



How safe is safe enough?

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ABSTRACT / INTRODUCTION

The IAEA Regulations for the Safe Transport of Radioactive Material, were historically established with the objective to reduce the probability that persons be exposed to unacceptable doses due to normal operation or accident situations during transport of radioactive material.

Based on the International Basic Safety Standards for Protection against Ionizing Radiation (BSS), the definition, which was adopted for an unacceptable dose for an accident situation, is the excess of the maximum dose limits permissible in a single year for the occupational exposure of a worker in the BSS.

Concerning the severity of accident situations, it has always be clearly stated that the objective of the tests for demonstrating ability to withstand accident conditions of transport was not to cover every accident condition, but solely most of them. The last available evaluations regarding the rate of accidents which are covered by the standardised accident conditions of transport defined in the IAEA Regulations give a range of about 80%, plus or minus 15% which depends on transport mode and studies.

Consequently, slight variations in the capabilities of the packages to meet the specified performance would probably not have significant consequences on the protection level in case of accident.

In the assessment of the compliance with the regulations, the tendency of experts, taking advantage of the enhanced performances of computer calculation codes, is to ask more and more calculations, with more and more accuracy, leading to more and more restrictions. Consequently, cost and delay are considerably increased without any evidence of an equivalent effect on the level of protection.

This paper will initiate a reflection on the general objectives and principles when implementing the Regulations, in such a way that demonstrations remain cost effective, taking into account evolution of the techniques and a high level of safety.

1. BASIS OF THE IAEA REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL

The principles developed by the IAEA in its "Regulations for the Safe Transport of Radioactive Material" to limit the probability that persons be exposed to unacceptable doses due to normal operation or accident situations during transport of radioactive material, were the followings:

- three general severity levels were defined to characterise the performance of the packages :
 - routine conditions of transport (incident free);
 - normal conditions of transport (minor mishaps);
 - accident conditions of transport.
- whatever the hazard of its radioactive content, a single package should not :
 - lead to exposures of the workers or the members of the public higher than those defined in the Basic Safety Standards [3] for normal situations, when subjected to routine conditions of transport or normal conditions of transport (1 mSv/y for public, 6 or 20 mSv/y for a worker according to its category) ;

- lead to exposures of the workers or the members of the public higher than those defined in the Basic Safety Standards [3] for occupational exposure of a worker in a single year (50 mSv), when subjected to accident conditions of transport;
- the type A package was defined as a package able to withstand routine and normal conditions of transport but not the accident ones;
- the type B package was defined as a package able to withstand routine, normal and accident conditions of transport;
- the special form radioactive material was defined as an indispersible solid radioactive material;
- A_1 was defined as the maximum activity of special form radioactive material in a Type A package;
- A_2 was defined as the maximum activity of radioactive material, other than special form radioactive material, in a Type A package.

The Q- SYSTEM: pragmatic but approximate.

To justify the A_1/A_2 values, as listed in the Regulations for the Safe Transport of Radioactive Material [1], a lot of pragmatic, but approximate, or even arbitrary, assumptions have been made. For illustration, here are some of these assumptions taken from the “Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material” [2]:

- “The median accident was defined as one which leads to complete loss of shielding and to a release of 10^{-3} of the package contents in such a manner that 10^{-3} of this released material was subsequently taken in by a bystander;”
- “A person is unlikely to remain at 1 m from the damaged package for more than 30 min.”

It can be understood at this stage, that this situation is a standardised one. On the one hand, most of real exposition situations will probably be less severe than this one, but on the other hand, there is no evidence that this standardised situation is the most severe one.

Looking just at these assumptions, the evidence is that the definition of A_1/A_2 as the quantification of radioactive hazard comprises approximations.

Accident conditions of transport: accident tests equivalent to very severe accident but not necessarily all conceivable accidents

Developing its approach, based on the Q-System, it was necessary for IAEA to standardise what is a “very severe accident”.

Tests were developed as producing damage to the package equivalent to that which would be produced by a very severe accident and they were also stated in terms which provided the engineering bases for the design.

