

WORKING MATERIAL

RATING OF TRANSPORT AND RADIATION SOURCE EVENTS

DRAFT ADDITIONAL GUIDANCE FOR THE INES NATIONAL OFFICERS FOR PILOT USE AND FEEDBACK

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Rating of Transport and Radiation Source Events

Draft Additional Guidance for the INES National Officers for

Pilot use and feedback

1. Background

The International Nuclear Event Scale (INES) is a means for promptly communicating to the public in consistent terms the safety significance of any reported event associated with radioactive material and/or radiation and to any event occurring during the transport of radioactive material. As described in the 2001 Edition of the INES User's Manual [1], events are classified on the scale at seven levels: the upper levels (4-7) are termed "accidents" and the lower levels (1-3) "incidents." Events which have no safety significance are classified below scale at Level 0 and termed "deviations". An overview of the principles for the rating under INES together with flow charts summarising the rating process is provided in Appendix I.

The 2001 Edition of the INES User's Manual provides some guidance for the rating of transport and radiation source events. At the technical meeting held in 2002 the INES National Officers requested the IAEA/NEA Secretariat to prepare additional guidance. Progress was reported at the Technical Meeting of the INES National Officers in March 2004 where preparation of this draft additional guidance was requested for pilot use.

2. Objectives

This note provides additional guidance on the rating of transport and radiation source events. It is for pilot use and feedback and is broadly consistent with the INES User's Manual. It provides more detailed information and an expanded approach for the rating based on actual exposure of workers and members of the public. It is designed to be used as a self-standing document with limited need for reference to the INES User's Manual.

The INES National Officers are encouraged to disseminate this guidance for use and collect feedback in a systematic manner, in close co-operation with those responsible for radiation and transport safety. Feedback of experience, questions, comments and proposals for improvement should be provided by the INES National Officers to the joint IAEA/NEA Secretariat throughout the pilot period to the following email address: INESGuidance@iaea.org. The users and experts concerned are encouraged to provide their feedback to the respective INES National Officer with copy to the above mentioned email address. This will be reviewed by the INES Advisory Committee with a view to preparing at the beginning of 2006 a revised guidance to be submitted for approval to the Technical Meeting of INES National Officers with involvement of the members of the IAEA Radiation Safety Standards Committee (RASSC) and the IAEA Transport Safety Standards Committee (TRANSSC).

3. Scope of transport and radiation source events to be rated under INES

This draft additional guidance is intended to cover all radiation source and transport events (including where sources or packages are lost or stolen) whether or not they occur at a facility. Facilities covered include nuclear installations, industrial, medical or research facilities, irradiators or accelerators. The guidance is only intended for use for civil (i.e. non military) applications.

It is not the purpose of INES to describe the activities or installations that have to be included within the scope of the regulatory control system for radiation protection and transport of radioactive material, nor to establish requirements for events to be reported by the users to the regulatory authority. It is also not the purpose of INES to establish requirements for communication to the public, but when an event is communicated this guidance provides criteria for its rating, and it puts the event into proper perspective for communication purposes.

This guidance provides an expanded approach for the rating based on actual exposure of individuals and, therefore should also be used for events involving unplanned exposure within nuclear installations (such as nuclear power plants, research reactors, and fuel cycle facilities). Events at these installations but **not** associated with radiation sources, transport or unplanned exposure, such as off-site releases, damage to radiological barriers or degradation of defence in depth should be rated using the 2001 Edition of the INES User's Manual.

This guidance can also be used for events involving the unplanned exposure of individuals in other regulated activities (e.g. processing of minerals in some countries).

In addition to events resulting in actual consequences (exposure, contamination, etc.) the scope of this guidance includes those events without actual consequences, where deficiencies in the safety provisions are identified, for example degradation of shielding, containment or deficiencies in administrative controls.

When a device is used for medical purposes (radiodiagnostic, radiotherapy, etc.), this guidance provides for the rating of events resulting in actual exposure of workers and the public, or involving degradation of the device or, more generally, deficiencies in the safety provisions. This guidance does not, at present, cover the actual or potential consequences on individuals intentionally exposed as part of medical procedures. The need for guidance on unplanned exposures during medical procedures is recognised and will be addressed in a future issue of the guidance.

The INES scale does not classify industrial accidents or events, which are not related to radiation safety.

4. Communicating events to the INES information service

INES is not a formal reporting system. The purpose of sending the rating of events to the INES Information Service (NEWS, at <http://www-news.iaea.org/news/default.asp>) is to facilitate communication and understanding between the nuclear community, the media and the public on the safety significance of the events. The criteria for identifying which events should be communicated are:

- Either events rated at Level 2 and above,
- Or events attracting international public interest.

The multinational nature of some transport events complicates the issue. The principles to be applied are as follows:

- The event rating form (ERF) for each event should only be provided by one country;

- The country in which the event is discovered is responsible for initiating the discussion about which country will provide the event rating form;
- As general guidance, if the event involves actual consequences, the country in which the consequences occur is likely to be best placed to provide the event rating form. If the event only involves failures in administrative control or packaging, the country consigning the package is likely to be best placed to provide the event rating form. In the case of a lost package, the country where the consignment originated is likely to be the most appropriate one to deal with rating and communicating the event.

When preparing an ERF, it is useful to include, amongst other things, the following elements in the event description:

- Mentioning, where appropriate, the radionuclides involved in the events;
- Mentioning, where appropriate, the activity and the categorisation of the radioactive source [2];
- Mentioning, where appropriate, the actual confirmed consequences such as deaths of, or acute health effects to workers and/or members of the public;
- Estimating number of exposed workers and/or members of the public as well as their actual exposure;
- Indicating, when known, the practice for which the source was used;
- Indicating immediate remedial action taken;
- Indicating the condition of the source and associated device, and any identifying source or device registration serial number(s);
- In case of loss or found source or device, additional relevant information should be provided as described in Section 5.4.1.

Where information is required from other countries, the information may be obtained via the appropriate competent authority, and should be taken into account when preparing the event rating form.

The scale is designed for prompt use following an event, however, there will be occasions when a longer time scale is required to know or estimate the actual consequences of the event. In these circumstances a provisional rating should be given with a final rating provided at a later date.

5. Rating of events

5.1 General approach

All events should be considered in terms of each of the criteria described below. The rating to be assigned should be the highest of the levels determined. Even if there are actual consequences, consideration of defence in depth may give a higher rating.

Actual consequences in terms of unplanned exposures of workers or members of the public are addressed in Section 5.2. Consequences in terms of the amount of activity released or amount of contamination spread are addressed in Section 5.3. Guidance for the rating of the degradation of safety provisions is provided in Section 5.4.

5.2 Rating of unplanned exposures of workers or members of the public events based on individual doses

The definitions below, which are based on the dose-risk relationships for adults recommended by the ICRP-60 [3] for stochastic effects and on the most up to date available data for deterministic effects [4], should be used to rate events, which have resulted (or could have easily resulted) in the exposure of workers¹ or members of the public. The methodology for estimation of doses to workers and the public should be realistic and follow the standard national assumptions for dose assessment.

The criteria below apply to doses resulting from the single event being rated (i.e. excluding cumulative exposure). They define a minimum rating if one individual (Section 5.2.1) is exposed and a higher rating if more individuals are exposed (Section 5.2.2).

In a situation where a dose limit is exceeded from an accumulation of exposures over a period, this constitutes in itself an event to be rated at Level 1.

5.2.1 Criteria for the assessment of the minimum rating (one individual exposed)

Level 1 is the minimum Level for events that result in:

- (a) Exposure of a member of the public in excess of statutory annual limits², or
- (b) Exposure of a worker in excess of dose constraints.³

Level 2 is the minimum Level for events that result in:

- (a) Exposure of a member of the public in excess of 10 mSv, or
- (b) Exposure of a worker in excess of statutory annual limits².

Level 3 is the minimum Level for events that result in

- (a) The occurrence or likely occurrence of an acute health effect⁴ or
- (b) Exposure of the order of a few hundred mSv.

Level 4 is the minimum Level for events that result in:

- (a) The occurrence or likely occurrence of an early death⁴ or
- (b) Exposure of the order of a few Sv/Gy.

5.2.2 Criteria for the consideration of the number of individuals exposed

For stochastic exposures, (i.e. those that do not meet the criteria defined in item (a) for levels 3 and 4 in Section 5.2.1) the minimum rating assessed in Section 5.2.1 should be increased by one Level if doses above the threshold value defined for the Level are received by more than 10 individuals, and by two levels if by more than 100 individuals.

¹ The Basic Safety Standards definition of a “worker” is: “Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection. (A self-employed person is regarded as having the duties of both an employer and a worker.)”

² The dose limits to be considered are all statutory limits including whole body effective dose, doses to extremities and doses to lens of the eye.

³ Dose constraint is a value below the statutory limit that may be established by the country.

⁴ These criteria relate to observable deterministic effects. If it is not known at the time of the rating whether a deterministic effect will actually occur, Appendix II should be used.

For deterministic exposures (occurrence or likely occurrence of an acute health effect or early death), a more conservative approach is taken. Thus, the rating should be increased by one Level if doses above the threshold value are received by several individuals, and by two levels if by a few tens of individuals.

For example for an event resulting in 15 members of the public receiving a dose of 20 mSv, the minimum rating is Level 2. Taken into consideration of the number of individuals exposed (15) leads to an increase of one Level giving a rating at Level 3. However if only 1 member of the public received a dose of 20 mSv and 14 received doses less than 10 mSv the rating would not be increased above 2. Figure I.1 in Appendix I presents the flow chart for rating events based on dose.

5.3 Rating based on actual releases to the environment

Actual releases refer to airborne releases (i.e., volatile or gaseous sources) and widespread (solid and/or liquid) contamination due to the loss of containment of radioactive material.

The INES User's Manual refers to criteria for rating of off-site and on-site impact. However, for transport events, the concept of separating on-site and off-site is not relevant. Equally, for radiation source applications, such as site radiography and portable gauges, there is not always a defined on-site/off-site boundary.

The guidance in Section 5.3.2 for rating on-site events should only be considered for sources within facilities with a well-established site boundary. All other releases should be considered using the criteria of Section 5.3.1.

As described in the INES User's Manual, the rating for off-site and on-site releases can be based on equivalence, from a radiological point of view, with a released quantity of a defined radionuclide. The equivalence value should be calculated by multiplying the actual activity released by the applicable off-site or on-site factor (see Appendix III to this Guidance) and then compared with the values given in the definition of each level. If further detail is needed on the methodology for calculation of equivalence then refer to Appendix I of Part VI of the 2001 Edition of the INES User's Manual.

5.3.1 "Off-site" impact

For the majority of events, it should be possible to assess the order of magnitude of the release. It is nevertheless accepted that for a significant accident at a radiation source facility, it will not be possible to determine with accuracy at an early stage the size of the off-site release. In such situations it is necessary to assign a provisional rating with a final rating provided at a later date.

Level 5 is defined in the 2001 Edition of the INES User's Manual, as "an external release, corresponding to a quantity of radioactivity radiologically equivalent to a release to the atmosphere of the order of hundreds to thousands of terabecquerels of ^{131}I " (this is equivalent to a release of the order of hundreds to thousands of A_2 for transport events⁵). Events that result in smaller airborne releases should be rated according to the guidance given in Section 5.2 above, based on a realistic assessment of the exposures to workers or members of the public.

For events involving off-site releases that do not become airborne, for example aquatic releases or ground contamination (spillage of radioactive material), the rating based on actual consequences should be established according to the guidance given in Section 5.2 above, based on a realistic

⁵ The A_2 value is defined in the national transport regulations and expresses the radiotoxicity of a radionuclide for the purposes of transport safety assessment. ^{131}I has an A_2 value of approximately one TBq.

assessment of the exposures to workers or members of the public and, if not applicable, against degradation of defence in depth.

