EVENT SEVERITY SCALES FOR, AND REPORTING OF, TRANSPORT ACCIDENTS AND INCIDENTS

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ABSTRACT

The International Nuclear Event Scale [1] (INES) has been used successfully for more than a decade to provide, to the media and the public, prompt communication of the safety significance of accidents and incidents at nuclear sites. The scale has recently been revised and now includes events involving the transport of radioactive materials, but the guidance on that application is brief. The study[2] reported on here sought to complement that guidance and give proposals on how to apply appropriate ratings to practical transport events. The study also considered ratings for transport events involving releases of radioactive materials into aquatic environments, which is not currently covered by the INES. Reporting transport events enables the safety of these operations to be monitored and the study made recommendations on the type of reporting appropriate within the European Union.

1. INTRODUCTION

Radioactive materials are transported internationally by all modes of transport. Many studies have shown that these operations are carried out with a high level of safety. Accidents, and other incidents with severe safety implications, are rare. Nevertheless, it is important to learn from any such events so that action can be taken to prevent their recurrence or to ensure that their frequencies, and effects, are reduced further. This requires a system for the collection and analysis of the details of such events. It is also necessary for harmonised and well-defined information on the radioactive cargo to be provided by the consignor so that the carrier can take appropriate action following an accident or incident. The transport of radioactive materials has always attracted the interest of the public and the media, out of concern for the safety aspects of those operations. Therefore, Competent Authorities and the European Commission institutions need to be well informed on any potentially serious event of this nature, and on the general state of safety in this transport field.

It is therefore proposed that a standardised notification and evaluation system throughout the European Union will facilitate the collection and dissemination of information on transport events. As part of this, it is proposed that a system be established to apply a rating that can quickly convey to the public and media the level of severity of such an event. The International Atomic Energy Agency and Nuclear Energy Agency of the OECD have already developed an International Nuclear Event Scale (INES), which has recently been extended to cover transport events[1]. Part of the project[2] reported on in this paper was to examine this scale and give guidance to aid its application to the transport of radioactive materials, and this part of the study built on two previous studies.

The European Commission (DG TREN) provided funding for this work. The contractors in this project were NRPB (project co-ordinator), UK, GRS, Germany, IPSN, France and C Ringot, France (sub-contractor).

2. OBJECTIVES

The main objectives of this study were to develop the proposals outlined in the introduction so that recommendations could be made on the following topics:

- Definition of objectives for a Community database and its management;
- Identification of the criteria and frequency for the notification of incidents/ accidents in the countries of the EU;
- Development and application of an INES scale for incidents/ accidents arising during the transport of radioactive materials;
- Definition of forms for the notification of incidents/ accidents in accordance with the incident/ accident type classification in the INES or other criteria that may be proposed.

3. NOTIFICATION OF EVENTS

There are national transport event databases in some EU Member States and the IAEA has established an international system (EVTRAM). The main objectives of these databases are to provide information on the type and severity of abnormal transport related events, the lessons learnt and on trends in the occurrence of events over a number of years. Annual reports are produced in some countries but the IAEA has not had sufficient data to provide regular reports as too few Member States provide data to EVTRAM.

The objectives of notification to the EC would be consistent with those for reporting to the existing databases but additionally there is the need to communicate certain details promptly and efficiently within set time periods depending on the nature and severity of the event.

National legislation normally gives basic criteria for reporting of events to the Competent Authority. Following any such incident, the carrier must notify the police and consignor (unless the driver has done so already), and other relevant government departments (for example, the competent authority). The carrier must then arrange for the examination of the load to determine whether serious package damage and/or radioactive contamination has occurred, and if so to arrange for the disposal of any contaminated materials, and the decontamination of the vehicle. Any package that has been involved in such an incident must not be transported unless the consignor or his agent has examined it and has issued a certificate confirming that it complies with the Regulations.

3.1 Proposed notification to EC

Two levels of event notification were proposed:

Category A, requires very limited information on a short time-scale depending on the significance of the transport-related event: details of location, date and time, brief description of the event, contacts and preliminary severity rating.

