"Harmonization" – Two Years' of Transportation Regulation Lessons Learned

K. Colborn
MHF Logistical Solutions
Suite 450, 800 Cranberry Woods Drive
Cranberry Township, PA 16066, USA

ABSTRACT

The U.S. Department of Transportation issued modifications to the Hazardous Materials Regulations in October, 2004 as part of an ongoing effort to "harmonize" U.S. regulations with those of the International Atomic Energy Agency. The harmonization effort had several predictable effects on low level radioactive materials shipment that were anticipated even prior to their implementation. However, after two years' experience with the new regulations, transporters have identified several effects on transportation which were not entirely apparent when the regulations were first implemented.

This paper presents several case studies in the transportation of low level radioactive materials since the harmonization rules took effect. In each case, an analysis of the challenge posed by the regulatory revision is provided. In some cases, more than one strategy for compliance was considered, and the advantages and disadvantages of each are discussed. In several cases, regulatory interpretations were sought and obtained, and these are presented to clarify the legitimacy of the compliance approach. The presentation of interpretations will be accompanied by reports of clarifying discussions with the U.S. DOT about the interpretation and scope of the regulatory change.

Specific transportation issues raised by the revised hazardous materials regulations are reviewed, including:

> The new definition of radioactive material in accordance with isotope-specific concentration and total activity limits. The new hazardous materials regulations (HMR) created a new definition for radioactive material. A case study is presented for soils contaminated with low levels of Th^{-230}. These soils had been being shipped for years as exempt material under the old 2,000 pCi/g concentration limit. Under the new HMR, these same soils were radioactive material. Further, in railcar quantities their activity exceeded an A_2 value, so shipment of the material in gondolas appeared to require an IP-2 package. Interpretations, discussions, and an exemption were obtained to secure the continued shipment of this material.
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> A provision to allow "natural" radioactive materials to be exempt from the requirements of the HMR at up to 10x the listed isotopic concentrations. The revised HMR exempts certain natural materials and ores from regulation as radioactive material at concentrations up to 10x that allowed if the materials are

not natural. The term "natural" is not well defined, and initial attempts to qualify for this exemption were thwarted by concerns over what degree of material processing, if any, materials could experience and still be considered "natural". The presentation includes an example from a project involving post-processed tungsten ore, and includes interpretations from the US DOT as well as clarifying language from current and drafted IAEA regulation and guidance.

New packaging descriptions allowing the use of cargo containers as IP-2 and IP-3 packages in some applications. The revised HMR provides an alternate certification procedure under which standard cargo containers can be used as IP-2 and IP-3 containers. There has been some confusion about how this high level of certification can apply to standard cargo containers when other sections of the regulations make this certification available only to considerably more stout containers after rigorous testing. The discussion includes interpretive guidance from the US DOT, and from the UK Department of Transport clarifying the same provision in IAEA regulations.

A new definition of contamination with apparently broad impact on the shipment of empty containers and conveyances. The revised HMR presented a definition of contamination not referenced by any other part of the HMR. The preamble to the revised HMR provides confusing guidance on the application of the definition to shipment of empty containers, and subsequent interpretive guidance letters appear to conflict with the preamble as well as with each other. The definition also has the effect of regulating materials for transport as radioactive even when US NRC and US Department of Energy (DOE) guidance documents suggest that the materials are free-releasable. This presentation provides the latest available information on this emerging issue.

The presentation strives to provide the benefit of recent real-world experience in new aspects of the HMR. The examples provides should have broad application to shippers of a variety of low level radioactive materials in the US and internationally.