5.3.2 “On-site” impact

5.3.2.1 General description

The rating of events under on-site impact takes account of the actual impact within the site controlled or supervised areas.

Rating radiation source events based on releases should only be considered for a facility inventory, which is sufficiently large to result in potential consequences equivalent to a Level 2 rating. This would typically involve inventory quantities radiologically equivalent to the order of a few tens of gigabecquerels of ¹³¹I. At facilities where the inventory cannot give rise to a Level 2 event due to a release of radioactivity, a release should still be rated against the criterion for worker doses (section 5.2) and, if not applicable, against degradation of defence in depth (section 5.4).

The significance of contamination is measured either by the quantity spread or the resultant dose rate. These criteria relate to dose rates in an operating area but do not require that a worker was actually present. They should not be confused with the criteria for doses to workers in section 5.2.1, which relate to doses actually received.

It is accepted that the exact nature of the release may not be known for some time following an event with on-site consequences of this nature. However, it should be possible to estimate in broad terms the extent of the release to decide whether to rate an event provisionally. It is possible that subsequent re-evaluation would require re-rating of the event.

5.3.2.2 Definition of levels

Level 5

Definition: As defined in the 2001 Edition of the INES User’s Manual, but not considered to be credible at facilities using radiation sources or at irradiation facilities.

Level 4

Definition: Events at radiation source facilities involving the release of a few thousand terabecquerels of activity from their primary containment, which cannot be returned to a satisfactory storage area.

Level 3.

Definition: Events resulting in the release of a few thousand terabecquerels of activity into a secondary containment where the material can be returned to a satisfactory storage area.

Level 2

Definition: Two types of events should be considered here, as follows:

- Events resulting in the sum of gamma plus neutron dose rates of greater than 50mSv per hour in a plant operating area (dose rate measured at one meter from the source).

OR

- Events leading to the presence of significant quantities of radioactivity in the installation, in areas not expected by design (see the definitions at the end of Part IV of the 2001 Edition of the INES User’s Manual) and which require corrective action. In this context ‘significant quantity’ should be interpreted as:

- (a) Contamination by liquids involving a total activity radiologically equivalent to about ten terabecquerels of ⁹⁹Mo;

- (b) A spillage of solid radioactive material of radiological significance equivalent to the order of a terabecquerel of ¹³⁷Cs, providing the surface and airborne contamination levels exceed ten times those permitted for operating areas (see the definitions at the end of Part IV of the 2001 Edition of the INES User’s Manual);
- (c) A release of airborne radioactive material, contained within a building and involving quantities of radiological significance equivalent to the order of a few tens of gigabecquerels of ¹³¹I.

5.4 Rating of events based on degradation of defence in depth

For all events, the safety significance, in terms of degradation of defence in depth, should be rated in addition to any ratings based on actual consequences, as described in the previous Section 5.3. In the case of an event with no actual known consequences the rating will be determined solely by defence in depth considerations (i.e., by considering the status of safety provisions available to prevent actual consequences from occurring).

As explained in the 2001 Edition of the INES User’s Manual, the rating under defence in depth depends on two factors: the maximum potential on-site and off-site consequences should all the safety provisions fail, and the status of the safety provisions in the event.

Maximum rating under defence in depth

The maximum potential consequences can be related to the IAEA Source Categorization, IAEA-TECDOC-1344 [2] for radiation source events and Regulations for the Safe Transport of Radioactive Material, No.TS-R-1 [5] for transport events.

Table 1 shows the relationship between source category, maximum potential consequences and maximum rating under defence in depth. In practice, the actual ratings will be equal to or less than those shown in this table.

TABLE 1 – MAXIMUM INES EVENT RATING DEPENDING ON THE SOURCE CATEGORY

	SOURCE CATEGORY			
	Cat. 4	Cat. 3	Cat. 2	Cat. 1
INES rating for the maximum possible consequences for an event (i.e. should all safety provisions fail)	2	3	4	5
Maximum rating using defence in depth	1	2	2	3

Since the maximum rating under defence in depth is the same for category 2 and 3 sources, they are considered together in the rest of this section.

When assessing a rating based on defence in depth, the first step in the process is therefore to determine the radioactive source categorization using the Appendix IV of this guidance (see also IAEA-TECDOC-1344 [2]). If the source activity (A) is known, the category should be preferably determined by dividing the activity (A) of the radionuclide by the appropriate ‘D’ value given in Table IV-2 (Appendix IV). The ‘D’ values are given in terms of an activity above which it is considered to be ‘a dangerous source’ and has a significant potential to cause severe deterministic effects if not managed safely and securely. The normalized A/D ratio can be compared to the A/D

ratios in the right-hand column of Table IV-1 (Appendix IV) and a category assigned based on activity (recognizing that other factors may need to be taken into consideration) [2].

For events where the radioisotope is not listed in Appendix IV, the A_2 values [5] should be used. For the purpose of rating these events, when the activity (A) is:

- “less than A_2 ” should be rated using the column for Category 4 sources;
- “between A_2 and hundreds of A_2 ” should be rated using the column for Category 3 and 2 sources;
- “greater than hundreds of A_2 ” should be rated using the column for Category 1 sources.

Category 5 radioactive sources and medical equipment for diagnostic purpose need only be rated at Level 0 or Level 1 (the higher rating for events where all intended safety provisions have been lost). Hence, they are not included in the sections below.

Status of safety provisions

The three sections below give guidance on the rating of a number of types of events associated with degradation of safety provisions. Section 5.4.1 covers events involving lost or found radioactive sources, devices or transport packages; Section 5.4.2 covers events where intended safety provisions have been degraded; Section 5.4.3 covers a number of other safety related events. For some situations where a choice of rating is provided, footnotes give guidance on the specific factors to be taken into account.

In all cases where there is a choice of rating, a significant issue will be the underlying safety culture implications. Examples of a deficiency in the overall safety culture could be: a shortfall in the quality assurance process; an accumulation of human errors; failure to maintain adequate control over radioactive materials resulting in a release to the environment; the repetition of an event, indicating that corrective actions were not taken after an initial event.

5.4.1 Lost or found source/device events

Table 2 should be used for those events involving radioactive sources, devices and transport packages that have been misplaced, lost/stolen or found. If a radioactive source, device or transport package cannot be located, it may, in the first instance, be regarded as “misplaced”. If, however, a search of the likely alternative locations is unsuccessful, it should be considered lost/stolen. Normally, this decision should be reached according to national requirements.

The loss of a radioactive source, device or transport package should be rated in terms of degradation of defence in depth. If the radioactive source, device or transport package is subsequently found, the original rating should be reviewed and the event could be re-rated (up or down) on the basis of any extra information provided (2001 Edition of the INES User’s Manual, Section I-1.4). Relevant information to be considered should include:

- The location in which the radioactive source, device or transport package was found and how it got there;
- The condition of the radioactive source, device or transport package;
- The length of time the radioactive source, device or transport package was lost;
- The number of persons exposed and possible doses.

The re-rating should cover both the original defence in depth rating **and** the actual on-site and off-site consequences. In most cases, it will be necessary to estimate/calculate the doses that have been received using realistic assumptions, rather than worst case scenarios.

A found source and a found device are considered together in the Table 2. The former is intended to describe an unshielded source. A “found device”, on the other hand, is intended to describe the discovery of an orphan source still within a secure, shielded container.

There have been many examples of lost or found “orphan” sources being transferred into the metal recycling trade. As a consequence, it is increasingly common for metal dealers and steel smelters to check for such sources in incoming consignments of scrap metals. The most appropriate rating for such events is determined by using the “found orphan source” row of the Table 2, irrespective of whether it is discovered at the time of receipt or after being melted. The earlier loss and subsequent discovery of the source should be considered as a single event. The rating will be the highest rating from consideration of on-site and off-site consequences and from degradation of defence in depth.

TABLE 2 – EVENT RATING FOR LOST OR FOUND RADIOACTIVE SOURCES, DEVICES OR TRANSPORT PACKAGES

TYPE OF EVENTS	EVENT RATING DEPENDING ON THE SOURCE CATEGORY		
	Cat. 4 or <A ₂ (see footnote ³)	Cat. 3 or 2 or A ₂ -100 A ₂	Cat. 1 or >100 A ₂
• Misplaced radioactive source, device or transport package subsequently recovered intact (actual exposures are covered by section 5.1).	1	1	1
• Found orphan radioactive source, device or transport package.	1	1/2 (see footnote ¹)	2/3 (see footnote ¹)
• Lost or stolen radioactive source, device or transport package not yet recovered.	1	2	3
• Misdelaivered transport package.	1	1+ (see footnote ²)	1+ (see footnote ²)

¹The lowest proposed rating is more appropriate where it is clear that some safety provisions have remained effective (e.g. a combination of shielding, locking devices and warning signs).

²Level 1 is the minimum rating because it is outside the authorised regime. A higher rating may be appropriate if the facilities and/or the management capabilities at the location to which the package was misdelaivered cannot provide adequate control.

³ The Source Category should be used in the first instance and A₂ values only used where there is no Source Category in Appendix IV.

5.4.2 Degradation of safety provisions

Table 3 should be used for those events where the source device or transport package is where it is expected to be and there has been a degradation of safety provisions, such as shielding containment, vaults, interlocks, source housing, safety/warning devices in hardware, and administrative controls (i.e. software).

TABLE 3 – EVENT RATING FOR EVENTS INVOLVING DEGRADATION OF SAFETY PROVISIONS

TYPE OF EVENTS	EVENT RATING DEPENDING ON THE SOURCE CATEGORY		
	Cat. 4 or <A ₂	Cat. 3 or 2 or A ₂ - 100 A ₂	Cat. 1 or > 100 A ₂
<p>1- No degradation of safety provisions. Although an abnormal event may have occurred, it has no significance in terms of the effectiveness of the existing safety provisions. Typical events includes:</p> <ul style="list-style-type: none"> • Superficial damage to shielding and/or source containers including minor contamination. Leaking sources resulting in minor surface contamination and spillage.¹ • Contamination in areas designed to cope with such events. • Foreseeable events where safety procedures were effective in preventing unplanned exposures and returning conditions to normal. This could include events such as the non-return of exposed sources (e.g. industrial radiography gamma source or brachytherapy source) provided they are safely recovered in accordance with existing emergency procedures. • No damage or minor damage to transport package, with no increase in dose rate. 	0/1	0/1	0/1
<p>2- Safety provision partially remaining.² One or more safety provisions have failed (for whatever reason), but there is at least one safety layer remaining. Typical events include:</p> <ul style="list-style-type: none"> • Failure of part of an installed warning or safety system designed to prevent exposures to high dose rates. This would also include failure to follow safety procedures (including radiological monitoring and safety checks), but where other existing safety provisions (hardware) remain effective. • Significant degradation of containment. • Faulty packaging or tie-downs, defective closures or seals. Security devices ineffective⁴ 	0/1 0/1 0/1	1/2 1/2 0/1	(See footnote ³) (See footnote ³) 1/2

TYPE OF EVENTS	EVENT RATING DEPENDING ON THE SOURCE CATEGORY		
DEGRADATION OF SAFETY PROVISIONS	Cat. 4 or <A ₂	Cat. 3 or 2 or A ₂ - 100 A ₂	Cat. 1 or > 100 A ₂
<p>3- No safety provision remaining. Event producing a significant potential for unplanned exposures, or which produce a significant risk of spreading contamination into areas where controls are absent. Typical events include:</p> <ul style="list-style-type: none"> • Loss of shielding, e.g. due to fire or severe impact, making direct exposure to the source possible. • Failure of warning and safety devices such that entry into areas of high dose rate is possible. • Failure to monitor radiation levels where no other safety provisions remain or all other safety provisions have failed, for example to check that gamma sources are fully retracted after site radiography exposures. • Events where a source remains accidentally exposed and there are no effective procedures in place to cope with the situation, or where such procedures are ignored. • Packaging found with inadequate or no shielding. Significant potential for exposures. 	1	1/2 (See footnote ⁵)	2/3 (See footnote ⁶)

¹Where the resulting contamination is unusual but of little or no radiological significance, the lower rating (Level 0) may be appropriate. In comparison, the higher rating (Level 1) would be appropriate if low-Level contamination of persons had occurred. For events producing major contamination, the on-site and off-site criteria described in Section 5.3 (i.e. for rating events in terms of actual consequences) should be considered.