Category B notification is a listing of events together with analyses including that by mode of transport, type of package and material. It is required on an annual basis. The minimum information should include:
Brief description of the event; Location, date, time of event;
Type of package; Nature of radioactive material; Mode of transport;
Emergency response implemented; Radiological consequences, and other consequences.

4. THE USE OF INES IN TRANSPORT

The development of the International Nuclear Event Scale (INES) to more broadly encompass transport has been supported by the IAEA Transport Safety Standards Committee (TRANSSC). At its meeting in May 2000, it was agreed that the revised INES User's Manual should incorporate transport events. The 2001 Edition of the INES User's Manual was published before the completion of this final contract report[2].

Accidents and incidents at nuclear plants or involving nuclear fuel materials have, for many years, been reported and rated on the INES system. The rating is the highest from three areas of assessment: (a) activity released, (b) exposures of workers or members of the public and (c) degradation of defence in depth. The INES manual[1] defines seven levels of severity, which are summarised below.

The main criteria for rating an event on the INES are shown in Table 1. The descriptions of Levels 3 to 7 correspond to those for off-site impacts, mainly with reference to fixed sites, but now include transport events. Levels 1 to 3 include events that have the potential to lead to accident conditions.

Table 1 Outline of INES criteria

Level	**Release to atmosphere/ exposure criteria**
7. Major Accident (Major Release)	Several tens of thousands of terabequerels of iodine-131 or more.
6. Serious Accident (Significant Release)	Thousands to tens of thousands of terabequerels of iodine-131
5. Accident with Off-Site Risk (Limited Release)	Hundreds to thousands of terabequerels of iodine-131
4. Accident without Significant Off-Site Risk (Minor Release)	Dose to the critical group of the order of a few millisieverts or an event, such as a lost source or transport event, which results in a dose to a member of the public of greater than 5 Gy (i.e. one with a high probability of early death).
3.Serious Incident (Very Small Release)	Dose to the critical group of the order of tenths of a millisievert or an event, such as a lost source or a transport event, which results in a dose to a member of the public leading to acute health effects (such as whole body exposure of the order of 1 Gy and body surface exposure of the order of 10 Gy). This level may also include events in which a further failure of safety systems could lead to accident conditions.
2. Incident	Incidents with significant failure of safety provisions, but with sufficient defence in depth remaining to cope with additional failures. This may include an event resulting in a dose to a worker exceeding a statutory annual dose limit and/or an event which leads to the presence of significant quantities of radioactivity in the installation in areas not expected by design and which require corrective action.
1. Anomaly	Anomaly beyond the authorised regime, but with significant defence in depth remaining. This may be due to equipment failure, human error, or procedural inadequacies.
0. Deviation	No safety significance

4.1 Summary of the main INES criteria : releases and doses

The definitions and criteria of the INES severity levels given above in terms of event related radionuclide releases and radiation exposures incurred are summarised in Table 2 and Table 3. The third column of Table 2 has been added to express the released activity levels as multiples of A_2. The A_2 value is the radionuclide specific Type A package contents limit for non-special form material listed in the Transport Regulations. A release of 1 A_2 value represents approximately the same level of risk whatever the radionuclide and it is therefore convenient to express releases in terms of A_2 values. The A_2 value of iodine-131 is 0.7 TBq which, for this purpose, may be rounded to 1 TBq.

Table 2 Releases of radioactive material to atmosphere

Level	External atmospheric release quantities	
	INES (TBq of I-131)	Transport equivalent, A_2 (TBq)
7	> several 10^4	-
6	10^3 to 10^4	> 10^3 A_2
5	10^2 to 10^3	some 10^2 A_2
4	-	-
3	-	-
2	-	-
1	-	-
0	-	-

Table 3 Exposures of workers and members of the public

Level	Individual exposure :	
	Workers (and members of the public exposed from transport events)	Members of the public exposed due to releases from nuclear sites
5 to 7	-	-
4	> 5 Gy	few millisieverts
3	> 1 Gy, < 5 Gy	few tenths of a millisievert
2	> 0.05 Sv, < 1 Gy	-
1	-	-
0	-	-

4.2 Degradation of Defence in Depth

If there is no accident with radiological consequences, but the safety systems are challenged or diminished, it is rated according to the degradation of the systems for defence in depth.

