of radioiodine to trap in nuclear facilities discharges;

— the distribution of radioactive methyl iodide along sorbent layer is exponential;

— there is an active mass transfer zone in the sorbent layer;

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