Nevertheless, it was recognised that these tests, despite their severity, do “not necessarily” be equivalent to “all conceivable accidents”; it is understood that some “conceivable accidents” could produce higher damages than the tests for demonstrating ability to withstand accident conditions of transport.

In conclusion, the tests do not cover all conceivable accidents, and it is stated in the Advisory Material [2] that, “since analysis is an acceptable method of qualifying designs, the tests were prescribed in engineering terms which could serve as unambiguous, quantifiable input to these calculations.” As a matter of fact, these tests represent more a “standardised very severe accident” than “very severe accidents” .

A conclusion about the principles adopted by the IAEA, is that the quantification of the effects of a release of radioactive material, as well as the characterisation of a very severe accident, have been made by a conservative approach but also an approximate one.

2. SOME PRACTICES OF EXPERTISE BY COMPETENT AUTHORITIES

Definitions of requirements within the regulations, which vary according to the conditions of transport and to the type of package, lead to misinterpretation of the regulations

According to the type of package or the considered situation, some prescriptions are written in a different way, and lead to various interpretations according to who is reading them.

- First example is the case of containment prescriptions for normal conditions of transport:
 - the containment system **shall retain** its radioactive contents under a reduction of ambient pressure to 60 kPa ([1], para. 643);
 - the package **would prevent loss or dispersal** of the radioactive contents if subjected to the tests for demonstrating ability to withstand normal conditions of transport ([1], para. 646);
 - the package **would restrict the loss** of radioactive contents **to not more than 10^6 A2 per hour** ([1], para. 656);

Considering these differences in writing, addressed to different situations or package types, it could be honestly considered that different criteria could be used to demonstrate the compliance to these different specifications. But in the fact, it could be observed an existing pressure coming from competent authority experts to use the most restricted interpretation, the 10^6 A2 per hour criteria.

- Second example is that of the ambient conditions of temperature to take into account for packages and means of transport.

For Type B(U) packages, to demonstrate that the heat generated by the contents cannot adversely affect the package, the ambient temperature shall be 38°C and solar insulation conditions shall be those prescribed in table XI of the Regulations for at least one week of duration ([1], para. 651). This prescription clearly concerns the package performances in a given situation, and is independent from the means of transport and from where the transport takes place.

In case of heat flux due to the radioactive contents greater than 15 W/m² at the surface of the package, a prescription is made to the consignor to provide the carrier supplementary requirements including any special stowage provisions for the safe dissipation of heat ([1], para. 555 and 565). This prescription clearly concerns the means of transport at the time and at the place of the shipment. No criteria and no conditions about the ambient temperature are prescribed for this last prescription.

At this stage, for the means of shipment, it could be understood that the only requirement is that the carrier shall verify (or guaranty) that safety is not impaired during the shipment due to the presence of equipment which can lead to reduce the heat dissipation capabilities of the shipped packages. This could be demonstrated taking care of the actual “ambient temperatures that are likely to be encountered in routine conditions of transport” ([1], para. 615) and /or taking into account special features like refreshment/cooler systems. In fact, the practice from the competent authority experts, taking advantage of the prescription requiring that “any features added to the *package* at the time of transport which are not part of the *package* shall not reduce its safety » ([1], para. 611), is more and more that to consider only the ambient temperature as required for the packages.

This extreme position leads to reduce the allowed heat power of the shipped package. From the one hand, the choice of a mean of transport is related to the effective route, and, at the time of planning of the shipment, when section V of the regulations has to be followed, the actual conditions of temperature can be well appreciated. Those actual conditions of transport are generally far from those prescribed to demonstrate the safety of the package design. From the other hand, in case of ambient conditions going above those foreseen before shipment, procedures can easily be put in place to reduce the effects of these means of shipment in such a way that the safety of the shipped packages is not impaired (venting or opening of the means of shipment for example).

These two examples show how the lack of criteria is interpreted in a restrictive way by competent authority experts when, from the point of view of the regulators, this lack of criteria has for objective to allow the free choice of these criteria.