²Where some, but not all, safety provisions remain, there is some scope for adjusting the rating for source categories 2, 3 and 4. This should be based on a judgment as to the number of safety provisions remaining. Where there is essentially only a single safety layer remaining, the higher rating should be used.

³Rating of events involving category 1 sources should refer to the safety layer approach to ratings described in Part IV-3.2.2 of the INES User's Manual. Facilities such as irradiation facilities or teletherapy units or Linear Accelerators, are likely to contain high integrity defence in depth provisions. In other applications involving category 1 sources, there will be a number of more administrative safety provisions. Examples of safety layers include: source position indicators, working procedures, use of survey meters, personal alarm dosimeters, emergency procedures and radiological monitoring.

⁴The upper Level would be appropriate unless the Level of degradation is very low.

⁵For category 3 sources judgment should be made of the likelihood of an unplanned exposure resulting from the failure. If an unplanned exposure is judged to be unlikely then the lowest rating (level 1) would be appropriate.

⁶Level 3 is only appropriate when the maximum potential consequences can be greater than Level 4. This may not be possible for category 1 sources installed within facilities.

5.4.3 Other safety relevant events

Table 4 should be used for other safety-relevant events that may not fall in Tables 2 or 3.

TABLE 4 – EVENT RATING FOR OTHER SAFETY RELEVANT EVENTS

TYPE OF EVENTS	EVENT RATING DEPENDING ON THE SOURCE CATEGORY		
	Cat. 4	Cat. 3 or 2	Cat. 1
<ul style="list-style-type: none"> • Workers or members of the public receiving cumulative doses in excess of statutory limits. 	1	1	1
<ul style="list-style-type: none"> • Absence or serious deficiency to maintain records such as source inventories, breakdowns in dosimetry arrangements. 	1	1	1
<ul style="list-style-type: none"> • Discharges to the environment in excess of authorised limits. 	1	1	1
<ul style="list-style-type: none"> • Non-compliance with licence conditions for transport. 	1	1	1
<ul style="list-style-type: none"> • Inadequate radiological survey of transport¹. 	0/1	0/1	0/1
<ul style="list-style-type: none"> • Contamination on packages/conveyance². 	0/1	0/1	0/1
<ul style="list-style-type: none"> • Shipping documents, package labels or vehicle placards incorrect or absent. Marking packages incorrect or absent³. 	0/1	0/1	0/1
<ul style="list-style-type: none"> • Material in supposedly empty package⁴. 	1	1/2	1/2/3
<ul style="list-style-type: none"> • Material in wrong type/inappropriate packaging⁵. 	0/1	1/2	2/3

¹The rating should take into account the degree of inadequacy of the surveys and the potential consequences to the public.

²The rating of surface contamination events will take into account the Level of contamination, the number of measurements revealing a contamination above the applicable limits, the total number of measurements performed, and the potential for the public to be contaminated.

³Non-compliance with the regulations concerning in particular: transport documents, labelling, placarding or instructions to the carrier, must be considered as a potential degradation of defence in depth. However, Level 0 will be appropriate if the consequences of the non-compliance are of no safety significance and there are no safety culture or procedural implications as defined in section IV-3.3 of the 2001 Edition of the INES User's Manual.

⁴The rating (of 1/2 or 1/2/3) should take into account the potential consequences to the public.

⁵The higher rating in each category reflects situations where the wrong or inappropriate packaging could reasonably result in inadvertent exposures.

6. Fissile material

For degradation of defence in depth where safety provisions necessary to prevent criticality are affected, the event rating of a package containing fissile material (which is not “fissile-excepted” as defined in the National Transport Regulations) should be done by using the column for category 1 sources and then following the guidance set out in Table 2 in Section 5.4.1.

Where there is a failure of a provision that does not relate to criticality safety, the rating should be based on the actual amount involved using the A and D values and Table 3 in Section 5.4, as defined above.

7. Examples

The following examples are all based on real cases, but with some modifications to better illustrate the use of the guidance supplied in this note.

EXAMPLE 1 – Loss of a high activity radiotherapy source

Event description

A source inventory check revealed that a teletherapy head containing a 100 TBq (2700 Ci) ^{60}Co source was missing. The unit was held in a dedicated hospital facility but had not been used, or accounted for, for several weeks. It was suspected that the unit had been taken out of the hospital by unauthorized persons. A search was carried out and one day later, the source was located on open land 2 kilometres away. The head had been dismantled; the source was unshielded, but intact, and it was recovered by the national authorities.

The subsequent investigation indicated that several persons had been exposed as a result of the event, as follows:

- 1 person: 20 Gy to hands, 500 mSv effective dose. Radiation injuries observed on one hand, requiring skin grafts and the amputation of one finger;
- 2 persons: 2 Gy to hands, 400 mSv effective dose;
- 12 persons: 100 mSv effective dose.

Event rating

The initial rating was made before the source was found. There were no known actual consequences at that time so the initial rating was only in terms of degradation of defence in depth. The event is a lost or stolen category 1 source/device. According to Appendix IV, Table IV-2, the D value for ^{60}Co is 3.E-02 TBq, the A/D ratio would be $A/D \geq 1000$, and the source is used in teletherapy. With these considerations, the event is rated at Level 3.

The discovery of the source allows a review of the initial rating.

Rating based on actual doses:

- 3 people received doses of several hundred mSv. One of those persons suffered a health effect. Thus this is Level 3. (See Figure I.2 in Appendix I);
- 12 persons received doses higher than 10 mSv. According to the dose received, the rating is Level 2 and it should be uprated to level 3 due to the number of persons affected.

The overall INES rating of the event is the higher value obtained from both the actual consequences and the degradation of defence in depth. In this case the overall rating is level 3.

EXAMPLE 2 – Stolen gamma radiography source

Event description

A stolen gamma site radiography device containing a 4 TBq (100 Ci) ^{192}Ir source was reported to the national authorities. A press release was issued and investigation of the surrounding areas was performed. 24 hours later the device was found with no damage to the shielding and completely intact. No individuals had been exposed.

Event rating

According to Appendix IV, Table IV-2, the D-value for ^{192}Ir is 8.E-02 TBq. The activity of the source is 4 TBq of ^{192}Ir , which provides the $A/D = 50$. For A/D range ($1000 > A/D \geq 10$), the source category is 2. The loss or theft of this category 2 source should be rated as level 2 under defence in depth using Table 2 in Section 5.4.1. If the device is found, a review of the rating will be possible. Since the device was found with all the safety provisions remaining a final rating of level 1 would be appropriate.

EXAMPLE 3 – Detachment and recovery of a radiography source

Event description

Site radiography was being undertaken at a petrochemical works using a 1 TBq (27Ci) ^{192}Ir source in a projection container. During an exposure, the source became detached in the exposed position. This was recognised when the radiographer re-entered the area with a survey meter. The controlled area barriers were checked and left in place, and assistance was sought from the national authorities. The authorities and the radiographers jointly planned the source recovery operation. Twelve hours after the event was first identified, the source was successfully recovered. Radiation doses received (by 3 persons) as a result of the event, including the recovery of the source, were all below 1 mSv.

Event rating

Actual consequences, in terms of doses received, were very low and would be rated at “below scale” (See Figure I.2 in Appendix I). In terms of impact on defence in depth, the following applies:

- This is a foreseeable event in industrial radiography and contingency plans and equipment to deal with such events are expected to be available;
- Although the source retraction mechanism failed, the monitoring by the radiographer was effective. This, and the safe recovery of the source, would normally warrant a rating at Level 0.

EXAMPLE 4 – Spillage of radioactive material in a nuclear medicine department

Event description

A trolley, used to transfer radionuclides from the radiopharmacy to the injection/treatment room in a hospital, was involved in an accident. The accident occurred in a hospital corridor and a single dosage of ^{131}I (4 GBq in liquid form) was spilled on the floor. Two persons (a nurse and a patient) were contaminated (hands, outer clothing and shoes), each by an estimated activity of 10 MBq of

¹³¹I. Staff from the nuclear medicine department were called and the two persons were decontaminated within 1 hour of the incident.

Estimated doses to the two persons involved were minimal (less than 0.5 mSv committed effective dose). The area of the spill was temporarily closed for 2 weeks (equivalent to 2 half lives) and was then successfully decontaminated by nuclear medicine staff.

Event rating

The event concerns a release of activity resulting in a dose to the public and to workers in an area not designed to cope with contamination since it is not a supervised or controlled area. The rating should be first based on actual consequences under off-site/on-site (Section 5.3). The release of activity does not reach the minimum criterion either for off-site or on-site. Based on individual doses to the workers or public the rating is also below scale.

The event should also be rated under defence in depth. Following Table 3 in Section 5.4.2, item “*No degradation of safety provisions*”, the event is related to “*Superficial damage to shielding and/or source containers including minor contamination. Leaking sources resulting in minor surface contamination and spillage*”. The final rating would be level 0/1. The footnote ¹ to the above-mentioned table explains that Level 1 should be chosen, as there was minor contamination to personnel.

EXAMPLE 5 – Melting of an orphan source:

Event description

An orphan source of 1 TBq (27Ci) of ¹³⁷Cs included in scrap metal was melted in a steel factory. 50 workers at the factory received an estimated dose of 0.3 mSv each.

Event rating

Consider first the rating based on actual consequences according to Section 5.3. In terms of activity released it has been estimated that a 10% activity is released due to the melting which results in an airborne activity release of 0.1 TBq of ¹³⁷Cs. The ¹³¹I radiological equivalence factor for ¹³⁷Cs is 30 (see Appendix III) so the total amount of activity released would be 3 TBq ¹³¹I equivalent. This release is far less than the criterion for level 5 off-site impact.

Based on the estimated doses to the workers of less than 1mSv and the number of workers exposed the rating based on actual consequences should be level 0.

According to Appendix IV, there is no information on the common practice and therefore, the A/D ratio should be used for getting the source category (Table IV-2 and 3). The D value for ¹³⁷Cs is 1.E-01 TBq) and the source activity (A) is 1 TBq, resulting in a A/D ratio of $10 > A/D \geq 1$, therefore it is classified as category 3 source.

Based on degradation of defence in depth, row 3 of Table 2 in Section 5.4.1 is appropriate, so the rating should be Level 1 or 2. Considering that the source was melted, the final rating is the higher rating obtained (see footnote ¹ of Table 2), that is Level 2.

EXAMPLE 6 – Theft of a density gauge

Event description

A moisture-density gauge was lost, and presumed stolen from a truck at a construction-site. The gauge contained a ^{137}Cs source (470 MBq) and a $^{241}\text{Am/Be}$ neutron source (1628 MBq). The gauge was recovered a few days later with no signs of damage.

