Type B Categories
and
The Scope of ASME Section III Division 3

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November 1, 1999

This document explains the "Categories" of Type B Containers as used in various NRC and DOE documents regulating packaging for the transportation of radioactive materials. The Categories identified as I, II and III are based on curies (Ci) or becquerels (Bq) and A quantities, so these will be defined and explained in detail. The standard NRC and DOE practice with regard to the application of various sections and divisions of the ASME Code for each Category is presented.

Note that the terminology "Category" is NOT consistent with ASME terminology. The classification of Type B into Categories I, II and III is exactly analogous to the classification of Section III Division 1 construction into Classes 1, 2 and 3. Classes 1, 2 and 3 apply to progressively less important to safety components; Categories I, II and III are progressively less hazardous quantities of radioactivity.

In the writer's opinion the introduction of the new term "Category" was unfortunate since the familiar and accepted term "Class" would have been appropriate. Another alternative would have been to divide Type B into Type B1, B2 and B3.

The "Categories" discussed here are completely unrelated to "Shipping Categories I, II or III" also referred to as "Radioactive I, II or III" which apply to hazardous material shipping labels based on the transport index of the radioactive contents, and are defined in IAEA SS6 Para 435 or in 49 CFR 172.403(c). Note that for Shipping Categories, III is the most severe while for Packaging Categories, I is the most severe.

BASIC DEFINITIONS

Definition of curie (Ci)

The curie (Ci) is a measure of the number of disintegrations events per unit time in a mass of radioactive material. One Ci is 37 x 10^9 events per second, or in computer terms 37 gigahertz. The number 2.2 x 10^12 disintegrations per minute is also used. The symbol ^ is used throughout to indicate exponentiation. Note that the Ci is a measure of the activity of some mass or quantity of material. It is not a material property such as specific activity which is measured in curies per gram (Ci/g). Also note that the numerical magnitude of activity is not itself a measure of relative hazard because the hazard evaluation needs to consider the type and energy of the disintegration, not just the number of disintegrations.

Up-to-date usage is replacing the curie with the becquerel (Bq) where one Bq is defined as one disintegration per second, so one Ci = 37 x 10^9 Bq .

As an example, the specific activity of natural uranium is listed as

	26 x 10^-9 TBq/g	0.71 x 10^-6 Ci/g
	(note that the T prefix means 10^12)	
which is	26 Bq/mg	0.7 Ci per ton (Metric).

Some isotopes of interest:

americium 241	0.13 TBq/g	3.4 Ci/g
iodine 131	4.6 TBq/mg	120 Ci/mg
thallium 201	7.9 TBq/mg	210 Ci/mg
cobalt 60	42 TBq/g	1.1 Ci/mg
carbon 14 in air	0.04 Bq/liter of air	1 pCi/liter of air

(The p prefix is 10^-12)

For comparison the EPA limit for radon is 6 pCi/liter of air.

Definition of radioactive material

IAEA SS6 Para 139 and 49 CFR 173.403(y) define radioactive material as any material whose radioactive activity exceeds 2 nCi/g (n designates 10^-9) or 70 Bq/g. Note that this definition is in terms of specific activity rather than total activity. The activity of natural uranium is 710 nCi/g. So soil or rock containing natural uranium at a concentration of 0.3 per cent or more is "radioactive" by this definition. The activity of carbon 14 in air is 0.03 Bq/g of air - about 2 disintegrations per minute per liter - bout 2000 times below the definition of radioactive.

Type A quantity

The Type A quantity of any particular material is the maximum quantity of that material that the regulations deem to be sufficiently non-hazardous to be transported in a Type A packaging. Note that Type A refers to the total activity rather than to the specific activity. For example, if some quantity of material exceeds the amount that may be transported in a Type A packaging, it is possible that this quantity may be transported in Type A packagings if it is subdivided into smaller quantities.

Type A quantities for various radionuclides are defined by tables in both IAEA SS6 and in 10 CFR 71. A distinction is made between tabulated A1 values and A2 values with A1 applying to materials that satisfy "special form" requirements and A2 applying to those that do not. (Note: the 1 and 2 in A1 and A2 are usually shown as subscripts, as A_1 and A_2, but I will ignore this detail throughout to simplify the text and improve readability.) "Special form" refers to materials that are not dispersible as demonstrated by a series of specified tests. In many cases the A1 values are the same as the A2 values, however in some cases, particularly for heavy metals, they are as much as 10,000 times higher. The values are given as the number of Ci and TBq of that material that constitute a Type A quantity. The quantity can readily be converted to grams by dividing by the activity per gram which is tabulated in the same table in 10 CFR 71 and in a corresponding table in IAEA SS37.

