Why "No Leakage" Is Enough for Type A Packages: A Regulatory Point of View

H.M.L. Gonzales, J.R.L. Vietri, R.G. Novo

Comisión Nacional de Energía Atómica, Gerencia de Protección Radiológica y Seguridad, Argentina

INTRODUCTION

The 1985 Edition of the IAEA *Regulations for the Safe Transport of Radioactive Material* (Safety Series No. 6, 1985) establishes for different kinds of packages the applicable tests and the respective after-test acceptance requirements.

In particular, paragraph 548 of the Regulations establishes that Type B packages shall be so designed that, if they were subjected to the tests for demonstrating ability to withstand normal conditions of transport, the loss of radioactive contents shall be restricted to not more than A2 E-06 per hour. On the other hand, paragraph 537 of the Regulations establishes that Type A and Industrial packages Type 2 and Type 3 shall be so designed that, when subjected to the tests for demonstrating ability to withstand normal conditions of transport, it would prevent loss or dispersal of the radioactive contents.

As prescribed in the Regulations, the after-test evaluation of radioactive releases from Type A designs does not require a quantitative assessment. Therefore, the Regulations allow the Designers, in agreement with the National Competent Authority, to select the method for verifying the compliance with the statement "prevent loss or dispersal of the radioactive contents".

Packages containing radioactive materials in gaseous form are not taken into account because the qualitative methods likely to be satisfactory for leakage evaluation (e.g., a bubble test, differential pressure test), are highly sensitive and able to be quantified if needed. Packages carrying special form radioactive materials are not considered in this paper.

WHY THE LEAKAGE OF TYPE B PACKAGES REQUIRES A QUANTITATIVE EVALUATION?

The Agency's Transport Regulations fundamentally specify the level of safety by the type of package requested (Excepted, Industrial, Type A or Type B) in function of the quantity and nature of the radioactive contents to be transported. For all kinds of designs but for Type B, there are regulatory limitations of the radioactive contents. For Type B packages, containment and shielding integrity shall be provided to withstand severe accident conditions and the maximum radioactive contents allowed is the one specified in each approved design. Therefore, Type B packages transporting not special form radioactive materials usually content from about tens of A2 to more than hundreds of thousands of A2.

During normal conditions of transport, Type B packages containing liquids or powders (the latter assumed as the worst solid form in relation with potential releases), could have a fraction of their radioactive contents aerolized into the primary containment. Also, as there will be usually a significant thermal power because of the radioactive decay, it can be assumed that the primary containment is always pressurized.

Summarizing, for a Type B package it should be assumed that in normal conditions of transport:

(a) the aerolized part of its radioactive contents could produce significant radiological consequences if released (several times A2 can be released); and

(b) a permanent and significant driving force from the containment system to the environment exists as a consequence of the expected higher than atmospheric pressure of the primary containment. Other phenomena, such as radiolysis, chemical reactions or helium generation, could increase this effect.

Therefore, as a perfect leaktightness is impossible, it should be assumed that there is a continuous leakage during the period of time when the package is filled. In this context, paragraph 548 of the IAEA Regulations establishes a quantitative leakage rate of not more than A2 E-06 per hour for Type B packages after the tests for demonstrating ability to withstand normal conditions of transport.

A leaktightness assessment for different types of closing devices (e.g., o-rings, threaded lids, tin-plate with crimped lids, welded lids) must be provided. At this respect, technical papers, test methods and standards have been developed (*Permeation through Elastomeric O-Ring Seals,* Brehm et al., PATRAM'86; *Leak Testing and Activity Leakage Rate evaluation-Practical Experiences, First Approaches to Some Systemization and Outstanding Problems,* Kowalewsky, PATRAM'80; *Containment System Evaluation,* Lake, PATRAM'83; *Correlation between Measured Gas Leaks and Possible Loss of Contents from Radioactive Materials Packagings,* Andersen, PATRAM'83; *Helium/Solid Powder O-Ring Leakage Correlation Experiments,* Leisher et al., PATRAM'83; and *American National Standard for Leakage Tests on Packages for Shipment of Radioactive Material,* ANSI-N14.5 1977, 1985). Some test methods are expensive and with a certain degree of technological complexity. The quantitative restriction of the leakage and the utilization of these methods are justified for Type B designs because, as explained above, in this case it is necessary to restrict the possible releases in order to limit potential radiological consequences.

