RESPONSE OF TYPE A PACKAGES TO ACCIDENT CONDITIONS OF TRANSPORT

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ABSTRACT

Data on accidents classify them on the basis of their severity. Such classification does not correspond exactly to the prescribed tests. The accident conditions simulated by the tests are normally applied only to the assessment of Type B(U)/(M) packages. In India, about 80% of the radioactive consignments may be classified as Type A packages. Therefore, it was felt necessary to assess the response of Type A packages to the accident conditions. An earlier study had suggested that it was essentially those Type A packages which were generally deployed for the transport of ^{131}I and ^{99}Mo which were mainly responsible for any possible dose during transport. The Type A packages which were generally used for these sources were identified and they were assessed for their response to the accident conditions of transport of twelve severity categories. While they could withstand the crush test without release of activity, (as witnessed by six such real accidents in Indian airports) they would not withstand the fire test. Thus they would survive four out of the twelve categories of accidents. Nucleonic gauges which are classified as Type A packages were assessed for their ability to withstand accident conditions and found to be performing better than the regulatory requirements.

CONDITIONS OF TRANSPORT AND ACTIVITY LIMITS

International and National Regulations for the Safe Transport of Radioactive Material [1,2] consider transportation under normal and accident conditions of transport. Packages designed for the transport of radioactive material are classified on the basis of their ability to withstand the rigours of transport. Regulations require that this ability be demonstrated by subjecting the packagings to the prescribed tests. These tests are broadly classified as those simulating normal conditions and accident conditions of transport. Since Type A packages are designed to withstand only normal conditions of transport, the activity of radioactive material that is permitted to be contained in such packages is restricted by regulatory limits, viz., A_1 and A_2. The only limits on the activity permitted

in a Type B(U)/B(M) package, unless transported by air, are those specified by the Competent Authority in the approval certificate.

RADIOLOGICAL RISK FROM RADIOACTIVE SHIPMENTS

The performance standards prescribed for a Type B(U) / B(M) package following the regulatory tests require that if such a package encounters an accident –

- radiation dose due to external exposure at 1 m from the package would not exceed 10 mSv/h; and
- radiation dose due to internal exposure would be restricted by the limit on release of activity of A_2 in one week.

However, a Type A packaging is not required to be subjected to tests simulating accident conditions of transport. In India, about 80% of the radioactive consignments may be classified as Type A packages. Therefore, it was felt necessary to assess the response of Type A packages to the accident conditions. An earlier study had suggested that it was essentially those Type A packages which were generally deployed for the transport of ^{131}I and ^{99}Mo which were mainly responsible for any possible dose during transport [3].

TYPE A PACKAGES ANALYZED

The Type A packages which were considered in this study to evaluate their ability to withstand accident conditions of transport are those used for the transport of radiopharmaceuticals and nucleonic gauge sources. Such packagings were identified and the design features of each model of such packagings were assessed for their response to the accident conditions of transport of the twelve severity categories. The analysis was made on the basis of -

(i) actual recorded accidents encountered by identical packages and the observed conditions of the packages following the accidents

(ii) results of design analysis or actual tests conducted on packagings in order to satisfy the relevant regulatory performance standards required for their intended use as source holders in industry (e.g. nucleonic guages) [5,6]

The packages which were considered for the study were described as TP-1, TP-2D, TP-2E and nucleonic gauges of various models. Particulars of TP-1/2D/2E are provided in Table 1. The design requirements of nucleonic devices which were included in the study are listed in Table 2. The performance standards include high and low temperature tests and also drop test.

ACCIDENT S vs REGULATORY TESTS

In order to be able to quantify the response of a package to an accident, it is necessary to establish the impact suffered by a package in an accident. Impact that may result from accidents can vary over a wide range of values. Therefore, a correspondence between regulatory tests and actual accident conditions was established by conservatively grouping the accidents so that each group defined the lower bound of a regulatory test. The exercise yielded twelve severity categories of accidents in respect of which the package response can be ***quantitatively*** determined, albeit approximately [4]. Some of the categories of accidents were more severe than the regulatory tests. The severity categorization is shown in Fig. 1 by Roman numerals in the individual cells The fractions indicate the probability of occurrence of accidents of the specified severity. The package descriptions in each cell indicate that the Type A packages listed therein would withstand the corresponding accident conditions.

On the basis of the design of a packaging it is possible to quantify the response of a package to a regulatory test. Now with the establishment of a correspondence between accident severity and regulatory tests, it is possible to quantify the response of a package to an accident condition of a specified severity category. The package failure fractions which can be determined with respect to the regulatory tests can be applied to the accidents on the basis of the severity categorization.

