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Evaluation of surface contamination —

Part 2 : Tritium surface contamination

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Évaluation de la contamination de surface

Partie 2: Contamination de surface par le tritium

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7503-2 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*.

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Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Evaluation of surface contamination —

Part 2 : Tritium surface contamination

1 Scope and field of application

This part of ISO 7503 applies to the evaluation of tritium contamination on surfaces of equipment and facilities, containers of radioactive materials and sealed sources.

It does not apply to the evaluation of tritium contamination of the skin and of clothing.

NOTE — Evaluation of surface contamination from beta-emitters (maximum beta energy greater than 0,15 MeV) and alpha-emitters is dealt with in ISO 7503-1. Other radionuclides of practical importance (for example electron capture and isomeric transition emitters) will be dealt with in a future International Standard.

2 Definitions

For the purposes of this part of ISO 7503, the following definitions apply.

2.1 tritium surface contamination: Total activity of tritium adsorbed upon and absorbed into the surface.

2.2 directly measurable tritium surface contamination: Fraction of the tritium surface contamination available for direct measurement.

2.3 removable tritium surface contamination: Fraction of tritium surface contamination which is removable or transferable under normal working conditions.

NOTES

1 The definition of the term "normal working conditions" is important for the evaluation of inhalation and incorporation risks in connection with surface contamination: it is assumed that under "normal working conditions", the maximum intensity of mechanical action which could bring about the removal of surface contamination is restricted to that of

- normal, non-accidental contacts of the human body (protected or unprotected by clothes) with surfaces, and
- non-destructive contacts of similar intensity between surfaces and parts of equipment being directly handled by men.

The intensity of action in smear testing should correspond to these types of mechanical action. A single smear will not normally remove all removable contamination.

2 It should be noted that:

- a) under external influences of a chemical nature (e.g. moisture, corrosion, etc.) or of a physical nature (e.g. ambient pressure or temperature changes, vibration, impact, expansion and contraction, etc.), and also as a result of diffusion, the total tritium activity may be transformed into removable contamination;
- b) tritium surface contamination may be volatile or contain volatile fractions which may volatilize under normal working conditions — this also contributes to the removable contamination and should be evaluated appropriately (see also 3.3).

2.4 activity per unit area: Ratio between the tritium surface contamination present and the area of that surface. It is expressed in becquerels centimetres to the power of minus two ($\text{Bq}\cdot\text{cm}^{-2}$).

2.5 indirect evaluation of removable tritium surface contamination: Evaluation of the removable tritium activity on a surface by means of a smear sample.

2.6 smear test: Taking of a sample of removable activity by wiping the surface with dry or wet material and the subsequent evaluation of the activity transferred to the material used to wipe the surface.

NOTE — In most applications, a wet smear has been found preferable for the determination of tritium surface contamination.

2.7 removal factor, F : Ratio of the activity removed from the surface by one smear sample to the activity of the removable surface contamination prior to this sampling (see also ISO 7503-1).

NOTE — For important combinations of contaminant and surface material, the removal factor F can be determined experimentally using the method of "exhaustive removal by repetitive smears". The step-by-step addition of the removed activities results in a good approximation of the total removable activity, to which the activity removed by the first smear can then be related to yield the removal factor.

3 Method for evaluating surface contamination

3.1 General

The problem with the detection of tritium lies in the exceedingly short range of its beta particles, even in air. Tritium, being an

isotope of hydrogen, has great mobility, and, as an unwanted contamination, it may penetrate into a surface to a depth that makes the direct or indirect evaluation of the total tritium surface contamination very difficult.

In many cases, tritium contamination is present in the form of contaminated water, which can evaporate, making the tritium airborne. Indeed, many tritium detection instruments sample air for airborne tritium content. Because of the ability of tritium to diffuse and to be absorbed into the surface and due to the low energy of its beta emission, special care shall be taken when evaluating tritium surface contamination. The total surface contamination cannot be accurately evaluated by direct or indirect methods. Direct measurements are carried out with contamination-measuring instruments which will not respond to all activity absorbed below the surface. Indirect measurements performed by wet smear tests generally provide a reasonable estimate of the removable surface contamination at the time of collection. However, diffusion of tritium contamination absorbed into the surface will tend to replace the removable surface contamination that was partially or totally removed by a decontamination process or by smear tests. Furthermore, a radiological hazard from volatile tritium may still remain. For a better understanding of the actual hazard in special situations, a combination of direct and indirect methods should be used. However, in most circumstances, smear test evaluation is an adequate method of assessing the actual radiological hazard arising from incorporation in the course of contact with surfaces contaminated by tritium.

3.2 Direct measurement of tritium contamination

3.2.1 Measuring instruments

Measuring instruments that directly detect tritium surface contamination may respond to both the removable activity and part of the activity absorbed into the surface. Specially designed windowless detectors, such as proportional and scintillation detectors, are available for direct detection of various forms of tritium surface contamination. Instruments subjecting the surface to a pressure or temperature change by their operation may detect the presence of volatile tritium fractions or diffusion characteristics.

Because of the small distances between detectors and surfaces required for the detection of tritium, the contamination of detectors often causes problems. Spacers or removable masks are used to prevent this.

3.2.2 Requirements to be met by the instruments

The instruments shall be capable of detecting activities below the level of the surface contamination limit, to which the results of the contamination measurements are to be compared (limits set by international or national regulations, or in the absence of such regulations, defined by standards or local consensus).

NOTES

1 Because of the low biological hazard of tritium, allowable levels of surface contamination may be fairly high, as recommended by ICRP Publication 25 which suggests $400 \text{ Bq}\cdot\text{cm}^{-2(1)}$.