THE CASE OF TYPE A PACKAGES

The paragraph 537 of the IAEA Transport Regulations establishes that Type A packages shall be so designed that, if they were subjected to the tests for demonstrating ability to withstand normal conditions of transport "it would prevent loss or dispersal of the radioactive contents".

The requirement mentioned above implies that:

(a) If using a visual monitoring leakages are detected, the package design must be rejected.

(b) When a visual monitoring is not enough to permit the determination of compliance with the acceptance criteria, it is possible to use some relatively simple methods of detection as it is mentioned in paragraph A.537.4 of IAEA *Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (1985 Edition) Third Edition* (Safety Series No. 37, 1987).

However, whichever be the method used, it is enough to obtain a qualitative result that practically demonstrates the compliance of the statement: "prevent loss or dispersal of the radioactive contents".

ANALYSIS OF POSSIBLE LEAKAGES IN ACCEPTED TYPE A DESIGNS

As it was explained, if using a suitable qualitative method it is confirmed that there is not loss or dispersal of the radioactive contents, this design will be accepted. However, always there will be a possible leakage small enough that cannot be detected by simple methods.

The objective of this paper is to explain that, if a leakage was not detected using a suitable qualitative method, the release should be quite small and their radiological consequences are negligible. As it was noted, only the cases of liquid and solid radioactive contents are considered. It is conservatively also assumed that any solid material is in powder form, which is the worst physical solid form if a leakage pathway exists.

If as a consequence of the tests for normal conditions of transport a leakage is produced and is not detected by suitable qualitative methods, it can be assumed that the release consists of aerolized solid particles, or a combination of aerolized liquid particles and vapours. Assuming that the primary containment is not completely filled by powder or liquid, the Authors have conservatively estimated the ratio between the amount of radioactive material in the aerosols or vapours of the gaseous phase and the total radioactive contents. As a result of such estimations it is determined that it is highly improbable that the amount of radioactive material included in the gaseous phase exceeds 1 E-04 of total radioactive contents. Assuming conservatively that a Type A package is filled with the maximum radioactive contents (A2), the amount of radioactive material able to be released is lower than A2 E-04.

In consequence, for a Type A package carrying not special form radioactive material it can be assumed that in normal conditions of transport:

(a) the aerolized part of its radioactive contents cannot produce significant radiological consequences if released (less than A2 E-04); and

(b) the thermal power to be removed is quite low, and a permanent and significant driving force from the containment system to the environment does not exist.

Therefore, although a perfect leaktightness is impossible, it is practically inconceivable that there is a continuous significant leakage during the period of time when the package is filled.

However, when Type A packages are subjected to the tests for normal conditions of transport, a transient internal overpressure occurs, and therefore, a part of the gaseous phase carrying radioactive materials can be released. Taking into account possible overpressure values (*Leakage of Radioactive Powders from Containers,* Curren and Bond, PATRAM'80), the different types of closing devices used in the great majority of Type A packages, and the analysis of bibliography related to leakage assessment, it is possible to infer that a very little amount of radioactive material can be carried out from the primary containment to the environment. Therefore, it can be assumed that A2 E-05 is the amount of activity that can leak out from an accepted Type A package in a single event which does not imply only significant radiological consequences since A2 E-03 and A2 E-04 are the limit contents for Excepted Packages established by the Regulations for solids and liquids respectively.

In addition it is noted that:

(i) the average radioactive contents of the great majority of Type A packages transported are of about A2 E-03 (Kowalewsky, PATRAM'80).

(ii) a lot of Type A package models such as those for radiopharmaceuticals, (about 80% of total Type A packages transported, Kowalewsky, PATRAM'80), have two or three containment barriers: the primary inner container (ampoule), the absorbent material, the shielding container (lead cylinder) and the outer container (can).

CONCLUSIONS

In all cases, using simple methods such as those recommended by IAEA Safety Series No. 37, 1987, it is possible to verify the compliance with the statement: "prevent loss or dispersal of radioactive contents". Although an undetected leakage is always possible, it is concluded that such leakages cannot produce any significative radiological consequence.

Therefore, it seems unnecessary to introduce quantitative leakage requirements for Type A packages. Furthermore, if in a special case it is justified to make a quantitative evaluation, the National Competent Authority is faculted to impose a special requirement as appropriate.

The possible lack of worldwide harmonization associated to the use of qualitative methods in evaluating Type A designs seems not to justify a change in the present requirement for Type A and Industrial Packages. In addition, the extra cost associated to quantitative requirement cannot be supported on technical grounds.

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