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REQUIREMENTS FOR CANISTERS USED FOR DELIVERY OF SPENT
NUCLEAR FUEL AND ASSOCIATED MATERIALS TO DOE
UNDER STANDARD DISPOSAL CONTRACTS

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Prepared by
E. R. Johnson Associates, Inc.
10461 White Granite Drive
Suite 204
Oakton, Virginia 22124
under
Purchase Order No. 41X-SD841

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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FOREWORD

This report is one of a series of eight prepared by E. R. Johnson Associates, Inc. (JAI) under ORNL's contract with DOE's OCRWM Systems Integration Program and in support of the Annual Capacity Report (ACR) Issue Resolution Process. The report topics relate specifically to the list of high priority technical waste acceptance issues developed jointly by DOE and a utility-working group. JAI performed various analyses and studies on each topic to serve as starting points for further discussion and analysis leading eventually to finalizing the process by which DOE will accept spent fuel and waste into its waste management system. The eight reports are concerned with the conditions under which spent fuel and high level waste will be accepted in the following categories:

1. Failed Fuel
2. Consolidated Fuel and Associated Structural Parts
3. Non-Fuel-Assembly Hardware
4. Fuel in Metal Storage Casks
5. Fuel in Multi-Element Sealed Canisters
6. Inspection and Testing Requirements for Wastes
7. Canister Criteria
8. Spent Fuel Selection for Delivery
9. Defense and Commercial High-Level Waste Packages

As a part of the report preparation, each was subjected to a rigorous peer review by a group of knowledgeable and independent experts. These reports have not yet been formally reviewed by DOE and, therefore, do not represent DOE policy.

REQUIREMENTS FOR CANISTERS USED FOR DELIVERY OF SPENT NUCLEAR FUEL
AND ASSOCIATED MATERIALS TO DOE UNDER STANDARD DISPOSAL CONTRACTS

The Department of Energy (DOE) is studying prospective changes to the waste acceptance criteria contained in the Standard Contract* which involve consideration of the possible acceptance of failed fuel, consolidated fuel rods, compacted structural parts resulting from at-reactor consolidation operations, and other non-fuel bearing materials on the same scheduling basis as used for standard fuel** under the existing Standard Contract. During the course of these studies it has become clear that all such forms of spent fuel and related wastes would have to be delivered to DOE (and stored at the reactor) in a container having an envelope about the same as the fuel assemblies from which the fuel forms originated. Thus, the first objective of the DOE effort has been to develop draft requirements for canisters to be used by utilities (and others) to deliver the foregoing forms of spent fuel and related wastes. These draft requirements have been completed and are included in the attachment hereto.

Separate DOE contractor efforts are being directed toward establishing the conditions under which failed fuel, consolidated fuel rods, compacted structural parts resulting from reactor consolidation, and other non fuel assembly (NFA) hardware might be accepted by DOE, when packaged in a canister meeting the requirements set forth herein, on the same scheduling basis as used for intact non-defective fuel assemblies under the existing Standard Contract. Such conditions may include limitations on the thermal output of the contents or the neutron and

*The Standard Contract between DOE and utilities (and others) for disposal of spent nuclear fuel and high level radioactive waste as set forth in 10CFR961.

**Standard fuel under the existing Standard Contract includes only intact and non-defective fuel assemblies which meet certain dimensional and thermal output limitations.

gamma dose rate at the surface of the canister, the minimum amount of consolidated fuel contained in the canister, and the like. Thus, delivery of these fuel and waste forms to DOE in a canister meeting these requirements is a necessary but not sufficient condition to permit acceptance thereof on the same scheduling basis as for intact non-defective fuel assemblies.