Event rating

According to Table IV-1, a moisture-density gauge with a ^{137}Cs is a category 4 source. The theft is initially rated at Level 1 following the guidance in Section 5.4.1. Its recovery would allow the event to be reassessed as a recovered source ‘misplaced source subsequently recovered intact’, but in this case the rating remains unchanged (Level 1)

EXAMPLE 7 – Package damaged by forklift

Event Description

A type A package was reported as damaged at an airport. Early reports suggested that the package had only been scuffed by the wheel of the fork lift. The consignor was requested to assess the damage to the package and determine what should be done with it. They were equipped to repack the contents (two low dose rate brachytherapy ^{252}Cf sources – 1.98 MBq each) and enable the package to continue; they were also equipped to overpack the type A package and return it to its origin.

The visit confirmed that there was minimal damage to the outer packaging.

Event Rating

There were no abnormal doses received or activity released. As per Table IV-1, the package contains category 4 sources and there was no degradation of safety provisions. According to the Table 3 in Section 5.4.2, the rating is Level 0.

EXAMPLE 8 – Stolen radioactive source during transport

Event Description

When a package of a sealed $1.85\text{E-}3$ TBq ^{60}Co radioactive source was delivered by the shipper, it was found to be empty. The source was found 7 hours later in a delivery truck. The package had been intentionally opened ($1.85\text{E-}3$ TBq of ^{60}Co results in a dose rate of 0.5 mSv/h at a distance of one meter).

It appeared that the incident was a direct result of failure to comply with the regulations for the transport of radioactive materials:

- The regulatory safety seal was not affixed to the packaging;
- The shipping declaration had not been made out;
- The “radioactive” label did not appear to have been stuck to the container (although this was never clearly established).

Event Rating

There were no abnormal doses received or activity released. Using the source categorization as described in the former examples, this is a 4 source. The package had become damaged and contained inadequate shielding with a significant potential for exposure. According to Table 3 in section 5.4.2, '*no safety provision remaining*', the rating is Level 1.

EXAMPLE 9– Train collision with radioactive material packages**Event Description**

A collision occurred between a train and a baggage truck which was crossing the railway line in a station.

Type A radioactive packages were amongst the luggage: 7 cartons containing a range of radio elements and two drums, each containing a technetium generator, representing a total "commercial" grade radioactivity of 15 GBq (30 GBq at the start of the journey).

Being light, the cartons were only slightly damaged and no radioactive material was lost from them. On the other hand, the two chromatography columns containing ⁹⁹Mo were thrown from the packages and one broke, contaminated the cab of the locomotive and the ballast of the track. 291 persons were screened for contamination, and 19 gave positive results, which were not found to be significant. The resulting contamination was no reason for concern in view of the small quantities involved and the short half-lives of the radioelements.

A substantial amount of decontamination equipment was deployed. Two tracks were closed for a day and the locomotive was decontaminated.

Event Rating

Considering the off-site impact in Section 5.3.1, the doses were less than 0.1mSv. As per Appendix IV, the A/D ratio should be used (A=15 GBq and D=700 GBq, therefore A/D = 0.02) and the sources were category 4 sources. In accordance with defence in depth, Table 3 in Section 5.4.2, with no or one safety provision remaining, Level 1 is appropriate.

EXAMPLE 10 – Train with spent fuel derailment**Event Description**

A train with three wagons, each containing a package of spent fuel, derailed at a speed of 28 km/h.

One of the wagons heeled over and was secured with props, the other two were derailed but remained upright. The rail broke when the train went over it. 36 hours later, the wagons were on their way again. There were no radiological consequences.

Event Rating

There were no abnormal doses received or activity released. The package contents were category 1 sources but there was no damage to the package. According to the Table 3 in section 5.4.2: '*no minor damage to transport package, with no increase in dose rate*', the rating could be either Level 0 or 1 (0/1). Level 0 is chosen, as there were no indications of degradation of safety culture.

EXAMPLE 11. – LINAC overexposure – suspicious case.

Event Description

While a service person was installing and adjusting a new LINAC system in a hospital, he was not aware of another company electric engineer working on the ceiling. He tested the LINAC beam towards the ceiling and the electric engineer was probably exposed. The estimated exposure range was between 100 mSv and 200 mSv. The electrician had no symptoms and his blood test was negative.

Event Rating

No deterministic effects occurred and the estimated exposure Level of the electrician **was less than a few hundred of mSv**. In this case, the electrician is considered as a member of the public because he had no intention (neither permission for) of radiation work. Therefore more than 10mSv for public is applicable and the minimum rating is 2. There is only one exposed individual, therefore the minimum rating does not need to be up-rated and the final rating is Level 2 (See Figure I.2 in Appendix I).

EXAMPLE 12 – Suspicious dose on film badge

Event Description

A radiological technician's annual cumulative exposure Level was indicated to be of 120.8mSv by its film badge record. This was found in the course of the surveillance of her hospital. The regulatory authority inspected the hospital thoroughly and found the individual one-monthly record indicating 53.8mSv. But the hospital did not take any special actions until the surveillance. The hospital has no high energy radiation generator such as LINAC and no obvious reason of its single over-exposure was found. There was some possibility of mischief by a colleague but no evidence was found either. According to the medical examination, which includes blood test, no abnormalities were found. The person also had no symptom suggesting a deterministic effect. The person was transferred to the other section and was restricted to enter limited areas under the assumption of a worst case.

Event Rating

There were no deterministic effects observed on the technician. If the blood test gave incontrovertible proof that no significant radiation exposure took place then the dose can be removed from the person's record and the event not rated for radiation exposure. If the biological tests are not conclusive, then a detailed investigation will be required to come to a view as to whether the radiation exposure took place or not.

If the investigation concludes that, taking into account the lack of any sources of high radiation in her normal workplace or anywhere she went during the dosimeter wearing period, or colleagues who were always near her during potential exposure periods additional dosimeters worn during some of the time; that she did not receive the radiation exposure then the dose should be removed from the person's record and the event not rated for exposure.

If the investigation is unable to conclude that an exposure did not take place, then the dose remains on the record and the event is rated according to the radiation exposure, which in this case is a Level 2, and does not need to be uprated because of the numbers of people involved.

If the investigation concludes that the radiation exposure did not take place, then the event has a basic rating of below scale or Level 0 and should then be possibly uprated due to other factors involved in the event, such as the failure to monitor people's radiation exposure records. If this was only one example of many such omissions and evidence of a serious safety culture problem in the workplace, then consideration should be given to uprating the event from below scale at Level 0 to Level 1.

APPENDIX I – PRINCIPLES OF THE INES SCALE

1. Background

The INES Scale, jointly developed by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), was first disseminated for widespread use in 1990. It was originally developed to meet the need of communicating the significance of events at nuclear installations, but has been steadily expanded to meet the growing need for communication of the significance of all events associated with radiation, radioactive material and its transport.

Its primary purpose is to facilitate communication and understanding between the scientific/technical community, the media and the public on the safety significance of events. For the vast majority of events such communications will only be of interest in the region/country where the event occurs and participating countries have set up mechanisms for such communications. However, in order to facilitate international communications for events attracting, or possibly attracting wider interest, the IAEA has developed a communications network, known as NEWS. This allows details of the event to be input on a specially designed event rating form (ERF) and it is immediately disseminated to all INES member countries.

It is important to realise that INES is not a formal reporting system. It does not seek to define which events should be reported to the regulator or the public. Each country has defined its own arrangements for such matters. The purpose of INES is simply to help to put into perspective the safety significance of those events that are to be reported. Equally INES is not intended to replace existing well-established criteria used for formal emergency arrangements in any country.

The detailed process to be used for rating events on INES is explained in the INES User's Manual. The last revision was published in 2001 and included a number of amendments arising from experience of use since its first publication in 1992. However, with the continuing wider use of the scale, a number of additional issues have been raised, particularly on applying the guidance to radiation source and transport events. As a result, it has been decided to write the draft additional guidance contained in this note, with the intention that it can be used with only limited reference to the INES User's Manual, particularly for those only involved in the use or transport of relatively small quantities of radioactive material.

This guidance has been written with the intention of maintaining the fundamental principles of INES while recognising the need to develop certain areas to better suit its application to its growing use in the wide area of radiation protection and to make it simpler to use for those not familiar with large nuclear installations. Wide application of this guidance during a pilot period will enable comments to be received and give confidence that a final version to be produced early in 2006 will meet the needs of a very wide and diverse audience.

2. Principle of INES

2.1 The levels

The early discussions, in 1989 and 1990, on the development of the INES scale agreed that events should be classified at 7 levels: the upper levels (4-7) are termed "accidents" and the lower levels (1-3) "incidents". Events that have no safety significance are classified below scale at Level 0 and are termed deviations. Events that have no radiation safety relevance (e.g. a non-radioactive chemical spill) are termed "out of scale".

The 1986 accident at the Chernobyl nuclear power plant in the USSR (now in Ukraine), is rated at Level 7 on the INES scale. It had widespread environmental and human health effects. One of the key considerations in developing the INES rating criteria was to ensure that the significance level of less severe and more localised events were clearly separated from this very severe accident. Thus Three Mile Island is rated at Level 5 on the INES scale.

2.2 The criteria

Defence in depth

INES is intended to be applicable to all events, the vast majority of which relate to failures in equipment or procedures. Whilst many such events do not result in any actual consequences for individuals, it is recognised that some are of greater safety significance than others. If all such events were rated at Level 0 the scale would be of no real value in putting these events into perspective. Thus, it was agreed at its original inception, that the INES scale needed to cover not only actual consequences but also potential consequences. A set of criteria was developed to cover what has become known as “degradation of defence in depth”. These criteria recognise that all applications involving radiation or radioactive material incorporate a number of safety provisions. The number and reliability of these provisions depends on the magnitude of the hazard. Events may occur where some of these safety provisions fail but others prevent any actual consequences. In order to communicate the significance of such events to the public, this draft guidance gives criteria to determine the rating, depending on the amount of hazardous material and the severity of the failure of the safety provisions.

Since these events only involve an increased risk of an accident, with no actual consequences, it was agreed that the maximum rating for such events should be Level 3 (i.e. a serious incident). Furthermore it was agreed that this maximum Level should only apply to activities where there was the potential, if all safety provisions failed, for a significant accident, i.e. one rated between levels 5 and 7 on the INES scale. For events associated with activities with a much smaller hazard potential, e.g. transportation of small medical sources, the maximum rating under defence in depth should also be Level 3. The detailed criteria, developed to implement these principles are defined in the draft additional guidance (Section 5.4).

One final issue that is addressed under defence in depth is what has become known as “safety culture” i.e. the characteristics and attitudes in organisations and individuals that establish that safety issues receive the attention warranted by their significance. Whilst a good safety culture helps to prevent incidents, a lack of safety culture could result in operators performing in ways not intended by design. To address this, the INES criteria allow the rating to be increased by one Level from the rating derived solely by considering the significance of the actual equipment failures. This increase in rating applies only to the rating under defence in depth and cannot increase the rating beyond the maximum for defence in depth defined above. To merit an increase in rating due to a deficiency in safety culture, the event has to be considered as a real indicator of a deficiency in the overall safety culture.

Examples of such indicators could be:

- A violation of formal approved limits or a violation of a procedure without justification;
- A deficiency in the quality assurance process;
- An accumulation of human errors;
- A failure to maintain proper control over radioactive materials, including releases into the environment or a failure in the systems of dose control;

- The repetition of an event, indicating that either the possible lessons have not been learnt or the corrective actions have not been taken after the first event.

Actual Consequences

The simplest approach to rating actual consequences would be to base the rating on the doses received. However, it was recognised that for very large accidents, this may not be an appropriate measure. For example, the efficient application of emergency arrangements for evacuation of members of the public may result in relatively small doses, despite a significant accident at an installation. To rate such an event purely on the doses received does not communicate the true significance of what happened at the installation, nor does it take account of the potential widespread contamination. Thus, for the highest levels of the INES scale (5-7) criteria have been developed based on the quantity of activity released. Clearly these criteria only apply to activities where there is the potential to disperse a significant quantity of radioactive material.