AN ISOTOPE-SPECIFIC DEFINITION OF RADIOACTIVITY

In 49 CFR 173.403 issues October 1, 2004, a new definition of radioactive material was established. The new definition reflects IAEA policies, and is based on the risk of exposure to radionuclides, that risk varying according to the type and energy of the isotope's emissions. Whereas the definition of radioactive material up to that time had been as follows:

Radioactive material means any material having a specific activity greater than 70 Bq per gram (0.002 microcurie per gram);

the new definition of radioactive material reads:

> *Radioactive material means any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in Sec. 173.436 or values derived according to the instructions in Sec. 173.433.*

The effects of the new regulation included the need for somewhat more rigorous characterization, particularly for mixtures of isotopes in materials that were exempt under the old definition. In addition, the new definition had the impact of significantly lowering the threshold at which some materials would be considered radioactive. The effect at one remediation site, where Th-230 was a contaminant of concern, was particularly dramatic. The site had shipped thousands of gondola railcars full of this remediation waste without incident, and exempt from regulation as Class 7 material since it was under the 2,000 pCi/g concentration limit. However, the new isotopic-specific exemption limit on Th-230 is only 27 pCi/g; two orders of magnitude lower than the old limit. With thousands of railcars of material still to be shipped from the remediation site, the project was faced with shipping materials that were not only regulated as Class 7, but now required an IP-2 packaging for compliant shipment.

Packaging thousands of tons of remediation waste in IP-2 packages would have an unacceptable cost and schedule impact on the project, so MHF Logistical Solutions was asked to help this client find compliant shipping alternatives that could allow the project to continue as it had with high production rates and low packaging and transportation costs. Two avenues were pursued to continue to use the Super Load Wrapper in a gondola railcar, upgrading the packaging;

- First to an IP-1 [from the old "strong tight" of 173.427(c)],
- Second, to an IP-2 packaging via an exemption (special permit).

Upgrading to an IP-1

The first action undertaken by MHF Logistical Solutions was to determine that the self-certification of the existing packaging could be upgraded from a 173.427(c) qualified package to 173.427(b)(4) qualified package. A determination that the package was indeed an IP-1 allowed the remediation materials to be shipped LSA-II concentrations, albeit limited to an A_2 total quantity. The net effect was to allow the site to continue to ship materials in concentrations up to about 400 pCi/g, where an 173.427(c) packaging would have limited shipping to about 100 pCi/g.

MHF Logistical Solutions prepared a self certification of the packaging, a Super Load Wrapper liner in a gondola railcar, and submitted the certification to the US DOT. In the request, MHF Logistical Solutions presented a innovative certification approach in which the Super Load Wrapper provided the needed containment of the radiological hazard, in conjunction with the railcar which provided the necessary structural envelope for the package. The DOT concurred with the MHF Logistical Solutions package certification;

refer to US DOT interpretations 04-0147 dated June 18, 2004, and 05-0138 dated July 5, 2005

Upgrading to an IP-2 Certification via Special Permit

While the IP-1 packaging allowed the project to continue to remediate its less-contaminated soils, more contaminated areas of the site remained to be excavated which would till require an IP-2 packaging. Discussions with the US DOT suggested that the regulator would consider a request for a special permit (or exemption from packaging requirements) for the material. Two approaches to the exemption were pursued:

- A general qualification of the packaging to 10 times the A_2 value, and
- A specific permit to resume shipping at up to 2,000 pCi/g in an IP-1 packaging

MHF Logistical Solutions first attempted a special permit which demonstrated the success history of the Super Load Wrapper in a gondola. The special permit request argued that the packaging’s performance had been demonstrated in thousands of successful gondola shipments of radioactive material. Based on this experience, an expansion of the capacity of the packaging was sought to bound the Th-230 content of the remediation soils in the subject project. The requested capacity expansion was set at 10 times the A_2 value for the mixture of isotopes in the packaging. MHF Logistical Solutions sought the exemption on these terms believing that the new and lower isotope-specific definition of radioactive materials was going to have a broad impact on remediation projects, and hoped to obtain the broadest possible permission to use the packaging at this increased capacity. However, the US DOT considered the capacity expansion to be too broad, and the special permit request was withdrawn.

In a second and parallel special permit request supported by MHF Logistical Solutions, the project requested only that the Super Load Wrapper IP-1 packaging continue to be used to ship materials containing up to 5,400 pCi/g Th-230. Based on site characterization data, this would allow the entire project to be completed without having to resort to the use of a fully-qualified IP-2 packaging. This special permit was granted, reference DOT-E 13958, dated July 1, 2005 (expires June 30, 2007).

