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THE EVOLUTION OF U.S. TRANSPORTATION REGULATIONS FOR RADIOACTIVE MATERIALS — A RETROSPECTIVE

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CHAPTER

52

THE EVOLUTION OF U.S. TRANSPORTATION REGULATIONS FOR RADIOACTIVE MATERIALS — A RETROSPECTIVE

Ronald S. Hafner

The discussion in this Chapter is a highly condensed version of the information presented previously in Chapter 52 of the 2nd Edition of the *Companion Guide to the ASME Boiler & Pressure Vessel Code*.[1] The full text of the previous Chapter 52, i.e., *Development of U.S. Regulations for the Transportation of Radioactive Materials — A Look Back over the Past 40 Years*, could not be reproduced here. Therefore, this Chapter offers a high-level overview of the information presented previously, including all of the appropriate references.

For the most part, the material that was not included in this version of Chapter 52 is available in the public domain. Due to the sheer volume of the information, readers interested in the preamble-only versions of the material referenced in this Chapter are redirected to Reference [1]. Readers interested in the full-text versions of the material referenced in this Chapter are redirected to the appropriate *Federal Register* and/or U.S. Nuclear Regulatory Commission (NRC) websites. Because some of the material dates back to pre-website times, readers interested in the full-text versions of some of the references may have to rely on the services of their local libraries.

52.1 INTRODUCTION

The discussion in this Chapter is a relatively straightforward, chronological description of the development of U.S. transportation regulations for radioactive materials over the past 40 years. Although primarily based on the development of U.S. regulations for the shipment of what is now known as *Type B* quantities of radioactive materials, the information presented details the interactions between a number of U.S. governmental agencies, commissions, and departments, and the International Atomic Energy Agency (IAEA).

For the most part, the information that follows was taken directly from the *Federal Register*, between 1958 and 2004, which, within the boundaries of the U.S., is considered law — or at least policy — at the federal level. Starting in 1978, however, the information also takes a look at a series of what are called *Guidance Documents*, including Regulatory Guides (i.e., Reg. Guides), NUREGs, and NUREG/CRs.* Developed originally by the U.S. Atomic Energy Agency (AEC), and later adapted by the NRC, the NUREGs and NUREG/CRs cited in this Chapter clearly specify a preferred methodology that can be used to meet the regulatory requirements of Title 10 of the Code of Federal Regulations, Part 71 (10 CFR Part 71, or, more simply, 10 CFR 71). As is appropriate for the discussion in this Chapter, the methodology preferred by the NRC, not as law but as guidance, was adapted directly from the requirements of the ASME's *Boiler & Pressure Vessel Code*.

The information is provided with little embellishment. By taking the information directly from the *Federal Register*, and from the NUREGs and NUREG/CRs that were developed at the time, it becomes a story that tells itself. The information is self-

* As is noted by their descriptions, Reg. Guides and NUREGs are guidance documents developed by the NRC, whereas NUREG/CRs are guidance documents developed for the NRC by NRC contractors. The primary difference between the three types of documents is that Reg. Guides specify NRC *policy*, NUREGs make recommendations speaking for the NRC, and NUREG/CRs make recommendations speaking for NRC contractors.

consistent, and it provides many of the details behind the numerous policy decisions that led to the development of the U.S. regulations, as they were in their time, and as they are now.

52.2 BACKGROUND

In 1958, at the request of the Economic and Social Council of the United Nations, the IAEA undertook the development of international regulations for the safe transportation of radioactive materials. The initial regulations published by the IAEA in 1961 were recommended to member states as the basis for national regulations and for application to international transportation. That began the process, in the United States, of a series of revisions to the U.S. regulations governing the transportation of radioactive materials.

In the hierarchical structure of the U.S. transportation regulations for hazardous materials, the Department of Transportation (DOT) sits at the top. DOT is responsible for the transportation of all hazardous materials within the physical boundaries of the United States. DOT is also responsible for the transportation of all hazardous materials into and out of the United States. In that capacity, the DOT functions as the *Competent Authority* for the United States in all regulatory matters dealing with the transportation of hazardous materials of any kind on a national and international basis.

From a regulatory standpoint, however, radioactive materials are considered to be a subset of hazardous materials. Termed *Class 7* materials in DOT's regulatory language, radioactive materials are currently subdivided into two additional subcategories: Type A quantities and Type B quantities, based on the relative hazard of the radionuclide(s) in question, and the total amount of the activity being shipped in a given package. Although the DOT generally defers to the NRC on technical matters dealing with the transportation of radioactive materials, the regulatory requirements for the transportation of Type A (i.e., relatively small) quantities of radioactive material fall under the purview of DOT regulations (in Title 49 of the Code of Federal Regulations, Parts 173–178, i.e., 49 CFR 173–178); whereas regulatory requirements for the transportation of Type B (i.e., relatively large) quantities of radioactive material fall under the purview of NRC regulations, in 10 CFR 71. But, whether it is a Type A package under the purview of the DOT, or a Type B package under the purview of the NRC, the one major subtheme that is constantly at work is the consistency between the regulations of the United States and those of the IAEA.

In this Chapter, we look at the development of the regulations, the policies, and the recommendations, for the transportation of radioactive material. Although the primary focus is on the development of the regulations for Type B shipping containers (10 CFR 71), we also, out of necessity, take an occasional look at the development of some of the regulations that fall under the purview of the DOT (49 CFR 173–178). Along the way, we also delve into a second major subtheme: compliance with the requirements of the ASME Boiler & Pressure Vessel Code, used as a metric to quantify the U.S. regulatory requirements.

52.3 TITLE 10, CODE OF FEDERAL REGULATIONS, PART 71 (10 CFR 71)

The first, real version of what we would now recognize as 10 CFR 71 was published in the *Federal Register* on July 22, 1966.[2] That version would become the cornerstone, because it combined the existing regulatory requirements from the older version of 10 CFR 71[3] with a recently proposed revision to 10 CFR 71[4] and the proposed regulatory requirements from a then proposed 10 CFR 72.[5, 6] It also went on to describe the initial framework that separated the regulatory jurisdiction of the Atomic Energy Commission† from the Interstate Commerce Commission.‡ It went on to describe the origins of the development of what we now refer to as "specification packages," and it provided a direct linkage between the U.S. regulations for the transportation of radioactive materials and those of the IAEA.[7]

52.3.1 10 CFR 71 — 1965 Proposed Rule

Prior to looking at the 1966 Final Rule, however, an examination of its immediate predecessor becomes worthwhile. Published as a *Proposed Rule Making* on December 21, 1965,[8] the proposed rule clearly outlines the framework for what would become the Final Rule:

> "The regulations of the Atomic Energy Commission, Parts 30, 40, and 70 of Title 10, code of Federal Regulations (10 CFR), require that before the Commission approves an application for license to receive, possess, use, or transfer byproduct, source, or special nuclear material, it must determine that the applicant's proposed program is adequate to protect health and minimize danger to life and property.
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> "In 1958, the Commission adopted 10 CFR Part 71, 'Regulations To Protect Against Accidental Conditions of Criticality in the Shipment of Special Nuclear Material.' This regulation established procedures for approval of transport of special nuclear material, but set only limited standards. Certain small shipments under specified conditions were made exempt from the licensing requirement.
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> "In 1960 and again in 1961, the Atomic Energy Commission published for public comment its proposed 10 CFR Part 72, 'Protection Against Radiation in the Shipment of Irradiated Fuel Elements,' to regulate the increasing number of shipments of irradiated solid nuclear fuel. That

† The Atomic Energy Commission would later be subdivided into the Nuclear Regulatory Commission (NRC) and the Energy Resource and Development Agency (ERDA). ERDA would later become the Department of Energy (DOE).

‡ The Interstate Commerce Commission would later become the Department of Transportation (DOT).

proposed regulation has never been adopted by the Commission as an effective regulation, although its previsions [*sic*] have been used as licensing criteria since their publication.

"On March 5, 1963, the Commission published a proposed revision of Part 71 (28 F.R. 2134), incorporating standards developed as the result of licensing experience as well as from the Commission's experience as a shipper of special nuclear material. In that proposed revision, the concept of different classes of packages of special nuclear material was introduced. This concept, which has been developed by the International Atomic Energy Agency at that time, is intended to distinguish among classes of packages according to the degree of control which must be exercised in transport in order to avoid criticality.

"Public response to the proposed revision of Part 71 to a large extent suggested that (1) the regulation should emphasize performance standards, insofar as possible, rather than detailed design specifications for shipping containers and shipping procedures, and (2) the method of shipment to satisfy those performance standards should be left to the ingenuity of the shippers. It was suggested that the detailed standards proposed might impair the growth of the industry and development of improved safety concepts and that the standards were already outdated and were in some cases inapplicable, inadequate, or overly restrictive. The comments indicated that licensing requirements based on performance standards would allow needed flexibility to develop improved shipping methods. It was also suggested that the regulatory relationship between the Atomic Energy Commission and the Interstate Commerce Commission be made clear.

"As a result of the numerous public comments and further study, the notice of proposed rule making issued on March 5, 1963, is withdrawn, and is superseded by this notice. The revision of 10 CFR Part 71 here proposed has deleted the detailed design standards of that proposal, and emphasizes performance standards to determine the adequacy of proposed shipping methods. The performance standards of this proposed revision are compatible with those developed by the International Atomic Energy Agency during the past few years.

"In response to public comments received on the proposed Part 72 dealing with the transport of irradiated fuel elements, and to provide flexibility of approach in that rapidly growing field, a revision was also undertaken of Part 72. As in Part 71, the requirements have, as far as possible, been modified into performance standards. Since the nuclear safety requirements of Part 71 are applicable to the shipment of irradiated as well as unirradiated special nuclear material, the two Atomic Energy Commission transport regulations, Parts 71 and 72 have been combined into a single document in the interest of clarity and to avoid duplication. The notice of proposed rule making issued on September 23, 1961, 10 CFR 72 (26 F.R. 8982), and a minor amendment issued March 5, 1963 (28 F.R. 2142), are withdrawn and superseded by this notice.

"A proposed amendment dated March 5, 1963, to 10 CFR Part 40, 'Licensing of Source Material,' would have provided transport control over certain large masses of source material which, when shipped in combination with materials having unusual moderating properties, might present a possibility of accidental criticality (28 F.R. 2111). Public comments on this proposed amendment questioned the level at which control would be imposed, and questioned the practical need for any control at all. Upon further consideration, the Commission determined that there is no practical need for the proposed control at this time. Accordingly, the notice of proposed rule making issued on March 5, 1963, to 10 CFR Part 40 (28 F.R. 2111) is withdrawn.

"Since 1948 shipments of radioactive material in interstate and foreign commerce have been regulated by the Interstate Commerce Commission under the Transportation of Explosives and other Dangerous Articles Act (18 U.S.C. 831–835). The Atomic Energy Commission has provided a safety evaluation of the same shipments in some cases, both as part of its regulation of the activities of its licensees and its control of its own shipments. To coordinate these efforts under a proposed agreement between the two agencies, the Atomic Energy Commission would adopt standards for the transport of large quantities of licensed radioactive material, as specified in the regulation, as well as the transport of all fissile material because of the additional potential hazard of criticality. The Commission would issue regulations applicable to its licensees, and would apply the same standards in rendering technical advice to the Interstate Commerce Commission for shipments requiring their approval. In regulating the transport of radioactive materials, the Interstate Commerce Commission would take into account the authority to ship granted by the Commission to its licensees and contractors, and the technical advice rendered to the Interstate Commerce Commission by the Commission.

"In summary, the revised Part 71 contains: (1) The substance of the earlier Part 71 which covered the shipment of unirradiated fissile materials, as revised to emphasize performance standards, (2) standards and requirements for the shipment of irradiated fissile materials, and (3) standards and procedures for the shipment of 'large quantities' of licensed material.

"Persons specifically licensed to receive, possess, use, or transfer source material have been included in the scope of this regulation because it is intended that any source material be considered in the evaluation of a package or shipment which also contains byproduct and special nuclear material in sufficient quantities that the standards of Part 71 apply. It is recognized that the exemption provisions of the proposed § 71.5 would probably apply to most, if not all, packages or shipments of source material per se.

"A 'large quantity' of licensed material is defined in the regulation in terms of the 'transport group' of the radionuclide in question (which is based on relative potential hazard in transport), and in terms of 'special form' of the licensed material. A 'special form' is a nondispersible form, so that there is no need for further consideration of the hazard of ingestion of the material by a human being. The criteria used to determine whether the material is in 'special form' are given in the definition of 'special form' in § 71.4(s), and depend upon the inherent properties of the material and the properties of a capsule in which it may be transported. It is anticipated that, under proposed regulations now being developed, responsibility for determining 'special form' by virtue of the inherent properties of the material will remain with the shipper. When 'special form' is based on encapsulation, it is anticipated that approval of the capsule design and properties will be required by the Interstate Commerce Commission.

"The proposed § 71.6(c) includes a general license for the transport of fissile material and large quantities of licensed material in 'specification packages' as they are and will be authorized in the regulations of the Interstate Commerce Commission for that purpose. At present, the Interstate Commerce Commission regulations (49 CFR Part 78) contain a number of 'specification containers' but these are authorized only for small quantities of nonfissile radioactive material (§ 73.393 of 49 CFR Part 73). It is anticipated that the Interstate Commerce Commission will soon publish some specifications for packages for use in the transport of fissile materials and large quantities of radioactive materials, at which time such 'specification packages' may be used, in accordance with § 71.6 (c), without further approval by the Atomic Energy Commission. The Atomic Energy Commission will review and approve 'specification containers' before they are listed by the Interstate Commerce Commission.[§]

"The proposed new Part 71 is divided into four subparts:

"Subpart A, 'General Provisions,' imposes the requirement of a license for certain shipments of licensed material (including fissile material). It specifies the quantities and methods of transport which are exempt and those which are under a general license. Exemption and general license provisions are applicable to shipments which are not dependent for safety on an individual packaging evaluation other than that provided under the regulations of the Interstate Commerce Commission.

"Subpart B, 'License Applications,' specifies the information which must be submitted to the Commission for specific licensing of any method of shipment not authorized under Subpart A.

"Subpart C, 'Package Standards,' specifies the standards which a package must meet for the shipment of fissile material or a large quantity of licensed material, and certain special requirements for the transport of Fissile Class II and Fissile Class III shipments.

"Subpart D, 'Operating Procedures,' specifies the general package determinations and shipping precautions required in order to assure the effectiveness of approved shipping methods.

