INTERNATIONAL STANDARD

ISO 18417

First edition
2017-03

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

Reference number
ISO 18417:2017(E)

Contents

Page

Foreword .... **iv**

Introduction .... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Principles of the method **2**

5 Preparation of the test **4**
5.1 General 4
5.2 Removal of air impurity and humidity into the installation 4
5.3 Radioactive methyl iodide used for sorbent testing 5
5.4 Preparation of sorbent samples 5
5.5 Measuring devices 6
5.6 Conditions for achieving equilibrium during the test 6
5.7 Safe conditions for workers and members of the public 6

6 Test conditions **7**

7 Sorbent testing **7**

8 Test performance **9**

9 Determination of the sorption capacity index **10**
9.1 Sorption capacity index determination 10
9.2 Calculating sorption capacity index 11
9.3 Uncertainties of measurements 12

10 Documenting test results **13**

Annex A (normative) **Format of test report (for the customer)** **14**

Annex B (normative) **Format of internal test report** **15**

Annex C (normative) **Measurements results** **16**

Annex D (informative) **Example of expected results for sorption capacity index** **17**

Bibliography **19**

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

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).

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

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):

$$V_{fr} = \chi \cdot V_{sorb} \quad (1)$$

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):

$$\tau = \frac{V_{fr}}{Q_{col}} \quad (2)$$

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;

— the amount of sorbed radioactive methyl iodide depends on the contact time between the gas and sorbent.

The sorption capacity index indicates the degree by which radioactive methyl iodide concentration in gas phase is reduced during the contact of the gas flow with the sorbent.

The principle of the method is the following:

— indoor laboratory air is used as carrier gas;

— air is transferred in the test plant by means of extraction device (fan, vacuum pump, etc.);

— in order to remove indoor laboratory air pollutants, aerosols and humidity, air flow passes through an aerosol filter, an air conditioning system used for humidity (e.g. zeolite or dehumidifier) and volatile compounds removal (e.g. activated charcoal);

— the humidity level shall be maintained to a specified value and be controlled. One example for this humidity control is to split the total air flow and pass one of the flows through a second air condition system (e.g. humidifier);

— the air temperature and air flow are regulated and measured before introduction in the sample to test (e.g. the air temperature is control by heat insulation of the sectional column or to place it in a vessel with controlled temperature);

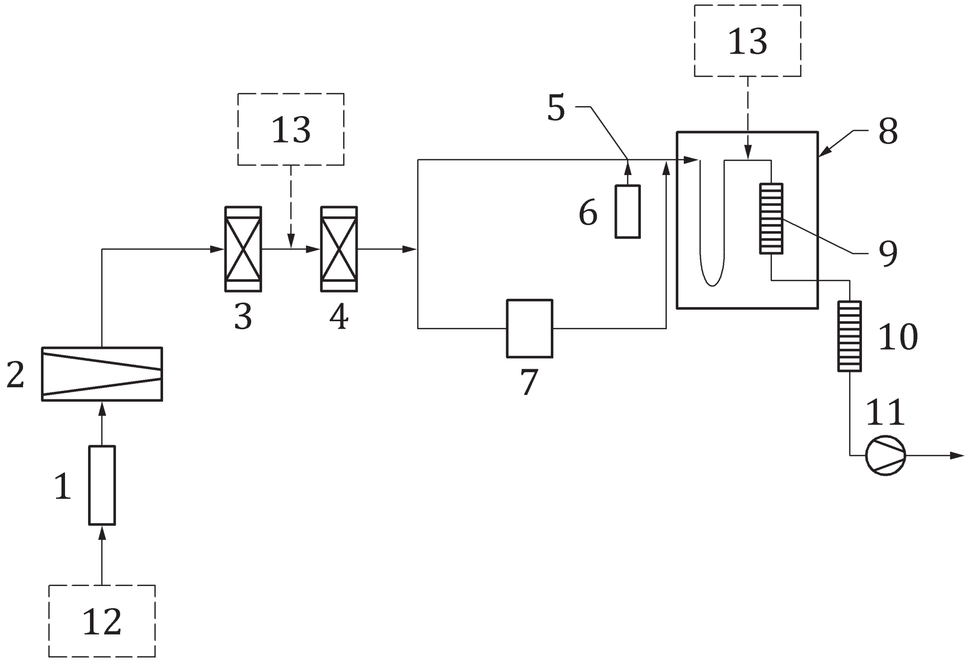
— radioactive methyl iodide is injected into the carrier gas from a generator and then it is trapped in the sectional columns containing the sorbent to be tested;

— before discharging the test gas, the air is passed through a protection column for radiation protection issues and for control of the penetration radioiodine and to ensure a low level of iodine active species in discharged air;

— each section test column is monitored for radioiodine content via gamma monitors (0,364 MeV for ^{131}I);

— the sorption capacity index is calculated using the formula given in Clause 9.