2 For specialized applications where tritium surface contamination has to be kept extremely low, methods are available that can detect down to $0,4 \text{ Bq}\cdot\text{cm}^{-2}$.

3.2.3 Detection procedure

Listening for a change in the frequency of the audio clicks, move the instrument over the surface or place it sequentially in such a way that the operational requirements of distance and gas composition are complied with. The audible indication is instantaneous — irrespective of the response time used. Once a contaminated area is detected, the detector should be positioned over this area and held stationary for a time sufficient to confirm the detection.

If practical, low-activity areas should be checked prior to those of high activity in order to minimize the risk of cross-contamination.

3.2.4 Measurement procedure

When making a measurement, the operating instructions relating to the measuring instruments used and the following requirements shall be complied with:

- a) the background count rate shall be determined at a place representative of the area to be surveyed (for example at the surface to be checked, which for this purpose, is covered by a clean sheet of paper);
- b) the background count rate shall be checked frequently, because the detector is liable to become contaminated;
- c) the correct functioning of the instrument should be verified using a suitable check source. Frequency: daily for instruments in frequent use, otherwise before each use. Deviations of more than 25 % from the agreed value shall give rise to a recalibration of the instrument;
- d) removable spacers may be required.

3.3 Indirect evaluation of removable surface contamination

3.3.1 General

The indirect method is particularly suitable for evaluating the contamination of surfaces which

- do not allow direct measurement (e.g. as a result of configuration, position, etc.), or which
- are located in radiation fields which upset direct measurement, or which
- have overlying material that reduces the intensity of radiation available for direct measurement.

However, the indirect method does not indicate the hazard from volatile tritium fractions present below the surface (see 3.1 and 3.2.1).

3.3.2 Detection limits

Currently available liquid scintillation counters and windowless counters are capable of measuring $0,4 \text{ Bq}$ and 40 Bq , respectively (see the note).

By complying with these lower limits when smearing an area of 100 cm² and applying a removal factor $F = 0,1$, removable tritium surface contamination can be measured down to 0,04 Bq/cm² and 4 Bq/cm², respectively.

NOTE — In a strict sense the above mentioned capability could better be described in terms of "lower detection limits" or "minimum detectable activities". However, there is no international agreement with regard to the definition of these terms. Furthermore, the equations for the calculation of the relevant values are too complex to be presented in the framework of this part of ISO 7503.

3.3.3 Guidelines on sampling

Detection and evaluation of removable tritium contamination should be carried out using wet smear samples.

NOTES

1 Expanded polystyrene has proved to be an effective smear material even without a wetting agent. An additional advantage is that it completely dissolves in some liquid scintillators, thus ensuring high counting efficiency^[2].

2 Where tritium contamination is present in a particulate form which is insoluble in liquid scintillators (e.g. metal hydrides), dry smears may be used for tritium detection purposes.

When taking smear samples from large areas, the following points shall be taken into consideration to determine the distribution of contamination:

- a) if possible, the area to be smeared shall measure 100 cm²;
- b) where regulations permit, larger areas to be smeared, such areas shall be used for sampling and their actual size shall be included in the calculation of the result in accordance with 3.3.4; smearing of very large areas with a single smear should be avoided since the removal factor decreases with increasing area;
- c) the smear material should be chosen to suit the surface to be checked and the counting requirements (for example filter paper for smooth surfaces, cotton textile for rough surfaces);
- d) a suitable wetting agent, preferably glycerol^[3], shall be used with the smear material; the wetting agent should not exude from the material;
- e) the smear shall be pressed moderately against the surface to be smeared, preferably by means of a holder which is designed to ensure uniform and constant pressure;
- f) the entire area of 100 cm² shall be smeared;
- g) for methods other than liquid scintillation counting, the sensitive area of the detector shall be larger than the smear sample;
- h) smears to be measured by liquid scintillation counting should directly be placed into the counting vial already containing an appropriate amount of scintillator liquid;
- i) wet smears shall be placed in the scintillator liquid for about 20 min prior to counting in order to approach equilibrium distribution of the tritium activity;

j) unused smear materials should be stored in a tritium-free atmosphere;

k) the use of disposable gloves is recommended during smear testing of highly contaminated surfaces; changing of gloves may be necessary to avoid cross-contamination of samples.

3.3.4 Measurement of smear samples

Whereas the use of proportional detectors (windowless or internal gas-flow types) is more appropriate to dry smears, the most consistent and generally applicable method for measuring tritium smear samples is by liquid scintillation counting.

Care should be taken that the introduction of the smear sample into the scintillator

— does not cause excessive losses of light due to the mass of the material or to quenching effects, and

— does not introduce spurious scintillations due to brightening agents.

The activity per unit area, A_R , of the removable tritium contamination of the surface being wiped, expressed in becquerels centimetres to the power of minus two, in relation to the activity of the smear sample, is given by the following equation:

$$A_R = \frac{A}{F \times S}$$

A is the activity of the smear sample assessed by a standard liquid scintillation counting technique, in becquerels;

F is the removal factor;

S is the area smeared, in centimetres squared.

The removal factor, F , should, preferably, be determined experimentally for the operational conditions, but if it is not, a value of $F = 0,1$ shall be used^[3].

4 Recording of contamination measurements

If a test report of surface contamination measurements is required, the following information should be included:

- a) date;
- b) location and sub-location;
- c) type of surface for indirect method;
- d) smear material (dry or wet);
- e) wetting agent;
- f) removal factor for indirect evaluation (measured or assumed);

- g) instrument used;
- h) calibration date;
- i) instrument reading of the contamination (surface or smear);
- j) instrument reading of the background;
- k) calculated removable activity per unit area;
- l) notes on the extent of the contamination;
- m) other observations (presence of volatile radioactivity, etc.);
- n) operator's name.

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