The approach to defence in depth is to consider the number of safety systems remaining - the "safety layer" approach. The maximum rating for degradation of defence in depth is always lower than the maximum rating that would be given if the accident actually happened. For example, in a situation where the maximum potential consequence could be level 5 or higher, level 3 is the maximum rating under defence in depth.

Based on the above and the general principles for rating events using the safety layers approach, the following table summarises the criteria given in the 2001 Edition of the INES User's Manual[1] for transport events.

Table 4 INES ratings - degradation of defence in depth

Reduction of safety layers	Activity in package		
	$<A_2$	A_2 - 100 A_2	> 100 A_2
Events not involving a transportation accident			
Only one safety provision remaining(*)	0	1	2
No safety provision remaining	1	2	3
Loss of package	1	2	3
Events involving a transportation accident			
No degradation of safety provisions	0	0	0
Major degradation of safety provisions (only one or no safety provision remaining)(*)	1	2	3

* Unless the provision meets the requirements of a high integrity layer.

4.3 Proposed development of the INES system for transport events

The INES User's Manual gives a broad outline of the method of rating transport events. However, some types of events are not covered in detail, as the main emphasis is on events at fixed sites. For example, dose criteria are not extended to the lower levels. Also, potential doses are not featured in rating degradation of defence in depth.

A study by Ringot[3] proposed a severity rating for transport events based on a previous 1992 edition of INES, and a further study extended those proposals[4]. Those combined proposals considered the possibility of package contents releases in areas of high population density, such as urban areas. The INES severity rating system only considers releases to atmosphere, with some inclusion of surface contamination on site. In the case of transport, there may be releases to aquatic environments that are not covered in the INES, and these situations were covered by the more recent study[2]. The developments proposed in that study are in accordance with the basic INES system, and will allow its application to a broader range of transport events.

4.4 Release criteria

Table 2 shows the basic rating system defined by INES for releases of radioactivity following an accident in a fixed nuclear installation. Table 5 shows the activity criteria for levels 5 and 6 in terms of A_2 values. These activity release criteria are extended to lower levels by an order of magnitude for each level. These expanded criteria are for use in transport events when one or a small number of individual members of the public or workers are affected. This will generally be the situation for most transport accidents of this type.

Table 5 Proposed criteria for radioactive material releases to atmosphere

Level	External atmospheric release quantities in low population density areas	
	INES (TBq of I-131)	Transport equivalent, A_2 (TBq)
7	> several 10^4	-
6	10^3 to 10^4	> 10^3 A_2
5	10^2 to 10^3	Some 10^2 A_2
4	-	Some 10 A_2
3	-	Some 1 A_2
2	-	Some 0.1 A_2
1	-	Some 0.01 A_2
0	-	-

4.5 Releases in urban areas

In transport accidents where large numbers of members of the public are exposed to a release to atmosphere, such as in an urban area of high population density, the situation would be more serious than that considered above. In such a situation, prompt radiological emergency response would be difficult if not impractical. These proposed release criteria are an order of magnitude less than those given in INES for off-site releases (Table 5). That is, for the same release in an urban area the severity level is raised by one, as radiological consequences are likely to be much greater in that situation.

4.6 Proposed exposure criteria

The INES levels 2, 3 and 4 are defined in terms of exposures of workers and/ or members of the public, as set out in Table 3. For transport events, the 2001 Edition of the INES User's Manual[1] gives dose criteria for members of the public that are the same as for workers. This situation applies where an individual or small number of members of the public are affected, and this represents most of the transport events of this type. In some very low probability transport events, a large number of members of the public might be exposed to dose levels comparable with those from off-site radionuclide releases from nuclear sites. In these situations, it is proposed that the criteria for off site releases may also be used as a basis for rating the transport event. These dose criteria are given in the third column of Table 3. However, it should be stressed that these circumstances would be very exceptional, and for most transport accidents of this type, the criteria in the second column of Table 3 are likely to apply.

