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FUNCTIONAL REQUIREMENTS

ATOMIC POWER ENGINEERING DEPT.

FUNCTIONAL REQUIREMENTS

IRRADIATED FUEL ASSEMBLY SHIPPING CONTAINER

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C. Revised to
 include
 ALW require-
 ments

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IRRADIATED FUEL ASSEMBLY SHIPPING CONTAINER

I. Introduction

This document describes the design of an irradiated fuel assembly shipping container which is to be used to ship one complete PWR fuel assembly to a laboratory for examination and testing. Irradiated denotes fuel that is used but not spent. Shipment is to be accomplished by either rail or truck.

Possible use of the fuel after laboratory inspection and utilization of Bettis facilities for the examination are factors influencing the design.

An estimated fuel life of 600 continuous operating hours and a fuel removal time of 70 hours for PWR core 1 together with the physical size of the container are the factors used to determine shielding and cooling capacities. Since the activity and decay heat of the fuel are functions of time after shutdown of the reactor, the shielding and cool capacities are not limiting in that the fuel may be stored at the Site before shipment.

The physical limits of the container are fixed so as to be compatible with Bettis Site handling facilities and shock and vibration requirements for the fuel. Where possible, the container is designed to permit ease of physical modification. With the use of suitable adapters, the container could be used to transport a single ALW type fuel cluster (see Part II-C-2-a).

II. Design Consideration

A. Shielding

1. Shielding complies with ICC regulation for shipping radioactive materials so that the dose rate at the surface of the container does not exceed 200 mr/hr and the dose rate one meter from the surface of the fuel does not exceed 10 mr/hr.
 - a. Shielding is calculated on the basis of the expected activity of a PWR core 1 enriched fuel assembly 70 hours after shutdown. The fuel is considered to have operated for 600 continuous full-power hours.

B. Decay Heat Removal

1. The decay heat of the fuel assembly is removed from the container by means of a secondary cooling system.
 - a. The over-all heat transfer coefficient for cooling by natural convection of the secondary cooling system is too low to remove decay heat at atmospheric pressure within the container. Therefore, a forced convection system containing a 5 gpm centrifugal pump is utilized.

B. Decay Heat Removal (Contd.)

- b. A secondary cooling system is used in preference to a primary one in order to eliminate the hazard of escaping contaminated fluid. (See Section II-B-2-b for further explanation.)
 - c. The capacity of the cooling system is 43,000 Btu/hr. This capacity is based on the expected amount of decay heat produced by an enriched PWR fuel assembly 70 hours after shutdown. The fuel is considered as having operated for 600 continuous full-power hours.
 - d. The container is mounted on a structure at an angle of 15 degrees from the horizontal during shipment in order to provide an adequate convective current for the primary water. This provides the primary water with a heat transfer coefficient capable of removing the decay heat from the fuel to the secondary cooling system.
 - e. Instrumentation describing pressure and temperature of the primary and secondary water provides a check on the effectiveness of the secondary cooling system.
 - f. Two outlets on the cask provide a means for adjusting the primary water level and flow necessary during the initial loading operation at the Site.
 - g. Operation of the secondary cooling pump and cooling fan on an outside single phase 110 volt electrical system is provided for by means of appropriate electrical connections in the case of emergency or prolonged site operation.
 - h. A solenoid valve and check valve are provided in the secondary cooling system to cut it off from the primary system in the case of power failure. Should a leak then develop between the primary and secondary systems, this would prevent escape of the primary water.
2. The container is designed to withstand twice the equilibrium pressure developed if the secondary cooling system should fail. The decay heat then would be removed by means of a natural convection of primary water, conduction through the container walls and radiation from the container surface. The equilibrium pressure is calculated to be 250 psi.
- a. The design complies with Section VIII of the ASME Boiler Construction Code except for a relief valve (see next Part b for explanation) and the ICC regulation governing shipment of explosive material.
 - b. Since natural convection is used as a back-up, depended upon only in the event of failure of the secondary cooling system, and the container is designed for safe operation under these conditions, it is not necessary to have a relief valve or a hermetically sealed container. This is desirable since it eliminates the hazard of

B. Decay Heat Removal (Contd.)

- b. escaping fluid due to a faulty relief valve and eases the difficulty of handling imposed by a hermetic seal.
- c. A good heat transfer condition must exist between the stainless steel inner liner, the carbon steel outer liner, and the lead shielding in order to dissipate the heat generated in the case of failure of the secondary cooling system. This is to be accomplished by a 95 to 100 per cent metallurgical bonding of the lead to the aforementioned surfaces (eliminating insulating effect of air gap). The bonding process and the inspection procedure of the bond are to be established by the vendor at the time of submittal of bids and is subject to the approval of the cognizant Westinghouse engineer.