In developing these canister requirements, it was recognized that DOE is obligated under existing disposal contracts to be able to handle intact fuel assemblies having a variety of handling fixtures, cross-sectional dimensions, and lengths, and thus similar ranges of variations have been permitted in the requirements for the canisters that are used to deliver failed fuel, consolidated fuel rods, compacted structural parts resulting from at-reactor consolidation, and other NFA hardware. Moreover, it has been recognized that utilities should have the maximum flexibility to design canisters that meet their individual requirements and to take advantage of prospective canister design innovations. Therefore, these requirements have provided only those necessary to enable DOE to handle the canisters both safely and efficiently in its facilities. Thus, they represent functional performance requirements only with respect to envelope dimensions, handling features, materials of construction, capability of the canisters to withstand the normal loads to which they are expected to be subjected, prevention of stress corrosion cracking, draining, identification and tamper-safing, and particulate containment (as applicable). This is intended to leave wide discretion to the utilities in designing canisters that can be used to store spent fuel at the reactor to achieve minimum cost and take advantage of changes in state-of-the-art for canister design, without compromising the ability of DOE to meet applicable safety requirements and maintain operational efficiency in its facilities.

The draft requirements shown in the attachment represent the first step toward the possible broadening of the variety of spent fuel and waste forms described in the Standard Contract that might be accepted by DOE on the same scheduling basis as intact non-defective spent fuel assemblies. Designs of canisters other than those meeting these requirements would be expected to be considered for use by DOE on a case

by case basis inasmuch as it is recognized that canister types other than those specified in the attachment may be acceptable for use in the DOE system.

The requirements for canisters to be used by utilities to deliver spent fuel and associated materials as described herein should not be confused with those that may be applicable for a common or universal canister; i.e., a canister that could be optimally used in both the utility and DOE spent fuel management systems.

STANDARD CANISTER REQUIREMENTS FOR RECEIPT OF SPENT NUCLEAR FUEL AND ASSOCIATED MATERIALS BY THE FOMS

This requirement shall be applicable to canisters of failed fuel assemblies, consolidated fuel rods, compacted structural parts and end fittings from consolidation operations, and non fuel assembly hardware (NFA) from commercial nuclear power plants. NFA hardware shall include control rod assemblies, burnable poison assemblies, thimble plug assemblies, instrument assemblies, neutron source assemblies, and BWR channels and poison curtains.

Requirement	Rationale
1.0 <u>CANISTER DIMENSIONS</u>	
1.1 The canisters shall fall within the following limiting envelope dimensions:	
<u>Cross Section</u>	
Maximum	
PWR Fuel	-- 9.1 x 9.1 in.
BWR Fuel	-- 6.1 x 6.1 in.
Minimum	
Length	-- Dimensions of original fuel assemblies
Failed Fuel Canisters (maximum inside length)	-- 3-in. longer than corresponding fuel assemblies
Consolidated Fuel Rod Canisters (maximum inside length)	-- 3-in. longer than corresponding fuel rods
Structural Parts and NFA Hardware Canisters (maximum outside length)	-- Length of fuel assemblies from which contents originated
Maximum Overall Length (outside)	-- Failed Fuel Canister -- 180-in. -- Other Canisters -- 170-in.
<u>Straightness</u>	
0.125-in. maximum deviation over length of canister.	
<u>Squareness</u>	
0.03-in. maximum deviation from square.	

The dimensional limitations shown are designed to limit the range of canister sizes to that similar to the range of dimensions generally indigenous to LWR fuel assemblies, except to the extent that allowances are necessary for the fuel form involved. Dimensions shown are those for the envelope in which a given canister must fall. The limitations specified for the cross-section of the envelope recognize that the canisters may have to be somewhat larger than that of the fuel assemblies in order to be able to accommodate failed fuel assemblies and otherwise be able to achieve the most efficient consolidation of fuel rods, compacted structural parts, end fittings, and NFA hardware. The limitations specified for the length of the envelope recognize that a 3-inch freeboard space is required for both failed fuel assemblies and consolidated fuel rods plus an allowance for the thickness of the lid and base of the canister and for the length of the handling device on the lid of the canister. The maximum length of the canister for consolidated fuel rods is intended to allow DOE the option of not opening the canister and recanning the contents in shorter canisters, in the event shorter canisters should be in general use in FOMS facilities for storage in MRS facilities and/or loading into repository containers. The total maximum length of all canisters is that necessary to minimize the special handling thereof in DOE shipping casks and FOMS facilities.