In order to define the quantity of activity released, the scale uses the concept of “radiological equivalence”. Thus the quantity is defined in terms of terabecquerels of ^{131}I , and conversion factors are defined to identify the equivalent level for other isotopes that would result in the same level of dose (Appendix III).

For lesser events, the rating is based on the doses received. The 2001 Edition of the INES User’s Manual [1] defined criteria based on the maximum doses, either to a “critical group” following an atmospheric release or to the most exposed person, following an overexposure. However, there were no explicit criteria defined for increasing the rating if a significant number of individuals were overexposed. This issue has been addressed in this draft additional guidance.

On-site issues

For many events involving radiation sources, the above criteria are all that need to be considered. However, for events at facilities with a well-defined site boundary it is appropriate to consider a further set of criteria. These criteria aim to address the significance of events where equipment or personnel failures have resulted in contamination spread within the site. Whilst there are no direct consequences to individuals outside the site and the event remains within the control of the site, the rating addresses the fact that, as with degradation of defence in depth, there was an increased risk of actual consequences to individuals.

The final rating

The final rating of an event needs to take account of all the criteria considered above. Each event should be considered against each of the above criteria and the highest derived rating is the one to be applied to the event. The overall approach to rating is summarised in the flow charts in Figures I.1, I.2, I.3 and I.4 .

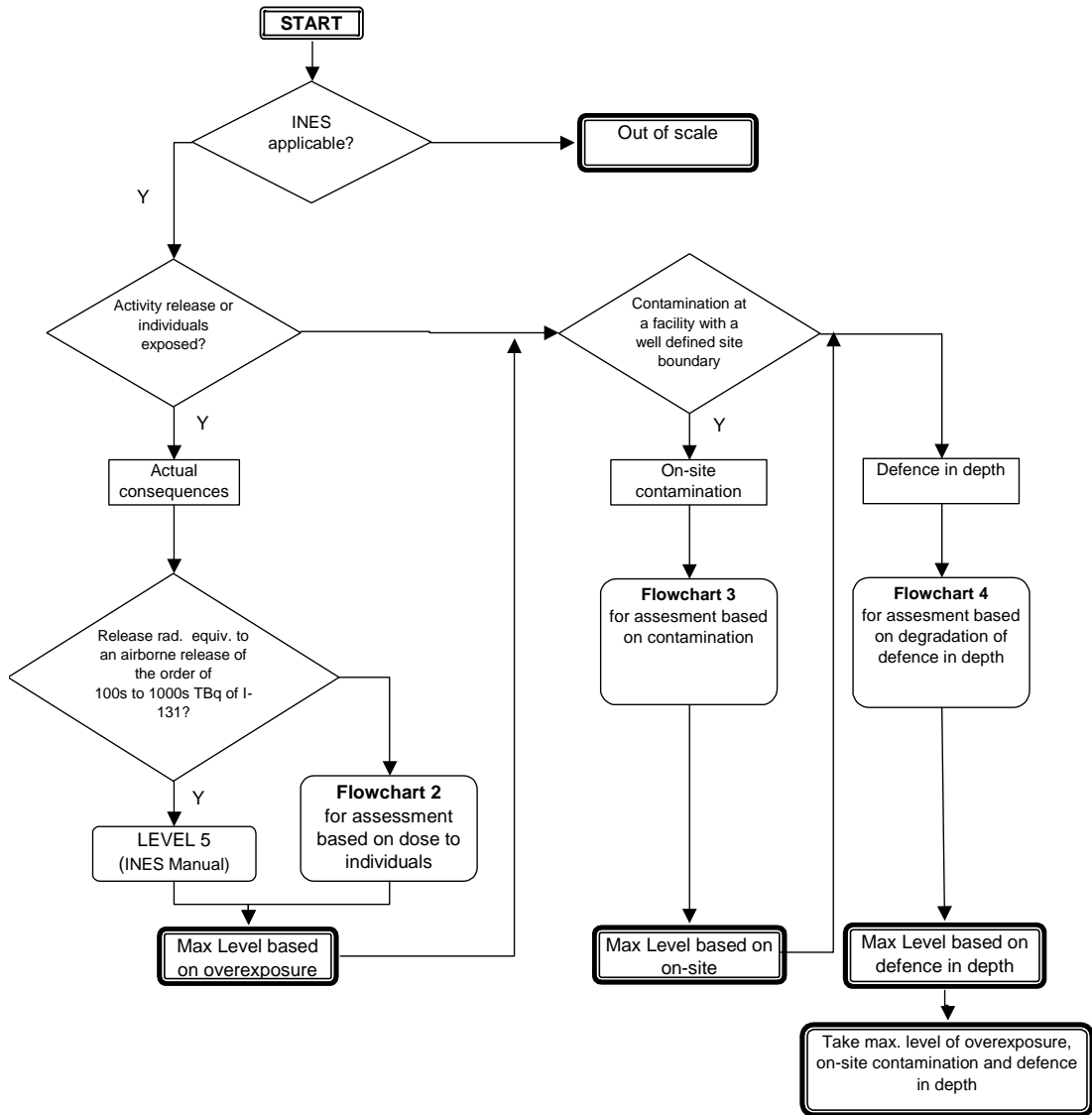
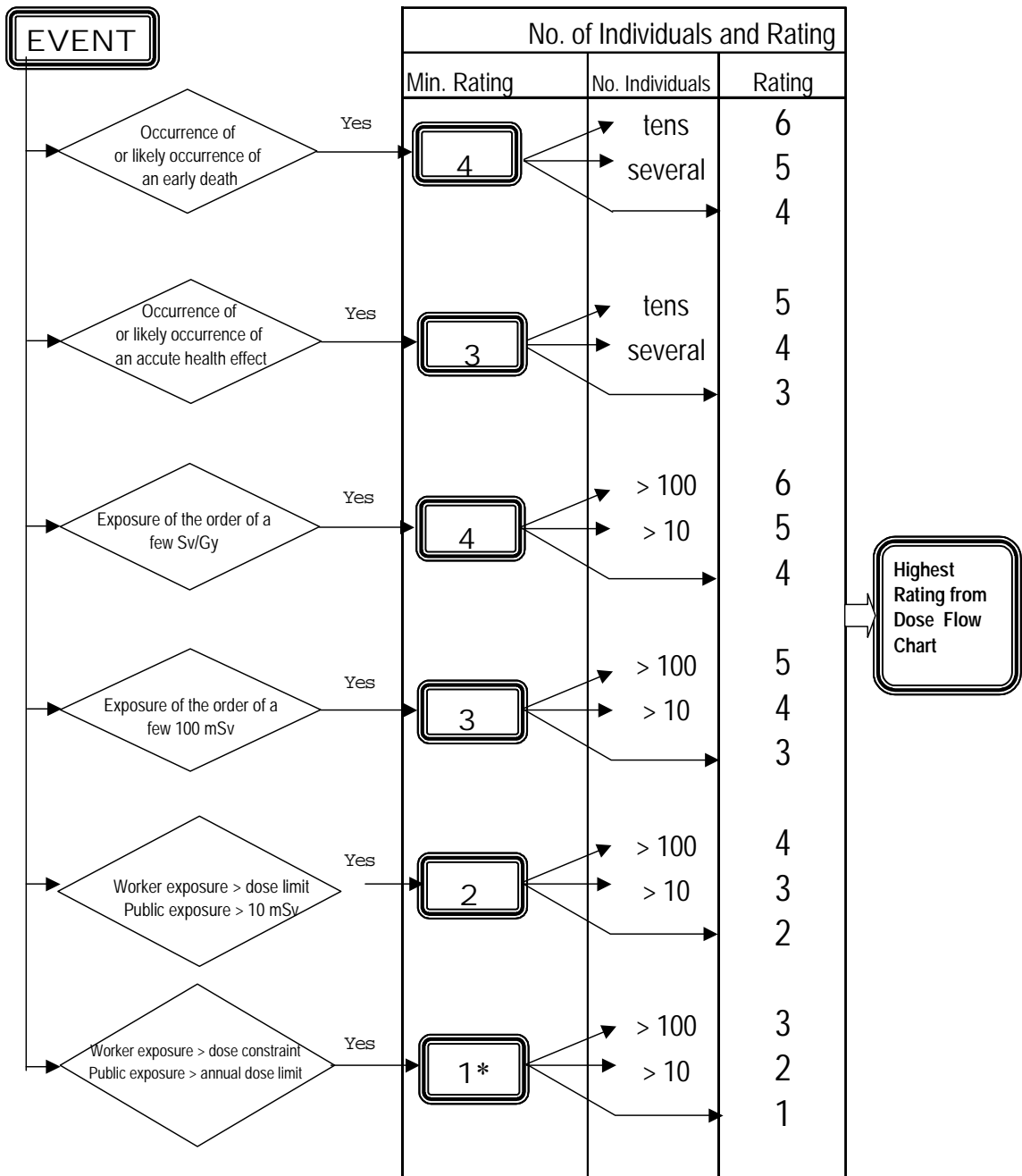


Fig. I.1– Flow Chart 1: Main procedure for INES rating



*In situations where a dose limit is exceeded from an accumulation of exposures over a period, this constitutes in itself an event to be rated at level 1 due to a deficiency in safety culture.

Fig. I.2 – Flow Chart 2: Sub-procedure for rating of events based on dose

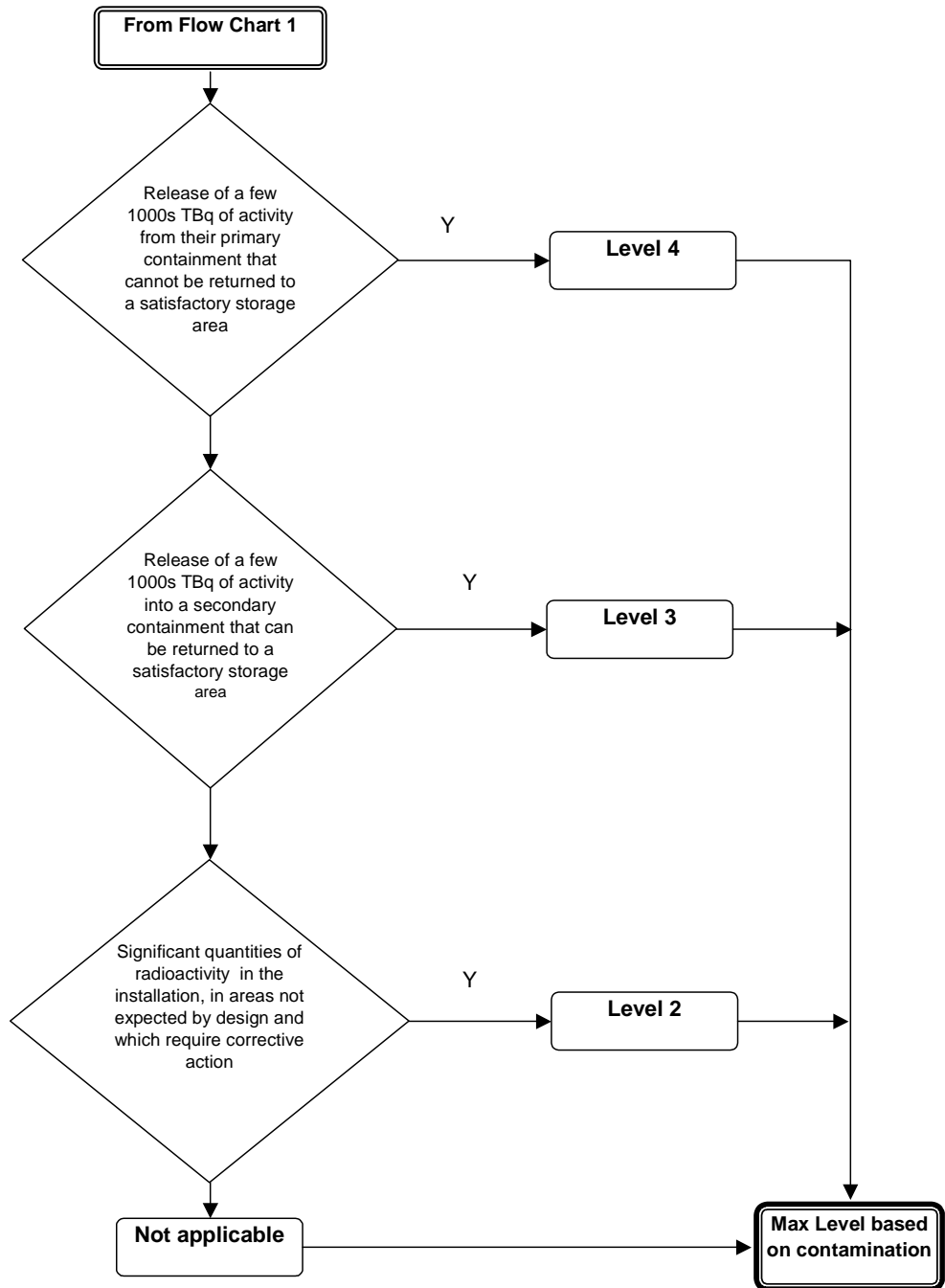


Figure I.3 – Flow Chart 3 - Sub-procedure for contamination at a facility with well-defined site boundary