EXEMPTION FOR “NATURAL” MATERIALS

The harmonization rules include a provision to allow “natural” radioactive materials to be exempt from the requirements of the HMR at up to 10x the listed isotopic concentrations [reference 49 CFR 173.401(b)(4)].

The regulatory provision offers relief from the hazardous materials regulations for those shipping tungsten, zirconium, and other ores that contain natural radioactivity. The provision allows these “natural” radioactive materials to be exempt from the requirements of the HMR at up to 10x the isotopic concentrations listed in 173.436. Unfortunately, the term “natural” is not well defined, and initial attempts to qualify for this exemption were thwarted by concerns over what degree of material processing, if any, materials could experience and still be considered "natural". Some assessors of the HMR assumed that chemical processing of the ore would cause the radioactive waste from this processing to fail to meet the definition of "natural".

The exact language of the US DOT natural materials provision in 173.401 exempts material as follows:

> *(b) This subpart does not apply to: (4) Natural material and ores containing naturally occurring radionuclides which are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the values specified in Sec. 173.436.*

The history of the site indicated that the contamination was from naturally-occurring radionuclides that remained from activities related to tungsten extraction; not as a result of activity designed to extract radionuclides. Further, the materials were being shipped as waste for disposal; hence, no future extraction of radionuclides was planned. For these reasons, the material appeared to meet the DOT's definition of "natural".

Further, the preamble to the new regulation states it is *"intended to exempt ores and materials that contain naturally occurring radionuclides, but whose benefits lie in their non-radiological qualities (such as… non-radioactive metals…)"*. These materials were processed to extract non-radioactive metals, and were not subjected to any known processing related to their radionuclide content. Hence the 10x exemption appeared to apply, making the materials exempt from DOT classification as radioactive material.

The exemption does not specifically mention waste products, but it seems reasonable to expect that the waste materials from beneficial extraction of non-radioactive metals would qualify for the exemption, since the intent of the regulation is to permit their *"continued use in commerce without making their use economically unfeasible"*.

Additional support of the applicability of the 10x concentration exemption was found in the IAEA Advisory Guide paragraph 107.4. This guidance explains that the IAEA regulations now reflected in 49 CFR *do not apply to other* [non-fuel cycle] *ores which may contain naturally occurring radionuclides* or processed materials… *where the processing was not for the purpose of extracting radionuclides*. Finally, the 2007 proposed language for TS-R-1 offers clarification that the exemption applies to post-processed material, stating the exemption applies to materials that "*have only been processed for purposes other than extraction of the radionuclides, and which are not intended to be processed for the use of these radionuclides*".

The US DOT concurred with MHF Logistical Solutions' assessment of the material and its qualification for the natural materials exemption (reference DOT interpretation number 05-0145 dated July 1, 2005). The interpretation also concurred with the proposed approach to determine the radionuclide concentration, and provided some clarification of natural materials footnotes in the exemption values table of 173.436.

FREIGHT CONTAINERS USED AS INDUSTRIAL PACKAGES

In 49 CFR 173.411(b)(6) the US DOT inserted new language to allow freight containers to be used as Industrial Packages Types IP-2 or Type IP-3, subject to specific conditions, specifically, freight containers can be used as industrial packagings provided that:

(i) *The radioactive contents are restricted to solid materials;*
(ii) *They satisfy the requirements for Type IP-1 specified in paragraph (b)(1); and*
(iii) *They are designed to conform to the standards prescribed in the International Organization for Standardization document ISO 1496-1: ``Series 1 Freight Containers--Specifications and Testing--Part 1: General Cargo Containers; excluding dimensions and ratings (IBR, see Sec. 171.7 of this subchapter). They shall be designed such that if subjected to the tests prescribed in that document…they would prevent …loss or dispersal of the radioactive contents…*