The tables are readily available on the internet at the NRC web site:
http://www.nrc.gov/index.html
which has the full Title 10 of the Code of Federal Regulations at:
http://www.nrc.gov/NRC/CFR/index.html
and specifically Part 71 of Title 10 at:
http://www.nrc.gov/NRC/CFR/PART071/index.html
The A1 / A2 table is at:
http://www.nrc.gov/NRC/CFR/TABLES/ISOTOPES/PART071/index.html

It is conventional to express a quantity of material as being "a certain number of A2" (or A1 if special form). It would be more logical to use the terminology "a certain number of Type A quantities" or "a certain number of A"; however, the form "the contents is 7.3 A2" is generally used. In any case the A1 or A2 measure can be considered a consistent unit of radiological hazard; whereas, as noted previously, the Ci cannot.

To give some examples, the A2 value for natural uranium is "unlimited" so that any quantity of natural uranium is zero A2. For I-131 the A2 value is 13.5 Ci, so with 120 Ci/mg the Type A quantity is 0.11 mg; or, 0.11 mg constitutes one A2. This means, as will be explained later, a single shipment of more than 0.11 mg of I-131 requires a Type-B packaging, unless the I-131 is encapsulated in a verified "special form" in which case the A1 value, which is 6 times higher, applies; and then up to 0.66 mg can be shipped without using Type-B packaging. For thallium 201 (specific activity of 210 Ci/mg) the A2 value is listed as 270 Ci, so an A2 is 1.3 mg. For thallium 201 the A1 is the same as the A2. For cobalt 60 the A2 value is 10.8 Ci so the Type A quantity is 10 mg. For americium 241 the A2 value is 0.0054 Ci but the A1 value is 54 Ci. For the air example, the A2 value for Carbon 14 is 2 TBq or 54 Ci and the Type A quantity is computed as about 50 cubic kilometers of air; however, as noted before, the activity is 2000 times less than the definition of radioactive so the Type A quantity is meaningless.

Radioactive material quantities are generally referred to in curie units, however the gram or mg equivalents are presented here to provide some "real world" feel for the quantities of material that are involved.

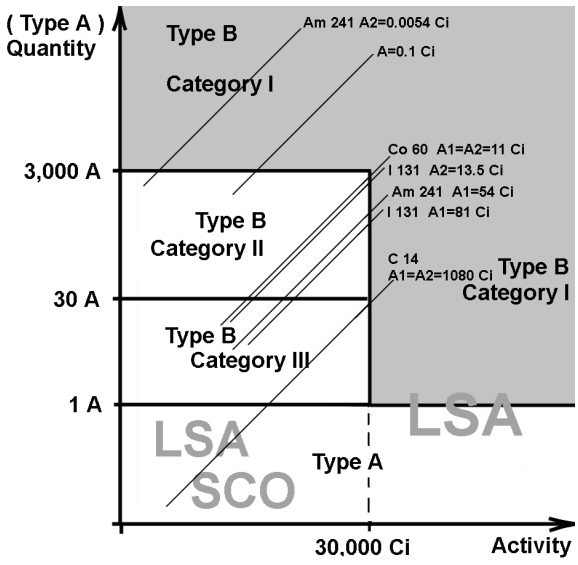
Categories of radioactive materials contents

Various radioactive materials of limited quantity, low specific activity (LSA), and surface contamination on objects (SCO) are exempt from the usual Type A or Type B packaging requirements by 49 CFR 173.403 as well as IAEA regulations. Curie levels and computed Type A quantities for such materials can substantial; however, they are irrelevant because the materials are transported under special rules. Other radioactive materials that do not exceed a Type A quantity must be packaged in a Type A packaging.

Materials that exceed a Type A quantity and are not exempt as per the previous paragraph must be packaged in a Type B packaging. Transport by air of certain special radioactive materials requires a Type C packaging.

Categories within the Type B contents range

DOE and NRC (but not IAEA) define three "Categories" for packaging contents in excess of a Type A quantity. These are: Category I for contents greater than 3,000 A or greater than 30,000 Ci; Category II for contents between 3,000 A2 and 30 A2, and not greater than 30,000 Ci; and, Category III for contents less than 30 A2 and less than 30,000 Ci. These definitions are for normal form. For special form just substitute A1 for A2. The above limits are best visualized on a plot of Type A Quantity vs. Ci as shown in the adjoining figure..



