Romanian Experience on Packaging Testing

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ABSTRACT

With more than twenty years ago, the Institute for Nuclear Research Pitesti (INR), through its Reliability and Testing Laboratory, was licensed by the Romanian Nuclear Regulatory Body– CNCAN and to carry out qualification tests [1] for packages intended to be used for the transport and storage of radioactive materials.
Radioactive materials, generated by Romanian nuclear facilities [2] are packaged in accordance with national [3] and the IAEA's Regulations [1, 6] for a safe transport to the disposal center. Subjecting these packages to the normal and simulating test conditions accomplish the evaluation and certification in order to prove the package technical performances. The paper describes the qualification tests for type A and B packages used for transport and storage of radioactive materials, during a period of 20 years of experience. Testing is used to substantiate assumption in analytical models and to demonstrate package structural response. The Romanian test facilities [1,3,6] are used to simulate the required qualification tests and have been developed at INR Pitesti, the main supplier of type A packages used for transport and storage of low radioactive wastes in Romania. The testing programme will continue to be a strong option to support future package development, to perform a broad range of verification and certification tests on radioactive material packages or component sections, such as packages used for transport of radioactive sources to be used for industrial or medical purposes [2,8].
The paper describes and contain illustrations showing some of the various tests packages which have been performed during certain periods and how they relate to normal conditions and minor mishaps during transport. Quality assurance and quality controls measures taken in order to meet technical specification provided by the design there are also presented and commented.

INTRODUCTION

The IAEA's Regulations for the Safe Transport of Radioactive Material gives specific requirements for packages and laying down detailed requirement which appropriate to the degree of hazard represented by the material taking into account its form and the quantity of it being carried. The objective is to protect persons, property and the environment [1,2] from the effects of radiation during the transport of radioactive material. Safety in the transport of radioactive material [8, 9, 10] is dependent on the appropriate packaging for the contents being shipped, rather than operational and/or administrative actions required on the package. It is assumed that a package may be damaged in a severe accident and a fraction of the contents may be released [6, 7].

Type A packages must be designed to satisfy all of the requirements imposed on an IP-3 package, and also to meet additional test requirements if the radioactive content is in liquid or gaseous form [2,3]. They must also satisfy stringent additional dimensional, ambient environment, internal pressure and containment specifications which are not imposed on industrial packages.
The packages, when tested to this requirements, should prevent:

- loss of dispersal of the radioactive contents, and
- loss of shielding integrity which result in more than a 20 % increase in radiation level at any external surface of the package

The packages should be designed so that any additional shielding which is provided shall be able of withstanding the static and dynamic stresses resulting from normal handling and/or routine conditions of transport to prevent a loss of shielding which would result in more than a 20% increase in the radiation level at any external surface of the package. The criteria for successful testing of some packages has used the phrase "*would prevent loss or dispersal*". The maximum allowable leakage rate for normal transport of Industrial and Type A packages has never been defined quantitatively in the Regulations but has been specified in a practical sense. The paper presents a review of the qualification tests performed for the type A packages developed within INR and intended to be used for storage and transport of radioactive materials, in Romania.

TEST FACILITIES

All qualifications (type) tests for type A waste packages were carried out internally by the Reliability and Testing Laboratory of the Institute for Nuclear Research Pitesti [3,4], where all the facilities for testing and quality control have been developed. The developed tested facilities support design, evaluation and certification of RAM transport packages. INR Pitesti is the unique manufacturer for radwaste packages (type A and type B, in the future). Romanian test facilities are used to perform and simulate the required qualification tests [2, 4, 5] as well as for type A and type B packages, in the nearest future. Impact testing (free drop testing) of packages up to 1,000 Kg are performed using a 20 t crane and special additional tools (welding cutter or other release mechanical methods). The instrumentation chain contains sensible ancillary electronic instruments (scopes, multimeters, power supply, etc.) and proper dedicated transducers which covers all the necessary data acquisition tools during package testing. Data collected were analyzed via high speed computers and the result were displayed or printed. The experience on testing is proved during RAM transportation to the disposal site.

