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From: Advanced Reactor Design

Date: July 18, 1967

Subject: Transmittal of WANL-TMI-1812
NR-1 Reactor Shipping Container
Design Requirements.

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ENGINEERING MECHANICS
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JUL 20 1967

The subject document is transmitted herewith for your information.

That portion of the document which pertains to requirements for meeting hypothetical accident conditions may be revised later. Relaxation of these requirements is contingent upon official definition of "credible hazards" associated with the NR-1 shipment.

JP:ju
Attachment

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MASTER

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WANL-TMI-1812
July 1967

NR-1 Reactor Shipping Container
Design Requirements

Prepared by:

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Advanced Reactor Design

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1. SCOPE

This document defines the requirements for design and performance of equipment identified as the NR-I Reactor Shipping Container. This component includes the shipping container and the simulated NR-I reactor (test weight) required for verification tests.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of invitation for bids form a part of this document to the extent referenced herein:

2.1 Project Documents

2.1.1 SNPO-C-I- Structural Design Specification

2.2 Military and Federal Specifications and Standards

2.2.1 MIL-D-1000 - Drawings, Engineering and Associated Lists.

2.2.2 MIL-R-6855 - Rubber, Synthetic, Sheeted, Molded, and Extruded.

2.2.3 MIL-D-3464 - Desiccants, Activated, Bagged, Packaging use and Static Dehumidification.

2.2.4 MIL-E-5556 - Enamel, Camouflage, Quick Drying.

2.2.5 MIL-I-26860 - Indicator, Humidity, Plug, Color Change.

2.2.6 MIL-V-8712 - Valve, Air Relief, Low Pressure.

2.2.7 NN-P-005156 - Plywood, Container Grade.

2.2.8 O-S-642 - Sodium Phosphate, Tribasic, Technical, Anhydrous, Dodecahydrate, and Monohydrate.

2.2.9 QQ-C-591 - Copper-Silicon, Copper-Zinc-Silicon, and Copper-Nickel-Silicon Alloys: Rod, Wire Shapes, forgings, and flat products, (flat wire, strip, sheet, bar and plate).

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2.2.10 QQ-S-763 - Steel Bars, Shapes, and Forgings Corrosion - Resisting.

2.2.11 QQ-S-776 and Amendment - 5 - Steel Plates, Sheets, and Strip - Corrosion Resisting.

2.2.12 MS-33586 - Metals, Definition of Dissimilar.

2.2.13 TT-C-490 - Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings.

2.2.14 TT-P-664 - Primer Coating, Synthetic, Rust Inhibiting, Lacquer-Resisting.

2.2.15 TT-Q-568 - Wood Preservative; Cresote - Petroleum Solution.

2.2.16 TT-W-570 and Amendment - 1 - Wood Preservative; Pentachlorophenol, Solid.

2.2.17 TT-Q-571 - Wood Preservation: Treating Practices.

2.2.18 Federal Standard No. 595 - Colors.

2.3 Drawings

2.3.1 Westinghouse Drawing No. 938-J-704, NR-1 Shipping Container Outline.

2.4 Other Publications

2.4.1 U. S. Atomic Energy Commission Manual, Chapter 0529.

2.4.2 AGC-90107 A - NERVA Engine Environment Specification

2.4.3 Westinghouse Process Specification - PS - 294551.

2.1.5 Copies of government specifications, standards, and other publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

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3. REQUIREMENTS

3.1 Performance

The shipping container shall protect the reactor from all harmful environmental conditions normally associated with shipping and storage. It shall also protect the reactor from certain hypothetical accident conditions as defined by paragraph 3.1.1.2.1 of this document.

3.1.1 Functional Characteristics

3.1.1.1 Primary Performance Characteristics

3.1.1.1.1 The maximum shock load that the container permits the reactor/pressure vessel assembly to experience shall not exceed 2.5 "G" vertically and 1.8 "G" horizontally when subjected to the tests outlined in Section 4 of this document.

3.1.1.1.2 The maximum vibration load that the container permits the reactor/pressure vessel assembly to experience through the range of predominant transportation frequencies (2.5 to 7.5 cps), shall not exceed 2.0 "G" vertically and 0.8 "G" horizontally.

3.1.1.1.3 The container shall satisfy all of the requirements associated with normal conditions of transport for a Fissile Class III Shipment as defined by U. S. Atomic Energy Commission Manual, Chapter 0529.