"In order to provide reasonable assurance of adequate radiation shielding, containment of the radioactive material, and absence of nuclear criticality during transport, the performance of the package and the control exercised over it during transport must be evaluated for normal transport conditions and for potential accident conditions. To avoid inconsistencies involved in guarding against every conceivable condition which could be encountered in transport, Part 71 specifies the transport conditions against which a shipping system must be evaluated. It specifies a set of 'normal conditions of transport' intended to represent conditions which may normally occur during transport. Packages must be designed to withstand these normal conditions. The regulation further specifies a set of 'hypothetical accident conditions' consisting of a 30-foot drop onto a flat surface, followed by a 40-inch drop onto a 6-inch diameter steel bar, followed by exposure to an environment at a temperature of 1475° F for 30 minutes, followed by immersion in water. The hypothetical accident conditions prescribed in the regulation are not intended to represent any one accident, but are so chosen that satisfactory performance of a package exposed to them may be considered to give reasonable assurance of satisfactory performance in accidents likely to occur in transportation.

§ Author's Note: The emphasis here on 'specification packages' will continue to show up, repeatedly, through this Chapter. Also note that, by regulation, these so-called *specification packages* could be used "…without further approval by the… Commission."

"A package is not expected to withstand without damage the hypothetical accident conditions specified. The extent of allowable damage to a package depends on the effect of that damage on the containment, shielding, and nuclear safety characteristics of the package. It is expected that, in accordance with the Interstate Commerce Commission, Coast Guard, or Federal Aviation Agency regulations, any package which is damaged in transport would not be carried further in normal transport until any necessary repairs were made.

"The 'Package Standards' in Subpart C, in prescribing the performance standards for a single package and for a permissible array of packages, require that a 'sample package' be subjected, by test or other assessment, to the specified transport tests and conditions. The 'sample package' must fairly represent the actual package to be introduced into transport. In some cases of Fissile Class III shipments, where the entire shipment is to be controlled during transport, the 'sample package' may be considered to be the entire shipment together with the transporting vehicle. It is the intent of these regulations that any analytical treatment which has a reasonable degree of certainty may be employed to predict the performance of a package under the specified test conditions. The results of subjecting a package to the test conditions might be determined by engineering analysis, by physical testing of prototype packages or of scale model packages, by testing of package components, or by any other method as long as a reasonable degree of certainty is established for the results. A great deal of effort has gone into the establishment of the test conditions to make it possible to use calculative methods of solution. It is hoped that good calculative methods will be developed so as to avoid, at least to some extent, the performance of physical tests which otherwise would be necessary….

"In addition to the standards which determine if a package performs adequately when subjected to the normal and accident conditions of transport, there are certain design requirements directed to structural integrity, temperature, radiation shielding, and other general design features of a package. The design requirements directed toward package lifting and tiedown systems are intended to assure that such devices are not torn from the package during use, and that stresses delivered to the package through the lifting or tiedown systems would not damage the package.

"The proposed § 71.13, 'Limited exemption for transport of special nuclear material' would require that every licensee now authorized to transport fissile material file a consolidated application for a superseding license. Information and procedures developed by applicants in past years, and embodied in license applications which have in turn been incorporated by reference in existing licenses, will in most cases require reevaluation. Moreover, many licenses have been the subject of numerous amendments which have incorporated by reference material in previous applications. It is the view of the Commission that issuance of new licenses based on consolidated applications, submitted in accordance with the technical standards of the proposed Part 71, will contribute significantly to the effective administration of these licenses, and ultimately to nuclear safety. The Commission has determined from its review that the continued use of certain existing packages (casks) now used for the transport of irradiated nuclear fuel does not constitute an undue risk to the health and safety of the public. The proposed § 71.42 therefore exempts from the package standards existing packages which have been approved since 1961 under the criteria of proposed Part 72.

"The proposed § 71.14, 'Limited exemption for transport of large quantities of licensed material' would provide a period of time for licensees to obtain approval of shipping procedures before the requirements of Part 71 come into effect. The Commission proposes to evaluate, on an individual basis, licensed material packages which have been constructed prior to the effective date of the regulation using the package standards of Part 71. Loss of shielding resulting from the puncture test followed by the thermal test will not be considered, in itself, ground for disapproval of such a package which meets all the other standards of Part 71.

"Notice is hereby given that adoption of the following rules is contemplated. All interested persons who desire to submit written comments and suggestions for consideration in connection with the proposed rules should send them in triplicate … within 60 days after publication of this notice in the FEDERAL REGISTER.** Comments received after that period will be considered if it is practical to do so, but assurance of consideration cannot be given except as to comments filed within the period specified.…"[8]

52.3.2 10 CFR 71 — 1966 Final Rule

The July 22, 1966 version of 10 CFR Part 71 was published as the final regulation, with the differences between the

** Author's Note: Normally, the preferred format for the term *Federal Register* would be in italics. In this case, however, the format shown, i.e., FEDERAL REGISTER, was provided by the U.S. Government Printing Office. This will show up again, repeatedly, throughout the remainder of this Chapter.

proposed rule and the final rule described appropriately in the preamble:

"The regulations of the Atomic Energy Agency (AEC), 10 CFR Parts 30, 40, and 70, require that before the AEC approves an application for license to receive, possess, use or transfer byproduct, source, or special nuclear material, it must determine that the applicant's proposed program is adequate to protect health and minimize danger to life and property.

"In 1958, the AEC adopted 10 CFR Part 71, 'Regulations to Protect Against Accidental Conditions of Criticality in the Shipment of Special Nuclear Material.' This regulation established procedures for approval of transport of special nuclear material, but set only limited standards. Certain small shipments under specified conditions were exempted from the licensing requirement.

"On March 5, 1963, the AEC published a proposed revision of Part 71 (28 F.R. 2134), incorporating many detailed specifications regarding acceptable shipping methods. Public response to that proposed revision suggested that the detailed standards proposed might impair the growth of the industry and development of improved safety concepts and that the regulation should emphasize performance standards rather than detailed design standards. Proposed Part 72, 'Protection Against Radiation in the Shipment of Irradiated Fuel Elements' (26 F.R. 8982, 28 F.R. 2142), which proposed standards and procedures for packaging and transport of irradiated solid nuclear fuel, elicited a similar public response.

"On December 21, 1965, the AEC published for comment a proposed revision of Part 71 (30 F.R. 15748). The proposed revision combined the standards for unirradiated and irradiated fissile material previously proposed separately as Parts 71 and 72, and added standards and procedures for the shipment of large quantities of licensed material. It emphasized performance standards to determine the adequacy of proposed shipping methods, with the method of satisfying those performance standards left to the ingenuity of the shippers. The proposed performance standards would be comparable with those developed by the International Atomic Energy Agency during the past 2 years.

"Subsequent to the publication of [the] proposed Part 71, a Memorandum of Understanding between the Interstate Commerce Commission (ICC) and AEC was signed. In the Memorandum, the two agencies agreed, subject to their respective statutory authorities, that (1) ICC will adopt appropriate regulations and requirements applicable to transport of all radioactive materials, and to shippers of all types and quantities of radioactive materials, but will avoid duplicatory standards with respect to preparation for shipments of fissile materials and large quantities of radioactive material, and (2) AEC will adopt appropriate regulations applicable to standards for the preparation for shipment of fissile material and large quantities of radioactive material and will be responsible for the adoption of regulations and requirements applicable to its licensees or contractors as may be necessary to protect against radiation and criticality hazards in the transportation of all radioactive material where shipment is outside the regulatory jurisdiction of ICC.

"Under the Memorandum of Understanding, the ICC will utilize the assistance of AEC on container approvals for fissile materials and large quantities of radioactive materials. The AEC and ICC are working together to develop criteria for additional 'specification containers' in order to reduce the number of special container permits issued by the ICC.

"Several changes have been incorporated in the regulation, as adopted, as a result of the Memorandum of Understanding, and the publication of amendments to ICC regulations on April 29, 1966 (31 F.R. 6492), covering some of the same areas covered in the notice of proposed rule making published by the AEC on December 21, 1965 (30 F.R. 15748). Thus, the following provisions that were contained in that AEC proposed rule have been omitted in the effective rule…

1. Section 71.11 of the proposed rule, which would have imposed ICC requirements through AEC authority;
2. References throughout the proposed rule to transport of radioactive material by a licensee;
3. The radiation level limitations in proposed § 71.34;
4. The definitions of 'milliroentgen per hour or equivalent' and 'transport unit' in proposed § 71.4 (j) and (u);
5. The requirement in proposed § 71.40 (b) that a Fissile Class II package be labelled [*sic*] as prescribed by ICC, although the procedure for determining the minimum 'radiation unit' for criticality control has been retained;
6. The requirement in proposed § 71.40 that a licensee not transport or deliver to a carrier more than 40 units of Fissile Class II packages, nor a single package with a calculated radiation unit of more than 10;
7. The requirement in proposed § 71.41(b) for Fissile Class III transport procedures to protect against commingling with other fissile material;
8. The requirement in proposed § 71.54 for routine determinations with regard to the radiation level

limits, surface contamination limits, and transport procedures.

"The definition of 'carrier' in proposed § 71.4 has been modified to conform to usage under the Transportation of Explosives and Other Dangerous Articles Act (18 U.S.C. §§ 832–837), which is administered by the ICC.

"Other significant differences from the regulation published for comment are:

1. The definition of the term 'fissile material' has been restricted to those isotopes of uranium and plutonium which must now be controlled during transport to avoid criticality.
2. A requirement in proposed § 71.31 (b) which imposed a temperature standard on the materials and fabrication of packaging has been deleted. Correspondingly, the temperature to be considered for Normal Conditions of Transport set out in Appendix A has been increased from 100° F. to 130° F. This increased ambient temperature would provide for the more extreme conditions which might be encountered in normal transport.
3. The requirement in proposed § 71.31 (e) that primary coolant not circulate outside of the shielding has been deleted.
4. The lifting and tie-down device requirements in proposed § 71.31 (f) and (g) have been modified to make it clear that the standards apply only to devices which are a structural part of the packaging. The modified requirements are included in § 71.31 (c) and (d) ….
5. The pressure design standards of the proposed § 71.32(b)–(d), including that for a pressure relief device, have been replaced by an internal pressure test to be initially performed on each individual package which will be subjected to significant internal pressure, set out in § 71.53(b).
6. The specific temperature restriction, contained in proposed § 71.33, on large quantity packages, assuming loss of coolant and cooling devices, has been omitted, as has the corresponding test requirement of proposed § 71.53(b). Temperature restrictions will be effectuated through the performance standards of §§ 71.35 and 71.36. Requirements have been included in § 71.35 … to assure that there will be no loss of coolant under the Normal Conditions of Transport.
7. The limitation on loss of shielding under Hypothetical Accident Conditions (Appendix B) has been revised to specify an allowable increase in radiation levels to 1,000 milliroentgens per hour or equivalent at 3 feet from the external surface of the package.
8. The provisions relating to assumed inleakage of water to and outleakage of liquids from fissile material packages in determining subcriticality in proposed § 71.37(b)(3) have been revised and redesignated § 71.33.
9. The requirement in proposed § 71.39 (a) that Fissile Class I packages be considered with other types of Fissile Class I packages has been deleted as unnecessary in view of the provision for assumed interspersed moderation.
10. The requirement in proposed § 71.51(a) for licensee quality control procedures has been replaced by a performance requirement in § 71.53(c) … that the licensee assure that the packaging is fabricated in accordance with the design approved by the AEC.
11. The list of items to be included in a licensee's operating procedures required by proposed § 71.51(b) has been deleted from the regulation.

"Additional minor changes from the proposed rule have been incorporated in the effective rule.

"The rule … establishes packaging standards for the shipment of fissile material, both unirradiated and irradiated, and of large quantities of licensed radioactive material. The rule specifies the quantities and methods of transport which are exempt from Part 71 requirements and those which are under a general license. The exemption and general license provisions are applicable to shipments which from a safety standpoint do not require an AEC packaging evaluation. Those shipments are subject to regulation by federal transport agencies. For shipments not exempted or generally licensed, the rule prescribes the determinations which must be made with respect to packaging and shipping precautions required in order to assure nuclear safety of shipping methods.

"With a few exceptions, the basic organization and standards … have not been changed significantly from those contained in the notice of proposed rule making, issued on December 21, 1965 (30 F.R. 15748). A detailed explanation of the organization and standards of Part 71 is made in the notice of proposed rule making.

"The rule … divides radionuclides into a number of groups, each having a comparable potential hazard in transport. These groups were derived from the International Atomic Energy Agency's Safety Series No. 6, 'Regulations for the Safe Transport of Radioactive Materials,' 1964 Revised Edition.…

"Published simultaneously with proposed 10 CFR Part 71 on December 21, 1965, were certain proposed amendments to 10 CFR Parts 30 and 70

(30 F.R. 15748), the basic licensing regulations for byproduct and special nuclear material, respectively, containing a reference to Part 71. Those amendments are no longer considered necessary and that notice of proposed rule making is, accordingly, withdrawn.

"Pursuant to the Atomic Energy Act of 1954, as amended, and the Administrative Procedure Act of 1946, the following revision of 10 CFR Part 71 is published as a document subject to codification, to be effective 30 days after publication in the FEDERAL REGISTER…."[2]

Thus, with little fanfare, the first, real version of what we would now recognize as 10 CFR 71 went into effect on August 21, 1966. For Type B packaging requirements, we have been living within the basic constraints of those regulations ever since.

52.4 MAJOR CHANGES — 1968

In 1968, a series of substantive changes was introduced into the U.S. regulations for the transportation of radioactive materials. Two of these changes, a proposed rule and a final rule, were introduced into the DOT regulations; one month later, a set of miscellaneous changes was introduced into the AEC's regulations. Each of these changes is examined in more detail.

52.4.1 DOT Changes — 1968 Proposed Rule

In January, 1968, the DOT introduced a major set of proposed rule changes to its existing Hazardous Materials Transportation Regulations (49 CFR 170–190).[9] In order to demonstrate the interactive linkage between the regulations of the DOT, the AEC, and the IAEA, the text of the preamble for this set of proposed rule changes is examined in more detail.

