CRITERIA FOR A TRANSPORT EVENT SCALE

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SUMMARY

Events involving the transport of radioactive material may occur in public areas and frequently receive significant media and public attention. The International Nuclear Event Scale (INES) is widely used for nuclear emergencies but it is mainly associated with events at fixed installations: transport for the nuclear industry has however always been within its scope.

Transport operations and systems have been considered in order to develop criteria appropriate to the levels on the International Nuclear Event Scale. The proposed criteria for the scale have been discussed with some competent authorities and international organisations. Improvements have been made and the criteria continue to be developed to facilitate broad acceptance. Examples of past transport events are being used to test the application of the scale. It is preferable to expand INES to fully encompass transport.

INTRODUCTION

It is important to have methods available of communicating to the public the safety significance of events occurring during the transport of radioactive material. The International Nuclear Event Scale (INES) is mainly concerned with nuclear installations: it has been widely used and reported (INES, 1992). Most consignments of radioactive material are for industrial and medical uses. Radioactive material transport generally takes place in public places and may be in any part of the world; in accident conditions there is a potential hazard to the public. Therefore there is a need for a consistent means of reporting transport events.

The most important parts of an event scale are the criteria associated with the different levels. For example, radiation exposure, release quantities, and other consequences. These factors have been examined in detail and criteria developed appropriate to transport but consistent with the existing INES. This work has been funded by DG XVII of the European Commission and builds on an earlier study (Ringot C., 1994).

TRANSPORT OPERATIONS

The majority of transport movements are of packages of radioactive material for medical and general industrial use. The nuclear fuel cycle only accounts for a small percentage of the total number of packages. Most packages are manually handled and start their movement by road, then possibly by air, sea or rail: other packages require remote handling due to their weight. At least part of road and rail travel will be through urban areas with members of the public in close proximity to the packages of radionuclides.

Radioactive materials are transported world wide in different types of container and by all modes of transport. Transport events arise mainly off-site and they can occur in public areas. All types of radioactive material may be involved in any mode of transport. The consignor has a duty to prepare the package for safe transport but there are some cases where the consignor has not adequately fulfilled this responsibility particularly in the transport of sources for industrial radiography. Information on transport events in Member States of the European Union (Lombard J. et. al., 1990; Hughes J.S. and Shaw K.B.,1996) shows that some of the most significant events have involved industrial radiography sources transported by road.

INTERNATIONAL NUCLEAR EVENT SCALE

The International Nuclear Event Scale (INES) has been in operation for a number of years: the range of the scale is from 0 to 7. There are four accident levels, three for incidents (including level 1 anomaly) and a below scale point. The scale takes account of on-site effects, off-site effects and degradation of defence in depth. The off-site and on-site impact criteria are detailed together with defence in depth considerations. Table 1 shows an outline of the Scale with some examples.

Table 1. Outline of the International Nuclear Event Scale.

Level	Descriptor	Examples
7	Major accident.	Chernobyl, 1986
6	Serious accident.	Kyshtym, 1957
5	Accident with off-site risk.	Windscale Pile, 1957 Three Mile Island, 1979
4	Accident without significant off-site risk.	
3	Serious incident.	
2	Incident.	
1	Anomaly.	
0	Deviation.	

Transport associated with the nuclear fuel cycle is considered to a limited extent within INES. Minor transport incidents which do not breach the container are rated at level 0. Events where irradiated fuel, plutonium or intermediate level waste are packaged in an unauthorised container are generally rated at level 3. Similar events involving uranium are rated at level 2. Faults in packaging are rated up to a maximum of level 3 by assessing the increased risk of off-site or on-site impact.

EVENT CHARACTERISTICS

Transport operations are world wide and involve all modes of transport. Packages of radioactive materials are frequently carried on passenger conveyances. Transport events may have unique characteristics, for example:

- they could occur in urban or rural areas,
- there could be an increase in external dose rate,
- there could be a local release with some atmospheric dispersion,
- criticality is a consideration for fissile material,
- packages/ shipments could be incorrect,
- packages could be lost,
- emergency response may take some time, and
- full recovery is always attempted.

There are many millions of packages of radioactive materials transported each year within, to and from IAEA Member States. Many such movements are from producers to users or are to and from airports and ports. Packages are designed, manufactured and assembled to meet internationally agreed specifications However emergencies do occur and contingency plans are required.

The varied locations of transport events in public areas and the proximity of emergency response necessitate a strong transport safety culture. Public safety is of prime concern and full recovery from an event is virtually always attempted.

