FABRICATION CRITERIA FOR SHIPPING CONTAINERS USED TO TRANSPORT RADIOACTIVE MATERIALS*

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ABSTRACT

Criteria are identified for controlling the fabrication of metal components of shipping containers used for transporting radioactive materials. The criteria have been selected from the ASME Code and are based on the level of radioactive materials being transported and the nuclear safety function of the container's components. Criteria are identified for fabrication processes which are related to materials control, forming, heat treatment, examination and acceptance testing. Implementation of criteria will ensure the structural integrity of shipping containers at levels consistent with the radioactive materials being transported.

BACKGROUND

To protect the public health and safety, shipments of radioactive materials are required to be in accordance with the provisions of 49CRF170-189 and 10CRF71.[1,2] All activities, which are related to the design, fabrication and use of shipping containers are documented in a Safety Analysis Report (SAR) and conducted under a quality assurance program, both of which are reviewed and approved by the U.S. Nuclear Regulatory Commission (NRC). Measures are implemented to assure that the applicable regulatory requirements and the approved design provided in the SAR are correctly translated into specifications, drawings, procedures, and instructions for fabrication. The measures also assure that special fabrication processes, including forging, heat treating and acceptance testing, are controlled and accomplished by qualified personnel using qualified procedures.

All codes and standards used in the fabrication of a shipping container are identified in the SAR as part of the approved design. In the absence of any codes or standards for a special process, information which describes the process, the controls and the quality assurance measures are included in the SAR. Although the shipping container industry uses many codes and standards for fabrication, no universal code or set of criteria has been adopted by industry for fabricating shipping containers. This paper identifies acceptable criteria that may be used in the fabrication and acceptance testing of shipping containers.

Objective and Scope

The objective of the work performed upon which this paper is based was to review and select acceptable fabrication criteria for shipping containers used to transport radioactive materials.[3] The scope of the review and selection process was as follows:

1. Fabrication processes were identified that could affect the shipping container structural integrity or safety function. Two processes, welding and brazing, were sufficiently broad in themselves that they were evaluated in a separate program and are reported in Ref. 4. Criteria are provided in Refs. 2 and 5 to ensure that quality assurance measures are established and maintained during fabrication.
2. Criteria were identified for the fabrication of metal components of existing types of shipping containers which include monolithic structures and multi-walled structures using stainless or ferritic steel containment vessels with lead or uranium shielding.
3. Fabrication criteria were selected from existing industry codes and standards for processes that could significantly affect the container's structural integrity or safety function.

Categories and Component Safety Groups

In accordance with Ref. 6, three categories are defined in terms of the type and quantity of radioactive material being transported. Category I defines high quantities of radioactive materials to be transported; whereas, Category II and III define medium and low quantities, respectively.

The shipping container is subdivided, on a functional basis, into three component safety groups to provide a graded approach in selecting criteria for fabricating the container's components. The first group, containment components, include all components used to retain the radioactive contents in the shipping container during transport. Containment components include the containment vessel, closure, seals, piping and bolts. The second group, criticality components, include all components used to control nuclear criticality during the transport of fissile materials in the shipping container. The criticality components include neutron absorber materials such as boron carbide and the associated structures which retain the relative positions of the fissile and neutron absorber materials during transport. The third group, other safety components, include all of the remaining safety related components which include: gamma and neutron shielding; secondary seals, bolts, and closures; impact limiters; lifting lugs and tie-down devices.

Criteria

A survey was performed to identify industry codes, standards and practices which could apply to the fabrication of shipping containers. Pertinent information, consultation and review on fabrication processes here obtained from the shipping container

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industry through personal contacts, reports and attendance of industry committee meetings. The most important code and standards identified in the survey were the ASME Code and the ASTM and ANSI Standards. The ASME Code was selected for the fabrication criteria because it has been proven to be a safe basis for controlling processes used in fabricating components for nuclear reactors.[7] In addition, the ASME Code provides fabrication criteria to ensure various levels of safety. Although there is no specific section in the ASME Code applicable to shipping containers the shipping container industry has used the ASME Code extensively for fabricating containers over the past twenty years.

The recommended criteria are based on the ASME Code and are identified in Table I. For Category I shipping containers the recommended criteria are contained in the ASME Code Section III, Subsection NB for containment components; Subsection NG for criticality components and Section/VIII, Division I for other safety components. An acceptable specification for drums and pails used in any of the component safety groups is DOE Specification 17C or better. For Category II shipping containers the recommended criteria are identical to Category I, except Section III, Subsection ND may be used for containment components. For Category III shipping containers the recommended criteria are identical to Category 1, except either Section III, Subsection ND or Section VIII, Division 1 may be used for containment components.

An acceptable method of assuring compliance with the criteria is to have the construction of a shipping container carried out by a fabricator having a valid certificate of authorization for the use of the ASME Code stamp for the appropriate section. It is not intended that the ASME Code stamp be applied to the shipping container. A fabricator having a Section III, Subsection NB, ND, or NF certificate of authorization is considered to be qualified for Section VIII fabrication and would not required a Section VIII certificate of authorization. Additional criteria and information are provided in Reference 3.