Categories for Type B Contents

Both NRC and DOE require the application of ASME Section III NB (Class 1) or WB **only** to Category I packaging containments. For Category II: Class 3 is considered adequate; and, for Category III: Division VIII is considered adequate. This is presented in the following table.

Table: Sections of ASME B&PV Code Applicable to Type B Packages

Component Function	Category I	Category II *	Category III **
Containment	Section III, Division 1, Subsection NB; or Section III, Division 3	Section III, Division 1, Subsection ND	Section III, Division 1, Subsection NF ***
Criticality (structural support)	Section III, Division 1, Subsection NG (NF for Buckling)		
Shielding and Other Safety Items	Section VIII, Division 1 or Section III, Division 1, Subsection NF		

* Category I criteria are also acceptable.

** Category I and II criteria are also acceptable.

This table is taken from the DOE "Packaging Review Guide … " listed below.

*** Sec. III Div. 1 NF is a typo. This should read "Section VIII, Division 1"

The NRC references for the above guidance are: NUREG-1609 - "Standard Review Plan for Transportation Packages for Radioactive Material" which can be downloaded from http ://www.nrc.gov/NRC/NUREGS/SR1609/SR1609.html ; and, NUREG/CR-3019, Table 1. The best DOE reference is the "Packaging Review Guide for Reviewing Safety Analysis Reports for Packagings" which can be downloaded from http://www.rampac.com/PCN/packaging_certification_news.htm .

Looking at the specific examples considered previously, single use medical does of iodine 131 are in the 3 to 300 mCi range. Since a Type A quantity is 13.5 Ci, multiple dose shipments can be made without using a Type B packaging. However a bulk shipment, such as would be made from a source producer to a pharmaceutical processor, could easily involve 120 Ci (about one mg) which is 9 A2. This falls in the Category III range and so even though a Type B package is

required, its containment boundary need not be designed to ASME Section III. For the thallium example, typical diagnostic doses are about 3 mCi. With the Type A quantity at 270 Ci, a Type B package would not be a consideration.

For the cobalt 60 example, radiographic sources are in the 100 Ci range which is well above the 10.8 Ci Type A limit so a Type B packaging is required; however, again a Category III package is sufficient and ASME Section III need not be involved. A cobalt 60 irradiator may use a 15,000 Ci source which is about 1400 A2 which puts it into the Category II range. A larger irradiator may well exceed the 30,000 Ci limit and require a Category I packaging which would require an ASME Section III containment. Note that for cobalt 60 the A1 value is the same as the A2 value so there is no shipping Category advantage to encapsulating the cobalt into a qualified special form.

Finally for the americium 241, the typical smoke detector has one micro curie so enough americium for 5400 could be shipped in a Type A package. (The Type A quantity is 5.4 mCi.) Larger quantities would require a Type B packaging, but again this would be Type B Category III packaging not requiring an ASME Section III containment.

Computational tool

DOE has released a handy computer program called Radcalc designed to compute the radiolytic generation of hydrogen gas and perform other sophisticated physics calculations. But it also performs all the computations discussed above, including the determination of the tabulated A1 or A2 quantities and specific activities, identification of the packaging type required, as well as selection of the appropriate Category. Radcalc version 2.11 is available on the internet at: ftp://ftp.emwebwin.com/pub/downloads/doc2/2613068.PDF .

Conclusions

ASME Section III Division 3 should not define its scope as "Type B Containments" as this is a much broader scope than justified by current practice and regulatory requirements. A scope of "containments for spent fuel and other high level radioactive materials" is appropriate. Note that a sharply defined scope is not necessary as it is not he function of Part WB, or any Code Part, to invoke itself. Rather it is the prerogative of the owner, following the appropriate regulatory jurisdiction's guidance, to select the applicable Code Part.

This is consistent with Section III Division 1. In particular the scope of Section III Division 1 Class 1 is defined in NB-1110(a) as "... rules for ... items that are intended to conform to the requirements for Class I construction." This scope carefully avoids defining the items that fall under Class I construction. Again, It is up to the owner, using appropriate guidance from his regulatory jurisdiction, to determine which items fall under the NB rules.