All of the above factors need to be taken into account when considering the criteria for the different levels on an event scale. Consistency with INES is essential but the specific features of transport operations have to be addressed.

TRANSPORT CRITERIA

Packages containing radioactive materials are designed to provide a level of integrity depending upon the quantity and characteristics of the radioactive content. Basic packages are used to transport insignificant materials whereas packages tested to severe accident conditions are required to transport, for example, irradiated nuclear fuel. The order of package integrity from highest to lowest is (IAEA, ST-1, 1996): Type C; Type B; Type A; Industrial; and Excepted.

In transport the main impact is off-site: there may also be some degradation of defence in depth due, for example, to partial loss of shielding. Off-site effects in transport will depend upon the circumstances of the event. For example, the damage to the conveyance, the damage to the package, loss of shielding, radionuclide releases, the location (urban or country) and in some cases the weather.

In a transport emergency the first information generally available is the type of package involved and the severity of any damage. Since the package type is related to the potential for consequences it is possible to identify an upper severity level for a package type or for multiple packages as shown in Table 2.

Table 2. An example showing upper severity levels depending on package type and multiple packages.

Maximum level	Package type
7	-
6	Type C or B packages
5	Single Type C or B package
4	-
3	Type A packages
2	Single Type A package or Excepted packages
1	Single Excepted package
0	-

In the above example it would not be possible for a single package to give rise to a level 6 or 7 classification. However multiple package releases could lead to a level 6 on the event scale. Most packages contain quantities of radionuclides well below the maximum allowed for that package type which will reduce the maximum classification for that particular package.

In many events there will be damage to the conveyance and possibly to the package but with no radiological consequences. If a release has occurred or there is loss of shielding then the radiological consequences will depend on many factors including: the activity involved , the duration of any release, the location of the event and the prevailing conditions. Information on quantities of radionuclides released and on radiation doses will take time to collect and analyse. Once this has occurred it is then possible to assign a scale level based on atmospheric releases as shown in Table 3. The radiological consequences will be dependent upon the population distribution in the vicinity of the event. Therefore a factor has been included to differentiate between consequences in urban and country areas. However, the magnitude of this factor and its application are still being considered.

Table 3. Examples of atmospheric releases from transport packages.

Level	Release quantities: Urban area (public in close proximity)	Release quantities: Country area (public remote from event)
7	-	-
6	$> 1{,}000\ A_2$	-
5	$>10 < 1{,}000\ A_2$	$> 1{,}000\ A_2$
4	$> 0.1 < 10\ A_2$	$> 10 < 1{,}000\ A_2$
3	$> 0.001 < 0.1\ A_2$	$> 0.1 < 10\ A_2$
2	$< 0.001\ A_2$	$> 0.001 < 0.1\ A_2$
1	-	$< 0.001 A_2$
0	-	-

The A_2 value is the maximum activity of a radionuclide allowed in a Type A package. The quantities in Table 3 are not package contents but actual atmospheric releases from packages. In the modelling of Type A package contents, for the inhalation pathway, it is assumed that the overall intake is 10^{-6} of the package contents with a resultant maximum exposure of 50 mSv.

Transport accidents may result in the loss or partial loss of package shielding. There may be no atmospheric release from the package but possibly an increase in the external dose rate leading to exposure of persons in the immediate vicinity. In such cases only a few people are likely to be exposed. Table 4 is an example of the classification for the local exposure to an individual from an unshielded source.

Table 4. An example of the classification for an individual exposure from an increase in external dose rate.

Level	An individual exposure (mSv)
7	-
6	-
5	> 1,000
4	> 50 < 1,000
3	> 1 < 50
2	> 0.05 < 1
1	-
0	-

Additional to the package built-in safety are a number of specific controls. There is therefore a defence in depth in transport, the loss of which may reduce the ability of the package to retain its integrity in an accident situation or affect the consequences of an event.

Degradation of defence in depth is an important consideration in transport. In INES this is only a consideration up to level 3 and the same condition is applied to transport. A number of factors may be considered that can increase the potential for consequences, for example, incorrect package, damage to the conveyance, loss of tie-downs and minor damage to the package. Other possibilities are incorrect values of Transport Index, excessive conveyance dose rates or wrong activity content.