QUALIFICATIONS (TYPE) TESTS OF PACKAGES USED FOR STORAGE AND TRANSPORT OF LOW LEVEL ACTIVITY RADIOACTIVE WASTES

The qualification tests for radioactive waste packages, have been performed in accordance with Technical Specifications (TS) covered by Romanian Standards [2, 3, 8] and have to comply to the IAEA's Regulations for Safe Transportation [1, 6].
Within INR Pitesti, have been developed several type A packages to be used for storage and transport radioactive materials. Among them there are the followings type A packages:

- ABBD-1 is a type A package used for final storage (30 years) of low level activity wastes up to 6.07GBq (0.164Ci)/drum. The drum is manufactured from 1mm thick mild steel and has the following dimensions**: height:** 915 ± 10mm, **diameter:** 600 ± 5mm, **volume:** 220liters, **total content weigh**t: 300÷600 Kg, (1994);

- Type II package used for temporary storage of solid low level activity wastes at CANDU NPP Cernavoda is manufactured from 1.5mm stainless steel, with a removable lid and a sealed tool; dimensions: **inner diameter**: 570mm, **max. diameter**: 600mm, **height**: 905mm, **weight** (empty): 35 Kg; volume: 220 liters; (1995);

- BON-1 220 liters type A packages, intended to be used for temporary storage of low and medium level of radioactive compacted solid radwaste; dimensions: **inner diameter** 570 ÷1mm, **max. diameter**: 600 mm, **height**: 905 ÷0.7 mm, **volum**e: 220 liters; **weight** (including content): 440Kg; (1997);

- CDF -1 420 liters type A package, intended to be used for final storage of low level radioactivity liquid radwastes; is made from 1.5 mm stainless steel and has the following dimensions: **inner diameter**: 720÷7mm, outer **diameter**: max. 750 mm; **height:** 1065 ÷ 3mm; volume: max. 420 liters, (1998);

- The drum-D_2O-200-04 – package intended to be used for handling, transport and temporary storage of the heavy water (2004), volume 200 liters.

For carrying out the qualification tests for radioactive waste packages, in accordance with Technical Specifications (INR Standard no. 130/1990), and meeting the IAEA Regulations concerning the number of specimens subjected to the tests (taking into consideration the usage, availability of packaging and cost of an individual package, the materials and methods of construction and the actual test results, together with the low use factor) only one package (drum) was tested for every kind of radioactive waste [1, 3, 9, 10]. It should be noted that the content of the specimen for testing is real radioactive waste intended to be transported and stored .

Test Requirements for Type A Packages

Before certification the packages were subjected to the production tests and qualified for durability to comply with standard requirements for mechanical properties, leaktightness, resistance to corrosion, loading and drop tests [2, 3, 8]. The drum was visually examined and no faults or damages or defects were detected during specific manufacturing controls, such as: welding control, visual inspection, sealing test, etc. With reference to the type A package radioactive waste contents, a selection has been made with respect to the predominance of the activity and to the representatives of the practices and exposures. More than 10 radionuclides with different activities were identified, such as Co-60, Co-58, Cs-137, MN-54, Sb-124, U-238, Nb-95, Cs-134**,** etc., with the following distribution: *Co-60*: 80%; *Co-58:* 18%; *Cs-137*: 0.5%; *Mn-54*: 0.5%. The knowledge of isotopes and their distribution is useful for the assessment of the expected radiological consequences and accident risks [9, 10]. Type A packages must be able to retain their contents or without allowing more than a specified increase in external surface

radiation level and shielding integrity if subjected to: *free drop test, compression and penetration test.* These tests requirements constitute the compulsory minimum specifications for the manufacturer and were performed by the Reliability and Testing Laboratory of SCN Pitesti in accordance with the Romanian [3] and IAEA's Regulations [1, 6], such as:
The free drop test: the test was performed for 2 hours **after** the end of the water spray test and the drum was thus dropped so as to suffer maximum damage; the drop height was *1.2 m.* ***Test pass criteria:*** no rupture of the outer shield, no release the sealing lid and the limits of the release fraction of the package contents, if any, to be within the range of *0.1%* to *1 %*. ***Post test examination criteria:*** after the test the container was subjected to visual inspection and no damage or defects were observed;

Figure no 1 The free drop test for ABBD-1 package

The compression test: the test is intended to ensure that effectiveness of containment, shielding and any spacers are maintained while package is stacked in such a way normally likely to occur during loading, unloading, transport and intermediate storage. Before testing, the drum was subjected to 1 hour water spray test. After two hours the compression test was performed. ***Test pass criteria****:* package to withstand for a period of 24 h at 5 times to its weight. ***Post test examination criteria:*** no damage were observed at the end of the test.