Figure 1 presents the principle of an example scheme of the test plant used for the method presented in this document.



Key

1 flowmeter
2 aerosol filter
3 dehumidifier
4 charcoal
5 injection of radioactive methyl iodide
6 generator of radioactive methyl iodide
7 humidifier
8 temperature controlled chamber
9 sectional column
10 protection column
11 vacuum pump
12 room air
13 controller humidity, temperature, absolute pressure and pressure drop

Figure 1 — Schematic of principle equipment and a process diagram of the test plant

5 Preparation of the test

5.1 General

Based on the typical arrangement proposed in Clause 4, the test involves the following stages.

5.2 Removal of air impurity and humidity into the installation

Removing air pollutant and controlling humidity and temperature are important for the tests because these parameters can have a significant impact on the results. In order to clean the installation before a new test, the indoor air is passed through an aerosol filter, dehumidifier and charcoal filter to remove particulates, humidity and some volatile compounds. As an example, dehumidifier with zeolite warms at the temperature 350 °C to 400 °C in vacuum during 6 h and activated carbon to warm at temperature 300 °C to 350 °C in vacuum during 6 h in order to avoid degradation of the charcoal properties.

5.3 Radioactive methyl iodide used for sorbent testing

If radioiodide is supplied in ready-to-use form of radioactive methyl iodide ($CH_3{}^{131}I$) received from producer, a certificate date and activity shall be required. It shall be stored in a dark place at conditions that slows down the process of its decomposition into the molecular form (I_2).

Otherwise, methyl iodide labelled with ^{131}I isotope is produced by its isotopic exchange (e.g. with $Na^{131}I$ or $K^{131}I$ without carrier). Its activity shall be defined and specified with a date. For this purpose, 2 cm^3 of methyl iodide are injected into the container with $Na^{131}I$ or $K^{131}I$ and kept at a room temperature of 20 °C for 48 h. To define the mass activity concentration (Bq/g), three portions of 5 g of activated carbon impregnated with triethylenediaminne (TEDA) are weighed and placed in weighing bottles, the diameter of which is close to that of the test column. Three samples of 4 µl of radio-labelled methyl iodide are taken and placed into weighing bottles with activated carbon. Activities of resulting samples are measured and correlated with methyl iodide mass that is defined as the volume of samples taken and methyl iodide density at the temperature of its storage.

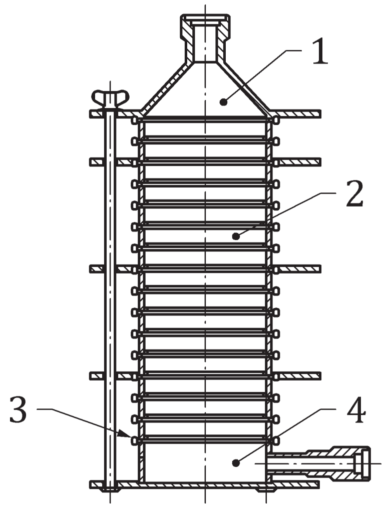
Mean value of mass activity concentration is calculated. The mass activity concentration (expressed in Bq/g) is used for calculation of the mass concentration of methyl iodide in the gas flow (see Formula 8).

5.4 Preparation of sorbent samples

Range of granulated/crushed grains sizes and bulk density ρ_{sorb} of the sorbent sample are determined if these data are absent. The methods used to determine grains size and the bulk density are defined according to a national or international standard.

When filing each section of the column, the filling shall be made uniformly in each section such that similar mass in each section is obtained, without specific compression or vibration.

The sectional column is used to conduct the sorbent test. Examples of such column and of a small section inside the column are shown in Figure 2 and Figure 3.



Key

1 removable cover with inlet nozzle

2 sorbent-containing section

3 guide rod

4 bottom with outlet nozzle

Figure 2 — Column for sorbent testing