DEFUELING CANISTER DESIGNS
FOR THE TMI-2 CORE REMOVAL PROGRAM

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ABSTRACT

The accident at TMI-2 resulted in most of the reactor core being reduced to debris ranging in size from very small fines to partial fuel assemblies. Babcock & Wilcox (B&W) has developed designs for three types of waste packages (canisters) which will be used with different defueling techniques to encapsulate the fuel debris for shipment to and subsequent storage at Idaho National Engineering Laboratory (INEL).

INTRODUCTION

Babcock & Wilcox has developed, under contract to GPU Nuclear Corporation, three canister designs consistent with the different defueling techniques to be used at TMI-2. Compatible with the spent fuel pool environment, these canisters are designed for submerged loading and provide an effective containment for the shipment and storage of the TMI-2 core debris. The canisters will retain and encapsulate debris ranging in size from very small fines (0.5 micron) to partial-length, full cross-section fuel assemblies. Special design features were factored into the canister design to ensure that the canister contents will remain sub-critical under normal and postulated accident conditions at the TMI-2 site, during transport and at INEL.

Generic Canister Design

Three types of canisters were designed to compliment the defueling of the TMI-2 core. Although identical in diameter, length, and lower head design, each canister design contains different internals components in order to be compatible with the various defueling techniques to be used. The three canisters -- fuel, knockout, and filter -- all use a 14 inch outside diameter (OD), 0.250 inch wall, pipe made of 304L stainless steel as the outer shell and a reversed dish made of 0.375 inch thich 304L as the lower head. The upper head is a flat plate closure that is welded to the shell on the filter and knockout canisters and is bolted to the shell via a welded bulkhead on the fuel canister. The thick plate ($\sim$2 inch) upper heads are made of 304L and contain penetrations for dewatering or hydraulic defueling and a recess for interface with the handling grapple. The upper head penetrations are mated with quick-disconnect fittings using National Pipe Thread (NPT) connections and nuclear grade thread sealant. Including a protective skirt at the top of all canisters, the maximum overall length is 150 inches.

All three canister designs use a bottom support plate welded to the inside of the shell just above the lower head to support their internal structure and their payload. This bottom support plate is made of 304L and ranges from 1/2-inch thick on the fuel canister to 1-inch thick on the filter canister and 1-1/4-inch thick on the knockout canister.

Recombiner catalysts are provided to keep any hydrogen and oxygen generated by radiolysis recombining into water. Most free water is removed from the canisters to ensure the efficient operation of the recombiners. The catalysts are in protected pockets that are distributed top and bottom such that a minimum quantity is above the maximum free water level at all canister orientations.

The same basic dewatering system is used to remove the free water in all three types of canisters prior to shipment. Argon gas introduced into the top of the canister drives the free water through an internal drain line and out of the canister. The inlet and exit dewatering fittings are Hansen self-sealing quick-disconnects.

All canisters will have been stamped per the ASME Code, Section VIII, Division 1, prior to loading. This requires 100% radiographic or ultrasonic inspection of pressure boundary welds, a hydrostatic test at 1.5 times the design pressure of 150 psig and Code material requirements.

Fuel Canister

The fuel canister, Fig. 1, is a receptable for large pieces of core debris that can be mechanically placed in the canister. For this reason, the upper closure head is removable to permit easy access for debris loading. An internal square shroud controls the size of the internal cavity and provides a means of encapsulating the neutron absorbing material, Boral™, used for criticality control. The space between the shroud and the inner diameter of the shell is filled with LICON™, a B&W-developed low density, high strength concrete.

The fuel canister, as are all canisters, is loaded underwater. A removable funnel will direct debris into the canister cavity and protect the closure sealing surface from damage. After the cavity volume is filled or the load limit is reached, the funnel is removed and the closure head installed. The closure head has Inconel X-750 O-rings around the loading hole and dewatering drain hole that are held inplate using wire clips and small screws. The closure head is attached to the fuel canister body by eight Inconel 625 bolts.

Impact plates mounted on the bottom support plate and upper closure head cushion any secondary impacts of the loose debris within the canister.