Requirement	Rationale
<p>1.2 The canister shall have the following minimum thickness:</p> <p>PWR canister -- 12 gauge (nominal 0.1072-in.) BWR canister -- 13 gauge (nominal 0.0919-in.)</p> <p>Notwithstanding the foregoing, the thickness of the canister lids and bottom shall be sufficient to meet the requirements of 3.0 and 4.0 hereof. Tolerances on the foregoing thickness shall be in accordance with ASTM A-480/A-480M, Table A1.2.</p> <p>1.3 The canister shall have no protrusions along the sides thereof that cause the canister with the protrusions to exceed the maximum cross-sectional dimensions set forth in 1.1 hereof.</p> <p>2.0 <u>MATERIALS</u></p> <p>2.1 The canisters shall be fabricated from Type 304L Stainless Steel. For sheet material, the requirements of ASTM-240 shall apply. For material made from bar stock, ASTM-A93 shall apply.</p> <p>2.2 Canisters may be welded or drawn to shape. Canisters shall be treated as necessary to limit the possibility of stress corrosion cracking.</p> <p>3.0 <u>HANDLING</u></p> <p>3.1 The canister shall be designed to be handled by the same fuel handling machine used at the reactor to handle fuel assemblies.</p> <p>3.2 The handling fixture shall be designed to have the same functional interface as that found on the reactor-specific spent fuel assemblies.</p> <p>4.0 <u>STRUCTURAL LOADS</u></p> <p>4.1 The canister shall be designed to accommodate all operational loads it will experience during handling and during loading of the shipping cask at the reactor.</p>	<p>The minimum shell thickness should provide adequate axial stiffness and load support.</p> <p>Protrusions should not be permitted to interfere with the insertion or removal of the canister into/from storage racks or cask baskets.</p> <p>304L SS is a widely used, well characterized material. Specific ASTM specifications are referenced to prevent other materials from being used.</p> <p>This provides general guidance for fabrication and addresses possible concerns about stress corrosion cracking.</p> <p>This insures that the canisters can be handled in essentially the same manner as the fuel assemblies at FOMS facilities.</p> <p>By requiring the handling fixture to have the same functional interface as that found on reactor-specific fuel assemblies, this assures that the FOMS can handle the canister the same as it could the corresponding assembly.</p> <p>This requires the utilities to determine and make allowances for loads the canister may experience that are unique to their facility.</p>

Requirement	Rationale
<p>4.2 The maximum weight of a canister and its contents shall not exceed the following:</p> <p>Consolidated fuel rods canister-</p> <p>PWR fuel -- 4000 lb.</p> <p>BWR fuel -- 2000 lb.</p> <p>All other canisters</p> <p>PWR fuel -- 2500 lb.</p> <p>BWR fuel -- 1600 lb.</p>	
<p>4.3 The canister shall be designed so that it can be picked up while loaded and on its side without permanent distortion of its straightness beyond the limits set forth in 1.1 hereof.</p>	<p>The canister may have to be handled in a horizontal position in FMMS facilities.</p>
<p>5.0 <u>CLOSURE</u></p>	
<p>5.1 The top end of the canister shall be equipped with a removable lid that is fabricated to meet the requirements of 3.0 and 4.0 hereof, the dimensions of which are no greater than the maximum cross-sectional dimensions set forth in 1.1 hereof.</p>	<p>This is required to facilitate removal of the contents of the can should DOE elect to do so after receipt at its facilities.</p>
<p>5.2 The lid shall be equipped with a mechanical locking device that permits positive mechanical locking of the lid to the shell of the canister. The mechanical locking of the lid to the canister shell shall be able to support the weight of the lid to the canister shell plus any additional loads to which it may be exposed during handling and during loading of the shipping cask at the reactor site.</p>	<p>Since the canister will most generally be picked up by the handling device mounted on the lid, the locking device should be capable of supporting the weight of the canister plus any additional loads experienced during handling and cask loading/unloading. Moreover, the locking device should be able to be positively locked in place to prevent it from becoming unlocked or partially unlocked inadvertently during handling.</p>
<p>5.3 The canister shall be designed to minimize the volume of trapped water remaining after draining, and the canister and its contents shall be blown dry prior to delivery to DOE.</p>	<p>The canisters will be shipped dry and will need to be capable of being readily and thoroughly drained.</p>
<p>5.4 The bottom end of the canister shall be fastened to the base of the canister shell.</p>	<p>The bottom of the canister must remain in place at all times during transport, storage and handling. Therefore, it must be fastened to the base in some manner (e.g., by welding, bolting, or latching). This does not preclude the use of a floating plate held in place by the fuel load above, provided there is assurance that the base will not fall out or become tilted during handling or shipment in the horizontal position.</p>