Some shippers are embracing the new provision as a broad license to use standard freight containers as IP-1, IP-2, and IP-3 packagings. However, closer examination of the container specifications and the requirements of this regulation suggest that the practice is not compliant with the regulations. The solid materials limitation is straightforward, but considering the next two requirements in turn:

(ii) They satisfy the requirements for Type IP-1 specified in paragraph (b)(1)

The requirements of an IP-1 packaging are not especially restrictive, and do not require testing or independent certification. However, the requirements of 173.410, and the requirements of 173 Subpart A and B apply to the container design, manufacture, and performance. While many container suppliers will certify standard freight containers to the IP-1 standard, shippers responsible for compliant package selection and shipment certification are advised to require the packaging supplier provide evidence that the design and manufacture of a freight container supports an IP-1 certification. The greatest challenge to a standard freight container is the requirement of 173.410 (b), that

> *Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.*

Freight containers typically bear only one certification, the International Convention for Safe Containers (CSC) plate. In order for a container to qualify for CSC certification, its fork pockets must be tested to 1.25 times the rated capacity of the container. A CSC plate alone provides no assurance that the container fork pockets meet the 3 times capacity requirement of the 173.410(b). Indeed, an engineering analysis commissioned by MHF Logistical Solutions indicates that the fork pockets of a standard freight container do not meet the safety factor of three required by the regulations (assuming a wood-floored container tested to 1.25R). Shippers are advised to request supporting evidence of fork pocket capacity before accepting a standard freight container for use as an IP-1 packaging.

(iii) They are designed to conform to the standards prescribed in the International Organization for Standardization document ISO 1496-1: ``Series 1 Freight Containers--Specifications and Testing--Part 1: General Cargo Containers…

Again, the only certification typically found on a freight container is the CSC plate. The CSC plate certification alone does not assure that the container has been constructed to the ISO-1496 standard. Investigation of a container certification may reveal that it meets both standards. However, the only way the shipper can assure that a container meets the ISO 1496-1 standard is to obtain certification of the design from the manufacturer. A link from the CSC plate to the ISO 1496 design may be possible from the approval reference number on the CSC plate. Freight containers are typically of foreign manufacture, and tracing the CSC plate approval number to documentation of construction to the ISO 1496-1 standard can be difficult, if not impossible.

Shippers seeking to assure strict compliance are advised; CSC plate certification and ISO 1496-1 construction certification are not equivalent. The standards are also not equivalent either (for example, ISO requires fork testing to 1.6 times capacity, versus the CSC’s 1.25 times requirement).

(iii) … They shall be designed such that if subjected to the tests prescribed in that document…they would prevent …loss or dispersal of the radioactive contents…

This language is a significant deviation from the language of IP-1 certification. IP-1 packages are required to prevent release of their contents in *conditions normally incident to transportation*. There are no test or rigorous documentation requirements to meet this IP-1, standard, it is generally considered to be a performance-based standard. However, use of a freight container as an IP-2 or IP-3 industrial package does require testing in accordance with this requirement. Neither ISO nor CSC establishes any requirements to test or certify containers against the release of their contents. Therefore, determination that the containment requirement is met is left to the shipper. Presumably, compliance may be determined by any of the methods prescribed in 173.461 (full scale testing, models, etc.).

The tests prescribed in ISO 1496 include transverse and longitudinal load testing for which the pass criterion is no permanent deformation. Temporary deflection of container walls of up to 60 mm (sufficient to temporarily unseat doors, lids, or other sealing surfaces) is entirely acceptable during the load test. A container passes the test if it experiences no permanent deflection.

Since temporary deflection can compromise container integrity, freight containers meeting ISO-1496 design and test requirements *will not necessarily prevent loss or dispersal of radioactive contents if used to ship loose bulk materials when subjected to the tests of that standard.* Therefore, it is not sufficient for a container to meet IP-1 and ISO-1496 requirements for it to be used as an IP-2 or IP-3 package. Such use [in accordance with 173.411(b)(6)] requires that the container *perform* as an IP-1, preventing loss or dispersal of its contents *while subjected* to the test conditions of ISO-1496.