RESPONSE OF TYPE A PACKAGES TO ACCIDENTS

The Type A packages, TP-2D and TP-2E could withstand the crush test without release of activity, (as witnessed by six such real accidents reported in Indian airports). Reduction in shielding integrity did not result in a significant increase in the radiation level at the external surface of the package. However, they would not withstand the fire test. The nucleonic gauges which were examined were designed to withstand the rigours of operation at increased temperature conditions and also, in some cases, required to withstand the 9 m drop test. Nucleonic gauges of class 3 of Indian standards [5], class 4 of the International (ISO) Standards [6] and class 7-9 of American National Standards [7] are designed to withstand increased temperatures and function normally. The nucleonic gauges designed to ISO and ANS and the draft revised Indian standards are required to satisfy thermal tests at temperatures of 800 ° C to 1160 ° C and for durations of 20 minutes to 4 hours. The packagings which were considered in this study are designed and declared as Type A packages only. However, the material strength inherent in the simple design, provides the ability to these packagings to withstand some, though not all accident conditions of transport, as simulated by the regulatory tests.

DISCUSSION

This study provided an insight into the behaviour of Type A packages under accident conditions. There are numerous nucleonic gauges which are transported all over

the country in packages which are always classified as Type A packages. Many of these packages may be expected to withstand at least eight out of the twelve severity categories of accidents. The possibility of failure of the packagings, included in this study, in accidents of higher severity should be weighed against the probability of the occurrence of such accidents. The accident probability values for transport by road are given in figure 1. This study shows that many common Type A packages can indeed withstand some of the accident conditions of transport. An earlier study reported that even in the air transport scenario, where impacts of accidents are severe, 60% of the accidents experience mechanical impacts of severity not greater than that caused by the 9 m drop test [8]. Probability of a fire accident during transport by road and rail is reported to be 0.016 per accident[9] and 0.02 [4] respectively. Given the low probability of occurrence of accidents of higher severity and considering that the activity of radionuclides transported in most of the Type A packages is a small fraction of the applicable regulatory limits, the most commonly deployed Type A packagings analyzed here offer a higher degree of safety than demanded by the regulations.

SEVERITY OF MECHANICAL IMPACT				
> Type B Tests	IX 1.780E-7	X 1.447E-9	XII 1.447E-9
Type B tests	V 1.582E-7 TP-2D TP-2E NG	VIII 1.286E-9 NG	XI 1.286E-9
Type A tests	II 6.527E-7 TP-1 TP-2D TP-2E NG	IV 5.306E-9 NG	VII 5.306E-9 NG
Nil	I 9.889E-7 TP-1 TP-2D TP-2E NG	III 8.0407E-9 NG	VI 8.040E-9 NG
	0	30	

DURATION OF (~ 800° C) FIRE IN MINUTES

Figure 1

ACCIDENT SEVERITY CATEGORIZATION
IN TERMS OF REGULATORY TESTS

(The packages which could withstand the accident conditions and the probability of occurrence of an accident of the specified severity are indicated in the severity cell.)

Table 1

Particulars of the Type A packages: TP-1 / 2D / 2E

Particulars	Package Identification		
	TP-1	TP-2D	TP-2E
Permitted Contents	Pure β- emitters and ^{131}I ~ 150 MBq	^{131}I and ^{99}Mo 2 GBq	^{131}I and ^{99}Mo 9 GBq
Primary Containment	Vial surrounded by absorbent material	Vial surrounded by absorbent material	Vial surrounded by absorbent material
Shielding (mm Pb)	Nil	20	30
Tertiary Containment	Sealed metal container	Sealed metal container	Sealed metal container
Outer Container	Thick card board box	Wooden box	Wooden box
Overall Dimensions (mm)	120 x 120 x 170	210 x 210 x 200	210 x 210 x 2000

Table 2
REGULATORY REQUIREMENTS OF
THE PERFORMANCE STANDARDS FOR NUCLEONIC GAUGES

(A) High and Low temperatures test and Drop Test

Class	Use condition temperature (Degree C)					
	High Temperature			Low Temperature		
	AERB/ SS-2	ANSI N538 1979	ISO 7205 1986	AERB/ SS-2	ANSI N538 1979	ISO 7205 1986
0	-	-	50	-	-	10
1	50	No test	100	0	No test	0
2	85	50	150	- 40	20	- 10
3	300	60	200	- 196	0	- 20
4	-	85	400	-	- 40	- 40
5	-	105	Special	-	- 79	Special
6	-	200	-	-	- 100	-
7	-	300	-	-	- 196	-
8	-	400	-	-	-	-
9	-	600	-	-	-	-
S	-	Special	-	-	Special	-

(B) Drop test

The specimen should be dropped through 9 m followed by a fall through 1 m as specified for Type B packages in the AERB Code on Safe Transport of Radioactive Material, AERB/SC/TR-1. There are no specifications in ANSI N538 1979 nor in ISO 7205 1986 for this test.

REFERENCE

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