3.1.1.2 Secondary Performance Characteristics

3.1.1.2.1 The container shall satisfy all the requirements associated with hypothetical accident conditions during a Fissile Class III shipment as defined by the U. S. Atomic Energy Commission Manual, Chapter 0529.

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3.1.2 Operability

3.1.2.1 Reliability

Assurance that reliability for the shipping container is achieved shall be provided by adequate design reviews, evaluations, analysis and test. Failure mode analyses shall be made prior to drawing release and the potential causes of failure thus identified shall be eliminated. Separate reliability tests will not be performed, however, data from all pertinent tests shall be factored into the overall reliability evaluation.

3.1.2.2 Maintainability

3.1.2.2.1 Maintenance Requirements

Inspection - The container shall be thoroughly inspected before and after each use.

Cleaning - Absolute cleanliness of the container internals is not necessary since the reactor is contained in a sealed pressure vessel, however, the container shall be kept free of rust, dirt, dust, chipped paint, grease or oil.

Trouble Analysis - The degeneration and/or failure of any container component should be apparent and easily traced. Damaged rubber shear mounts, leaking or frayed hydraulic shock absorbers, damaged threaded fasteners and defective gaskets are all failures that can be noted by visual observation. The most common failures, if any, will be defective gaskets, thread damage and leaks from shock absorbers.

3.1.2.2.2 Maintenance and Repair Cycles

No specific maintenance and repair cycles are required.

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3.1.2.2.3 Service and Access

3.1.2.2.3.1 The container shall be designed to provide ready accessibility to interior supports and shall permit the installation and removal of the reactor/pressure vessel assembly by means of overhead lifting devices through a sequence of simple operations.

3.1.2.2.3.2 Closure fastenings shall be such that only common hand tools will be sufficient to open and close the container. Padlocks and keys shall be provided 180 degrees apart on the bolted flange of the container. All locks and keys shall be identical.

3.1.2.2.3.3 An access ladder, steel rung type, shall be attached to the container shell and shall extend the full length of the cylindrical section. The structural configuration attached to the shell for limiting center-to-center dimensions of loaded containers (See paragraph 3.2.1.1.2 of this document) shall be designed for alternate use as a work platform and shall be equipped with guard rails or safety lines accordingly.

3.1.2.2.3.4 A cylindrical record receptacle, 4 inches minimum inside diameter and 14 inches minimum clear inside length, shall be provided. The receptacle shall be closed from the outside with a watertight cover. Provisions shall be made for security sealing of the record receptacle with lead seals and safety wire.

3.1.2.2.3.5 Provision shall be made for application of a security seal to all closures (lead seal and safety wire).

3.1.2.3 Useful Life

3.1.2.3.1 Operating Life

The shipping container shall be capable of meeting all of the

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requirements of Section 3.1.1 of this document after being exposed to the conditions normally imposed by shipping, handling, and storage over a minimum period of five years provided that the maintenance requirements of Section 3.1.2.2 of this document are fulfilled. This requirement is not contingent upon the frequency of usage.

3.1.2.3.2 Storage Life

The shipping container shall be capable of meeting all of the requirements of Section 3.1.1 after being stored under the conditions of Section 3.1.2.4.1 of this document provided that the maintenance requirements of Section 3.1.2.2 of this document are fulfilled. Storage time shall be construed to mean that time normally spent in storage during a 5 year use period.

3.1.2.4 Natural Environment

3.1.2.4.1 Transportation and Storage

3.1.2.4.1.1 Temperature

The container shall be designed for service in temperature environment of -40°F to 130°F .

3.1.2.4.1.2 Atmosphere

The external shell of the container shall be exposed to ambient atmosphere. Prior to shipment and/or storage of the container, with a Nuclear Subsystem installed therein, the container internals shall be purged with dry nitrogen until a dewpoint of -30°F is reached. The container shall then be pressurized with dry nitrogen to 5-7 psig and this pressure maintained during shipment and/or storage.

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3.1.2.5 Transportability

3.1.2.5.1 Modes of Transport

The shipping container shall be transportable by railroad or truck.

3.1.2.5.2 Handling

Three lifting lugs, 120 degrees apart, capable of withstanding the tests as specified in Section 4 of this document without failure or visible permanent deformation (The loaded container shall be lifted by means of each of the three lifting lugs) shall be provided on the lower shell for lifting the loaded container. These lugs shall be located near the interface between the container halves and shall be above the c. g. of the suspended mass. Additional lifting lugs (3 lugs, 120 degrees apart) shall be attached to the container cover for the purpose of handling the cover separately.

