On the Compliance of Type A Packages With the Requirements of the Regulations

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INTRODUCTION

In the national and international regulations on the transport of radioactive materials, which are based on the IAEA Regulations for the Safe transport of Radioactive Material, requirements are given for the type A packages. There is, however, no official type testing and competent authority approval necessary for these type of packages. It is the responsibility of the consigner and the manufacturer of the packagings to comply with the regulations.
In the Netherlands the competent authority wanted to get more information, whether the type A packages used for the transport of radioactive material fulfil the requirements as given in the regulations. Therefore the TNO Packaging Research Institute was asked to carry out a study with the aim to make an inventory on the kind of type A packages in use in The Netherlands for the transport of radioactive material and to investigate whether they comply with the regulations.
After performing the inventory phase a detailed test procedure was developed, based on the test program for type A packagings as given in the regulations. This appeared te be necessary in order to be able to perform the tests in a reproducable way.
Then a selection was made from the various kinds of packagings, which were tested according to this test procedure. Conclusions were drawn with respect to the compliance of type A packages with the requirements of the regulations and recommendations given for improvement.

INVENTORY

In this inventory phase firstly a comparison was made between the national regulations for land, sea and air transport (which are in principle identical to the corresponding international regulations) for radioactive materials and the IAEA Regulations
for the Safe Transport of Radioactive Materials 1979 (1973 Revised

Edition As Amended). It was concluded, that the parts with respect to the type A packages were identical so that any of these regulations can be used as a basis for the development of a more detailed test procedure. There is, however, one exception: in the present regulations for land transport the additional requirements for type A packages for liquids are not applicable when sufficient absorbent material is present.
A more detailed study of the test procedures as described in the regulations showed, that it was necessary to develop a more detailed test procedure for clarification purposes and in order to be able to perform the tests in a more reproducable way.
Secondly an inventory was made concerning the kind of type A packages in use for transport. Two main categories can be distinguished: packages used for the transport of radio-isotopes for medical, research and industrial applications and packages used for the transport of radioactive waste.

TEST PROCEDURE

A detailed test procedure was developed for type A packagings, based on the test program as given in the regulations. Here the results of an earlier study (Edling et al) were taken into account.
A summary is given of the most important matters, which were introduced in this procedure.
1. The criterion loss or dispersal of the radioactive contents after the performance of the tests should be quantified. As the contents was liquid or solid substance it should be established if any of this contents leaks as a result of the tests. It was decided that a sufficient sensitive way would be the addition of a finely divided, water-soluble colourant to the contents. Rhodamine B appeared to be a suitable substance and this was used in a concentration of 0.1% for solids (if granular) and 0.2% for liquids. Detection with moistured filtration paper after the tests will lead to a detection limit of less than some milligrams of solid substance and less than 0.1 ml of liquid.
2. It has to be established, how the criterion loss of shielding integrity which would result in any increase of the maximum radiation level at the external surface of the packaging should be determined. In preliminary experiments where radiation intensities were measured by inserting radioactive sources in the packagings in tested and original packagings it turned out that it was very difficult to detect small differences in intensities in this way. Moreover problems occurred with inserting a source in a tested packaging in a safe way. The alternative of performing the experiments with radioactive substances was not feasible on a short term because of the necessary licences needed. It was thus decided, that the fulfilment of this criterion would be established on the basis of calculation methods. For this method ^{192}Ir was chosen as a reference substance. For this substance the transmission data for lead are known (ICRP Publication). Before performing the tests the

maximum value of T_r/r^2 is determined, where T_r is the relative transmission of radiation from ^{192}Ir through a certain thickness of shielding material and r is the distance between the source and the surface of the packaging. After the tests on the basis of movements of the radioactive source and/or the containment system and damage of the containment system and/or the shielding material the maximum value of T_r/r^2 on the surface of the packaging is again determined. The ratio of radiation intensity δ is then defined as (T_r/r^2)after divided by (T_r/r^2)before.

3. Besides the test requirements there are also general requirements for packages for radioactive materials and specific requirements for type A packages. It was decided to bring these requirements in the form of a checklist. This checklist was assayed for every type of packaging investigated, but this was done only globally also because sometimes the requirements are subjective.
4. It was decided to set the number of samples per test part in principle at 3 in order to have some impression of the variation in the test results. It can, however, for specific reasons occur, that less samples can be made available or that some tests have to be performed on the same sample.

TESTING OF TYPE A PACKAGINGS

1. Selection of packagings

Four types of packagings were selected for testing: two in the first category and two in the second category with in both categories packagings for liquids and solids.
In the first category for solid radioactive substance a packaging for a dry molybdenum generator was selected. This packaging consists of radioactive substance adsorbed on an (inert) carrier in a glass tube. The tube is surrounded by a lead pot and a tinplate can which forms the containment system. The glass tube is connected to a system for soluting radioactive substance with a liquid. The containment system is placed in a fibreboard box with an expanded polystyrene interior.
In the first category for radioactive liquids a packaging for the transport of injectable radioactive liquid was selected. This packaging consists of a glass bottle surrounded by expanded plastic. This is surrounded by a lead pot with a lead lid which is taped on the pot. The lead pot is placed in a tinplate can with expanded plastic interior forming the containment system. The can is placed in a fibreboard box fixated centrally by a fibreboard interior.
In the second category for solid radioactive waste a 90 l open head steel drum with lever action closure was selected. The wall thickness is 1 mm all round. In the second category for liquid

radioactive waste a 30 l composite steel drum with polyethylene inner receptacle centrally placed in the 90 l open head steel drum was selected. The 30 l drum has a UN-mark indicating that it was type-tested for the transport of dangerous goods. The 30 l drum is fixated by a metal interior, whereby empty room is filled up with vermiculite.
For both packagings for radioactive waste the 90 l drum forms the containment system.
Except for the dry molybdenum generator, water with Rhodamine B was used as a liquid and silver sand or vermiculite with Rhodamine B as the solid substance.