3. PROPOSAL FOR GENERAL OBJECTIVES AND PRINCIPLES FOR IMPLEMENTATION OF THE REGULATIONS

General objectives and principles when implementing the Regulations should be such that demonstrations remain cost effective, taking into account evolution of the techniques and a high level of safety.

The objective of the regulations – to protect persons, property and the environment from the effects of radiation during the transport of *radioactive material* – is achieved by (see [1], para. 104):

- (a) containment of the *radioactive contents*;
- (b) control of external *radiation levels* ;
- (c) prevention of criticality; and
- (d) prevention of damage caused by heat.

The regulations make a graded approach leading to three general severity levels (see [1], para. 106):

- (a) routine conditions of transport (incident free);
- (b) normal conditions of transport (minor mishaps);
- (c) accident conditions of transport.

A better definition of what are the ambient conditions of these transport conditions should be specified in the regulations:

- Routine conditions of transport: ambient temperatures and pressures should be those that are “likely to be encountered” during transport (see [1], para. 615);
- Tests for demonstrating ability to withstand normal conditions of transport (minor mishaps during shipment): ambient temperatures and pressures should be those of the routine conditions of transport,
- Tests for demonstrating ability to withstand accident conditions of transport (severe accident): ambient temperatures and pressures should be those of the routine conditions of transport.

Within the ambient temperatures and pressures of the routine conditions of transport, two kinds of situation can be distinguished:

- one for the more probable situations taking into account the real use of the package (for example, large packages developed for the shipment of irradiated nuclear fuel between nuclear power plants (NPP) and reprocessing or storage facilities within Europe are not likely to travel at altitudes greater than about 1000 m high, therefore the lowest ambient pressure they could be exposed is higher than 60 kPa);
- one for the less probable situations (or extreme situations) taking into account a wider range of temperatures and/or pressures (for example an ambient pressure of 60 kPa , for large packages developed for the shipment of irradiated nuclear fuel between NPP and reprocessing or storage facilities within Europe, which are not likely to travel at altitudes greater than about 1000 m high, is an extreme situation).

The margins required for simplification of the demonstrations or for taking into account defaults of the real packages should be adapted to those two kinds of situation:

- demonstration based on a nominal package (package dimensions and characteristics at mean values and not at extreme ones) should be considered as sufficient for the less probable situations;
- on the contrary, for the more probable situations, it should be required to take into account extreme values of dimensions and characteristics to demonstrate that the safety of the package is not impaired.

On the same way, a discussion could be made on the necessity to be strictly in compliance with the more stringent criteria for the less probable situations. The proposal could be made to allow less restrictive criteria for the lowest probable situations, and keep the most restrictive ones to the most probable situations.

This approach can also be applied to accidental situation. When it can be shown that the probability of occurrence of an accident situation is very low, less stringent criteria should be allowed. For example, when angles of orientation before the drop tests have to be so precise that it became difficult to perform the tests, it should be recognised that the probability that such a situation occurs is so low that there is no need to comply strictly with the criteria.

Unrealistic situations should be turned down (for example reduction of ambient pressure to 60 kPa should not be cumulated with an ambient temperature of 38°C (60 kPa correspond to an altitude of 4000 m high, and maximum ambient temperature at this altitude is generally about or less 0°C).

CONCLUSION

In the assessment of the compliance with the regulations, the tendency of experts, taking advantage of the enhanced performances of computer calculation codes, is to ask for more and more calculations, with more and more accuracy, leading to more and more restrictions. Consequently, cost and delay are considerably increased without any evidence of an equivalent effect on the level of protection.

A better definition of the objective of the regulation through an adaptation of the criteria to the situations, taking into account their probability of occurrence, could help both applicants and competent authority experts to be more efficient for the safety at lower cost and delay.

This is an appeal to come to one's sense!

REFERENCES

- [1] - Regulations for the Safe Transport of Radioactive Material – 1996 Edition (Revised) – No. TS-R-1
- [2] - Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material – No TS-G-1.1
- [3] - International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources – Safety Series No 115 – IAEA, 1996