4.7 Proposed criteria for degradation of Defence in Depth

Most of the accidents and incidents involving the transport of radioactive materials do not result in releases of radioactive material or exposures of individuals. These events are therefore rated according to the extent of the degradation of defence in depth, as shown in Table 4. The study[2] extends the conditions given in Table 4 by:

- extending the table to lower activities,
- including safety culture and procedural inadequacies,
- giving practical examples.

4.8 Transport events involving radionuclide releases into aquatic environments

Transport events associated with radionuclide releases into marine or freshwater bodies have the potential to result in widespread radioactive contamination of aquatic environments and exposure of

the population. The study included a review of relevant radiological assessments. The doses expected from releases of various magnitudes, in a number of water body types, were compared with the INES criteria. This produced the proposed criteria shown in Table 6.

Table 6 Proposed rating system for transport events involving radionuclide releases into aquatic environments

INES Event rating	Activity released in different aquatic environments		
	Prolonged deep sea release (2500 m)	Release in coastal waters or fishing grounds	Prolonged navigable waterway (3000 $m^3 s^{-1}$) or large lake release
3	-	some 100,000 A_2	some 100,000 A_2
2	-	some 10,000 A_2	some 10,000 A_2
1	some 100,000 A_2	-	-
0	-	-	-

5. DISCUSSION

Throughout the EU, there are likely to be several hundreds of incidents and accidents occurring annually involving the transport of radioactive materials, but very few of these may have serious radiological consequences. From time to time, serious or otherwise important events of this type will need to be notified to the EC so that information is available at the European Union level. Among many national authorities, it is the current practice to notify the IAEA INES Information Service of events at nuclear sites that are at either Level 2 or above. It would appear appropriate for this criterion for rapid notification to also apply to transport events.

The feasibility of the application of a system of reporting and rating transport events has been demonstrated by the experience in France, of a year-long trial period. Also, many Competent Authorities already have systems to record these events and the additional rapid notification to the EC, with longer-term analyses, would be consistent with those activities.

Since its inception, the INES system has provided a good method of informing the media and the public of the safety significance of nuclear events. Until recently, events involving the transport of radioactive materials have been only partly covered by the INES. The 2001 Edition of the INES User's Manual[1] has increased the application of the INES in this important field. The multi-national study[2] advances this application by giving examples of how practical events can be rated on the INES system. In particular, the rating of events by degradation of defence in depth has been expanded in this study. This was considered a useful advancement, since most transport events fall into this category. Transport events differ from nuclear site events in that they can occur in many environments and in particular could lead to consequences in areas of high population density, such as urban areas. This study proposes a method of taking these circumstances into account. Transport events that involve releases of radioactive material into aqueous environments are likely to lead to lower consequences than for similar releases to atmosphere. A novel system of rating events that take place in aqueous environments is proposed in this study.

The proposals in this multi-national study may benefit from a wider discussion among Competent Authorities and other institutions that may have an interest in this topic. The participants in the study therefore recommended that there should be a workshop on this topic held at a European level. The results of the discussions at that workshop would be an input to further material that may be

developed to facilitate the use of the system. In particular, the participants in this study suggest the development of decision trees and tutorial material for this purpose. In response to this recommendation, an EU Workshop was held in London in June 2001 and further guidance developed.

6. CONCLUSIONS

This multi-national study has considered the requirements for notification and evaluation of accidents and incidents involving the transport of radioactive materials. It is recommended that the information supplied to EC is collated, analysed, and form material for periodic feedback to the Competent Authorities of EU Member States and international organisations. This will improve the consistency of reporting and enable lessons to be learned by a wide international audience so that safety in respect to transport can be enhanced.

The latest INES Users Manual[2] includes events involving the transport of radioactive materials to a greater extent than previous editions. This study further enhances that coverage by giving examples on the application of the rating system to practical events. Also, a method of application of rating events that occur in urban and in aqueous environments is recommended.

It was recommended that a workshop should be held to inform, discuss and improve the system of notification and of rating events included in this study. Following this recommendation an initial Workshop was held in London in June sponsored by DGTREN.

7. REFERENCES

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