2. Testing of packagings

The four types of packagings were tested according to the test procedure as described in the regulations and as outlined in the chapter on test procedures. The tests consisted of a drop test with a drop height of 1.2 m and additionally 9 m for packagings containing liquids; a penetration test with a drop height of 1 m and additionally 1.7 m for packagings containing liquids; a compression test and for the fibreboard packagings a drop test on each of the corners of the box with a drop height of 0.3 m. For the fibreboard boxes the tests were preceded by a water spray test. The drop tests (except the 0.3 m test) and the penetration tests were performed in such a way that the maximum damage would be obtained. These positions were established by preliminary tests or by judgment.

3. Results

All results are summarised in Table 1.

The following comments can be made:

Packaging for dry molybdenum generator.
The packaging does not fulfil the general requirement of possessing means for manual handling. From table 1 it appears, that no leakage occurs. A slight increase of the calculated radiation at the surface occurred in some cases because of a slight movement of the containment system because of the tests.

Packaging for injectable radioactive liquid
In this packaging no absorbent material appeared to be present. In one instance in the penetration test with a drop height of 1.7 m the glass bottle broke. However, there was no leakage outside the containment system. In several tests a rather large increase of the calculated radiation at the surface was observed, which is also caused by the moderate water resistance of the fibreboard box, leading to large deformations in the compression test.

Packaging	Drop test						Compression test		Penetration test			
	0.30 m		1.20 m		9.0 m				1.00 m		1.70 m	
	L	δ	L	δ	L	δ	L	δ	L	δ	L	δ
I	no	100%	no	104%	-	-	no	107%	no	100%	-	-
I	no	100%	no	104%	-	-	no	107%	no	100%	-	-
I	no	100%	no	104%	-	-	no	107%	no	100%	-	-
II	no	100%	no	108%	no	100%	no	490%	no	270%	no	780%
II	no	100%	no	110%	no	100%	no	490%	no	130%	no *1	780% *5
II	no	100%	no	110%	no	270%	no	490%	no	170%	no	195%
III *3	-	-	yes	100% *5	-	-	*2	100%	no	100%	no	100%
III *3	-	-	no	100%	-	-	*2	100%	no	100%	no	100%
III *3	-	-	no	100%	-	-	*2	100%	no	100%	no	100%
IIIA *3	-	-	yes	100% *5	-	-	-	-	-	-	-	-
IV	-	-	*4	*4	no *1	130% *5	*4	*4	*4	*4	*4	*4

Table 1. Test results for type A packagings

Packaging I = packaging for dry molybdenum generator
II = packaging for injectable radioactive liquid
III = packaging for solid radioactive waste (21 kg)
IIIA= packaging for solid radioactive waste (60 kg)
IV = packaging for liquid radioactive waste
L = leakage from containment system
δ = ratio of radiation intensity

*1 leakage within containment system
*2 packaging tested without contents
*3 assuming that the partition of radioactivity is not changed because of the tests
*4 judgment based on results for packaging III
*5 assuming that there was no leakage

Packaging for solid radioactive waste
The leakage which was observed after the drop test can be ascribed to the impact of the drop; no further leakage was observed. The deformation of the drums was so minor, that no radiation increase is calculated because of this effect. It is supposed, however, that the partition of radioactivity in the drum is not changed because of the tests. It is not known whether this condition will be met in practice. The penetration test lead only to minor damage to the steel drum.

Packaging for liquid radioactive waste
Only one sample was available. It was decided, that the 9 m drop test would be performed with this sample, while from preliminary experiments with similar packagings it could be concluded that the flat drop on the side would lead to maximum damage. Leakage was observed from the inner packaging, however, no leakage from the outer drum (the containment system) was observed. From the results of the other tests with the drum for solid radioactive waste it was concluded, that the compression and penetration tests would not lead to leakage of the inner packaging or radiation increase at the surface. The same conclusion goes for the 1.2 m drop test with the remark, that a slight increase in radiation is possible because of the deformation of the outer packaging.

DISCUSSION AND CONCLUSIONS

The results show, that the requirements for the type A packages are not always met for the packagings investigated. Both leakage and radiation increase were observed. It must be noted, however, that the criterion for radiation increase is not practical. Even slight movements of the surface of the packaging in relation to the radioactive source will lead to a radiation increase. As this can not be avoided in practice and is very difficult to detect by measurements, some criterion more than 0 % should be set. The new criterion of the IAEA Regulations (1985) (20%) is thus an improvement, but from this study it is hard to say whether it is the optimum figure. Further it could be considered whether there should be a relation between the percentage and the radiation level at the surface of the packaging.
It is clear, that reconsideration of some designs will be necessary. It might also be worthwhile to review the general requirements as these are not practical in all cases. Also it could be examined if the requirements concerning the performance with decreased outer pressure are fulfilled, because no data in this respect could be obtained for the packagings investigated.
Further it appeared to be necessary to develop a detailed test procedure in order to be able to perform the tests in a unambiguous and reproducable way. It might be worthwhile to develop (international) standards in this field.

There was the impression, that the packagings had not always been tested in a systematic way in order to show that they meet the requirements. The availability of test facilities and detailed test procedures together with the introduction of quality assurance programmes should improve the situation with respect to the compliance of type A packages with the requirements of the regulations.

REFERENCES

ICRP Publication no. 33, Protection against ionizing radiation from external sources used in medicine (1982).

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