"On April 1, 1963, the Interstate Commerce Commission (ICC) published its Notice No. 58 in Docket No. 3666. The notice proposed to modify the ICC Regulations for transporting radioactive materials to bring them into accord with the recommended regulations of the International Atomic Energy Agency (IAEA). Based upon the comments received pursuant to that notice of proposed rule making and after discussion with representatives of the U.S. Atomic Energy Commission (USAEC), it became apparent that it would not be in the public interest to adopt those amendments at that time. This area of regulation was transferred to the Department of Transportation by the Department of Transportation Act (80 Stat. 931).

"Since that time this Department, the ICC, and the Atomic Energy Commission have worked toward the preparation of a revision to the radioactive materials regulations. Many meetings have been held between industry and Government representatives. Several significant 'enabling' regulatory amendments have been adopted which now make it practical to propose a revised major revision of these regulations. In 1966, the USAEC published its packaging standards in Part 71 of Title 10, CFR. At the same time, the ICC published Order No. 70 relating to transportation of fissile radioactive materials. Early in 1967, the ICC also published Order No. 74 which made further modifications regarding radioactive materials.

"During the past 18 months, a task force comprised of representatives of the USAEC and its contractors prepared a series of draft regulatory changes designed to incorporate the principles of the recommended regulations of the IAEA into the regulations as amended by Orders 70 and 74. These drafts were further modified as a result of participation by representatives of the ICC, Federal Aviation Administration, U.S. Coast Guard, and various atomic energy and transportation industry personnel. The results of all of these reviews and discussions are reflected in this notice of proposed rule making.

"This notice includes proposed amendments to the Hazardous Materials Regulations of the Department of Transportation (49 CFR Parts 171–178) (formerly a part of the ICC Regulations) and Part 103 of the Federal Aviation Regulations (14 CFR Part 103). The purpose of this notice is to request public comment on procedures proposed for the transportation of radioactive materials. Interested persons are invited to participate in the making of proposed rules by submitting such written data, views, or arguments as they may desire.…

"Communications received … would be considered by the Board before taking final action on the notice. All comments will be available for examination by interested persons … both before and after the closing date for comments. The proposals contained in this notice may be changed in light of comments received.

"Several references are made in the proposed regulatory amendments to authorizations issued under Part 170 of Title 49, CFR. Part 170 has been reserved for the Rules of Procedure for the Hazardous Materials Regulations Board. Part 170 has been published as a notice of proposed rule making but has not yet been adopted. It is expected that Part 170 will be in effect before the expiration of the comment period for this notice of proposed rule making. Part 170 will include the procedures for general rule making as well as those for handling applications for special permits.

"The basic consideration in the transportation of radioactive materials is that they may present radiation and contamination hazards to transportation workers, passengers, and the general public. In addition, radiation exposure may damage other materials in transport, such as undeveloped photographic film.

The proposed regulatory amendments will provide for the control of these potential hazards by considering the three basic factors of (1) relative hazard potential (2) packaging performance and (3) the transportation environment. The existing regulations place the primary emphasis on the packaging requirements for normal conditions of transportation. The proposed revisions will provide a system of allowing sufficient emphasis to be placed not only on the normal conditions of transportation, but also on the environmental conditions which a packaging of radioactive materials might encounter in an accident.

"This notice of proposed rule making establishes a separate hazard classification category for radioactive materials, apart from the poisonous category. Radioactive materials would be classified as radioactive materials and not as Class … D poisons as they currently are. Appropriate changes are being proposed to the commodity list in Part 172….

"In Part 178 revisions are made to specifications 6L and 12B, and two new specifications are being proposed. Specification 6L is being modified to provide a wider flexibility in drum size and centering mechanisms. Tests have shown the inadequacy of the present closure requirements and the specification is being modified to require higher strength locking rings. A newer specification 6M metal package is being proposed for both fissile and nonfissile radioactive materials.[††] The special specification 12B fiberboard box for radioactive materials would be deleted since the requirements contained therein would now be included in § 173.393. A new specification 7A general package is being proposed for radioactive materials. Specification 7A provides for performance criteria rather than detailed engineering design requirements. The shipper would be given a great deal of flexibility in the exact design of his specification 7A package.

"A number of editorial changes are being proposed in this Notice which do not directly bear on substantive requirements for the transportation of radioactive materials, but are being made in related provisions as a part of the general updating of the regulations….

"This amendment is proposed under the authority of Title 18, United States Code, section 9 of the Department of Transportation Act (49 U.S.C. 1657), and Title VI and section 902(h) of the Federal Aviation Act of 1958 (49 U.S.C. 1421–1430 and 1472(h)).

"In consideration of the foregoing, it is proposed to amend Titles 14 and 49 of the Code of Federal Regulations as hereinafter set forth…."[9]

52.4.2 DOT Changes — 1968 Final Rule

In October 1968, the DOT published the final version of its regulatory changes, based on the comments it had received as a result of its proposed rulemaking, earlier in the year.[10] The text of the preamble for this final set of rule changes is examined in more detail.

"On January 20, 1968, the Hazardous Materials Regulations Board published Docket No. HM-2; Notice No. 68-1 (33 F.R. 750), which proposed amendments to the Department's Hazardous Materials Regulations (49 CFR Parts 170–190 and 14 CFR Part 103). These proposals dealt with a major revision to the regulations for the transportation of radioactive materials, along with a number of other general packaging modifications. The public was given 90 days for comment. Numerous comments were filed and have been studied by the Department staff. Several meetings and discussions were held with staff personnel of the U.S. Atomic Energy Commission (AEC), as required by 18 U.S.C. 834(b), and the amendments reflect the results of those discussions. All other comments suggesting changes, additions, or deletions were carefully considered….

"Many of the modifications in these amendments will require parallel changes in the AEC regulations (10 CFR Part 71) to assure harmony between the two complementary sets of regulations. The AEC has indicated that it expects to be able to publish the necessary amendments to its Part 71 prior to the effective date of these amendments.

"Many of the new procedures prescribed in these amendments have been previously authorized by Departmental special permits. Special Permit No. 5000 authorized the use of a drum-type birdcage now listed as the Specification 6M package. Special Permit No. 5300 authorized the use of a type of packaging now listed as the Specification 7A package. Special Permit No. 5400 provided for the shipment of enriched uranium under the terms of § 71.6 of the AEC regulations, and the terms of that permit are now included in § 173.396 of these regulations. Special Permit No. 5417 provided for the transportation of

†† Author's Note: As a DOT Specification Package, the 6M package was, in effect, a Type B fissile shipping container that would be used extensively throughout the AEC-, the ERDA-, and the DOE-Complex, for more than 30 years. As a DOT Specification package, however, the 6M was *not* subject to the Hypothetical Accident Condition test requirements specified in 10 CFR 71. While this was not a problem in 1968, it would become a problem when the majority of the licensing responsibilities for Type B packages was transferred from the DOT to the AEC. (See Sections 52.5.1 and 52.5.2.) Although it would still be around for decades, the beginning of the end of the 6M package would eventually come with the regulatory changes introduced in 2002, and finalized in 2004. (See Sections 52.16 and 52.17, respectively.)

radioactively contaminated items, and the terms of that permit are not included in the low specific activity provisions of § 173.392. Accordingly, those special permits are no longer appropriate, and are hereby terminated….

"The notice of proposed rule making did not utilize the Type A–Type B quantity provisions of the IAEA regulations, but instead referred only to specified quantities of radioactive materials for the various categories of packaging. This was done at the request of a number of interested parties in the atomic energy field. These parties felt that there was a certain stigma attached to these terms as a result of previous unsuccessful rule making efforts by the Interstate Commerce Commission. However, the comments received indicated that the use of those IAEA terms would be not only acceptable but would clarify and simplify the packaging provisions. Accordingly, those terms are defined and used in these amendments.

"On February 28, 1969, all existing Bureau of Explosives (Association of American Railroads) permits for radioactive materials packages will expire. Many comments indicated that the regulations were not sufficiently clear as to whether those previously authorized containers could ever be used again. The acceptability of these containers after February 28, 1969, will be a function of their ability to meet the prescribed structural integrity, shielding, and thermal resistance criteria. In each case, the shipper should examine the design and construction details of his container and compare them to the new regulations. If the container does not fit within one of the prescribed categories or usages, he may not use the container after that date without first having secured a Department special permit. The Department's safety evaluation of each of those containers will be based upon the criteria in these amendments.…

"The Department acts as the U.S. competent authority as that term is used in the IAEA regulations. In issuing special permits for radioactive materials packages, the Department is often asked to provide the certificate required of competent authorities in the IAEA regulations…. In order to provide this information, it will be necessary for the petitioner for the special permit to certify in his petition that his packaging, and the contents (particularly with respect to the special form criteria), meet all of the standards prescribed in the IAEA regulations. Although these amendments will bring the U. S. regulations more in harmony with the international standards, there are still some significant differences that will be dealt with in future rule making actions. It is the shipper's responsibility, as prescribed in § 173.393, to make the determination that his package meets all of the requirements of the foreign countries as well as the United States, and the shipper must certify to the Department that he has made that determination. He must present to the Department the basis of his evaluation that those standards have been met. The Department will review the petitioner's data and, if it is satisfied that the petitioner has in fact made a proper determination, it will issue the necessary IAEA certificate as a part of the special permit….

"In addition to the general changes discussed above, a number of specific changes to the notice of proposed rule making are worthy of highlighting.

"Proposed § 173.22 has been modified to separate the subject of shipper's responsibility from the types of packages authorized under 'grandfather clauses.' The latter have been included in a new § 173.23. In § 173.23, two additional months have been provided for continued use of packages operating under permits from the Bureau of Explosives. The expiration date of the B of E permits is now February 28, 1969.

"A table of steel thicknesses has been added to the general construction standards in § 173.24. The general prohibition against vented packages has been deleted….

"In § 173.390, an additional transport group, Group VII, has been added to conform with the IAEA regulations, and to obviate the need for descriptive limits throughout the packaging regulations. The provisions for determining the transport group of unknown mixtures have been expanded to conform with the IAEA definition….

"Proposed § 173.393 has been modified to provide for a security seal, similar to the present special permit requirements, and in accord with the IAEA provisions. Section 173.393(d) has been clarified with regard to the requirements for internal bracing. Section 173.393 now includes restrictions on the surface temperatures in order to prevent injury to employees and to reduce the fire hazard to other cargo. The temperature restrictions are those commonly provided in special permits. Special permits are required for all shipments involving high internal decay heat, so this addition represents no change from present practice….

"Proposed §§ 173.394 and 173.395 have been modified to provide for delivery of IAEA Type A packages to their destination in the United States without need for special permit. Type B packages, other than Spec. 55 or 6M, will require Departmental approval in every case at the present time due to a lack of specification containers for Type B quantities.

"Proposed § 173.396 has been modified to provide for package limits for the Specs. 6L and 6M metal packages. The limits are presently specified in Part 178.

"Proposed § 173.398 has been modified to prescribe the criteria for Type A packages (normal conditions incident to transportation) as well as the previously prescribed criteria for Type B packages (hypothetical accident conditions). The allowable release of radioactive material from packages under the Type B tests, and the test conditions themselves, have been clarified to conform with the present requirements of 10 CFR Part 71 of the AEC or the IAEA regulations….

"Specification 2R, in § 178.34, has been modified to provide for reduced size of the letters of identification….

"Specification 6L, in § 178.103, has been modified to provide for additional types of spacers ('spiders'). The total quantity of required vermiculite has been deleted as extraneous because the required density provides automatically for the total weight control. Marking requirements have been modified to conform with other steel drum requirements. Closure requirements have been modified to require a specified metal thickness and locking ring attachment. Recent accident tests demonstrated the inadequacy of the more common lightweight locking rings. Loading capacity limitations have been relocated to § 173.396….

"Because of the complex nature of these amendments, and the impact that they will have on the transportation of radioactive materials, and to allow a reasonable time for compliance with the changes made herein, the effective date of the amendments is December 31, 1968. However, compliance with these amendments is authorized on and after the date of publication in the FEDERAL REGISTER.

"In consideration of the foregoing, the Hazardous Materials Regulations of the Department of Transportation (14 CFR Part 103 and 49 CFR Parts 170–190) are amended effective December 31, 1968 ….''[10]

52.4.3 Miscellaneous Changes, AEC — 1968

In November 1968, a set of miscellaneous amendments was introduced into the requirements of 10 CFR 71.[11] This set of amendments brought the requirements of 10 CFR 71 into agreement with the recently introduced changes in the requirements of 49 CFR Parts 170–190.[9, 10]

"On July 22, 1966, the Atomic Energy Commission published in the FEDERAL REGISTER (31 F.R. 9941) regulations for the packaging of fissile material and large quantities of licensed radioactive material, 10 CFR Part 71. The explanatory statement indicated the relationship of those regulations to the safety regulations of the Interstate Commerce Commission (ICC). Among other things, the regulations of the ICC under the Transportation of Explosives and Other Dangerous Articles Act prescribed the conditions of transportation for shipments prepared in accordance with 10 CFR Part 71.

"On April 1, 1967, the functions of the ICC under the Transportation of Explosives and Other Dangerous Articles Act were transferred to the Department of Transportation (DOT). The DOT has continued to apply the former ICC regulations pertaining to safety in the transportation of radioactive materials; those regulations are now known as the DOT's Hazardous Materials Regulations (49 CFR Parts 170–190, 14 CFR Part 103).

"On January 20, 1968, the DOT published in the FEDERAL REGISTER (33 F.R. 750) for comment, as Notice 68-1, Docket No. HM-2, a proposed major revision of its regulations for transporting radioactive material. The DOT has given due consideration to the numerous comments received and, after consultation with the AEC and the atomic energy industry, has made modifications in the proposed requirements. On October 4, 1968, the DOT published in the FEDERAL REGISTER (33 F.R. 14918) a revision of its regulations pertaining to safety in transport of radioactive material, authorizing compliance on publication and making the amendments effective on December 31, 1968. The changes in the Commission's 10 CFR Part 71 set out below will conform 10 CFR Part 71 with the revision of the DOT regulations. Since the revision of the DOT regulations was published for public comment, the Commission has found that good cause exists for omitting notice of proposed rulemaking and public procedure thereon with respect to the following changes to 10 CFR Part 71, to the revision of the DOT regulations, as unnecessary….