C. Structure

1. The internal construction of the container allows for possible bow or twist of a used fuel assembly in that the center grid support is made adjustable.
2. Individual replacement and/or removal of the internal components of the container allow for ease of modification and maintenance.
 - a. The inner shell, cooling coils, grids, bottom adapter, cap adapter, and end plug are designed for easy, remote removal. Modification of these components would make the container suitable to ship an ALW type fuel cluster.
3. Removable structures are furnished for vertical handling and shipping and horizontal handling facility is built into the structure of the container. This not only leads to simpler over-all handling structures, but also facilitates handling procedure at Bettis and ECF.
4. A removable plug at the closed end of the container provides for the insertion of a ram to aid in the removal of the fuel.
5. Limitations of the Bettis hot lab facilities consisting of a 15 ton crane and a 3 ft high and 18 ft long access to hot cells serve to impose restrictions on the physical size and handling structure of the container.
 - a. Although the weight limit is exceeded, a handling procedure has been evolved whereby the crane will not have to lift the full load of the container.

D. Shock of Vibration

1. The structural strength of the fuel and the support the fuel receives from the internal components of the container are the factors used to determine the shock and vibration limits in shipment. Preliminary calculations indicate that a seed or blanket as it is supported in the container can sustain up to a 20 g shock load in any direction without being harmed. The lowest resonant frequency, 140 cps, is found to occur in the blanket assembly as it is supported in the container.

D. Shock of Vibration (Contd.)

2. It is necessary to furnish special blocking for the bundles in the blanket assembly so that the assembly can take a 20 g axial shock load. The movement of the bundles relative to the blanket shell is restricted by two supports - one is an extension of the container's bottom adapter and the other a three-column support which will be held in place by the container cap. The three-column support will be inserted in the top of the fuel after the fuel is set in the container. Without these supports an axial shock load of approximately 2 gs would be enough to yield the rake assembly inside the blanket.

III. Physical Description

The container is cylindrical with its ends in the shape of truncated cones. The fuel in the container is immersed in water, is surrounded by stainless steel cooling coils and is supported by grids. Enclosing this system are stainless steel casings followed by lead and a carbon steel outside liner. One end has a cap which is removed when loading or unloading. A poison rod is provided when enriched fuel is to be shipped. The container as shipped weighs 20 tons, is 8 ft long, 5 ft wide, and 6 ft high. The secondary cooling unit which accompanies the container weighs 2 tons and is 7 ft long, 6 ft wide, and 5 ft high.

IV. Schematic Diagram of Cooling System (See Pages 6, 7, and 8)

SCHEMATIC *
COOLING SYSTEM
IRRADIATED FUEL ASSEMBLY
SHIPPING CONTAINER
1-AP-8003-BG FOR PWR CORE I

* FOR KEY TO EQUIPMENT NOTATION.
 SEE PAGES 7 & 8

SCHEMATIC

Key to Equipment Notation

<u>Symbol</u>	<u>Description</u>
E	Diesel Power Unit R. H. Sheppard Company, Inc. Model #8 Capacity - 3 hp, 2 kw, 110 v, 60 cycle, single phase
F-1	Quick Connective Coupling Hansen Manufacturing Company Model #4HK Stainless - two-way shutoff Capacity - 500 psi
F-2	Weatherhead Ermeto Fitting 1/2 in. diameter - pipe to tube Stainless
F-3	Valve Vogt Stainless Steel Gate Valve Capacity - 750 psi
F-4	Gate Valve Crane Company Model #18840
F-5	Air Vent Valve Crane Company Model #976 Seal #14A Capacity - 150 psi
F-6	High Pressure, Two-way Solenoid Valve Special Automatic Switch Company Capacity - 500 psi, 500°F
F-7	Check Valve Crane Company Model #18826 Capacity - 500 psi
I-1	Pressure Indicator Mansfield & Green Model #AH2 Continuous duty clean out type with flushing connection Pressure Range - 0 to 500°F Twin Seal Diaphragm (good for 1,000 psi) Operating Temperature Range - 0 to 500°F

Key to Equipment Notation
(Contd.)

<u>Symbol</u>	<u>Description</u>
I-2	Temperature Indicator Wheelco Instruments Chromel Constantan Thermocouple Range - 0 to 1,000°F
I-3	Dial Thermometer Harris Pump and Supply Company Type 6242RB
I-4	Water Level Gauge Direct Reading Liquidometer Liquidometer Corporation
R	Radiator Nesbitt Propeller Fan Unit Heater Model #18J22 Propeller type hot water unit heater Capacity - 43,000 Btu/hr
S	Surge Tank
P	Centrifugal Pump Eastern Industries Model #3J Capacity - 5 gpm Differential Pressure - 65 psi