The US DOT has stated the need for testing freight containers for their ability to prevent leakage of their contents in an interpretation number 06-0063, dated June 16, 2006. In addition, the UK Department for Transport has issued a *DfT Guide to the Approval of Freight Containers as Type IP-2 and Type IP-3 Packages*, expressing similar reservations about loosely interpreting the requirement of this new provision in the regulations [reference A.R. Webster, DfT/RMTD/0002 (freight containers) Issue 2, July 2005].

CONTAMINATION DEFINITION CONFLICTS AND CONFUSION

The HMR on October 1, 2004 introduced a definition for contamination that had not previously been expressed in the DOT regulations. Specifically, the definition states:

> *Contamination means the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters or 0.04 Bq/cm^2 for all other alpha emitters. Contamination exists in two phases.*
> *(1) Fixed radioactive contamination means radioactive contamination that cannot be removed from a surface during normal conditions of transport.*
> *(2) Non-fixed radioactive contamination means radioactive contamination that can be removed from a surface during normal conditions of transport.*

The definition is not referenced elsewhere in the HMR, so it is not readily apparent how the definition is to be used, and what bearing it has on shipping compliance. However, interpretations issued subsequent to the introduction of the definition have clarified the intended impact of the definition. For example, in DOT interpretation number 05-0094. dated July 20, 2005, the DOT offered that:

1. The limits on contamination represent a combined total of fixed and loose contamination
2. That empty containers and objects contaminated in excess of the definition are regulated by the HMR as Class 7 material
3. Empty packagings contaminated above the limits in 173.403 must be transported in accordance with 173.428 (or appropriate category of SCO)

4. The contamination limit on exposed surfaces of contaminated empty packages shipped as Class 7 is determined in accordance with 173.443

Later, in interpretation number 06-0002, dated June 30, 2006, the DOT offered that:

1. Fixed and loose contamination must be measured separately, and complied with separately (an apparent contradiction to the combined limit of 1 above)
2. Confirmed that objects, packages, and conveyances contaminated above the definition levels are regulated as Class 7 by the HMR
3. Confirmed that 173.443 expresses limits for contamination only for Class 7 packages or shipments, and are not limits below which shipments were unregulated as Class 7 by the HMR

The definition may not appear to present a new challenge to readers from IAEA-regulated countries, where the contamination definition is used consistently both as a free-release criterion by nuclear entities, and as a defining criterion for regulating shipment of a contaminated item. The definition may also appear familiar to some in the NRC-regulated community, since the contamination definition is similar to that established in 1998 by NUREG-1608.

However, the definition of contamination presents several challenges to shippers of multi-use packagings and conveyances in the United States, where the definition of contamination remains far from uniform. For example:

NRC License and DOE Criteria Differ

The agreement state license for a large United States' private radioactive materials disposal facility allows for unrestricted release of objects from the licensee's control at levels equivalent to NRC Reg. Guide 1.86; at least two times, and up to almost seven times higher than the contamination definition of 173.403 and the NRC's definition of an SCO in NUREG 1608.

The same license exempts conveyances from the Reg. Guide 1.86 contamination requirements, and in practice, conveyances are released as return to service without any DOT markings or restrictions on use at the contamination levels set forth in 173.443(c). This level of release is supported by a DOT interpretation issued well after the existence of NUREG-1608. Specifically, interpretation number 00-0304, dated March 13, 2001, sates that a trailer or railcar meeting the limits of 173.443(c) can be placed back in transportation for general use.

A second disposal facility, permitted only to accept certain naturally occurring radioactive materials that are exempt from NRC regulation, also releases containers and conveyances to the 173.443(c) contamination levels, citing the same DOT interpretation (00-0304) as a basis.

The DOE's criteria for unrestricted release in DOE Order 5400.5 and 10 CFR 835 Appendix D are essentially equivalent to the release criteria of NRC Reg. Guide 1.86, several times higher than the DOT definition of contamination.