"Pursuant to the Atomic Energy Act of 1954, as amended, and sections 552 and 553 of the United States Code, the … amendments of 10 CFR Part 71 are published as a document subject to codification, to be effective December 31, 1968. Compliance with these amendments is authorized on and after the date of publication in the FEDERAL REGISTER."[11]

52.5 TRANSFER OF LICENSING RESPONSIBILITIES FROM DOT TO AEC

In 1971 and in 1973, the AEC published a proposed rulemaking and a final rulemaking, respectively, the title of which, in both cases, was the *Approval of Type B, Large Quantity, and Fissile Material Packagings*.[12, 13] In both cases, the rulemakings had to do with the transfer of specific licensing requirements from the DOT to the AEC.

52.5.1 Approval of Type B, Large Quantity and Fissile Material Packagings — 1971 Proposed Rule

"On January 8, 1971, with the agreement of the Atomic Energy Commission, the Hazardous Materials Regulations Board of the Department of Transportation (DOT) published in the FEDERAL REGISTER a notice (Docket No. HM-73; Notice 71-1) proposing to transfer the administrative requirement for approvals of radioactive materials packages from the Department to the U.S. Atomic Energy Commission (AEC). Interested persons were invited to comment on the proposal within 60 days after publication of the notice in the FEDERAL REGISTER. After consideration of the comments and consultation with the AEC and the atomic energy industry, … the DOT is publishing a revised notice of proposed rule making proposing amendments to 49 CFR Part 173 which would transfer the administrative requirement for approvals of radioactive materials packages to the AEC. The amendment would provide, inter alia, that DOT discontinue issuing special permits for packagings except for waivers or exemptions from DOT regulations and that shippers be required to have AEC approval for routine packaging for type B, large quantity, and fissile material shipments.

"The proposed changes in 10 CFR Part 71 … would provide a means for implementing the transfer of packaging approvals from DOT to AEC by adding to Part 71, standards and requirements for AEC approval of type B packagings and describing the procedures for obtaining AEC approval of type B, large quantity, and fissile material packagings.

"The provisions of Part 71, in effect since August 1966, require AEC licensees who wish to ship fissile material or large quantities of byproduct, source, or special nuclear material to apply to the AEC for a license or license amendment indicating AEC approval of the type of package to be used. The amendments published herein would require AEC licensees also to apply for a license or license amendment approving of the package to be used to deliver to a carrier type B quantities of radioactive material.

"The proposed amendments to the DOT regulations … would require AEC approval of packagings, other than specification packagings prescribed in the DOT regulations, which are used to ship any quantity of fissile material, or more than a type A quantity (i.e., a type B or large quantity) of other radioactive material. AEC approval could be (1) a license (either specific or general) or license amendment issued under 10 CFR Part 71, (2) an administrative approval issued to AEC contractors by AEC field offices in accordance with standards and procedures published in the AEC manual, or (3) an approval issued by the AEC's Division of Materials Licensing to persons under DOT jurisdiction who are not AEC licensees. The latter category of non-AEC licensees would include, for example, agreement State licensees and radium shippers who wish to ship type B or large quantities of radioactive material.

"To obtain AEC approval, all persons, other than AEC license-exempt contractors, would be required to submit an application to the Director, Division of Materials Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545. The contents of the application are set forth in §§ 71.21, 71.22, 71.23, and 71.24 of 10 CFR Part 71.

"AEC license-exempt contractors would apply to the appropriate AEC field office for approval in accordance with the provisions of the AEC manual.

"Provisions would be made for uninterrupted use of containers which have been in use under DOT special permits which are valid on the date the revised rule goes into effect. Each AEC licensee would be permitted to continue to use fissile material and large quantity packagings under the AEC license or license amendment which was issued to him by the AEC under 10 CFR Part 71. Under the proposed § 71.8, an AEC licensee using a type B container under a valid DOT special permit would be allowed to continue to use that container until the AEC acts on an application which he had submitted no later than 90 days after the effective date of the rule or the expiration date of the special permit, whichever date is later.

"A non-AEC licensee, other than a license-exempt contractor, would be considered to have AEC approval for continued use of a type of packaging for which he had a DOT special permit in effect on the effective date of the amendments provided he submitted to the AEC a request for approval of that type of packaging within 90 days of the effective date or prior to the date on which the special permit expires, whichever date is later. This AEC approval would remain in effect until the application has been approved or rejected by the Commission.

"The proposed amendment to the DOT regulations, published concurrently, would authorize the use of packaging approved by the AEC. The amendment to DOT regulations also would require each person using a design of packaging approved for use by another to register with AEC prior to first use and to comply with the conditions of the original approval. AEC licensees are already required to follow that same procedure under the conditions of the general license in § 71.1(b) of the AEC regulations.

"Other changes being proposed in 10 CFR Part 71 are minor editorial changes, redesignation of some sections to bring together the exemption provisions, and addition of a new § 71.7 to exempt certain fissile materials from the nuclear criticality safety provisions of Part 71. Section 71.12, *Limited exemption for shipment of special nuclear material* would be deleted, since the authority granted by that section has expired.…"[12]

As a prelude of things to come, the following new definitions were added to the proposed regulations:

"(q) 'Type A quantity' and 'Type B quantity' means [*sic*] a quantity of radioactive material the aggregate radioactivity of which does not exceed that specified in the following table:

Transport Groups (Paragraph (p) of this section)	Type A quantity (in curies)	Type B quantity (in curies)
I ……..…	0.001	20
II ……...	0.05	20
III ……...	3	200
IV ……...	20	200
V ……	20	5,000
VI and VII …….	1,000	50,000
Special Form …….	20	5,000

Although the values cited in the above table would not last, the concept of Type A and Type B quantities of radioactive material had finally been introduced into the U.S. regulations. It was a concept that was here to stay.

52.5.2 Approval of Type B, Large Quantity and Fissile Material Packagings — 1973 Final Rule

"On November 20, 1971, the Atomic Energy Commission published in the FEDERAL REGISTER (36 FR 22184) proposed amendments to 10 CFR part 71 of its regulations. The proposed amendments would provide a means for implementing the transfer of the approval of type B packagings from the Department of Transportation (DOT) to the AEC (in its regulatory function) by adding to part 71 standards and requirements for AEC approval of type B packagings, and procedures for obtaining AEC regulatory staff approval of type B, large quantity, and fissile material packagings. The transfer of the approval function for packages used by license-exempt AEC contractors is being implemented by a change in AEC manual, chapter 5201. Proposed amendments to DOT regulations, published concurrently, would require AEC approval of packagings, other than specification packagings prescribed in the DOT regulations and packagings approved by a foreign national competent authority under the 1967 regulations of the International Atomic Energy Agency, used to ship quantities of fissile material which exceed the small quantities specifically exempted by DOT regulations or to ship quantities of other radioactive material which exceed type A quantities, as defined in DOT regulations.

"After consideration of the comments received and other factors involved, the Commission has adopted the amendments published for comment with the following changes:

1. The definition of a 'Type A quantity' in § 71.4(q) has been modified to limit Californium-252 in special form to 2 curies instead of 20 curies, to conform to that limit recently introduced into DOT regulations.
2. The general license provided in § 71.12 for shipment in DOT specification containers and in packages licensed for use by licensees has been amended to include packaging approved by a foreign national competent authority. The amendment to the DOT regulations, to be made effective concurrently, requires that packages approved by a foreign competent authority be revalidated by DOT before use in the United States.
3. In § 71.10 the period during which persons are exempted from the requirements for an AEC approval for Type B packages being used under a DOT special permit has been lengthened from 3 to 6 months after the effective date of the amendments.

"Other minor corrective and editorial changes have been made….

"Pursuant to the Atomic Energy Act of 1954, as amended, and sections 552 and 553 of title 5 of the United States Code, the … amendments to Title 10, Chapter I, Code of Federal Regulations, part 71, are published as a document subject to codification to become effective June 30, 1973…."[13]

52.6 DOUBLE CONTAINMENT FOR PLUTONIUM, AND QUALITY ASSURANCE REQUIREMENTS — 1973 TO 1978

Between August 1973 and June 1978, a series of changes was introduced into the requirements of 10 CFR 71. Centered on two major focal points, the changes dealt with plutonium issues and with Quality Assurance issues. All of the changes would have a long-lasting impact on the requirements specified in 10 CFR 71.

52.6.1 Double Containment for Plutonium — 1973 Proposed Rule

In August 1973, the AEC published a Proposed Rule in the *Federal Register*, a proposed rule that would eventually require

double containment for plutonium.[14] Excerpts from the preamble for that proposed rule reads as follows:

> "The Atomic Energy Commission is considering the amendment of its regulations in 10 CFR Part 71, 'Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions' to require that all plutonium in quantities greater than 20 curies shall be packaged for shipment as a solid in capsules which meet the requirements for special form and shall be shipped inside packaging that meets the requirements of Part 71 for radioactive material in normal form. The proposed requirements would become effective three years after the effective date of the amendment.
>
> "In light of anticipated significant changes in the characteristics and quantity of plutonium to be transported in the future, the Commission has considered the matter of form for shipping plutonium from the standpoint of public health and safety. Existing regulations permit the shipment of plutonium in any chemical or physical form, including liquid plutonium nitrate. Using the present criteria and requirements of Part 71, hundreds of plutonium nitrate shipments have been made with no reported instances of plutonium leakage from the containment vessel.
>
> "However, the present situation with respect to plutonium transportation in the private sector is expected to change drastically over the next several years. Increasingly larger quantities of plutonium will be recovered from power reactor fuel. Consequently, increases in quantities of plutonium shipped and number of shipments made are expected. For example, the amount of plutonium available for recovery is estimated to be 500 kg in 1973 as compared to 21,000 kg in 1980.[‡‡] In addition, the specific activity of the plutonium will increase with higher reactor fuel burnup, resulting in higher gamma and neutron radiation levels, greater heat generation, and greater pressure generation potential from plutonium nitrate solutions in shipping containers.
>
> "Because of these expected changes in plutonium transport and the inherent susceptibility of liquids to leakage, the Commission believes that safety would be significantly enhanced if the basic form for shipments of plutonium were changed from liquid to solid and if the solid form of plutonium were required to be shipped in a package providing at least double containment of the contents. Such a change is considered to be feasible from an economic and technological standpoint.
>
> "The Commission's assessment indicates that there will not be a significant increase in the quantities of plutonium available for recovery in the next few years. However, the Commission believes that any change in the requirements regarding the form of plutonium for shipment should be announced promptly so that firms that design and build fuel reprocessing and fuel fabrication plants can make timely plans to accommodate this change. It is anticipated that if a solid form for shipment is required, plutonium recovered at fuel reprocessing plants would be converted to the oxide form for shipment to fuel fabricators. Based on the Commission's assessment of process and equipment changes necessary to permit shipment of plutonium as oxide, and the time when increased plutonium shipments will occur, about three years appears to be a sufficient time period. Accordingly, if the proposed amendments are adopted, the effective date would be specified as three years from the effective date of such adoption...."[14]

52.6.2 Quality Assurance Requirements for 10 CFR 71 — 1973 Proposed Rule

In December 1973, the proposed rule for Quality Assurance requirements for 10 CFR 71 was published in the *Federal Register*.[15] Excerpts from the preamble for that proposed rule reads as follows:

> "The Atomic Energy Commission has under consideration amendments to its regulations in 10 CFR Part 71 'Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions,' to upgrade requirements for quality assurance in the design, fabrication, assembly, testing, use and maintenance of packagings for shipping and transporting licensed radioactive material. The amendments would also revoke, subject to a timely application for reapproval [*sic*], the present authority to use certain shipping casks for solid irradiated nuclear fuel which had been approved under criteria used before the current standards were developed.
>
> "Under the proposed amendments … each licensee subject to 10 CFR Part 71 would be required to assess the adequacy of his quality assurance program against the upgraded standards and requirements, and to make whatever changes are required to comply with those standards and requirements. AEC would verify compliance with the standards through its licensing

‡‡ Author's Note: In 1977, President Carter signed the documentation that effectively killed the prospects for fuel reprocessing in the United States. As a consequence, this part of the NRC's 1973 argument would later become a moot point. Although the *double containment* rule would, in fact, become a regulatory requirement in 1974 (see Section 52.6.3), it would later be removed from the requirements of 10 CFR 71. Before it could be removed, however, it would take another 30 years. (See Sections 52.15.2, 52.16, and 52.17.)

and inspection programs. Each applicant for a license or license amendment under 10 CFR Part 71 would be required to describe his quality assurance program to be applied to the design, fabrication, assembly, testing, maintenance and use of his proposed packaging. The applicant would further be required to identify the codes, standards and general requirements to be imposed under the program. Within this framework, the licensee would be required to document his quality assurance program in detailed written procedures and requirements, and follow those procedures and requirements in his operations. The adequacy of the detailed written documents and the licensee's implementation of them would be determined through the Commission's compliance program. That adequacy will be judged in part on the complexity and proposed use of the package under consideration, and on the complexity and importance of safety of its components.

"The quality assurance requirements proposed here would apply to a licensee's design, fabrication, assembly, testing, use and maintenance of a Type B, Large Quantity or Fissile material package which he constructs for himself or has someone else construct it for him. In the case of a licensee using a package approved for another licensee's use, in accordance with the general license provisions of present § 71.12, the quality assurance requirements of the licensee for whom the package was first approved must be followed in the use, testing and maintenance of the package by the second licensee. Any changes in the program must be approved by the Commission.

"A new provision would require notification of the Commission's Directorate of Regulatory Operations before fabrication is begun of packaging with certain heat loads or anticipated internal pressures. This would facilitate communication between the licensee and the Commission's regulatory staff to resolve any differences on the adequacy of the quality assurance program before significant expenditures and irretrievable effort are committed to packaging of such importance….