Requirement	Rationale
<p>5.5 The canister may contain holes extending through the thickness thereof, provided that:</p> <p>(1) the canister is equipped with a device that prevents contents from falling or being removed from the canister through the holes</p> <p>(2) the size of the holes do not reduce the mechanical strength of the canister to the point that it cannot support a maximum vertical load equal to the weight of the contents of the canister plus any additional loads to which they may be exposed during handling and during loading of the shipping cask at the reactor site.</p>	<p>It may be desirable to have a flow path for the pool water through the canister while stored at the reactor.</p> <p>There should be assurance that fuel rods cannot fall through the holes in either the top or bottom of the canister during handling in all positions. Moreover, safeguards objectives may necessitate assurance that individual fuel rods could not be intentionally removed through the flow holes without significant tampering with the structure of the canister.</p> <p>Holes in the canister may reduce its mechanical strength and may require the use of correspondingly thicker sheet/plate.</p>
<p>5.6 In cases where failed fuel assemblies or fuel rods are included in the canister contents, or where compacted structural parts or other non-fuel bearing components are so included, the canister shall be equipped with a particulate barrier covering each hole to prevent the release of large particulates from the canister. The particulate barrier shall have the following maximum and minimum hole sizes:</p> <p>Minimum Hole Size -- 400 mesh^a Maximum Hole Size -- 200 mesh^a</p>	<p>For failed fuel, compacted structural parts and NFA hardware, it is desirable to prevent the spread of contamination from the canister. Spread of contamination can be limited by the use of particulate barriers that will retain the larger (38-75 microns) particles. This means that no void in the containment provided by the canister should exceed 75 microns except for the gap associated with the lid and latching mechanism. This level of porosity of the particulate barrier should permit the flow of water through the barrier.</p>
<p>^aASTM E11</p> <p>The maximum gap around lid and latching mechanism shall be no greater than 60 mils.</p>	
<p>6.0 <u>QUALITY ASSURANCE</u></p> <p>The purchase and acceptance of canisters shall be effected under the quality assurance program established for the reactor site under the requirements of 10CFR50 and the license conditions for the facility.</p>	<p>This directs the utility to use its existing 10CFR50 QA program, as applicable, for canister fabrication. The quality assurance level acceptable to NRC for the handling, storage and cask loading at the reactor is acceptable to DOE for the purposes of transport and unloading at FOMS facilities.</p>

7.0 CANISTER & CONTENTS IDENTIFICATION

7.1 The canister and its closure shall be permanently stamped with alphanumeric identification having characters at least 0.5 inch high that uniquely identifies the canister and provides a means of relating it to the written records describing the contents of the package. The identification shall be legible from both the top and the side of the canister. The suggested marking code is as follows:

	Utility/Reactor Designator	Contents Designator	Serial No. ^a
Failed Fuel Assemblies	XXXX	A	XXXX
Consolidated Fuel Rods (non-failed)	XXXX	B	XXXX
Consolidated Fuel Rods (failed)	XXXX	C	XXXX
Structural Parts From Consolidation	XXXX	D	XXXX
Non Fuel Assembly Hardware	XXXX	E	XXXX

^aConsecutively numbered for each type of contents.

7.2 The closure latch shall be fitted with a tamper-indicating device to provide a visual indication of tampering.

This is for the purpose of determining that the contents of a canister have not been changed.

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