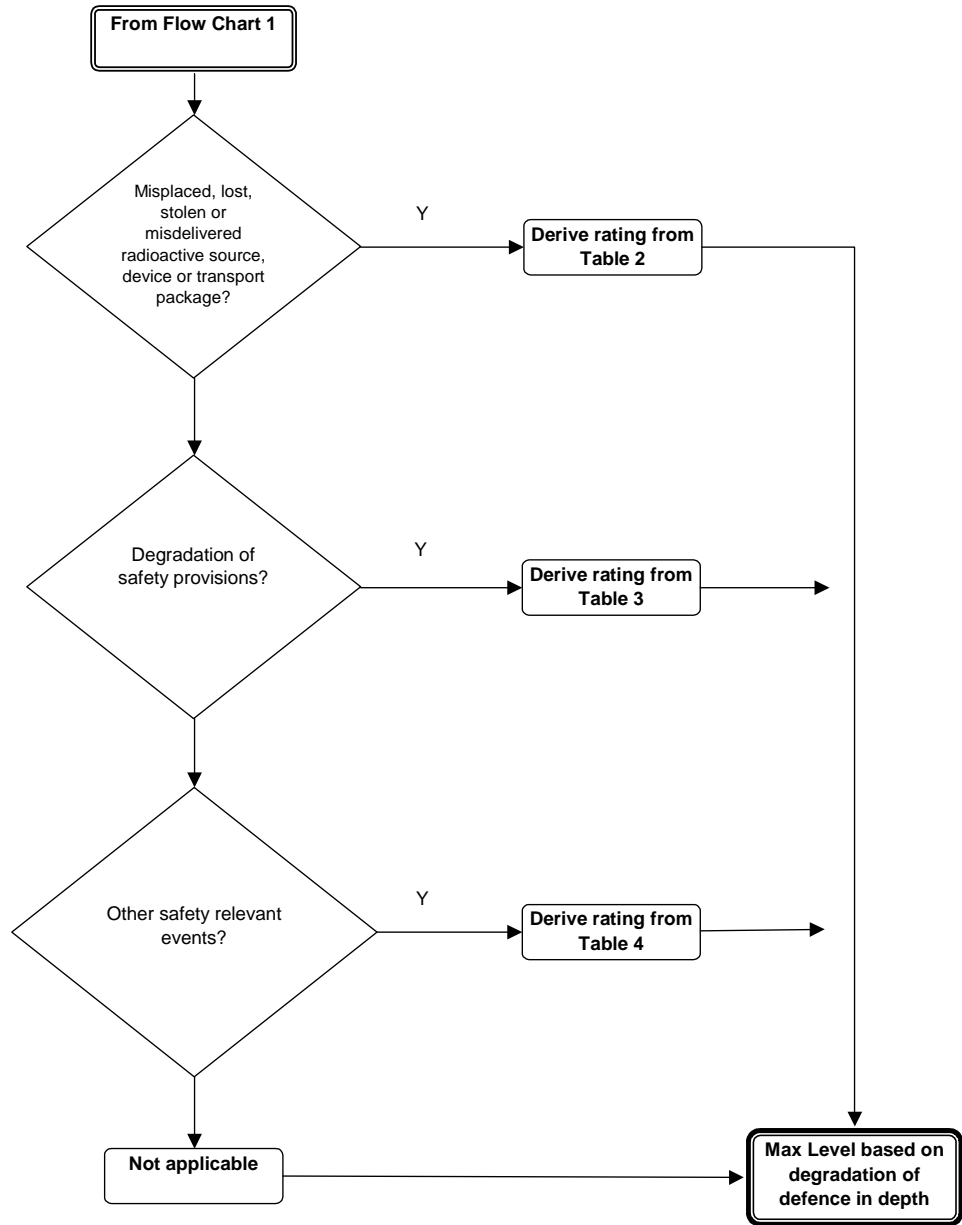


Figure I.4 – Flow Chart 4 - Sub-procedure for degradation of defence in depth

APPENDIX II -. THRESHOLD LEVELS FOR DETERMINISTIC EFFECTS*

Lethal Effects	Target Organ	Threshold Dose (Gy)¹
Embryo or foetus death	Embryo or foetus	0.3
Bone marrow irradiation syndrome	Bone marrow	2
Lung irradiation syndrome	Lung	27
Gastrointestinal syndrome	Small intestine, colon	11

Non lethal disabling effects	Target Organ	Threshold Dose (Gy)
Severe burns		25
Serious backwardness	Foetus in utero	0.2
Serious infertility (woman)	Ovary	1.6
Serious infertility (man)	Testicles	0.5
Fibrosis	Lung	12

Non lethal non disabling effects	Target Organ	Threshold Dose (Gy)
Vomiting	Abdomen	0.9
Diarrhoeas	Abdomen	1
Hypothyroidism	Thyroid	12
Burns	Skin	15
Cataract	Crystalline	1.8

*These data are valid for dose rates of about 1 Gy/h.

¹ There are values proposed for the pilot, based on UK NRPB recommendations. It is expected that the IAEA will publish recommended values during the pilot period, that will be incorporated in the final version.

APPENDIX III – RADIOLOGICAL EQUIVALENCESTABLE III-1 – RADIOLOGICAL EQUIVALENCES TO I-131 FOR
OFF-SITE CONSEQUENCES [2]

Nuclide	Multiplication Factors
I-131	1
HTO	0.02
P-32	0.3
Mn-54	4
Co-60	50
Sr-90	10
Mo-99	0.1
Ru-106	7
Cs-137	30
Cs-134	20
Te-132	0.3
Ir-192	2
U-235(S) ⁽¹⁾	800
U-235(M) ⁽¹⁾	300
U-235(F) ⁽¹⁾	100
U-238 (S) ⁽¹⁾	700
U-238(M) ⁽¹⁾	300
U-238 (F) ⁽¹⁾	50
Unat	800
Pu-239	10000
Am-241	9000

TABLE III-2 – RADIOLOGICAL EQUIVALENCES FOR ON-SITE CONSEQUENCES [2]

Nuclide	Multiplication Factors		
	Equivalence to Mo-99	Equivalence to I-131	Equivalence to Cs-137
I-131	10	1	2
HTO	0.02	0.002	0.003
P-32	3	0.3	0.4
Mn-54	1	0.1	0.2
Co-60	15	1.5	3
Sr-90	70	7	11
Mo-99	1	0.1	0.2
Tc-99m	0.03	0.003	0.004
Ru-106	40	3	5
Te-132	3	0.3	0.4
Cs-134	9	0.9	1
Cs-137	6	0.6	1
Ir-192	4	0.4	0.7
U-235(S) ⁽¹⁾	5500	600	900
U-235(M) ⁽¹⁾	1600	200	300
U-235(F) ⁽¹⁾	500	50	90
U-238 (S) ⁽¹⁾	5000	500	900
U-238(M) ⁽¹⁾	1500	100	200
U-238 (F) ⁽¹⁾	500	50	100
Unat	6000	600	900
Pu-239	100000	9000	15000
Am-241	25000	2000	4000

⁽¹⁾ Lung absorption types: S- slow; M- medium; F- fast

APPENDIX IV – SOURCE CATEGORIZATION

The Tables in this Appendix are extracts from IAEA Source Categorization, Revision of the IAEA-TECDOC-1191, Categorization of radiation sources, IAEA-TECDOC-1344 [2].

TABLE IV-1. CATEGORIZATION TABLE

Category	Categorization of common practices ^a	Activity ratio ^b (A/D)
1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy Fixed, multi-beam teletherapy (gamma knife)	$A/D \geq 1000$
2	Industrial gamma radiography High/medium dose rate brachytherapy	$1000 > A/D \geq 10$
3	Fixed industrial gauges -Level gauges -dredger gauges -conveyor gauges containing high activity sources -spinning pipe gauges Well logging gauges	$10 > A/D \geq 1$
4	Low dose rate brachytherapy (except eye plaques and permanent implant sources) Thickness/fill-Level gauges Portable gauges (e.g. moisture/density gauges) Bone densitometers Static eliminators	$1 > A/D \geq 0.01$
5	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence devices Electron capture devices Mossbauer spectrometry Positron Emission Tomography (PET) checking	$0.01 > A/D \geq \text{Exempt}^c/D$

^aRecognizing that factors other than A/D have been taken into consideration.

^bThis column can be used to determine the category of a source, based purely on A/D. This may be appropriate if, for example: the practice is not known or is not listed; sources have a short half-life and/or are unsealed; or sources are aggregated (See Section 3.3).

^cExempt quantities are given in Schedule I of the BSS. [5]

TABLE IV.2 – ACTIVITY^a CORRESPONDING TO A ‘DANGEROUS’ SOURCE (D-VALUE^b) FOR SELECTED RADIONUCLIDES AND USEFUL MULTIPLES THEREOF.

Radionuclide	1000 x D		10 x D		D		0.01 x D	
	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c
Am-241	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Am-241/Be	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Au-198	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Cd-109	2.E+04	5.E+05	2.E+02	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Cf-252	2.E+01	5.E+02	2.E-01	5.E-00	2.E-02	5.E-01	2.E-04	5.E-03
Cm-244	5.E+01	1.E+03	5.E-01	1.E+01	5.E-02	1.E+00	5.E-04	1.E-02
Co-57	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
Co-60	3.E+01	8.E+02	3.E-01	8.E+00	3.E-02	8.E-01	3.E-04	8.E-03
Cs-137	1.E+02	3.E+03	1.E+00	3.E+01	1.E-01	3.E+00	1.E-03	3.E-02
Fe-55	8.E+05	2.E+07	8.E+03	2.E+05	8.E+02	2.E+04	8.E+00	2.E+02
Gd-153	1.E+03	3.E+04	1.E+01	3.E+02	1.E+00	3.E+01	1.E-02	3.E-01
Ge-68	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
H-3	2.E+06	5.E+07	2.E+04	5.E+05	2.E+03	5.E+04	2.E+01	5.E+02
I-125	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
I-131	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Ir-192	8.E+01	2.E+03	8.E-01	2.E+01	8.E-02	2.E+00	8.E-04	2.E-02
Kr-85	3.E+04	8.E+05	3.E+02	8.E+03	3.E+01	8.E+02	3.E-01	8.E+00
Mo-99	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02
Ni-63	6.E+04	2.E+06	6.E+02	2.E+04	6.E+01	2.E+03	6.E-01	2.E+01
P-32	1.E+04	3.E+05	1.E+02	3.E+03	1.E+01	3.E+02	1.E-01	3.E+00
Pd-103	9.E+04	2.E+06	9.E+02	2.E+04	9.E+01	2.E+03	9.E-01	2.E+01
Pm-147	4.E+04	1.E+06	4.E+02	1.E+04	4.E+01	1.E+03	4.E-01	1.E+01
Po-210	6.E+02	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Pu-238	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Pu-239 ^d /Be	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Ra-226	4.E+01	1.E+03	4.E-01	1.E+01	4.E-02	1.E+00	4.E-04	1.E-02
Ru-106(Rh-106)	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02
Se-75	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Sr-90(Y-90)	1.E+03	3.E+04	1.E+01	3.E+02	1.E+00	3.E+01	1.E-02	3.E-01
Tc-99 ^m	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01

Radionuclide	1000 x D		10 x D		D		0.01 x D	
	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c	(TBq)	(Ci) ^c
Tl-204	2.E+04	5.E+05	2.E+01	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Tm-170	2.E+04	5.E+05	2.E+02	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Yb-169	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02

^aBecause this table does not show which dose criteria were used, these D-values should not be used in reverse to derive doses from sources of known activity.