"Authority to use certain shipping casks for solid irradiated nuclear fuel is contained in § 71.41 of Part 71 'Previously constructed packages for irradiated solid nuclear fuel.' This authority applies to shipping casks approved after September 23, 1961 and constructed by January 1, 1967, when the current package standards system was first adopted in the United States. Under these proposed amendments, any such casks still in use must be shown to comply with current package standards, either in their present condition or after modification…."[15]

52.6.3 Double Containment for Plutonium — 1974 Final Rule

In June 1974, the final rule for double containment for plutonium was published in the *Federal Register*.[16] For the most part, the preamble for that final rule reads as follows:

"On August 1, 1973, the Commission published in the FEDERAL REGISTER a notice of proposed rulemaking (38 FR 20482) that would have required that all plutonium in excess of twenty curies per package be shipped as a solid material contained within a 'special form' capsule placed within a package meeting the conditions for normal form material. The effective date proposed was three years after the adoption of the amendment. All interested persons were invited to submit written comments and suggestions for consideration in connection with the proposed amendment within 60 days after publication of the notice of proposed rulemaking in the FEDERAL REGISTER. After careful consideration of the comments received and other factors involved, the Commission has adopted the amendments as published for comment with the following changes:

(1) The proposed requirement that the inner containment vessel meet the 'special form' capsule requirement has been replaced with a requirement that the inner containment vessel must maintain its integrity after the entire package has been subjected to the normal and accident test conditions prescribed by Part 71. The effect of the amended provisions is still to require double containment of the contents. A number of commenters [*sic*] expressed the view that while double containment of plutonium is an important safety objective, a requirement that the inner container meet the stringent performance specifications required of a 'special form' capsule was unnecessary. The Commission considers it most important that solid form plutonium be doubly contained and that both barriers in the packaging maintain their integrity under normal and accident test conditions. The present packaging required for normal form material provides the outer barrier. In specifying the 'inner barrier' in the proposed rule, the Commission proposed a form of encapsulation that was already defined in Part 71, with corresponding performance specifications. Since the inner containment requirements are intended to take into account the fact that the plutonium may not be in a 'nonrespirable' form, the Commission has concluded that if it can be

demonstrated that the inner container will maintain its integrity in the packaging after the package is subjected to the normal and accident test conditions, sufficient protection will be afforded.

(2) Solid plutonium in the following forms has been exempted from the double containment requirements: (a) Reactor fuel elements; (b) metal or metal alloy; and (c) other plutonium bearing solids that the Commission determines suitable for such exemption. Since the double containment provision compensates for the fact that the plutonium may not be in a 'nonrespirable' form, solid forms of plutonium that are essentially nonrespirable should be exempted from the double containment requirement; [*sic*] Therefore, it appears appropriate to exempt from the double containment requirements reactor fuel elements, metal or metal alloy, and other plutonium bearing solids that the Commission determines suitable for such exemption….

(3) The implementation period has been extended from three to four years. Many comments suggested that the proposed three-year implementation period was not long enough, considering the necessary plant design effort, licensing, and construction of facility modifications necessary to meet the requirements. Additional time was requested. The Commission believes that the increases in the amounts of plutonium to be shipped and the changing characteristics of plutonium will not change significantly in the next four years when compared to years beyond 1978. The four-year period for compliance should give the nuclear industry a sufficient period for implementation…."[16]

52.6.4 Quality Assurance Requirements for 10 CFR 71 — 1977 Final Rule

In August 1977, the final rule for Quality Assurance Requirements for Transport Packages was published in the *Federal Register*.[17] The *Summary* for that final rule[§§] reads as follows:

"The Nuclear Regulatory Commission is amending its regulations for packaging of radioactive material for transportation and transportation of radioactive materials. The amendments would upgrade requirements for quality assurance in the design, fabrication, assembly, testing, use, and maintenance of packagings for shipping and transporting licensed radioactive material. The amendments would also revoke, subject to a timely application for re-approval, the present authority for licensees to use certain shipping casks for solid irradiated nuclear fuel which had been approved under criteria used before the current standards in these regulations were adopted…."[17]

The importance of this (then) new rule cannot be overstated: 1) As is stated in the Summary, this Final Rule updated the 10 CFR 71 requirements for quality assurance in the design, fabrication, assembly, testing, use, and maintenance of packagings for shipping and transporting licensed radioactive material. 2) As was also stated in the Summary, this Final Rule revoked — subject to a timely application for re-approval — the existing authority for licensees to use certain shipping casks for spent nuclear fuel that had been approved under criteria used before the then current standards in 10 CFR 71 were adopted.

What was not stated in the Summary (but was clearly defined in the actual text), was that this Final Rule established the so-called *Grandfathering Clause*, that would gradually phase-out the use of *all* radioactive materials transport packages designed before the then-current standards of 10 CFR 71 were adopted.

What was also not stated in the Summary, was that this Final Rule for QA Requirements would have no immediate impact on the continued use of DOT Specification Packages, such as the 6M. (See the related footnote in Section 52.3.1. See also the related Discussions in Sections 52.16 and 52.17.)

52.6.5 Extension of the Implementation Period for QA Requirements — 1978 Effective Rule

In June 1978, an effective rule for Quality Assurance Requirements for Transport Packages was published in the *Federal Register*.[18] The purpose of this Effective Rule was to extend the effective date for the rule that had previously been proposed from July 1, 1978 to January 1, 1979.

52.7 NRC REGULATORY GUIDE 7.6

In March 1978, the NRC introduced Revision 1 of its Regulatory Guide (Reg. Guide) 7.6 into the situation.[19] Although a previous version of this Reg. Guide had been introduced some 13 months earlier, this was the first version to have some real substance to the content, and it was this version that would be relied upon for the next 13 years.

The title of Reg. Guide 7.6 was (is) *Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels.* This was the first of the NRC Guidance documents to introduce ASME Boiler & Pressure Code requirements into the recommendations for the design for shipping containers for Type B quantities of radioactive materials.

§§ Author's Note: As was noted in the Introduction, space limitations prevent the full text of this section from being reproduced here. The preamble-only version for this section can be found in Reference [1]. The full-text version can be found in Reference [17].

"A. INTRODUCTION

"Sections 71.35 and 71.36 of 10 CFR Part 71, 'Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions,' require that packages used to transport radioactive materials meet the normal and hypothetical accident conditions of Appendices A and B, respectively, to Part 71. This guide describes design criteria acceptable to the NRC staff for use in the structural analysis of the containment vessels of Type B packages used to transport irradiated nuclear fuel. Alternative design criteria may be used if judged acceptable by the NRC staff in meeting the structural requirements of §§ 71.35 and 71.36 of 10 CFR Part 71.

"B. DISCUSSION

"At present, there are no design standards that can be directly used to evaluate the structural integrity of the containment vessels of shipping casks for irradiated fuels. This guide presents containment vessel design criteria that can be used in conjunction with an analysis which considers the containment vessel and other principal shells of the cask (e.g., outer shell, neutron shield jacket shell) to be linearly elastic. A basic assumption for the use of this guide is that the principle of superposition can be applied to determine the effect of combined loads on the containment vessel. However, use of this guide does not preclude appropriate nonlinear treatment of other cask components (e.g., impact limiters and lead shielding).

"Design criteria for nonlinear structural analyses are not presented in this guide because of the present lack of data sufficient to formulate substantial nonlinear criteria. The NRC staff will review criteria other than those given in this guide on a case-by-case basis.

"Section III of the ASME Boiler and Pressure Code contains requirements for the design of nuclear power plant components. Portions of the Code that use a 'design-by-analysis' approach for Class 1 components have been adapted in this guide to form acceptable design criteria for shipping cask containment vessels. The design criteria for normal transport conditions, as defined in 10 CFR Part 71, are similar to the criteria for Level A Service Limits (formerly called 'normal conditions') of Section III, and the design criteria for accident conditions are similar to those for Level D Service Limits (formerly called 'faulted conditions'). However, Section III was developed for reactor components, not fuel casks, and many of the Code's requirements may not be applicable to fuel cask design.

"The criteria in this guide reflect the designs of recently licensed shipping casks. The containment vessels having these designs were made of austenitic stainless steel, which is ductile even at low temperatures. Thus, this guide does not consider brittle fracture. Likewise, creep is not discussed because the temperatures of containment vessels for irradiated fuel are characteristically below the creep range, even after the hypothetical thermal accident requirement of 10 CFR Part 71. The nature of the design cyclic thermal loads and pressure loads is such that thermal ratchetting [*sic*] is not considered a realistic failure mode for cylindrical containment vessels. Containment vessel designs that are significantly different from current designs (in shape, material, etc.) may necessitate the consideration of the above failure modes…."[19]

52.8 1979 PROPOSED RULE, 10 CFR 71

In August 1979, a proposed rule for major changes to 10 CFR 71 was published in the *Federal Register*.[20] As was noted by the NRC at the time, "The major changes … being proposed deal with [the] assignment of individualized Type A quantities for each radionuclide, and the addition of new Type B(U) and Type B(M) packaging standards…."[20]

The full text of this section is not reproduced here. The preamble-only version of the text for this section can be found in Reference [1]. The full-text version can be found in Reference [20].

52.9 NUREG/CR-1815, 1981

In August of 1981, the NRC published NUREG/CR-1815, *Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick*.[21] Written by W. R. Holman and R. T. Langland of Lawrence Livermore National Laboratory, this NUREG/CR became the second NRC guidance document to link the requirements of 10 CFR 71 with the requirements of the ASME Boiler & Pressure Vessel Code.

As Holman and Langland noted in their Executive Summary,

> "This report addresses the problem of brittle fracture in ferritic steels and recommends fracture toughness criteria that will provide three levels of safety in shipping containers licensed for transporting radioactive materials. Recommendations are given for defining three categories of fracture toughness criteria that will provide degrees of safety appropriate to the various materials transported in the containers.…"[21]

Holman and Langland further recommended that

1) A fracture control plan be implemented for each container design;
2) Fracture-critical components be identified and treated as specified in the report;
3) Specific fracture toughness testing requirements be established; and
4) Appropriate specification and qualification procedures be adopted for all fracture critical welds.

With respect to the category requirements, Holman and Langland went on to note that,

> "The largest margin of safety is provided in Category I by requiring sufficient toughness to assure that there is no crack propagation at the lowest service temperature. Steels with this level of toughness can tolerate large flaws under dynamic loading conditions.
>
> "A smaller margin of safety is allowed for Category II, in which the minimum level of toughness at the lowest service temperature is specified at somewhat above the level of toughness at the plane strain limit for dynamic loading conditions. If the shock mitigating system is effective in reducing the loading rate in the fracture critical components, then an intermediate loading rate can be assumed and an additional reduction in the minimum toughness is permitted for Category II.
>
> "The level of safety required for Category III is less than that for Category II, and the minimum toughness requirements are correspondently reduced. Good engineering practices and selection of steels with a low NDT temperature make it unlikely that brittle fracture will occur.…"[21]

This was the first of three NUREG/CRs that would eventually lead to the publication of Reg. Guide 7.11. (See Section 52.13.)

52.10 1983 FINAL RULE, 10 CFR 71

In August 1983, the final rule for major changes to 10 CFR 71 was published in the *Federal Register*.[22] This was the follow-up to the 1979 Proposed Rule described above in Section 52.8.

As was noted above with respect to Section 52.8, the major changes being finalized in the 1983 Final Rule dealt with the assignment of individualized Type A quantities for specific radionuclides, and the addition of new Type B(U) and Type B(M) packaging requirements.

As was also noted above with respect to Section 52.8, the full text of this section is not reproduced here. The preamble-only version of the text for this section can be found in Reference [1]. The full-text version can be found in Reference [22].

52.11 ADDITIONAL REGULATORY GUIDANCE, NRC, 1985

In 1985, two additional guidance documents were produced by the NRC: NUREG/CR-3019 and NUREG/CR-3854.[23, 24]

52.11.1 NUREG/CR-3019

In March of 1985, the NRC published NUREG/CR-3019, *Recommended Welding Criteria for Use in the Fabrication of Shipping Containers for Radioactive Materials*.[23] Written by R. E. Monroe, H. H. Woo, and R. G. Sears of Lawrence Livermore National Laboratory, this NUREG/CR became the third in a series of NRC guidance documents to link the requirements of 10 CFR 71 with the requirements of the ASME Boiler & Pressure Vessel Code.*** More importantly, this particular NUREG/CR became the first to reference the ASME Code requirements to quantify the *welding* requirements for 10 CFR 71 transport packages.

As Monroe, Woo, and Sears noted in their Summary,

> "This NUREG presents the recommended criteria for welding and related operations used in the fabrication of shipping containers for radioactive materials. The welding criteria given … are divided into three categories that are associated with the levels of safety for the type of containers and radioactive contents being transported. Category I provided the largest margin of safety; Categories II and III provide lesser margins of safety consistent with the characteristics and quantities of the radioactive material being transported. The same Category designations also have been used in the development of fracture toughness criteria applicable to the containment vessel. [See Section 52.9.] For each category, the welding criteria are further divided into three weld types that are associated with the functions of the welds. The three types are containment-related welds, criticality-related welds, and other safety-related welds.
>
> "The welding criteria include a number of related elements to ensure adequate control. The ten key elements are as follows:
>
> 1. Base Materials
> 2. Welding and Brazing Materials
> 3. Joint Preparation
> 4. Welding
> 5. Brazing
> 6. Heat Treatment
> 7. Qualification of Procedures and Personnel
> 8. Examination
> 9. Quality Assurance
> 10. Fracture Toughness.
>
> "For each Weld Type and Category, the selected welding criteria are based on an appropriate Section of the ASME Boiler and Pressure Vessel Code, as summarized in [the Table below]. These selected Code sections provide a level of confidence consistent with the Category and Weld Type.…"[23]

*** Author's Note: As was noted in Section 52.7 with the development of Reg. Guide 7.6, the NRC had long since found it convenient to *recommend* the requirements of the ASME Boiler & Pressure Vessel Code as a metric to quantify the often subjective requirements of the regulations.

"Summary of Recommended Welding Criteria for Use in the Fabrication of Shipping Containers

Weld Type	Category I	Category II	Category III
Containment-Related Welds	ASME Code Section III, Subsection NB	ASME Code Section III, Subsection ND	ASME Code Section VIII-Division 1
Criticality-Related Welds	ASME Code Section III, Subsection NG		
Other Safety-Related Welds	ASME Code Section VIII-Div. 1 or Section III, Subsection NF (as appropriate)		

52.11.2 NUREG/CR-3854

In March of 1985, the NRC also published NUREG/CR-3854, *Fabrication Criteria for Shipping Containers*.[24] Written by L. E. Fischer and W. Lai of Lawrence Livermore National Laboratory, this NUREG/CR became the fourth in a series of NRC guidance documents to link the requirements of 10 CFR 71 with the requirements of the ASME Boiler & Pressure Vessel Code. Published as a companion document to NUREG/CR-3019, this particular NUREG/CR became the first to link ASME Code requirements to the *fabrication* requirements for 10 CFR 71 transport packages.

As Fischer and Lai noted in their Summary,

> "This NUREG provides fabrication criteria from the metal components of shipping containers used for transporting radioactive materials. The criteria are divided into three categories that are associated with the levels of safety for the types and quantities of radioactive materials being transported. For each category, the fabrication criteria are subdivided into three component safety groups that are formed according to their safety function. The categories and component safety group designations are the same as those used in developing the welding criteria in [NUREG/CR-3019].