In transport, defence in depth may apply to the transport controls required for the package on the conveyance. For example tie-downs, shock absorbers and special handling procedures. The loss of such additional controls may not directly affect the package but may increase the consequences from a subsequent accident. In some events an incorrect package has been used: this may in itself have consequences and is likely to be important in the event of an accident. The degradation of defence in depth as given in Table 5 shows the scale levels appropriate to the given circumstances. Package activity content is an important factor in such considerations and three ranges of activity are listed.

Table 5. Degradation of defence in depth.

Safety controls available.	Classification corresponding to package activity		
	< 0.01 A_2	0.01- 1 A_2	> A_2 or fissile
Full.	0	0	0
Lack of one control (e.g. tie-downs).	1	1	1
Lack of more than one control (e.g. tie-downs and shock absorbers).	1	2	2
Incorrect package.	1	2	3
Loss of package.	1	2	3

The level for lost packages as shown in Table 5 is appropriate to the immediate notification of loss of the package; any further rating would depend upon subsequent events and consequences.

The duration of any emergency action is another parameter to be considered in transport accidents and emergencies. Many transport events occur in public areas and the length of the emergency response is therefore important. Table 6 is an example of such a classification.

Table 6. Preliminary classification based on emergency response.

Level	Classification based on duration of emergency response (days)
7	-
6	-
5	-
4	-
3	> 7
2	> 1 < 7
1	< 1
0	-

The duration of emergency response may be unrelated to the radiological consequences but has considerable significance for the public and the media.

EXAMPLES

Data on transport accidents and incidents have been published nationally and internationally (Lombard J. et.al.,1990; Hughes J.S. and Shaw K. B., 1996; IAEA, 1997). The release of radioactive material from any package is rare and none has been found for Type B packages. The most significant radiological consequences have been to industrial radiographers resulting from incorrectly prepared packages. Table 7 shows examples of the possible classification of transport events.

Table 7. Examples of the possible classification of transport events.

Level	Example
7	-
6	-
5	-
4	Industrial radiographer (1 package,1 person highly exposed)
3	Mont Louis (multiple packages of uranium hexafluoride damaged)
	Technetium generators (several packages and persons potentially contaminated)
2	Lailly en Val (1 package of irradiated fuel overturned, several persons in vicinity)
1	Apach (derailment, packages of irradiated fuel not damaged)
0	-

In the case of the industrial radiographer only one person was exposed to a single package but the radiation dose was about 1 Sv. Mont Louis was a cargo ship carrying uranium hexafluoride cylinders and was involved in a serious collision: degradation of defence in depth leads to a level 3 classification. The technetium generator event involved a collision between a train and a trolley carrying the generators: one package was crushed. At Lailly en Val a road transporter left the road and an irradiated nuclear fuel flask was slightly damaged. The Apach event involved the derailment of three wagons carrying irradiated nuclear fuel: there was no damage to the packages.

DISCUSSION

The development of acceptable criteria for transport as part of an international event scale requires detailed discussions with interested authorities. Initial proposals, as described above, have been prepared and discussed with some authorities. These proposals are now being developed and will be improved and discussed further on a wider basis. It is important to achieve a consensus in this area.

The International Nuclear Event Scale is widely recognised and used in the event of a nuclear accident. A separate transport event scale could lead to misunderstandings and it is preferable to expand the current INES to more fully encompass transport.

Degradation of defence in depth is an important consideration in transport. The scale level will depend upon the package activity and on the lack of controls. Lost packages are important in transport situations but the potential for consequences can be variable. A lost package may be classified according to its content up to a maximum level of 3. The classification could be revised once the package was recovered or the full consequences known.

Further proposals are also under consideration. For example, how to take account of the chemical effects of uranium hexafluoride. If uranium hexafluoride is involved in an emergency then the potential chemical effects may be important. The International Nuclear Event Scale is based on radiological consequences and any chemical effects are considered separately. For transport a similar position is recommended with a separate scale available for the chemical hazard of uranium hexafluoride.

CONCLUSION

The proposed criteria for transport events are being discussed with Competent Authorities and International Organisations: the success of the system depends upon its acceptance and subsequent use. Consultation with appropriate authorities is important so that the scale development is based on broad agreement. In order to facilitate discussions, examples of criteria for transport events have been prepared and discussed. These criteria will be further developed and discussed internationally. Examples of transport events have been used to demonstrate the effectiveness of the scale. A decision tree will further assist in the application of the system to future transport events.

The main parameters for the classification of transport events have been identified and preliminary values assigned. However these values require detailed consideration and development at an international level before they are applied. It is preferable to expand the current International Nuclear Event Scale to more fully encompass transport.

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