3.1.2.5.3 Two wood skids, one piece or laminated, shall be provided on the bottom of the container. A metal channel, welded to the container base, shall encase the upper four inches of each skid. The skid shall be attached to the channel by bolts through the skid and the channel flanges. The vertical clearance between the bottom plane of the skids and the bottom of the container shall be a minimum of four inches. Skids shall be of Group IV woods as classified in Specification NN-P-515.

3.1.2.6 Human Performance

Not applicable.

3.1.2.7 Safety

The shipping container design shall meet all of the requirements for Fissile Class III shipments as defined by U. S. Atomic Energy Commission Manual,

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Chapter 0529 - "Safety Standards for the Packaging of Radioactive and Fissile Materials".

3.1.2.8 Induced Environment

The shipping container shall be designed to fulfill the performance requirements of Section 3.1 of this document when subjected to the shipping environment defined by AGC - 90107 A - NERVA Engine Environment Specification.

3.2 Design and Construction

The shipping container style, general arrangement, suspended mass, center of gravity and envelope dimensions are shown on Westinghouse Drawing No. 938-J-704. The container shall consist of an outer shell, support skirt, suspension system and appurtenances as described in paragraph 3.2.1 of this document. The reactor/pressure vessel assembly shall be positioned and rigidly held, in a vertical nozzle down position, by the support skirt. The support skirt, with the reactor/pressure vessel assembly installed therein, shall be suspended by an arrangement of rubber mounts and hydraulic shock absorbers located between the support skirt and the container shell. Honeycomb material, which has predictable crush characteristics, shall be attached at specific locations inside the container shell to absorb energy in event of severe impact. The container assembly shall be skid mounted. Instrumentation connectors, gas fill and vent connectors, pressure gage and humidity indicators shall be furnished on the container.

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3.2.1 General Design Features

3.2.1.1 Container Shell

3.2.1.1.1 The shipping container shall be a single shell design.

3.2.1.1.2 The basic shipping container shell shall consist of cylindrical halves with integral dished heads and connecting flanges. The shell design shall provide the necessary penetrations and connections for instrumentation, pressure gages, humidity indicators, fill and vent lines and drains. The shell design and attachments thereto shall also include lifting lugs, connections for tie down and access ladders. The spacing of loaded containers shall be limited to a center-to-center dimension which satisfies nuclear safety requirements. The structural configuration of the container shell shall prevent spacing of containers closer than the center-to-center dimension specified for nuclear safety. All parts of the container in excess of the outside diameter of the container shell (perpendicular to the direction of travel) shall be removable.

3.2.1.1.3 The container shall be capable of being pressurized to 15 psig with dry nitrogen and shall be capable of retaining 5 psig after repeated use at standard atmospheric conditions. A pressure relief valve conforming to MIL-V-8712 actuated at 7 to 10 psig and reseating at 7 psig shall be provided on the container. A pressure gage and gas filling valve shall be provided on the container. The gas filling valve shall be capable of flowing a minimum of 50 cubic feet of free air per minute with 50 to 100 psig inlet pressure.

3.2.1.1.4 The container shall be equipped with interior receptacle for desiccants. Each receptacle shall include a refillable enclosure which shall retain bagged desiccant conforming to Specification MIL-D-3464, while permitting the passage of gas. The total capacity of the receptacles shall be .50 cubic feet for each

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100 cubic feet of free air volume. The thickness of the desiccant to be contained in the holder shall not exceed three inches from its mounting surface.

3.2.1.1.5 Joining of the top and bottom sections of the container shell shall be accomplished by a bolted-gasketed closure. The sealing gasket shall be continuous and shall be in conformance with MIL-R-6855, Class II, Grade 40. Joining surfaces shall be compatible with gasket to ensure sealing.

3.2.1.1.6 Provisions shall be incorporated to insure that every pocket on the exterior structure of the container, is provided with a means of drainage in the normal storage position of the container. Holes shall be provided where necessary to permit drainage. These holes shall be of sufficient size to permit drainage without danger of subsequent stoppage by painting.

3.2.1.1.7 A humidity indicator conforming to MIL-I-26860, Type I, a pressure relief valve, a fill valve and pressure gage shall be mounted flush with the inner surface of the container and shall be protected by adequate housing.

3.2.1.1.8 Major sections of the container which may be assembled in more than one relative position shall be furnished with assembly guides and suitable markings which will permit assembly in one relative position only.

3.2.1.1.9 A drain plug shall be installed in the lowest point of the container shell. The plug shall be removable from the outside and shall be protected against damage from normal handling operations.