"Summary of Fabrication Criteria Based on the ASME Code

Component Safety Group	Container Contents		
	Category I	Category II	Category III
Containment	Section III, Subsection NB	Section III, Subsection ND	Section VIII, Division 1
Criticality	Section III, Subsection NG		
Other Safety-Related	Section VIII, Division 1, or Section III, Subsection NF		

> "The fabrication criteria are based on the American Society of Mechanical Engineers Boiler and Pressure Vessel Code …, as summarized in [the Table above] for each of the categories and component safety groups.… The selected ASME Code criteria provide levels of confidence in controlling fabrication processes consistent with the categories and component safety groups. The criteria should be used with the welding criteria contained in [NUREG/CR-3019] when fabricating shipping containers for transporting radioactive materials…."[24]

52.12 MAJOR CHANGES, 10 CFR 71, 1988 PROPOSED RULE

In June 1988, the proposed rule for major changes to 10 CFR 71 was published in the *Federal Register*.[25] The major proposed changes at the time were as follows: 1) additional accident test requirements for certain packages; 2) an expansion in the number of radionuclides with listed limits for the quantity of radioactive material in a single package; 3) a number of changes in the listed limits; 4) simplification of the fissile material transport classes; 5) updating requirements for shipment of low-specific-activity materials; and 6) inclusion of the criteria for air transport of plutonium.

The full text of this section is not reproduced here. The preamble-only version of the text for can be found in Reference [1]. The full-text version can be found in Reference [25].

52.13 REG. GUIDES 7.11 and 7.12, 1991

In June 1991, the NRC issued Reg. Guide 7.11, *Fracture Toughness of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches*.[26] As an NRC policy statement, this document became a cornerstone in its own right because, for the first time, it provided the direct linkage between the Category I, Category II, and Category III criteria from NUREG/CR-1815, NUREG/CR-3019, NUREG/CR-3854, and the A_1 and A_2 values specified in 10 CFR 71.

In June 1991, the NRC also issued Reg. Guide 7.12, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) but not exceeding 12 Inches (0.3 m)*.[27] While the issuance of this particular Reg. Guide was just as important in its own right as the issuance of its Reg. Guide 7.11 counterpart, it pertained to far fewer transportation-related containment vessels.

Selected excerpts from Reg. Guide 7.11 are presented below:

"A. INTRODUCTION

> "Part 71, 'Packaging and Transportation of Radioactive Material,' of Title 10 of the Code of Federal Regulations requires that packages used to transport radioactive materials withstand the conditions in § 71.71, 'Normal Conditions of Transport,' and § 71.73, 'Hypothetical Accident Conditions.' In this guide, the terms packaging, shipping cask, and shipping container are used interchangeably.

"The regulations require that accident conditions with an initial temperature as low as -20 ºF (-29 ºC) be considered. At this temperature, several types of ferritic steels are brittle and subject to fracture. This guide describes fracture toughness criteria and test methods acceptable to the NRC staff for use in evaluating Type B (U) and Type B (M)[†††] ferritic steel shipping cask containment vessel base material having a maximum thickness of 4 inches (0.1 m) and having a maximum static yield strength of 100 ksi (690 kPa). The containment vessel is a major component of the containment system as defined in § 71.4 of 10 CFR Part 71. This guide is applicable to the containment vessel only and not to other components of the package.

"Alternative fracture toughness criteria and test methods may be used provided the applicant can demonstrate that their use will ensure equivalent safety….

"B. DISCUSSION

"This guide presents fracture toughness criteria and test methods that can be used for evaluating ferritic steel containment vessel base material having a maximum wall thickness of 4 inches (0.1 m) with a maximum static yield strength of 100 ksi (690 kPa).

"Section III of the ASME Boiler and Pressure Vessel Code … contains requirements for material fracture toughness; however, these requirements were developed for reactor components only and do not address hypothetical accident conditions appropriate for packaging (e.g., severe impact loads at low temperatures). Therefore, the code requirements are not directly applicable to shipping container design.

"NUREG/CR-1815, 'Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick' [Ref. 21], contains background and other information pertinent to the development of the criteria in this guide. These criteria are divided into three categories that are associated with the levels of safety appropriate for the radioactive contents being transported. Table 1 in this guide identifies the radioactivity limits for each of the three categories. Tables 4, 5, and 6 in NUREG/CR-1815[‡‡‡] … list the fracture toughness criteria associated with each category. … A qualitative description of the margins of safety against brittle failure for each of the three categories is given in Appendix C to NUREG/CR-1815 [Ref. 21].

Table 1

	Category I	Category II	Category III
Low Specific Activity		Greater than 30,000 Ci or greater than 3,000 A_1* or greater than 3,000 A_2*	Less than 30,000 Ci and less than 3,000 A_1 and less than 3,000 A_2
Special Form	Greater than 3,000 A_1 or greater than 30,000 Ci	Between 3,000 A_1 and 30 A_1 and not greater than 30,000 Ci	Less than 30 A_1 and less than 30,000 Ci
Normal Form	Greater than 3,000 A_2 or greater than 30,000 Ci	Between 3,000 A_2 and 30 A_2 and not greater than 30,000 Ci	Less than 30 A_2 and less than 30,000 Ci

* Defined in 10 CFR 71.4

"Additional information regarding the basis for the criteria is contained in Appendix B of NUREG/CR-1815 [Ref. 21]…."

52.14 10 CFR 71, 1995 FINAL RULE

In September 1995, the final rule for major changes to 10 CFR 71 was published in the *Federal Register*.[28] This was the follow-up to the 1988 Proposed Rule described above in Section 52.12.

As was noted by the NRC,

"…Most of the revisions presented in the proposed rule are being adopted in the final rule. These include additional hypothetical accident test criteria for certain types of packages, an increase in the number of radionuclides with listed A_1 and A_2 values, changes in the currently listed A_1 and A_2 values for some radionuclides, simplification of fissile material transport classes, revised requirements for shipment of LSA materials, and inclusion of criteria for packages used to transport plutonium by air…."[28]

The full text of this section is not reproduced here. The preamble-only version of the text can be found in Reference [1]. The full-text version can be found in Reference [28].

52.15 DOUBLE CONTAINMENT ISSUES REVISITED

In May 1997, the proposed rule for a change to the *Double Containment* requirements of 10 CFR 71 was published in the *Federal Register*.[29]

††† "Type B(U) and Type B(M) packages are defined in 10 CFR 71.4." *(This footnote was part of the original citation.)*

‡‡‡ "The following corrections should be made to the NUREG: Table 1, Category III revise to read '...Fine Grain Practice...'; Table 4, Criteria..., third line 'has $\sigma_{ys} \geq 70$ ksi, either:'; Figure 6, vertical scale should be '...0, 20, 40...'; Section 5.3.1, subsection 1, 'By selecting a normalized steel ....'" *(This footnote was also part of the original citation.)*

52.15.1 Elimination of Double Containment for Plutonium for Vitrified High Level Waste — 1997 Proposed Rule

As the NRC noted in its Summary,

> "…The Nuclear Regulatory Commission (NRC) is proposing to amend its regulations to remove canisters containing vitrified high-level waste (HLW) containing plutonium from the packaging requirement for double containment. This amendment is being proposed in response to a petition for rulemaking (PRM–71–11) submitted by the Department of Energy (DOE)…."[29]

The full text of this section is not reproduced here. The preamble-only version of the text for can be found in Reference [1]. The full-text version can be found in Reference [29].

52.15.2 A Petition to Eliminate the Double Containment Requirement, 1998

In February 1998, a petition to eliminate the *Double Containment* requirements of 10 CFR 71 was published in the *Federal Register*.[30] In this case, however, the petitioner was seeking to eliminate the double containment requirement, all together:

> "…The Nuclear Regulatory Commission (NRC) has received and requests public comment on a petition for rulemaking filed by the International Energy Consultants, Inc. The petition has been docketed by the Commission and has been assigned Docket No. PRM-71-12. The petitioner requests that the NRC amend its regulations that govern packaging and transportation of radioactive material. The petitioner believes that special requirements for plutonium shipments should be eliminated…."[30]

The full text of this section is not reproduced here. The preamble-only version of the text can be found in Reference [1]. The full-text version can be found in Reference [30].

52.15.3 Elimination of Double Containment for Plutonium for Vitrified High Level Waste — 1998 Final Rule

In June 1998, the final rule for a change to the *Double Containment* requirements of 10 CFR 71 was published in the *Federal Register*.[31]

As the NRC noted in its Summary,

> "…The Nuclear Regulatory Commission (NRC) is amending its regulations to add vitrified high-level waste (HLW) contained in a sealed canister designed to maintain waste containment during handling activities associated with transport to the forms of plutonium which are exempt from the double-containment packaging requirements for transportation of plutonium. This amendment responds to a petition for rulemaking submitted by the Department of Energy, Office of Civilian Radioactive Waste Management (DOE/OCRWM). This final rule grants the petition for rulemaking, with modifications, and completes NRC action on the petition…."[31]

The full text of this section is not reproduced here. The preamble-only version of the text can be found in Reference [1]. The full-text version can be found in Reference [31].

52.16 10 CFR 71, 2002 PROPOSED RULE

In April 2002, the proposed rule for major changes to 10 CFR 71 was published in the *Federal Register*.[32] We will look at the information presented in the preamble for the 2002 Proposed Rule. In this case, however, it important to note from the outset that the bureaucratic requirements with respect to the format and the content changed dramatically between what is presented in that Proposed Rule and what has been presented previously.

With that forewarning, selected excerpts from the preamble for the 2002 Proposed Rule for 10 CFR 71 reads as follows:

> "**SUMMARY**: The Nuclear Regulatory Commission (NRC) is proposing to amend its regulations on packaging and transporting radioactive material to make them compatible with the International Atomic Energy Agency (IAEA) standards and to codify other applicable requirements. These changes would be compatible with ST-1 (TS-R-1), the latest revision of the IAEA transportation standards. This rulemaking would also address the unintended economic impact of NRC's emergency final rule entitled 'Fissile Material Shipments and Exemptions' (February 10, 1997; 62 FR 5907) and a petition for rulemaking submitted by International Energy Consultants, Inc. (PRM–71–12: February 19, 1998; 63 FR 8362)….
>
> "The Commission directed the NRC staff in Staff Requirements Memorandum (SRM) 00–0117 dated June 28, 2000: (1) To use an enhanced public-participation process (website and facilitated public meetings) to solicit public input on the part 71 rulemaking; and (2) to publish the staff's Part 71 issues paper in the **Federal Register** (65 FR 44360; July 17, 2000) for public comment. The issues paper presented the NRC's plan to revise Part 71 and provided a summary of all changes being considered, both IAEA-related changes and NRC-initiated changes. The NRC published the issues paper to begin an enhanced public participation process designed to solicit public input on the part 71 rulemaking. This process included establishing an interactive website and holding three facilitated public meetings: a 'roundtable' workshop at the NRC Headquarters, Rockville, MD, on August 10, 2000, and two 'townhall' meetings—one in Atlanta, GA, on

September 20, 2000, and a second in Oakland, CA, on September 26, 2000.

"SRM–00–0117 also directed the staff to proceed, after completion of the public meetings, with the development of a proposed rule for submittal to the Commission by March 1, 2001. Oral and written comments received from the public meetings, by mail, and through the NRC website, in response to the issues paper, were considered in the drafting of the proposed changes contained herein.

"*Past NRC–IAEA Compatibility Revisions*

"Recognizing that its international regulations for the safe transportation of radioactive material should be revised from time to time to reflect knowledge gained in scientific and technical advances and accumulated experience, IAEA invited Member States (the U.S. is a Member State) to submit comments and suggest changes to the regulations in 1969. As a result of this initiative, the IAEA issued revised regulations in 1973 (Regulations for the Safe Transport of Radioactive Material, 1973 edition, Safety Series No. 6). The IAEA also decided to periodically review its transportation regulations, at intervals of about 10 years, to ensure that the regulations are kept current. In 1979, a review of IAEA's transportation regulations was initiated that resulted in the publication of revised regulations in 1985 (Regulations for the Safe Transport of Radioactive Material, 1985 edition, Safety Series No. 6).

"The NRC also periodically revises its regulations for the safe transportation of radioactive material to make them compatible with those of the IAEA. On August 5, 1983 (48 FR 35600), the NRC published in the **Federal Register** a final revision to part 71, 'Packaging and Transportation of Radioactive Material.' That revision, in combination with a parallel revision of the hazardous materials transportation regulations of the U.S. Department of Transportation (DOT), brought U.S. domestic transport regulations into general accord with the 1973 edition of IAEA transport regulations. The last revision to Part 71 was published on September 28, 1995 (60 FR 50248), to make part 71 compatible with the 1985 IAEA Safety Series No. 6. The DOT published its corresponding revision to Title 49 on the same date (60 FR 50291).

"The last revision to the IAEA Safety Series 6 was named Safety Standards Series ST-1, published in December 1996, and was revised with minor editorial changes in June 2000, and was redesignated as TS-R-1. This rulemaking effort is to evaluate TS-R-1 for potential adoption in Part 71 regulations.

"Historically, the NRC coordinated its Part 71 revisions with DOT, because DOT is the U.S. Competent Authority for transportation of hazardous materials. 'Radioactive Materials' is a subset of 'Hazardous Materials' in Title 49 regulations under DOT authority. Currently, DOT and NRC co-regulate transport of nuclear material in the United States. NRC is continuing with its coordinating effort with the DOT in this rulemaking process. Refer to the DOT's corresponding rule for additional background on the positions proposed in this notice.

"*Scope of 10 CFR Part 71 Rulemaking*

"As directed by the Commission, NRC staff compared TS-R-1 to the previous version of Safety Series No. 6 to identify changes made in TS-R-1, and then identified affected sections of Part 71. Based on this comparison, NRC staff identified 11 areas in part 71 that needed to be addressed in this rulemaking process as a result of the changes to the IAEA regulations. The staff grouped the part 71 IAEA compatibility changes into the following issues: (1) Changing part 71 to the International System of Units (Sl) (also known as the metric system) exclusively; (2) Radionuclide specific exemption values; (3) Revision of A_1 and A_2 values; (4) Uranium hexafluoride (UF_6) package requirements; (5) Introduction of criticality safety index requirements; (6) Type C packages and low dispersible material; (7) Deep immersion test; (8) Grandfathering previously approved packages; (9) Adding and modifying Part 71 definitions; (10) Crush test for fissile material package design;[§§§] and (11) Fissile material package design for transport by aircraft.