^bFull details of the derivation of the D-values, and D-values for additional radionuclides are given in reference [4].

^cThe primary values to be used are given in TBq. Curie values are provided for practical usefulness and are rounded after conversion.

^dCriticality and safeguard issues will need to be considered for multiples of D.

TABLE IV-3 - SOME PRACTICES AND RADIONUCLIDES OF INTEREST AND THEIR RANGE OF ACTIVITIES AND CATEGORIES

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Category 1								
Radioisotopic thermoelectric generators (RTGs)	Sr-90	Max	6.8E+05	2.5E+04	1.0E+00	2.5E+04	1	
	Sr-90	Min	9.0E+03	3.3E+02	1.0E+00	3.3E+02	2	1
	Sr-90	Typ	2.0E+04	7.4E+02	1.0E+00	7.4E+02	2	
	Pu-238	Max	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	
	Pu-238	Min	2.8E+01	1.0E+00	6.E-02	1.7E+01	2	1
	Pu-238	Typ	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	
Irradiators: sterilization and food preservation	Co-60	Max	1.5E+07	5.6E+05	3.E-02	1.9E+07	1	
	Co-60	Min	5.0E+03	1.9E+02	3.E-02	6.2E+03	1	1
	Co-60	Typ	4.0E+06	1.5E+05	3.E-02	4.9E+06	1	
	Cs-137	Max	5.0E+06	1.9E+05	1.E-01	1.9E+06	1	
	Cs-137	Min	5.0E+03	1.9E+02	1.E-01	1.9E+03	1	1
	Cs-137	Typ	3.0E+06	1.1E+05	1.E-01	1.1E+06	1	
Irradiators: self-shielded	Cs-137	Max	4.2E+04	1.6E+03	1.E-01	1.6E+04	1	
	Cs-137	Min	2.5E+03	9.3E+01	1.E-01	9.3E+02	2	1
	Cs-137	Typ	1.5E+04	5.6E+02	1.E-01	5.6E+03	1	
	Co-60	Max	5.0E+04	1.9E+03	3.E-02	6.2E+04	1	
	Co-60	Min	1.5E+03	5.6E+01	3.E-02	1.9E+03	1	1
	Co-60	Typ	2.5E+04	9.3E+02	3.E-02	3.1E+04	1	
Irradiators: blood/tissue	Cs-137	Max	1.2E+04	4.4E+02	1.E-01	4.4E+03	1	
	Cs-137	Min	1.0E+03	3.7E+01	1.E-01	3.7E+02	2	1
	Cs-137	Typ	7.0E+03	2.6E+02	1.E-01	2.6E+03	1	
	Co-60	Max	3.0E+03	1.1E+02	3.E-02	3.7E+03	1	
	Co-60	Min	1.5E+03	5.6E+01	3.E-02	1.9E+03	1	1
	Co-60	Typ	2.4E+03	8.9E+01	3.E-02	3.0E+03	1	
Multi-beam teletherapy (gamma knife)	Co-60	Max	1.0E+04	3.7E+02	3.E-02	1.2E+04	1	
	Co-60	Min	4.0E+03	1.5E+02	3.E-02	4.9E+03	1	1
	Co-60	Typ	7.0E+03	2.6E+02	3.E-02	8.6E+03	1	
Teletherapy	Co-60	Max	1.5E+04	5.6E+02	3.E-02	1.9E+04	1	
	Co-60	Min	1.0E+03	3.7E+01	3.E-02	1.2E+03	1	1
	Co-60	Typ	4.0E+03	1.5E+02	3.E-02	4.9E+03	1	
	Cs-137	Max	1.5E+03	5.6E+01	1.E-01	5.6E+02	2	
	Cs-137	Min	5.0E+02	1.9E+01	1.E-01	1.9E+02	2	1
	Cs-137	Typ	5.0E+02	1.9E+01	1.E-01	1.9E+02	2	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Category 2								
Industrial radiography	Co-60	Max	2.0E+02	7.4E+00	3.E-02	2.5E+02	2	
	Co-60	Min	1.1E+01	4.1E-01	3.E-02	1.4E+01	2	2
	Co-60	Typ	6.0E+01	2.2E+00	3.E-02	7.4E+01	2	
	Ir-192	Max	2.0E+02	7.4E+00	8.E-02	9.3E+01	2	
	Ir-192	Min	5.0E+00	1.9E-01	8.E-02	2.3E+00	3	2
	Ir-192	Typ	1.0E+02	3.7E+00	8.E-02	4.6E+01	2	
	Se-75	Max	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	
	Se-75	Min	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	2
	Se-75	Typ	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	
	Yb-169	Max	1.0E+01	3.7E-01	3.E-01	1.2E+00	3	
	Yb-169	Min	2.5E+00	9.3E-02	3.E-01	3.1E-01	4	2
	Yb-169	Typ	5.0E+00	1.9E-01	3.E-01	6.2E-01	4	
Tm-170	Max	2.0E+02	7.4E+00	2.E+01	3.7E-01	4		
Tm-170	Min	2.0E+01	7.4E-01	2.E+01	3.7E-02	4	2	
Tm-170	Typ	1.5E+02	5.6E+00	2.E+01	2.8E-01	4		
Brachytherapy - high/medium dose rate	Co-60	Max	2.0E+01	7.4E-01	3.E-02	2.5E+01	2	
	Co-60	Min	5.0E+00	1.9E-01	3.E-02	6.2E+00	3	2
	Co-60	Typ	1.0E+01	3.7E-01	3.E-02	1.2E+01	2	
	Cs-137	Max	8.0E+00	3.0E-01	1.E-01	3.0E+00	3	
	Cs-137	Min	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	2
	Cs-137	Typ	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	
	Ir-192	Max	1.2E+01	4.4E-01	8.E-02	5.6E+00	3	
	Ir-192	Min	3.0E+00	1.1E-01	8.E-02	1.4E+00	3	2
	Ir-192	Typ	6.0E+00	2.2E-01	8.E-02	2.8E+00	3	
Calibration facilities	Co-60	Max	3.3E+01	1.2E+00	3.E-02	4.1E+01	2	
	Co-60	Min	5.5E-01	2.0E-02	3.E-02	6.8E-01	4	Not assigned
	Co-60	Typ	2.0E+01	7.4E-01	3.E-02	2.5E+01	2	
	Cs-137	Max	3.0E+03	1.1E+02	1.E-01	1.1E+03	1	
	Cs-137	Min	1.5E+00	5.6E-02	1.E-01	5.6E-01	4	Not assigned
	Cs-137	Typ	6.0E+01	2.2E+00	1.E-01	2.2E+01	2	

Category 3

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Level gauges	Cs-137	Max	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	
	Cs-137	Min	1.0E+00	3.7E-02	1.E-01	3.7E-01	4	3
	Cs-137	Typ	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	
	Co-60	Max	1.0E+01	3.7E-01	3.E-02	1.2E+01	2	
	Co-60	Min	1.0E-01	3.7E-03	3.E-02	1.2E-01	4	3
	Co-60	Typ	5.0E+00	1.9E-01	3.E-02	6.2E+00	3	
Calibration facilities	Am-241	Max	2.0E+01	7.4E-01	6.E-02	1.2E+01	2	
	Am-241	Min	5.0E+00	1.9E-01	6.E-02	3.1E+00	3	Not assigned
	Am-241	Typ	1.0E+01	3.7E-01	6.E-02	6.2E+00	3	
Conveyor gauges	Cs-137	Max	4.0E+01	1.5E+00	1.E-01	1.5E+01	2	
	Cs-137	Min	1.0E-01	3.7E-03	1.E-01	3.7E-02	4	3
	Cs-137	Typ	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	
	Cf-252	Max	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	
	Cf-252	Min	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	3
	Cf-252	Typ	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	
Blast furnace gauges	Co-60	Max	2.0E+00	7.4E-02	3.E-02	2.5E+00	3	
	Co-60	Min	1.0E+00	3.7E-02	3.E-02	1.2E+00	3	3
	Co-60	Typ	1.0E+00	3.7E-02	3.E-02	1.2E+00	3	
Dredger gauges	Co-60	Max	2.6E+00	9.6E-02	3.E-02	3.2E+00	3	
	Co-60	Min	2.5E-01	9.3E-03	3.E-02	3.1E-01	4	3
	Co-60	Typ	7.5E-01	2.8E-02	3.E-02	9.3E-01	4	
	Cs-137	Max	1.0E+01	3.7E-01	1.E-01	3.7E+00	3	
	Cs-137	Min	2.0E-01	7.4E-03	1.E-01	7.4E-02	4	3
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
Spinning pipe gauges	Cs-137	Max	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	
	Cs-137	Min	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	3
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
Research reactor startup sources	Am-241/Be	Max	5.0E+00	1.9E-01	6.E-02	3.1E+00	3	
	Am-241/Be	Min	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	Not assigned
	Am-241/Be	Typ	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	
Well logging	Am-241/Be	Max	2.3E+01	8.5E-01	6.E-02	1.4E+01	2	
	Am-241/Be	Min	5.0E-01	1.9E-02	6.E-02	3.1E-01	4	3
	Am-241/Be	Typ	2.0E+01	7.4E-01	6.E-02	1.2E+01	2	
	Cs-137	Max	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
	Cs-137	Min	1.0E+00	3.7E-02	1.E-01	3.7E-01	4	3
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
	Cf-252	Max	1.1E-01	4.1E-03	2.E-02	2.0E-01	4	
	Cf-252	Min	2.7E-02	1.0E-03	2.E-02	5.0E-02	4	3
	Cf-252	Typ	3.0E-02	1.1E-03	2.E-02	5.6E-02	4	
Pacemakers	Pu-238	Max	8.0E+00	3.0E-01	6.E-02	4.9E+00	3	
	Pu-238	Min	2.9E+00	1.1E-01	6.E-02	1.8E+00	3	Not assigned
	Pu-238	Typ	3.0E+00	1.1E-01	6.E-02	1.9E+00	3	
Calibration sources	Pu-239/Be	Max	1.0E+01	3.7E-01	6.E-02	6.2E+00	3	
	Pu-239/Be	Min	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	Not assigned
	Pu-239/Be	Typ	3.0E+00	1.1E-01	6.E-02	1.9E+00	3	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Category 4								
Brachytherapy - low dose rate	Cs-137	Max	7.0E-01	2.6E-02	1.E-01	2.6E-01	4	
	Cs-137	Min	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	4
	Cs-137	Typ	5.0E-01	1.9E-02	1.E-01	1.9E-01	4	
	Ra-226	Max	5.0E-02	1.9E-03	4.E-02	4.6E-02	4	
	Ra-226	Min	5.0E-03	1.9E-04	4.E-02	4.6E-03	5	4
	Ra-226	Typ	1.5E-02	5.6E-04	4.E-02	1.4E-02	4	
	I-125	Max	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	
	I-125	Min	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	4
	I-125	Typ	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	
	Ir-192	Max	7.5E-01	2.8E-02	8.E-02	3.5E-01	4	
	Ir-192	Min	2.0E-02	7.4E-04	8.E-02	9.3E-03	5	4
	Ir-192	Typ	5.0E-01	1.9E-02	8.E-02	2.3E-01	4	
	Au-198	Max	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	
	Au-198	Min	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	4
	Au-198	Typ	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	
	Cf-252	Max	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	
	Cf-252	Min	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	4
	Cf-252	Typ	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	
Thickness gauges	Kr-85	Max	1.0E+00	3.7E-02	3.E+01	1.2E-03	5	
	Kr-85	Min	5.0E-02	1.9E-03	3.E+01	6.2E-05	5	4
	Kr-85	Typ	1.0E+00	3.7E-02	3.E+01	1.2E-03	5	
	Sr-90	Max	2.0E-01	7.4E-03	1.E+00	7.4E-03	5	
	Sr-90	Min	1.0E-02	3.7E-04	1.E+00	3.7E-04	5	4
	Sr-90	Typ	1.0E-01	3.7E-03	1.E+00	3.7E-03	5	
	Am-241	Max	6.0E-01	2.2E-02	6.E-02	3.7E-01	4	
	Am-241	Min	3.0E-01	1.1E-02	6.E-02	1.9E-01	4	4
	Am-241	Typ	6.0E-01	2.2E-02	6.E-02	3.7E-01	4	
	Pm-147	Max	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	
	Pm-147	Min	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	4
	Pm-147	Typ	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	
	Cm-244	Max	1.0E+00	3.7E-02	5.E-02	7.4E-01	4	
	Cm-244	Min	2.0E-01	7.4E-03	5.E-02	1.5E-01	4	4
	Cm-244	Typ	4.0E-01	1.5E-02	5.E-02	3.0E-01	4	
Fill-level, thickness gauges	Am-241	Max	1.2E-01	4.4E-03	6.E-02	7.4E-02	4	
	Am-241	Min	1.2E-02	4.4E-04	6.E-02	7.4E-03	5	4
	Am-241	Typ	6.0E-02	2.2E-03	6.E-02	3.7E-02	4	
	Cs-137	Max	6.5E-02	2.4E-03	1.E-01	2.4E-02	4	
	Cs-137	Min	5.0E-02	1.9E-03	1.E-01	1.9E-02	4	4
	Cs-137	Typ	6.0E-02	2.2E-03	1.E-01	2.2E-02	4	
Calibration facilities	Sr-90	Max	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	
	Sr-90	Min	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	Not assigned
	Sr-90	Typ	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	
Moisture detectors	Am-241/Be	Max	1.0E-01	3.7E-03	6.E-02	6.2E-02	4	
	Am-241/Be	Min	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	4