3.2.1.1.10 Structural members (plates - gussets - brackets) shall be arranged radially on the container cover and welded thereto to provide connection points for container tie downs.

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3.2.1.2 Support Skirt

The support skirt shall be cylindrical with a top cover and connecting flanges. (The function of the top cover is primarily associated with energy absorption in event of severe impact). The support skirt shall be mounted inside the container shell via a suspension system as defined by paragraph 3.2.1.3 of this document. The skirt shall support the reactor/pressure vessel assembly, in the nozzle down position, from the pressure vessel flange. (A fixture defined by paragraph 3.2.1.4 of this document, is required for completion of the interface between the pressure vessel flange and the support skirt). The support skirt diameter shall be the minimum which is consistent with the pressure vessel dimensions.

3.2.1.3 Suspension System

The suspension system, totally housed by the bottom section of the shipping container, shall utilize rubber shear mounts and hydraulic shock absorbers to provide the shock and vibration isolation necessary to meet the performance requirements of paragraph 3.1.1.1 of this document. The suspension system shall include 32 shear mounts and 32 shock absorbers of the size and physical characteristics required for design. The mount system shall be separated by a continuous ring, located approximately at the c.g. of the reactor/pressure vessel assembly so that 16 mounts are located above the ring and 16 mounts are below the ring thus providing stability under maximum shear mount deflection. The mounts shall be inclined at 45° , for both lateral and vertical protection, and shall be attached to brackets on the container shell, the continuous ring and the support skirt. The mounts shall be arranged symmetrically around the container.

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The hydraulic shock absorbers shall also be mounted in a symmetrical pattern around the container, with 16 above the shear mounts and 16 below, and shall be attached to brackets on the container shell and on the support skirt.

3.2.1.4 Reactor/Pressure Vessel Assembly Lifting and Shipping Fixture

The lifting and shipping fixture shall provide means for lifting and handling of the reactor/pressure vessel assembly and for attachment and support of the assembly in the shipping container. The fixture shall be designed to accept the contoured shape of the pressure vessel flange and shall not damage the flange surface during use. The fixture shall be attached to the pressure vessel flange and to the shipping container support skirt flange by a bolting arrangement.

3.2.1.5 Simulated NR-1 Reactor (Test Weight)

The test weight shall accurately simulate the NR-1 reactor/pressure vessel assembly in-so-far as overall weight, mass moment of inertia, center of gravity and interface surfaces. The design of the test weight shall be simplified with interface surfaces mocked-up by use of adapters as required. The test weight must be solid, that is, no change in c. g. or other change in physical properties shall occur as a result of handling and turning operations.

3.2.2 Selection of Specifications and Standards

All component and assembly drawings shall conform to MIL-D-1000, Drawings, Engineering and Associated Lists. All standards and specifications, referenced herein, have been used previously for NRX reactor shipping container design.

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3.2.3 Materials Parts and Processes

3.2.3.1 The shipping container support skirt shall be fabricated from stainless steel per Specification QQ-S-766, Class 304, Condition A and/or QQ-S-763, Class 304, Condition A. The container shell and other container components, including all suspension system mounts, shall be fabricated from carbon steel in accordance with ASTM Standards, or equivalent.

3.2.3.2 The wood skids shall be sound and free from all defects that would materially affect strength or interfere with fastenings. The wood shall be free from knots and from cross grain diverging more than 1 inch in 10 inches along the grain. After fabrication has been completed, the skids shall be pressure treated for use in contact with the ground in accordance with Specification TT-W-571. A minimum of 10 pounds of creosote in accordance with Specification TT-W-556 or TT-W-566, 12 pounds of creosote in accordance with Specification TT-W-568, or 10 pounds of pentachlorophenol in accordance with Specification TT-W-570 shall be used for each cubic foot of skid lumber.

3.2.3.3 Welding shall be conducted in accordance with Westinghouse Process Specification 294551-1. The welds shall conform to the requirements of Section 4.3.2. All welding fluxes, scale, weld splitter, acids, or basic solutions shall be completely removed.

3.2.3.4 The inside and outside surfaces of the container shall be treated in accordance with Specification TT-C-490 Method 1, using 120 mesh aluminum oxide iron-free grit threaded and other working surfaces.

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3.2.3.5 The inside of the support skirt shall have all weld surfaces ground flush, all chips and foreign particles removed and the machined surfaces mating with the reactor vessel shall have a 125 rms or better finish.