"Eight additional NRC-initiated issues (numbers 12 through 19) were identified by Commission direction, and through staff consideration, for incorporation in the Part 71 rulemaking process. These NRC-initiated changes are: (12) Special package approvals; (13) Expansion of Part 71 quality assurance (QA) requirements to holders of, and applicants for, a Certificate of Compliance (CoC); (14) Adoption of the requirements of American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel (B&PV) Code for fabrication of spent fuel transportation packages; (15) Adoption of change authority; (16) Revisions to the fissile exempt and general license provisions to address the unintended economic impact of the emergency rule (SRM-SECY-99-200); (17) Decision on Petition for Rulemaking PRM-71-12, which requested deletion of

[§§§] Authors Note: The introduction of this so-called *Dynamic* Crush Test marked the beginning of the end for the DOT Specification 6M fissile material package. See also the related footnotes in Sections 52.4.1 and 52.17.

the double containment requirements for plutonium; (18) Surface contamination limits as applied to spent fuel and high-level waste packages (SRM-SECY-00-0117); and (19) Part 71 event reporting requirements. NRC published the first 18 issues in an issues paper in the **Federal Register** on July 17, 2000 (65 FR 44360).

"The Part 71 rulemaking is being coordinated with DOT to ensure that consistent regulatory standards are maintained between NRC and DOT radioactive material transportation regulations, and to ensure coordinated publication of the final rules by both agencies. On December 28, 1999 (64 FR 72633), DOT published an advance notice of proposed rulemaking regarding adoption of TS-R-1 in its regulations…."[32]

52.17 10 CFR 71, 2004 FINAL RULE

In January 2004, the final rule for major changes to 10 CFR 71 was published in the *Federal Register*.[33] Because much of the information presented in the preamble for the 2004 Final Rule was (is) a repeat of the comparable information already presented for the 2002 Proposed Rule, the information presented in this section will focus primarily on the final results.

"This section is structured to present and discuss each issue separately (with cross references as appropriate). Each issue has four parts: Summary of NRC Final Rule, Affected Sections, Background, and Analysis of Public Comments on the Proposed Rule.****

"*A. TS-R-1 Compatibility Issues*

"Issue 1. Changing Part 71 to the International System of Units (SI) Only

"*Summary of NRC Final Rule.* The NRC has decided to continue using the dual-unit system (SI units and customary units) in part 71. This will not conflict with TS-R-1, which uses SI units only, because TS-R-1 does not specifically prohibit the use of a dual-unit system.

"We have decided not to change part 71 to use SI units only nor to require NRC licensees and holders and applicants for a Certificate-of-Compliance (CoC) to use SI units only because doing so will conflict with NRC's Metrication Policy (61 FR 31169; June 19, 1996) which allows a dual-use system. The NRC did not make metrication mandatory because no corresponding improvement in public health and safety would result; rather, costs would be incurred without benefit. Moreover, as noted in the proposed rule (67 FR 21395–21396), the change to SI units only could result in the potential for adverse impact on the health and safety of workers and the general public as a result of unintended exposure in the event of shipping accidents, or medical dose errors, caused by confusion or erroneous conversion between the currently prevailing customary units and the new SI units by emergency responders or medical personnel.

"*Affected Sections.* None (not adopted)….

"Issue 2. Radionuclide Exemption Values

"*Summary of NRC Final Rule*. The final rule adopts, in §§ 71.14, 71.88 and Appendix A, Table A-2, the radionuclide activity concentration values and consignment activity limits in TS-R-1 for the exemption from regulatory requirements for the shipment or carriage of certain radioactive low-level materials. In addition, the final rule provides an exemption from regulatory requirements for natural material and ores containing naturally occurring radionuclides that are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the applicable values. These amendments conform part 71 with TS-R-1 and with DOT's parallel IAEA compatibility rulemaking for CFR 49.

"During the development of TS-R-1, it was recognized that there was no technical justification for the use of a single activity-based exemption value for all radionuclides for defining a material as radioactive for transportation purposes (a uniform activity concentration basis) and that a more rigorous technical approach would be to base radionuclide exemptions on a uniform dose basis. The values and limits in TS-R-1, and adopted in Appendix A, Table A-2, establish a consistent dose-based model for minimizing public exposure. Overall, NRC's analysis shows that the new system would result in lower actual doses to the public than the uniform activity concentration basis system. NRC's regulatory analysis indicated that adopting the radionuclide-specific exemption values contained in TS-R-1 is appropriate from a safety, regulatory, and cost perspective. Moreover, the final rule assures continued consistency between domestic and international regulations for the basic definition of radioactive material in transport.

"*Affected Sections.* Sections 71.14, 71.88, and Appendix A….

"Issue 3. Revision of A_1 and A_2

"*Summary of NRC Final Rule.* The final rule adopts, in Appendix A, Table A-1 of part 71, the new A_1 and A_2 values from TS-R-1, except for molybdenum-99 and

**** Author's Note: For purposes of this discussion, the *Summary of the NRC Final Rule* and the *Affected Sections* will be presented, verbatim. For the complete discussion on the *Background* and the *Analysis of Public Comments on the Proposed Rule*, readers are encouraged to see the full text of Reference [33].

californium-252. The final rule does not include A_1 and A_2 values for the 16 radionuclides that were previously listed in part 71 but which do not appear in TS-R-1.

"The A_1 and A_2 values were revised by IAEA based on refined modeling of possible doses from radionuclides. The NRC believes that these changes are based on sound science, incorporating the latest in dosimetric modeling and that the changes improve the transportation regulations. The regulatory analysis indicates that adopting these values is appropriate from a safety, regulatory, and cost perspective. Further, adoption of the new A_1 and A_2 values will be an overall benefit to public and worker health and international commerce by ensuring that the A_1 and A_2 values are consistent within and between international and domestic transportation regulations. The NRC is not adopting the A_1 value for californium-252 because the IAEA is considering changing the value that appears in TS-R-1 back to what presently appears in part 71. The NRC is not adopting the A_2 value for molybdenum-99 for domestic commerce because this would result in a significant increase in the number of packages shipped, and therefore in potential occupational doses, due to the lower A_2 value in TS-R-1.

"*Affected Sections.* Appendix A….

"Issue 4. Uranium Hexafluoride (UF_6) Package Requirements

"*Summary of NRC Final Rule*. The final rule provides, in new § 71.55(g), a specific exception for certain uranium hexafluoride (UF_6) packages from the requirements of § 71.55(b). The exception allows UF_6 packages to be evaluated for criticality safety without considering the in leakage of water into the containment system provided certain conditions are met, including that the uranium is enriched to not more than 5 weight percent uranium-235. The rule makes part 71 compatible with TS-R-1, paragraph 677(b). Other uranium hexafluoride package requirements in TS-R-1 (paragraphs 629, 630 and 631) do not necessitate changes for compatibility because NRC uses analogous national standards and addresses package design requirements in its design review process.

"The specific exception being placed into the regulations for the criticality safety evaluation of certain uranium hexaflouride [*sic*] packages does not alter present practice which has allowed the same type of evaluation under other more general regulatory provisions. NRC has decided to provide this specific exception: (1) To be consistent with the worldwide practice and limits established in national and international standards (ANSI N14.1 and IS 7195) and current U.S. regulations (49 CFR 173.417(b)(5)); (2) because of the history of safe shipment; and (3) because of the essential need to transport the commodity.

"*Affected Sections.* Section 71.55….

"Issue 5. Introduction of the Criticality Safety Index Requirements

"*Summary of NRC Final Rule.* The final rule adopts the TS-R-1 (paragraphs 218 and 530). Paragraph 218 results in NRC incorporating a Criticality Safety Index (CSI) in part 71 that is determined in the same manner as current part 71 'Transport Index for criticality control purposes,' but now it must be displayed on shipments of fissile material (paragraphs 544–545) using a new 'fissile material' label. NRC's adoption of TS-R-1 (paragraph 530) increases the CSI-per package limit from 10 to 50 for fissile material packages in nonexclusive use shipments. (The previous Transport Index criticality limit was 10.) The TI is determined in the same way as the 'TI for radiation control purposes' and continues to be displayed on the traditional 'radioactive material' label. The basis for these changes that makes part 71 compatible with TS-R-1 is that NRC believes the differentiation between criticality control and radiation protection would better define the hazards associated with a given package and, therefore, provide better package hazard information to emergency responders. The increase in the per package CSI limit may provide additional flexibility to licensees by permitting the increased use of less expensive, nonexclusive use shipments. However, licensees will still retain the flexibility to ship a larger number of packages of fissile material on an exclusive use conveyance. The adoption of the CSI values would make part 71 consistent with TS-R-1 and, therefore, would enhance regulatory efficiency.

"*Affected Sections.* Sections 71.4, 71.18, 71.20, 71.59….

"Issue 6. Type C Packages and Low Dispersible Material

"*Summary of NRC Final Rule*. The final rule does not adopt the Type C or Low dispersible material (LDM) requirements for plutonium air transport as introduced in the IAEA TS-R-1. NRC decided not to adopt Type C or LDM requirements because the U.S. regulations in §§ 71.64 and 71.71 governing plutonium air transportation to, within, or over the United States contains more rigorous packaging standards than those in the IAEA TS-R-1. Furthermore, the NRC's perception is that there is a lack of current or anticipated need for such packages,

and NRC acknowledges that the DOT import/export provisions permit use of IAEA regulations.

"*Affected Sections*. None (not adopted)….

"Issue 7. Deep Immersion Test

"*Summary of NRC Final Rule*. The final rule adopts the requirement for an enhanced water immersion test (deep immersion test) which is applicable to any Type B or C packages containing activity greater than 10^5 A_2. The purpose of the deep immersion test is to ensure package recoverability. The basis for expanding the scope of the deep immersion test to include additional Type B or C packages containing activity greater that 10^5 A_2 was due to the fact that radioactive materials, such as plutonium and high-level radioactive waste, are increasingly being transported by sea in large quantities. The threshold defining a large quantity as a multiple of A_2 is considered to be a more appropriate criterion to cover all radioactive materials and is based on a consideration of potential radioactive exposure resulting from an accident. Also, the NRC is retaining the current test requirements in § 71.61 of 'one hour w/o collapse, buckling or leakage of water.' The NRC is retaining this acceptance criterion of 'w/o collapse, buckling, or leakage' as opposed to the acceptance criterion specified in TS-R-1 of only 'no rupture' of the containment. NRC has determined that the term 'rupture' cannot be determined by engineering analysis and the term 'w/o collapse, buckling or leakage of water' is a more precise definition for acceptance criterion.

"*Affected Sections.* Sections 71.41, 71.51, 71.61….

"Issue 8. Grandfathering Previously Approved Packages

"*Summary of NRC Final Rule*. The final rule adopts the following grandfathering provisions for previously approved packages in section 71.13:

(1) Packages approved under NRC standards that are compatible with the provisions of the 1967 edition of Safety Series No. 6 may no longer be fabricated, but may be used for a 4-year period after adoption of a final rule;

(2) Packages approved under NRC standards that are compatible with the provisions of the 1973 or 1973 (as amended) editions of Safety Series No. 6 may no longer be fabricated; however, may still be used;

(3) Packages approved under NRC standards that are compatible with the provisions of the 1985 or 1985 (as amended 1990) editions of Safety Series No. 6, and designated as '-85' in the identification number, may not be fabricated after December 31, 2006, but may be continued to be used; and

(4) Package designs approved under any pre-1996 IAEA standards (*i.e.*, packages with an '-85' or earlier identification number) may be resubmitted to the NRC for review against the current standards. If the package design described in the resubmitted application meets the current standards, the NRC may issue a new CoC for that package design with a '-96' designation.

"Thus, the final rule adopts, in part, the provisions for grandfathering contained in TS-R-1. The NRC believes that packages previously approved under the 1967 edition of Safety Series No. 6 lack the enhanced safety enrichments which have been incorporated in the packages approved under the provisions of the 1973, 1973 (as amended), 1985 and 1985 (as amended) editions of Safety Series No. 6. For example, later designs demonstrate a greater degree of leakage resistance and are subject to quality assurance requirements in subpart H of part 71. Furthermore, NRC believes that by discontinuing the use of package designs that have been approved to Safety Series No. 6, 1967, for both domestic and international transport of radioactive material, it will ensure safety during transportation and thus will increase public confidence. However, NRC has not adopted the immediate phase out of 1967-approved packages as the IAEA has, [*sic*] Instead, NRC implemented a 4-year transition period for the grandfathering provision on packages approved under the provisions of the 1967 edition of Safety Series No. 6. This period provides industry the opportunity to phase out old packages and phase in new ones, or demonstrate that current requirements are met. NRC recognizes that when the regulations change there is not necessarily an immediate need to discontinue use of packages that were approved under previous revisions of the regulations. The final rule includes provisions that would allow previously-approved designs to be upgraded and to be evaluated to the newer regulatory standards. Note that in 1996, IAEA first published that the 1967-approved packages would be eliminated from use. Thus, with the final rule 4-year phase out of these older packages, industry will have had 12 years (*i.e.*, until 2008) to evaluate its package designs and prepare for the eventual phase out.

"*Affected Sections*. Section 71.13….

"Issue 9. Changes to Various Definitions

"*Summary of NRC Final Rule*. The final rule adopts the TS-R-1 definition of Criticality Safety Index (CSI). NRC believes this provides internal consistency and compatibility with TS-R-1.

Additionally, the following definitions have been revised to improve their clarity and maintain consistency with DOT: A_1, A_2, Consignment, LSA-I, LSA-II, LSA-III, and Unirradiated uranium. NRC believes that terms must be clearly defined so that they can be used to accurately communicate requirements to licensees. By modifying existing definitions and adding new definitions, the licensee would benefit through more effective understanding of the requirements of part 71.

"*Affected Sections*. Section 71.4….

"Issue 10. Crush Test for Fissile Material Package Design[††††]

"*Summary of NRC Final Rule*. The final rule adopts, in § 71.73, the TS-R-1 requirement for a crush test for fissile material package designs and eliminated the 1000 A_2 criterion, but maintained the current part 71 testing sequence and drop and crush test requirements.

"By adopting TS-R-1, the weight and density criteria will apply to fissile uranium material packages, and packages that were previously exempted because of the 1000 A_2 criterion will now require crush testing. Adopting crush test requirements and eliminating the 1000 A_2 criterion is appropriate because not adopting the TS-R-1 requirements would result in an inconsistency between part 71 requirements and TS-R-1, which could affect international shipments, and fissile material package designs would continue to not be evaluated for criticality safety against a potential crush test accident condition.

