CONSIDERATION ON THE FIRST ROMANIAN TEST OF TYPE B PACKAGE USING ¼ SCALE MODEL

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ABSTRACT

Testing large type B packages is expensive and often limited by the availability of test facilities. As IAEA's Regulations recommend, an alternative one is to test reduced ¼ scale model. The paper presents carrying out of the type testing at INR Pitesti (except for fire and water immersion tests, which will be done by adequate computer codes) for the scale-model such as: 3 free drops from 9 m (one longitudinal, one axial and one at 25° inclination), 3 free drops from 1m onto a mild steel bar perpendicular rigidly mounted to the target surface, and 3 free drops from 1.2 m onto target surface. Also, the paper describes the feasibility and difficulties of using such model for the required tests taking into consideration the Romanian experience in the field. The paper shows that the package drop testing results and the impact responses associated with the failure modes of the package scale model testing will help to improve prototype design. The need for proper interpretation of data acquisition test measurements and the proper modeling of target characteristics is also emphasized.

INTRODUCTION

The transport regulations are designed to ensure protection of the public, transport workers, property and the environment from the effect of radioactive material during transport. Hazards associated with malicious acts such as theft or diversion for no peaceful purposes, are not included in the scope of the transport regulations, but are covered by International Convention on the Physical Protection of Nuclear Materials, according to the IAEA legal series no. 12.

The consigners should be responsible for ensuring safety during transport and those who prepare packages for shipment must ensure that regulatory requirements are met. This minimizes the contribution required from carriers, and allows consignments of radioactive materials to be transported with minimal special handling. Required packaging is based on the assurance that the level of safety built into a package is commensurate with the potential hazards of the contents being transported.

The type B packages are used to carry larger amounts of radioactive material. These packages must be able to withstand the effects of severe accidents. To demonstrate this ability, tests for resistance to impact, penetration, fire and water immersion, representing hypothetical accident conditions are required. In addition, each design must be approved by the competent authority of the country in which the package was designed, and, under some conditions, by the competent authority of each country through or into which it is shipped. Type B packages must be capable of withstanding both type A and B tests.

WHY ¼ SCALE MODEL TESTING?

The main reason for performing ¼ scale model testing of type B packaging is related to cost. Prototypes of large type B containers are very expensive to manufacture, and several may be

needed to perform a suitable range of developmental and compliance tests. In addition, the total cost of the full-scale package testing is in itself considerable. Not only is full-scale manufacture and testing expensive, but they also take quite a long time. Finally, scale model testing enables a great deal more optimization of key package features, particularly with respect to package orientation and the resulting damage from drop tests. Model testing is useful and valid for certain tests provided that appropriate scaling factors are used. In general, the use of models for the thermal test is not recommended, as the results are very difficult to validate. Similarly, it is difficult to extrapolate the results of scale model testing involving seals and sealing surfaces to the response expected on a full sized package (container). However, experience has shown that the testing of scale models may be very useful for the mechanical tests, where the conditions of similitude are relatively simple to create, provided the same materials and constructions methods are used for the model as for the full-seized container. In some tests, such as penetration test, it will also be necessary, if considered, to scale the bar to produce accurate results.
In general, the scale ration M (model dimension: prototype dimension) should not be less than ¼. For such models the effect of strain rate dependence on the mechanical properties will be negligibly small.

ROMANIAN ¼ SCALE MODEL TYPE B PACKAGE

Taking into account the above consideration, INR Pitesti manufactured a ¼ scale model type B prototype container, as shown in Figure 1:

Figure 1 ¼ Scale model type B container

The main technical characteristics are: a) weight: 68.3 Kg; b) Dimensions: 279 x 459 mm (without shock absorbers); temperature range: - 40° C ÷ + 38° C; minimum thickness of the radiological protection: 70 mm.

TESTING OF THE ¼ SCALE MODEL TYPE B CONTAINER

The full sized container will be used for the transport of a CANDU Spent fuel bundle from NPP Cernavoda to INR Pitesti, bundle to be analyzed within our hot cells. The scale model prototype has been subjected to the following qualification tests:

- Three free drop tests from 1.2 m such as: on the lid, on the generator, with a 25° inclination;

- Three free drop tests from 1m on the top face of a rigidly mounted 150 mm diameter mild steel bar (the target is shown in Figure 2), as: on the lid, on the generator, with 25° inclination;
- Three free drop tests from 9m on an unyielding surface, such as: axial, on the generator, with 25° inclination.