TABLE I

Fabrication Criteria Based on the ASME Code[1]

Component safety group	Container contents		
	Category I	Category II	Category III
Containment[2,3,4] Primary vessel, bolts piping, fittings, valves, closure Primary seal Relief device	Section III Subsection NB	Section III Subsection ND	Section VIII Division 1
Criticality[5] Support structures/ neutron absorber	Section III, Subsection NG		
Other Safety [6,7,8,9,10] Gamma shielding Secondary bolts, shell and closure Secondary seal Neutron shielding, piping, fittings, valves, relief device, and tanks Lifting lugs Impact Limiters Tie down devices Heat transfer devices	Section VIII, Division 1 or Section III, Subsection NF		

*Numbers on this table refer to the section titled "Notes."

Notes

1. These criteria should be referenced in the associated SAR. Criteria for special processes used, but not included in this table, should be documented in the SAR. Fabrication criteria for welding and brazing are recommended in Ref. 4. Quality assurance criteria are provided in Refs. 4 and 5. Referenced supporting portions of Section II; Section III, Subsection NCA; and Section V of the ASME Code are part of the recommended criteria.

2. The ASME Code was written for pressure vessel fabrication and does not include many of the materials used in the shipping container industry. The designer may specify the material to be used by either a commerical trade name or an applicable ASTM specification. For each material used, information or references should be included in the SAR to permit an evaluation of the materials properties and the intended use.

3. Leak testing of the primary containment, including seals, should be performed in accordance with Ref. 8.

4. The ASME Code does not have specification for either gasket or seal materials. The designer may specify the material and configuration by a commerical trade name. Information which demonstrates the qualification of the seal or gasket (including those used for valves and relief devices) should be included in the SAR.

5. The designer may specify a neutron absorber material by a commerical trade name or as a mixture of elements or common compounds. When appropriate, qualification data should be included in the SAR to demonstrate that the mateial functions as specified. When special absorber materials are used to control criticality, an acceptance test should be performed for each container to ensure that the absorber mterial has been properly installed.

6. The installation of shielding may involve processes such as lead pouring around the primary vessel or shrink fitting of uranium castings onto the primary vessel which could affect the vessels structural integrity. In such cases, the fabrication criteria for the specific process and an engineering evaluation of any associated structural effects should be included in the SAR. Acceptance testing of the gamma shield should be performed to ensure its effectiveness.

7. The designer may specify a neutron shielding material by a commerical trade name or as a mixture of elements or common compounds. When appropriate, qualification data should be included in the SAR to demonstrate that the material functions as specified. Acceptance testing may be required to demonstrate the effectiveness of the neutron shielding.

8. Shipping containers involved in critical lifts in nuclear facilities should have their lifting lugs fabricated and tested to the criteria specified in Refs. 9 and 10.

9. Impact limiters may use special materials such as wood or honeycomb metals to provide the specified crushing characteristics. Any special processes, physical properties, or other information needed to install the impact limiter or qualify its proper function should be included in the SAR.

10. Heat transfer devices required to contain pressure should be hydrostatically tested to Section VIII, Subsection UG-99. Acceptance testing for each shipping container may be necessary to ensure that the specified heat transfer rate is obtained.

REFERENCES

1. Office of the Federal Registrar, Title 49, Code of Federal Regulations, Parts 170-189, Office of the Federal Registrar, Washington, D.C., (January 1, 1983).

2. Office the Federal Registrar, Title 10, Code of Federal Regulations, Part 71, Office of the Federal Registrar, Washington, D.C., (January 1, 1984)

3. L. FISCHER and W. LAI, "Fabrication Criteria for Shipping Containers," Lawrence Livermore National Laboratory, Livermore, California, UCRL-53544, NUREG/CR-3854, (1984).

4. H. WOO, "Welding Criteria for Use in the Fabrication of Radioactive Material Shipping Containers," Lawrence Livermore National Laboratory, UCRL-53044, NUREG/CR-3019, (1983).

5. U.S. Nuclear Regulator Commission, Regulatory Guide 7.10, Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Material, U.S. Nuclear Regulatory Commission, Washington, D.C. (January 1983).

6. (Draft) Regulatory Guide 7., Fracture Toughness Criteria for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of Four Inches (0.1m).

7. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, 1983 edition, the American Society of Mechanical Engineers, United Engineering Center, 345 Each 47th Street, New York, NY 10017.

   Section II, Material Specifications
   Section III, Rules for Construction of Nuclear Power Plant Components
     Division I
     Subsection
       NCA General Requirement for Division 1 and Division 2
       NB Class 1 Components
       ND Class 3 Components
       NF Component Supports
       NG Core Support Structures
   Section V, Nondestructive Examination
   Section VIII, Rules for Construction of Pressure Vessels
     Division I

8. ANSI N14.5-1977, Leakage Tests on Packages for Shipment of Radioactive Materials, American National Standards Institute, 1430 Broadway New York, NY, 10018.

9. NUREG 0612, Control of Heavy Loads at Nuclear Power Plants, National Technical Information Service, Springfield, Va 22161

10. ANSI N14.6, Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (45000Kg) or More for Nuclear Materials, American National Standards Institute, 1430 Broadway, New York, NY 10018.