Licensees and DOE facilities routinely release vehicles and objects from restricted areas to the controlled areas of their sites using the unrestricted release criteria that regulate their activities. Such items and vehicles may leave the controlled area and enter the public domain months or years after their survey, and may exceed the DOT definition of contamination requiring a regulated shipment. Hence, vehicles and objects may be released for off site transportation long after their release from a contaminated area, obscuring both the equipment's past use and the potential for contamination above the DOT limits.

Further, it would seem fully compliant for a piece of excavation equipment to be correctly surveyed for unrestricted release to a beta gamma standard of 5,000 dpm/100cm^2 and subsequently shipped as SCO-I to an equipment rental company. The rental company could remove the SCO-I markings on receipt, since the markings are relevant only to transportation. In such a case, the equipment rental company could be expected to keep records of the fact that the equipment is contaminated above DOT limits, even though it was released without restriction from a DOE or NRC licensed site. In strict accordance with the HMR, the rental company should conduct training of its shipping personnel in HMR requirements, and restore the SCO-I status to the shipment when it is delivered to the next rental customer (perhaps instructing the delivery driver to remove the SCO-I markings in the receiver's parking lot after transportation is ended so as not to alarm the receiver). The rental company might also have to develop a health physics program to monitor for contamination, even though it only accepts equipment that radioactive material licensees have surveyed for "unrestricted release".

Differing Administrative Treatment of Radioactive Material

United States' regulation of radioactive material features differing treatment of materials based on their origin and use. The contamination definition presents a challenge in this regard even within the HMR itself. For example, in the project mentioned above, in which the exemption of natural materials was utilized [173.401(b)(4)], full containers of contaminated soil were eligible for shipment completely exempt from Class 7 controls in full compliance with the HMR. However, empty containers exceeded the contamination definition, and were shipped as empty, Class 7, back to the remediation site for refilling. Since the contamination definition does not acknowledge the regulatory permission given to natural materials, these empty containers were subject to more stringent regulation than full containers of radioactive waste.

Even if containers making multiple trips to a site known to possess exempt natural material were exempt from contamination surveys at the end of that particular journey, the contamination definition still presents a problem for users of multi-use containers. Consider the case of an unmarked gondola car, subjected to a random scan for beta-gamma activity in a freight yard. A gondola with fixed contamination of 4,000 dpm/100cm^2 might have been released from a disposal facility in full compliance with their license. It might have never contained HMR-regulated material if the material was known to be natural when it was shipped. It may have been used in a DOE shipment and surveyed for unrestricted release in accordance with DOE regulations. Indeed, a railcar may have been used for all of these activities at some point in its history. And yet, the railcar, released by any (or perhaps all) of these entities in full compliance with their governing regulations sits in a rail yard subject to marking and control as a radioactive item by the DOT. Even if the precise use history of the gondola is known, the origin of remaining contamination is not likely to be determinable. Freight yards and conveyances as large as gondola cars are not ready candidates for detailed isotopic analysis to determine the administrative status of small quantities of fixed contamination. The event is not uncommon, and, beyond marking the gondola as an SCO for shipment, the corrective actions required to address such a situation are unclear. This is particularly true from the standpoint of radiological control. Since the equipment has been determined to be eligible for unrestricted release, decontamination to below-SCO levels would appear to be an unregulated activity. Nonetheless, it would be difficult from a public perception standpoint to attempt decontamination of a gondola or other packaging marked “radioactive” at an unregulated facility. If wastes from the decontamination were determined to be regulated, their precise regulatory status would be difficult to determine, since the contamination may represent a mix of materials from a variety of administrative categories.

Attempts at Clarification

On December 21, 2005, MHF Logistical Solutions co-authored with EnergySolutions, parallel letters to the US DOT and the US NRC that expressed concern with the new contamination definition and interpretation guidance. The letters also requested additional clarification of the actions to be taken when an object or conveyance is discovered in commerce that exceeds the DOT definition of contamination even though it has been properly released by the DOE, NRC licensee, or agreement state licensee. At this writing, the NRC has not responded to the request. The DOT interpretation 06-0002 was issued in response, but subsequent communications suggest that additional guidance will be forthcoming after DOT holds further discussions with the NRC.