"The NRC did not adopt the TS-R-1 test sequence requirements because no new information existed to address concerns from a previous rulemaking regarding the difference in test requirements between essentially the same IAEA requirements contained in Safety Series No. 6 and part 71. The NRC chose to remain more conservative than the IAEA by requiring both a drop and crush test, rather than one or the other as TS-R-1 would permit.

"*Affected Sections*. Section 71.73….

"Issue 11. Fissile Material Package Design for Transport by Aircraft

"*Summary of NRC Final Rule*. The final rule adopts TS-R-1, paragraph 680, Criticality evaluation, in a new § 71.55(f) that only applies to fissile material package designs that are intended to be transported aboard aircraft. Section 71.55 specifies the general package requirements for fissile materials, and the existing paragraphs of § 71.55 are unchanged. Among other requirements, TS-R-1, paragraph 680, requires that packages must remain subcritical when subjected to the tests for Type C packages, because:

(1) The NRC has deferred adoption of the Type C packaging tests (see Issue 6);
(2) TS-R-1, paragraph 680 requires Type C tests; and
(3) Paragraph 680 applies to more than Type C packages; only the salient text of paragraph 680 was inserted into § 71.55(f) and applies to domestic shipments.

"Adopting this change will provide regulatory consistency. Shippers would have been required to meet the TS-R-1 air transport requirements even if the NRC did not adopt them, because the International Civil Aviation Organization had adopted regulations consistent with TS-R-1 on July 1, 2001. U.S. domestic air carriers require compliance with the ICAO regulations even for domestic shipments. Therefore, these changes are expected to benefit industry by eliminating the need for two different package designs.

"*Affected Sections*. Section 71.55….

"*B. NRC-Initiated Issues*

"Issue 12. Special Package Authorizations

"*Summary of NRC Final Rul*e. The final rule adopts, in § 71.41, special package authorizations that will apply only in limited circumstances and only to one-time shipments of large components. Special package authorization regulations are necessary because there are no regulatory provisions in part 71 for dealing with nonstandard packages, other than the exemption provisions and § 71.41(c). The NRC processing of one-time exemptions for nonstandard packages, such as the Trojan reactor vessel, has required the expenditure of considerable NRC resources. Further, the NRC's policy is to avoid the use of exemptions for recurring licensing actions. Special package authorization requirements will result in enhanced regulatory efficiency by standardizing the requirements to provide greater regulatory certainty and clarity, and will ensure consistent treatment among licensees requesting authorization for shipment of special packages.

"Any special package authorization will be issued on a case-by-case basis, and requires the applicant to demonstrate that the proposed shipment would not endanger life or property nor the common defense and security, following the basic process used by

[††††] Author's Note: As was noted previously in Section 52.16, the proposed adoption of the so-called *Dynamic* Crush Test marked the beginning of the end for the DOT Specification 6M fissile material package. The actual death-knell for the package was finally sounded here, in 2004, with the adoption of the requirements in this Final Rule, since it required *both*, the Dynamic Crush Test *and* the 30-foot Drop Test.

applicants to obtain a CoC for nonspecial packages from NRC.

"The applicant will be required to provide reasonable assurance that the special package, considering operational procedures and administrative controls employed during the shipment, would not encounter conditions beyond those for which it had been analyzed and demonstrated to provide protection. The NRC will review applications for special package authorizations. Approval will be based on NRC staff determination that the applicant will meet the requirements of subpart D of 10 CFR part 71. If approved, the NRC will issue a CoC or other approval (*i.e.*, special package authorization letter).

"NRC will consult with DOT on making the determinations required to issue an NRC special package authorization.

"*Affected Sections*. Section 71.41….

"Issue 13. Expansion of Part 71 Quality Assurance (QA) Requirements to Certificate of Compliance (CoC) Holders

"*Summary of NRC Final Rule*. The final rule adds the terms 'certificate holder' and 'applicant for a CoC' to subpart H, part 71 and adds a new section, § 71.9, on employee protection. Adopting these requirements will ensure that the regulatory scheme of part 71 will remain more consistent with other NRC regulations in that certificate holders and applicants for a CoC will be responsible for the behavior of their contractors and subcontractors.

"This expansion is necessary to enhance NRC's ability to enforce nonconformance by the certificate holders and applicants for a CoC. Although CoC's [*sic*] are legally binding documents, certificate holders and/or applicants and their contractors and subcontractors have not clearly been brought into the scope of part 71 requirements. This is because the terms 'certificate holder' and 'applicant for a certificate of compliance' do not appear in part 71, subpart H; rather, subpart H only mentions 'licensee' in these regulations. Consequently, the NRC has not had a clear basis to cite applicants for, and holders of CoC's [*sic*] for violations of part 71 requirements in the same way it has licensees.

"The NRC also added a new section (§ 71.9) on employee protection to part 71. The NRC believes that employee protection regulations should be added to cover the employees of certificate holders and applicants for a CoC to provide greater regulatory equivalency between part 71 licensees and certificate holders.

"*Affected Sections*. Sections 71.0, 71.1, 71.6, 71.7, 71.8, 71.9, 71.91, 71.93, 71.100, and 71.101 through 71.137….

"Issue 14. Adoption of the American Society of Mechanical Engineers (ASME) Code

"*Summary of NRC Final Rule*. The NRC has decided not to incorporate the ASME Code, section III, division 3 requirements into part 71. Public Law 104-113 requires that Federal agencies use consensus standards in lieu of government-unique standards, if this use is practical or inconsistent with other existing laws. Because a major revision to the ASME Code is forthcoming and because the changes in that revision are not yet available for staff and stakeholder review, the NRC staff considered it an imprudent use of NRC and stakeholder resources to initiate rulemaking on the current ASME Code revision only to have the ASME Code requirements change during the part 71 rulemaking.

"*Affected Sections.* None (not adopted)….

"Issue 15. Change Authority for Dual-Purpose Package Certificate Holders

"*Summary of NRC Final Rule*. The Commission does not reach a final decision on the issue of change authority for dual-purpose package certificate holders in this final rule. The NRC has determined that implementation of this change would result in new regulatory burdens and costs which could be significant. The Commission believes it needs further input from stakeholders on the values and impacts of this change before deciding whether to adopt a final rule providing change authority for dual-purpose package certificate holders. The NRC staff plans to conduct public meetings with appropriate stakeholders to develop a final regulatory solution which it will propose to the Commission. At that time, the Commission will either issue a final rule resolving this issue, taking into account the comments received on the proposed rule and in any future public meetings, or will withdraw 10 CFR part 71 subpart I of the proposed rule.

"*Affected Sections.* None….

"Issue 16. Fissile Material Exemptions and General License Provisions

"*Summary of NRC Final Rule*. The final rule adopts various revisions to the fissile material exemptions and the general license provisions in part 71 to facilitate effective and efficient regulation of the transport of small quantities of fissile material. The fissile exemptions (§ 71.15) have been revised to include controls on fissile package mass limit combined with package fissile-to-nonfissile mass ratio. The general license for fissile material (§ 71.22) has been revised to consolidate and simplify current fissile general license provisions from §§ 71.18, 71.20, 71.22, and 71.24. Under the final rule, the

general license is based on mass-based limits and the CSI. In light of comments and applicable DOT requirements, the final rule removes proposed rule language references to 'storage incident to transportation.' Also, the exemptions for low level materials in § 71.14 were revised to apply only to nonfissile and fissile-exempt materials.

"*Affected Sections*. Sections 71.4, 71.10, 71.11, 71.18, 71.20, 71.22, 71.24, 71.53, 71.59, and 71.100. (Currently effective § 71.10 was relocated to § 71.14 with additional language. Currently effective §§ 71.18, 71.20, 71.22, 71.24, and 71.53 are replaced by new §§ 71.15 and 71.22.).…

"Issue 17. Decision on Petition for Rulemaking on Double Containment of Plutonium (PRM-71-12)

"*Summary of Decision on PRM-71-12*. Currently in 10 CFR 71.63(b), plutonium in excess of 0.74 TBq (20 Ci) must be packaged in a separate inner container placed within an outer packaging. This is referred to as double containment. It is the combination of the inner container and the outer packaging that is subjected to the normal conditions of transport (§ 71.71) and the hypothetical accident conditions (§ 71.73). Upon application of the normal conditions of transport and hypothetical accident conditions, the acceptance criteria for shielding, containment, and subcriticality in § 71.51 must be also met for the total package (inner container and outer packaging), but the containment dispersal acceptance (10^{-6} A_2/hour or 1 A_2/week) are applied to each boundary (*i.e.*, the inner container and the outer packaging). Note however, as a point of clarification, double containment does not mean two Type B containers nested into one.

"The final rule grants the petitioner's request to remove the double containment requirement of § 71.63(b). However, the requirement of § 71.63(a) that shipments whose contents contain greater than 0.74 TBq (20 Ci) of plutonium must be made with the contents in solid form is retained. Thus, the petitioner's alternative proposal is denied. This completes action on PRM-71-12.

"The NRC has decided to remove the double containment requirement because this regulation is neither risk informed nor performance-based. There are many nuclides with A_2 values the same or lower than plutonium's for which double containment has never been required. Thus, requiring double containment for plutonium alone is not consistent with the relative hazard rankings in Table A-1. The Type B packaging standards, which the outer containment of plutonium shipments must meet, in and of themselves, provide reasonable assurance that public health and safety and the environment are protected during the transportation of radioactive material. This position is supported by an excellent safety record in which no fatalities or injuries have been attributed to material transported in a Type B package. The imposition of an additional packaging requirement (in the form of a separate inner container) is fundamentally inconsistent with this position and is technically unnecessary to assure safe transport. Further, removal of this requirement will reduce an unnecessary regulatory burden on licensees, will likely result in reduced risk to radiation workers, and will serve to harmonize part 71 with TS-R-1.

"On the other hand, the imposition of the requirement that plutonium in excess of 0.74 TBq (20 Ci) per package be shipped as a solid does not create a regulatory inconsistency with the Type B package standards. The NRC considers the contents of a package when it is evaluating the adequacy of a packaging's design. The approved content limits and the approved packaging design together define the CoC for a package. However, other than criticality controls and the solid form requirement of § 71.63(a), subparts E and F do not contain any restrictions on the contents of a package. Thus, while the inner containment requirement in § 71.63(b) can be seen as conflicting with the Type B package standard because the inner containment affects the packaging design, the solid form requirement of § 71.63(a) does not conflict with the packaging requirements of the Type B package standard because the solid form requirement affects only the contents of the package, not the packaging itself.

"*Affected Sections*. Section 71.63….

"Issue 18. Contamination Limits as Applied to Spent Fuel and High-Level Waste (HLW) Packages

"*Summary of NRC Final Rule*. The final rule does not adopt any changes to part 71 for this issue because experience with regulations requiring that licensees monitor the external surfaces of labeled radioactive material packages for contamination upon receipt and opening indicates the rate of packages exceeding allowable levels en route is low, and therefore, in transit decontamination of packages is not warranted. Further, requiring such decontamination of packages could result in a significant increase in worker doses without a commensurate increase in public health and safety.

"*Affected Sections*. None (not adopted)….

"Issue 19. Modifications of Event Reporting Requirements

"*Summary of NRC Final Rule*. The final rule revises, in § 71.95, the event reporting submission period to provide a written report from 30 to 60 days. Other

regulatory requirements to orally notify the NRC Operations Center promptly of an event and for licensees to report instances of failure to follow the conditions of the CoC while packaging was in use remain unchanged. The revision lengthening the time for submission of the written report is consistent with changes to similar requirements in Part 50.

"*Affected Sections.* Section 71.95….

52.18 CONCLUSIONS

In the preceding pages, we have taken a look at the development of U.S. regulations for the transportation of radioactive materials. Primarily based on the requirements for Type B quantities of radioactive material, the information included a number of detailed interactions that have taken place between a variety of U.S. governmental agencies, commissions, and departments. The information also included details on the many interactions that have taken place between these governmental agencies and the IAEA.

From a regulatory perspective, the Chapter covered the time period from 1965 through 2004, or about 40 years. Starting in 1978, however, we also began to look at the interactions between the regulatory requirements of 10 CFR 71 and the regulatory guidance provided by the NRC in the form of Reg. Guides, NUREGs, and NUREG/CRs.

As we have seen above in Sections 52.7, 52.9, 52.11, and 52.13, the regulatory guidance provided by the NRC specifically noted that the requirements of 10 CFR 71 could be met by using the requirements defined in specific sections of the ASME's Boiler & Vessel Pressure Code (the Code) as a metric for the design, fabrication, assembly, testing, use, and maintenance of packagings used for the transport of Type B quantities of radioactive materials.

We have also seen that, for the most part, the NRC has been reluctant to introduce the requirements of the Code directly into the regulatory requirements of 10 CFR 71, preferring instead to introduce Code requirements through the use of its guidance documents. The one exception to this occurred with the adoption of the 1998 Final Rule for the *Elimination of Double Containment for Plutonium for Vitrified High Level Waste* (see Section 52.15.3). In this case, however, all direct references to Code requirements were later eliminated from 10 CFR 71 with the adoption of the 2004 Final Rule, and the simultaneous elimination of the long-standing, *double-containment* requirement for plutonium.

Finally, we have seen, in the 2004 Final Rule, that the NRC has chosen *not* to adopt ASME Boiler & Pressure Vessel Code requirements directly into the regulatory requirements for 10 CFR 71. Although it would now seem that we have come full circle, this may not be the case. In reality, two additional situations are at work: 1) the IAEA has adopted a two-year revision cycle for its regulations, in the hope that the latest revisions can be incorporated more quickly than under the previous ten-year revision cycle; and 2) major revisions to the ASME's Boiler & Pressure Vessel Code have, for some time now, been a work in progress with respect to transportation packages. (For additional detail on that subject, see Chapter 15, *Containments for Transportation and Storage of Spent Nuclear Fuel and High-Level Radioactive Material and Waste*, by D. Keith Morton and D. Wayne Lewis.) At some point, it seems likely that these situations will eventually cross paths, and that the requirements specified in a totally revised version of the ASME's Boiler & Pressure Vessel Code *will* find their way back into the regulatory requirements of 10 CFR 71.

52.19 ACKNOWLEDGEMENTS

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