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide	Typ	Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Density gauges	Am-241/Be	Typ	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	
	Cs-137	Max	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
	Cs-137	Min	8.0E-03	3.0E-04	1.E-01	3.0E-03	5	4
	Cs-137	Typ	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
Moisture/density gauges	Am-241/Be	Max	1.0E-01	3.7E-03	6.E-02	6.2E-02	4	
	Am-241/Be	Min	1.0E-02	3.7E-04	6.E-02	6.2E-03	5	4
	Am-241/Be	Typ	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	
	Cs-137	Max	1.1E-02	4.1E-04	1.E-01	4.1E-03	5	
	Cs-137	Min	8.0E-03	3.0E-04	1.E-01	3.0E-03	5	4
	Cs-137	Typ	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
	Ra-226	Max	4.0E-03	1.5E-04	4.E-02	3.7E-03	5	
	Ra-226	Min	2.0E-03	7.4E-05	4.E-02	1.9E-03	5	4
	Ra-226	Typ	2.0E-03	7.4E-05	4.E-02	1.9E-03	5	
	Cf-252	Max	7.0E-05	2.6E-06	2.E-02	1.3E-04	5	
	Cf-252	Min	3.0E-05	1.1E-06	2.E-02	5.6E-05	5	4
	Cf-252	Typ	6.0E-05	2.2E-06	2.E-02	1.1E-04	5	
Bone densitometry	Cd-109	Max	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	
	Cd-109	Min	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	4
	Cd-109	Typ	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	
	Gd-153	Max	1.5E+00	5.6E-02	1.E+00	5.6E-02	4	
	Gd-153	Min	2.0E-02	7.4E-04	1.E+00	7.4E-04	5	4
	Gd-153	Typ	1.0E+00	3.7E-02	1.E+00	3.7E-02	4	
	I-125	Max	8.0E-01	3.0E-02	2.E-01	1.5E-01	4	
	I-125	Min	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	4
	I-125	Typ	5.0E-01	1.9E-02	2.E-01	9.3E-02	4	
	Am-241	Max	2.7E-01	1.0E-02	6.E-02	1.7E-01	4	
	Am-241	Min	2.7E-02	1.0E-03	6.E-02	1.7E-02	4	4
	Am-241	Typ	1.4E-01	5.0E-03	6.E-02	8.3E-02	4	
Static eliminators	Am-241	Max	1.1E-01	4.1E-03	6.E-02	6.8E-02	4	
	Am-241	Min	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	4
	Am-241	Typ	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	
	Po-210	Max	1.1E-01	4.1E-03	6.E-02	6.8E-02	4	
	Po-210	Min	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	4
Diagnostic isotope generators	Mo-99	Max	1.0E+01	3.7E-01	3.E-01	1.2E+00	3	
	Mo-99	Min	1.0E+00	3.7E-02	3.E-01	1.2E-01	4	Not assigned
	Mo-99	Typ	1.0E+00	3.7E-02	3.E-01	1.2E-01	4	
Medical unsealed	I-131	Max	2.0E-01	7.4E-03	2.E-01	3.7E-02	4	
	I-131	Min	1.0E-01	3.7E-03	2.E-01	1.9E-02	4	Not assigned
	I-131	Typ	1.0E-01	3.7E-03	2.E-01	1.9E-02	4	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Category 5								
X ray fluorescence analyzers	Fe-55	Max	1.4E-01	5.0E-03	8.E+02	6.2E-06	5	
	Fe-55	Min	3.0E-03	1.1E-04	8.E+02	1.4E-07	5	5
	Fe-55	Typ	2.0E-02	7.4E-04	8.E+02	9.3E-07	5	
	Cd-109	Max	1.5E-01	5.6E-03	2.E+01	2.8E-04	5	
	Cd-109	Min	3.0E-02	1.1E-03	2.E+01	5.6E-05	5	5
	Cd-109	Typ	3.0E-02	1.1E-03	2.E+01	5.6E-05	5	
	Co-57	Max	4.0E-02	1.5E-03	7.E-01	2.1E-03	5	
	Co-57	Min	1.5E-02	5.6E-04	7.E-01	7.9E-04	5	5
	Co-57	Typ	2.5E-02	9.3E-04	7.E-01	1.3E-03	5	
Electron capture detectors	Ni-63	Max	2.0E-02	7.4E-04	6.E+01	1.2E-05	5	
	Ni-63	Min	5.0E-03	1.9E-04	6.E+01	3.1E-06	5	5
	Ni-63	Typ	1.0E-02	3.7E-04	6.E+01	6.2E-06	5	
	H-3	Max	3.0E-01	1.1E-02	2.E+03	5.6E-06	5	
	H-3	Min	5.0E-02	1.9E-03	2.E+03	9.3E-07	5	5
	H-3	Typ	2.5E-01	9.3E-03	2.E+03	4.6E-06	5	
Lightning preventers	Am-241	Max	1.3E-02	4.8E-04	6.E-02	8.0E-03	5	
	Am-241	Min	1.3E-03	4.8E-05	6.E-02	8.0E-04	5	5
	Am-241	Typ	1.3E-03	4.8E-05	6.E-02	8.0E-04	5	
	Ra-226	Max	8.0E-05	3.0E-06	4.E-02	7.4E-05	5	
	Ra-226	Min	7.0E-06	2.6E-07	4.E-02	6.5E-06	5	5
	Ra-226	Typ	3.0E-05	1.1E-06	4.E-02	2.8E-05	5	
	H-3	Max	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	
	H-3	Min	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	5
	H-3	Typ	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	
Brachytherapy: low dose-rate- eye plaques and permanent implants	Sr-90	Max	4.0E-02	1.5E-03	1.E+00	1.5E-03	5	
	Sr-90	Min	2.0E-02	7.4E-04	1.E+00	7.4E-04	5	5
	Sr-90	Typ	2.5E-02	9.3E-04	1.E+00	9.3E-04	5	
	Ru/Rh-106	Max	6.0E-04	2.2E-05	3.E-01	7.4E-05	5	
	Ru/Rh-106	Min	2.2E-04	8.1E-06	3.E-01	2.7E-05	5	5
	Ru/Rh-106	Typ	6.0E-04	2.2E-05	3.E-01	7.4E-05	5	
	Pd-103	Max	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	
	Pd-103	Min	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	5
	Pd-103	Typ	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	
Positron Emission Tomography (PET) checking	Ge-68	Max	1.0E-02	3.7E-04	7.E-01	5.3E-04	5	5
	Ge-68	Min	1.0E-03	3.7E-05	7.E-01	5.3E-05	5	5
	Ge-68	Typ	3.0E-03	1.1E-04	7.E-01	1.6E-04	5	5
Mossbauer Spectrometry	Co-57	Max	1.0E-01	3.7E-03	7.E-01	5.3E-03	5	5
	Co-57	Min	5.0E-03	1.9E-04	7.E-01	2.6E-04	5	5
	Co-57	Typ	5.0E-02	1.9E-03	7.E-01	2.6E-03	5	5
Tritium targets	H-3	Max	3.0E+01	1.1E+00	2.E+03	5.6E-04	5	
	H-3	Min	3.0E+00	1.1E-01	2.E+03	5.6E-05	5	Not assigned
	H-3	Typ	7.0E+00	2.6E-01	2.E+03	1.3E-04	5	
Medical unsealed	P-32	Max	6.0E-01	2.2E-02	1.E+01	2.2E-03	5	Not assigned
	P-32	Min	6.0E-02	2.2E-03	1.E+01	2.2E-04	5	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
	P-32	Typ	6.0E-01	2.2E-02	1.E+01	2.2E-03	5	

REFERENCES

- [1] The International Nuclear Event Scale (INES) User's Manual, 2001 Edition.
- [2] IAEA Source Categorization, Revision of the IAEA-TECDOC-1191, Categorization of radiation sources, IAEA-TECDOC-1344.
- [3] International Commission for Radiological Protection (ICRP), Publication 60, 1990.
- [4] National Radiation Protection Board, Risk from Deterministic Effects of Ionising Radiation, Document of the NRPB Vol.7 no3, 1996).
- [5] IAEA Regulations for the Safe Transport of Radioactive Material 1996 Edition (Revised), Safety Standard Series No.TS-R-1.
- [6] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).
- [7] INTERNATIONAL ATOMIC ENERGY AGENCY, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency. (Updating IAEA-TECDOC-953, Emergency Preparedness and Response Series), Vienna (in preparation).
- [8] IAEA International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources Details, Safety Series No. 115, 1996, English.