Figure 2 The target having the rigidly mounted 150 mm diameter mild steel bar mounted.

a. free drop testing from 1.2 m

Three free drop tests from 1.2 m were performed, such as: *on the lid, on the generator, on the lid with a 25° inclination*. In figures 3 and 4 the prototype subjected to these tests, on the generator and with *a 25°* inclination (without shock absorber mounted), is shown:

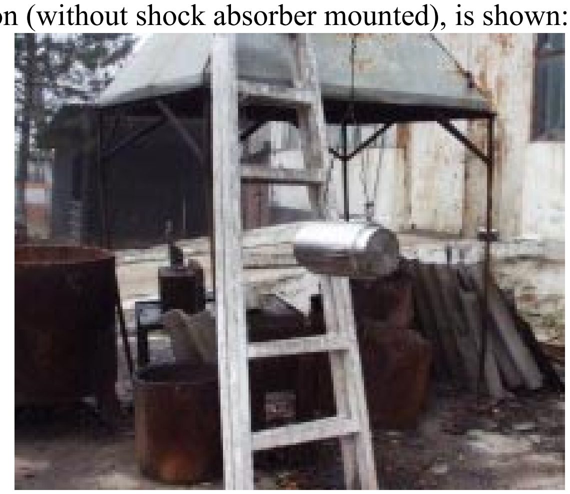

Figure 3. The ¼ scale model prototype subjected to the 1.2 m free drop test (on the generator)

Figure 4. The ¼ scale model prototype subjected to the 1.2 m free drop test (*on the lid with a 25° inclination*

After performing of each of the above-mentioned tests, the sample was subjected to a leak rate test. ***Test*** p***ass criteria***: ***leak rate < 10^{-7} mbar/sec***. The prototype passed these severe acceptance criteria. ***Results:*** after testing the container has been subjected also to a detailed visual inspection and there was not observed any deterioration such as to affect the operating functions of the prototype.

b. free drop testing from 1 m on the target having a rigidly 150 mm diameter mild steel bar mounted.

Three free drop tests from 1 m, on the target having the rigidly 150 mm diameter mild steel bar mounted, were performed, such as: *on the lid, on the generator, on the lid with a 25° inclination*. In figures 5 and 6 the prototype subjected to these tests, on the lid and on the generator (with shock absorber mounted), is shown:

Figure 5. The ¼ scale model prototype subjected to the 1 m free drop test (on the lid)

Figure 6. The ¼ scale model prototype subjected to the 1 m free drop test (on the generator)

After performing of each of the above-mentioned tests, the scale model package was subjected to a leak rate test. ***Test pass criteria***: ***leak rate < 10^{-7} mbar/sec***.
Results: the prototype passed these acceptance criteria. After testing the container has been subjected also to a detailed visual inspection and the maximum indenting (measured on the lid shock absorber) was ***7 mm.***

a. 9m free drop testing

There were carried out three 9m free drop testing: ***on the lid, on the generator and on the lid with a 25° inclination.*** Before testing the package was equipped with two accelerometers (one for the package itself and one for the contents that simulated spent fuel basket). Also, there were mounted two strain gauges in order to determine material strains. In figure 7 the prototype having the accelerometer and gauge strain mounted is shown:

Figure 7. The container prepared before 9 m free drop testing (with shock absorbers mounted)

Figures 8 and 9 show the ¼ scale prototype type B container subjected to the 9 m free drop test on the generator and with a 25° inclination.

Figure 8. The package subjected to the 9m free drop test on the generator

Figure 9. The package subjected to the 9 m free drop test with 25° inclination

To provide an adequate range of data collection, recording and processing facilities for hard-wired instrumentation of the package during those three free drop tests, an instrumentation chain containing dedicated B&K components has been used, as shown in Figure 10:

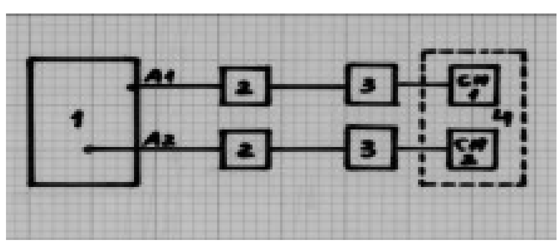

Figure 10. The instrumentation chain used for data collection during 9m free drop tests

Where: 1 – ¼ scale model type B package; A1-Accelerometer for the package; A2-Accelerometer for the simulated spent fuel contents; 2-B & K Preamplifier; 3-B&K Amplifier;

4-Digital Tektronix Oscilloscope model TDS 3032. Also, a special dedicated instrumentation B&K chain has been used for the strain gauges.
After performing of each of the above-mentioned free drop tests, the package was subjected to a leak rate test. ***Test pass criteria***: ***leak rate < 10^{-7} mbar/sec***. The prototype passed these severe acceptance criteria. ***Results:*** after testing the container has been subjected also to a detailed visual inspection and there was not observed any deterioration such as to affect the operating functions of the prototype. The measured accelerations were: a) for the free drop test on the lid: 190 g for the content and 40 g for the package itself; b) for the free drop test with a 25° inclination: 30 g for the package and 30 g for the simulated content. No data are available for the strain measurements.
Conclusions: The qualification tests carried out for the first Romanian manufactured Type B package (1/4 scale model) meant a very useful experience and data obtained will be used in the future for improving the design of the manufactured full size type B container.

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