Figure no 2 The stacking test for type II package

The penetration test: the test is intended to demonstrate the capability of the package to withstand the kind of puncture damage which may arise in routine transport, such as: *sharp objects falling on the package, damage from loading hooks, and the like*. ***Test pass criteria:*** no rupture of the outer shield, and the limits of the release fraction of the package contents, if any, to be within the range of 0.1% to 1%**.** ***Post test examination criteria:*** the drum shield was indented about 0.1 mm and the sealing lid was not affected. No release fraction of the content and no other damages were observed.

Figure no 3 The penetration test for type II package

The water spray test have been performed in accordance with the IAEA's Regulations for the Safe Transport of Radioactive Materials [1, 6], para. 721, so the specimen have been subjected to "*a water spray test that simulates exposure to rainfall of approximately 5 cm per hour for at least one hour*".
The 9 m free drop test: the 9m free drop test was performed for packages used for transport and storage of liquids radwaste [2, 8]. The simulated contents was water. ***Post test examination criteria***: the yielding of the shells resulted in a 1.2% increase in the diameter of the test specimen at this location (this increase was also indicated by permanent strain measured by means of strain gauges); post test helium leak testing indicated that the specimen on both ends remaining leak tight. No other severe damages were observed.

Figure no. 4 The 9m free drop test for CDF-1 package designated to liquid wastes (before and after)

It is assumed that a type A packages may be damaged in a severe accident and that a fraction of their contents may be released. Therefore the Regulations prescribe limits on the maximum amounts of radionuclides that can be transported in such packages [1, 3, 6]. These limits ensure that in the event of a release the risks from external radiation or contamination are maintained to a low level. The qualification program are conclusive enough to qualify the container as a reliable one, suitable for conditioning, temporary or final storage of LLW wastes.
In figure 5 is shown the drum-D_2O subjected to the slope test:

Figure no 5 The D_2O drum subjected to the slope testing

Post test examination criteria: no damages of the lid and no leakage of the content.

QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) ORGANIZATION AND RESPONSIBILITY

QA and QC were carried out by the manufacturing staff themselves. In this way the responsibility for high quality products always rests with the manufacturer, and the consciousness of, and desire for, quality in each worker involved will be stimulated. QC was reduced to certain special criteria which indeed will be fulfilled, but the quality of the complete

product itself will have first priority. It was also incorrect to postulate possible treatment worker or shipping error and as a result of this to define additional requirements.
Before testing the specimen to be subjected to the test was inspected and examined and no faults were found or recorded, nor any damage due to defects during manufacturing or preparations for testing: *no corrosion, accidental deterioration or other distortions of features or divergences from specifications or drawings were found*. Conformity with the specifications was checked on receipt for supplied materials and intermediate products [2, 3, 7]. Protection against corrosion (paint, oil films, etc.) was also checked. Additionally, before starting the qualifications tests, the sample was checked for non-fixed radioactive contamination on its external surface, using the wipe method by swabbing with alcohol. The measured activity was less than 1 Bq (allowed limit: less than 185 Bq).

CONCLUSIONS

The experience of twenty years with testing has shown that the existing packages are adequate to withstand the required qualification tests. It is considered that these results, with respect to the qualification tests carried out, are satisfactory, and meet Romanian and the IAEA's Regulations for the Safe Transport of Radioactive Materials.. Nevertheless this testing experience will be improved, in the future. Our conclusion is that these type A packages (for solid and liquid radwastes) will survive most potential road and rail accidents intact but will fail to forces grater than those specified in the IAEA's Regulations .

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