3.2.3.6 An alternate to passivating may be performed as follows:
Treat the inside and outside surfaces of the support skirt in accordance with Specification TT-C-490, Method 1, using 120 mesh aluminum oxide iron-free except on threaded and other working surfaces. All treated surfaces shall be subjected to a fluoroxide etch test. Indications from the test shall be purple on all treated surfaces.

3.2.3.7 The container, excluding the stainless steel of the support skirt, shall be painted inside and outside with one coat of primer conforming to Specification TT-P-664 followed by two coats of enamel per Specification MIL-E-5556. The enamel shall be light blue per Federal Standard 595, color chip no. 35231. Westinghouse Benolite Gray Primer, B-5-305, and Blue Enamel B-6-402, may be used as an alternate.

3.2.3.8 The final painting of the container shall follow completion of the tests defined by Section 4 of this document unless precluded by schedular commitments.

3.2.4 Standard and Commercial Parts

Standard parts (MS, AN or JAN) shall be used wherever they are suitable for the purpose, and shall be identified on the drawing by their part numbers. Commercial utility parts such as screws, bolts, nuts, cotter pins, etc. may be used, provided the corresponding standard part numbers are referenced in the parts list and on the drawings. In the event there is no suitable corresponding standard part, commercial parts may be used provided they conform to all

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requirements of this specification. In each pair of mating threaded parts, one part shall conform to Federal Specification QQ-S-763, Class 303, Condition A and the other shall conform to Federal Specification QQ-C-591, Composition B, hard (Silicon Bronze). The use of Silicon Bronze for bolts is preferred.

3.2.5 Moisture and Fungus Resistance

The shipping container internals are not subjected to moisture and/or fungus environment. During shipping and storage (with NSS installed) the shipping container shall be sealed and pressurized as described in paragraph 3.2.1.1.5 of this document.

External surfaces including wood skids are painted and treated to resist moisture and fungus as specified in MIL-STD-810 A.

3.2.6 Corrosion of Metal Parts

The corrosion control requirements for the shipping container are essentially satisfied by the selection of materials and processes as defined by paragraph 3.2.3 of this document. The use of dissimilar metals (as defined by MS-33586) in direct contact shall be prohibited.

3.2.7 Interchangeability and Replaceability

Interchangeability and replaceability requirements are applicable primarily to the suspension system components. All components of the suspension system shall be interchangeable with other components bearing the same part number.

3.2.8 Workmanship

The shipping container, including all parts and assemblies, shall be constructed and finished in accordance with the requirements of this

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document and the specifications referenced therein. All seal welds and all welds associated with the suspension system mounts shall be inspected by liquid penetrant methods and shall conform to the acceptance standards of Westinghouse Process Specification 294551-1. All carbon steel welds (not seal or suspension system welds) shall be magnetic particle inspected and shall conform to the acceptance standards of Westinghouse Process Specification 294551-1. Repair of weld defects shall be in accordance with Westinghouse Process Specification 294551-1.

3.2.9 Electromagnetic Interference

Not applicable.

3.2.10 Identification and Marking

Paint shall conform to Specification MIL-E-5556. Color of markings shall be insignia white conforming to Federal Standard 595, Color chip no. 37875. Westinghouse Benolite White Enamel, B-6-121 may be used as an alternate. The following markings shall be applied to all containers at the locations and in the sizes indicated.

3.2.10.1 Adjacent to lifting lugs for the entire container in 1-3/4 inch letters: LIFT LOADED CONTAINER HERE. Arrows five inches long shall point to the lifting lugs.

3.2.10.2 On opposite sides of the upper section of the container, corresponding to lift truck openings on the base, in four-inch letters: DO NOT DROP.

3.2.10.3 Adjacent to the gas filling valve in one-inch letters:

GAS VALVE

FILL TO FIVE POUNDS PRESSURE

CAUTION: RELEASE PRESSURE BEFORE OPENING CONTAINER.

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3.2.10.4 Adjacent to the shipping record receptacle in one-inch letters:

SHIPPING RECORDS

3.2.10.5 Adjacent to the relief valve in one-inch letters:

RELIEF VALVE

DO NOT DISTURB

RELIEVES AT 7-10 PSIG

3.2.10.6 In four places on the shell adjacent to and above the closure flange in one-inch letters:

CAUTION: RELEASE PRESSURE BEFORE OPENING CONTAINER.

3.2.11 Storage

The shipping container storage requirements including storage duration, storage environment, and maintenance requirements are defined in that order by paragraphs 3.1.2.3.2; 3.1.2.4.1.2; and 3.1.2.2.1 of this document.