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Determination for dangerous quantities of radioactive material

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Table of Contents

Foreword	III
1 Scope	1
2 Normative References	1
3 Terms and Definitions	1
4 Exposure Scenarios and Exposure Pathways	1
5 Health Effects	2
6 Consideration of Radioactive Material Characteristics	3
6.1 Radiation Characteristics	3
6.2 Criticality Characteristics	3
6.3 Chemical Toxicity	3
7 Hazardous Quantity of Radioactive Substances (D-Value)	3
8 Application of D-Value	16
Annex A (Informative) Lethal and Non-lethal Effects	17
A.1 Lethal Effects	17
A.2 Non-lethal Effects	17
Annex B (Informative) Characteristics of Radioactive Substances	18
B.1 Decay of Radionuclides	18
B.2 Radiation and Interaction	18
B.3 Criticality Characteristics	18
B.4 Chemical Toxicity	21
Annex C (Informative) Two Calculation Methods for D-Value	22
C.1 Two Methods for Calculating D-Value	22
C.2 Expert Method	22
C.3 Risk Method	25
References	28

Foreword

This document is drafted in accordance with the provisions of GB/T 1.1-2020 Directives for Standardization—Part 1: Structure and Drafting Rules for Standardizing Documents.

Please note that certain contents of this document may involve patents. The issuing authority of this document shall not assume the responsibility for identifying such patents.

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Determination for dangerous quantities of radioactive material

1 Scope

This document specifies the exposure scenarios, exposure pathways, health effects and characteristics of radioactive substances considered for determining the hazardous quantity of radioactive substances (D-value), as well as the D-value and its application.

This document applies to the determination of the hazardous quantity of radioactive substances (D-value) for nuclear and radiation emergency preparedness.

2 Normative References

This document contains no normative references.

3 Terms and Definitions

The following terms and definitions apply to this document.

3.1 D-value

The hazardous quantity of radioactive substances. If this quantity of radioactive substances is out of control, it may cause death or permanent injury that impairs the quality of life to exposed personnel.

3.2 deterministic effect

A health effect of ionizing radiation that generally has a dose threshold; when the absorbed dose exceeds the threshold, the higher the dose, the more severe the effect will be.

Note 1: Such effects are referred to as severe deterministic effects if they are fatal, life-threatening, or result in permanent injury that reduces the quality of life.

Note 2: The dose threshold is associated with the type of deterministic health effect and has little correlation with the individual differences of exposed personnel. Examples of deterministic effects include erythema, hematopoietic system damage and acute radiation sickness. Deterministic effects are also known as harmful tissue reactions.

[Source: GB 18871-2002, J 3.2, modified]

3.3 exposure pathway

The route through which radiation or radionuclides reach the human body and induce exposure.

[Source: GB 18871-2002, J 5.15, modified]

4 Exposure Scenarios and Exposure Pathways

4.1 When considering exposure scenarios for determining the D-value, radioactive substances are classified into two categories: one is non-dispersive substances (D-value denoted as D_1), and the other is dispersive substances (D-value denoted as D_2). The specific definitions are as follows:

- a) D_1 -value refers to the activity of radionuclides in non-dispersive substances; if the source is out of control without dispersion, the radionuclides may trigger an emergency and are expected to cause severe deterministic effects.
- b) D_2 -value refers to the activity of radionuclides in dispersive substances; if the source is out of control and disperses, it may trigger an emergency and is expected to cause severe deterministic effects.
- c) The D-value is the smaller value between the D_1 -value and D_2 -value of the radionuclide.

4.2 When determining the D-value, the personnel exposure scenarios that may be caused by radioactive substances after being out of control shall be taken into account. The scenarios and assumptions are based on past experience and other relevant factors, such as the malicious use of radioactive substances [e.g., use in a Radiological Dispersal Device (RDD)]. The considered exposure scenarios and exposure pathways are listed in Table 1.

Table 1 Considered Exposure Scenarios and Exposure Pathways for D-value Determination

Organ or Tissue	D_1 -value (Non-dispersive Substances)		D_2 -value (Dispersive Substances)			
	Pocket Scenario (I)	Room Scenario (II)	Inhalation Scenario (III)	Ingestion Scenario (IV)	Contamination Scenario ^a (V)	Immersion Scenario (VI)
Red Bone Marrow	×	✓	✓	✓	×	✓
Colon	×	✓	✓	✓	×	✓
Lungs	×	✓	✓	✓	×	✓
Skin	×	×	×	×	✓	×
Soft Tissue	✓	×	×	×	×	×
Thyroid Gland	×	✓	✓	✓	×	✓
Lens of the Eye	×	✓	×	×	×	✓
Gonads	×	✓	×	×	×	✓
Note: "✓" indicates that the exposure scenario is considered; "×" indicates that the exposure scenario is not considered.						
^a Refers to skin contamination.						

4.3 When calculating the D_1 -value, the following conditions should be taken into account:

- a) Pocket Scenario (I): It is assumed that personnel carry an unshielded radiation source in a pocket, resulting in local soft tissue damage.
- b) Room Scenario (II): It is assumed that personnel stay near an unshielded radiation source in a room for several days to weeks, leading to whole-body exposure to external penetrating radiation.

4.4 When calculating the D_2 -value, the following conditions should be taken into account:

- a) Inhalation Scenario (III): It is assumed that a fire or explosion (e.g., a Radiological Dispersal Device (RDD) incident) occurs, exposing personnel to airborne radioactive substances.
- b) Ingestion Scenario (IV): The first assumption is that a radioactive material leak occurs, and contact with the leaked material results in the inadvertent ingestion of radioactive substances by personnel. The second assumption is that radioactive substances enter the public water supply system, leading to water contamination, and then personnel consume such contaminated water.
- c) Contamination Scenario (V): It is assumed that personnel are exposed due to skin contamination by leaked radioactive substances.
- d) Immersion Scenario (VI): It is assumed that personnel are exposed following the release of radioactive inert gases.

5 Health Effects

When calculating the D-value, two types of severe deterministic health effects should be taken into account, namely lethal effects and non-lethal effects (see Annex A).

- a) Lethal effects refer to those effects that result in death if they occur. Experience and research have shown that deaths caused by radiation exposure are ultimately the result of multiple organ failure. In nuclear and radiation emergency situations, key organs and tissues are taken into account when determining the D-value. Controlling the absorbed dose of these organs and tissues below the threshold can prevent the occurrence of lethal effects.
- b) Non-lethal effects refer to effects that impair the quality of life and are associated with the radiation sensitivity of organs or tissues.