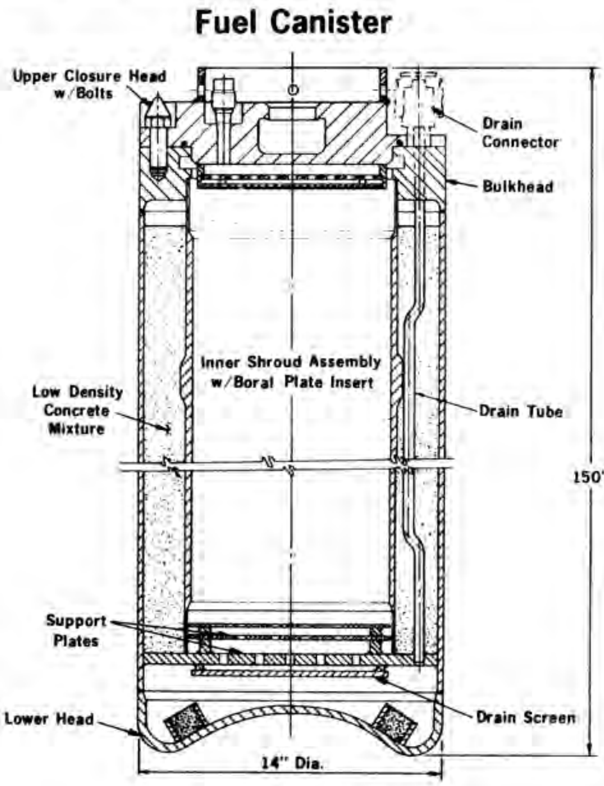

Fig. 1. Fuel Canister

Knockout Canister

Debris ranging up to about 1/2 inch diameter, including whole fuel pellets, will be vacuumed up and routed initially into a knockout canister, Fig. 2. The slurry enters the knockout canister through a 2-inch cam-loc fitting and goes through an inlet pipe to about 2 feet into the canister. The inlet pipe is curved and gives the slurry a radial velocity as it exits into the canister cavity. The water turns and leaves the canister through another 2-inch cam-loc fitting on the upper head. This sudden reduction in velocity and change in flow direction "knocks out" heavier particles from the slurry stream and they settle to the bottom of the canister. A 20 mesh screen at the flow exit prevents particles larger than 840 microns from passing through. When either the load limit is reached or a ΔP limit on the canister inlet/outlet lines is reached, the system will be shutdown. The ΔP limit is usually an indicator that the debris level is close (usually within 12 inches) to the inlet pipe exit and the slurry is kicking up more debris, thereby plugging the screen. The system may be backflushed to clean the screen if further operation is desired. After the knockout canister is filled, the vacuum connections will be removed and plugs will be inserted into the bore of the cam-loc fittings.

The internals structure for the knockout canister is supported from a bottom support plate welded to the outer shell and is positioned by welded chock blocks at the upper support plate. An array of four outer absorber rods around a central absorber rod is located in the canister for criticality control. The four outer rods are 1.315-inch OD, 0.250 wall tubes filled with a neutron absorbing material, vibrapacked B_4C powder. The central absorber rod is comprised of a 2.875-inch OD, 0.312-inch wall strongback tube surrounding a 2.125-inch OD, 0.063-inch wall rod also filled with vibrapacked B_4C powder. Lateral support for the absorber rods and center assembly is provided along their length by seven intermediate support plates that have a nominal 0.125-inch radial clearance to the shell. The plates and strongback tube are made of 304L while the tubes containing the B_4C are made of 316L. The strongback tube is welded to both sides of each intermediate support plate and the upper support plate and to the top side of the bottom support plate. The outer absorber rods have flanges at the bottom end which are captured between the bottom support plate and a seal plate. The outer rods have a nominal 0.061-inch radial clearance to the positioning holes in the intermediate and upper support plates and are not attached to them. The center rod is enclosed by but not attached to the strongback tube or the support plates; it has a nominal 0.125-inch diametral gap and 0.375-inch total axial gap.

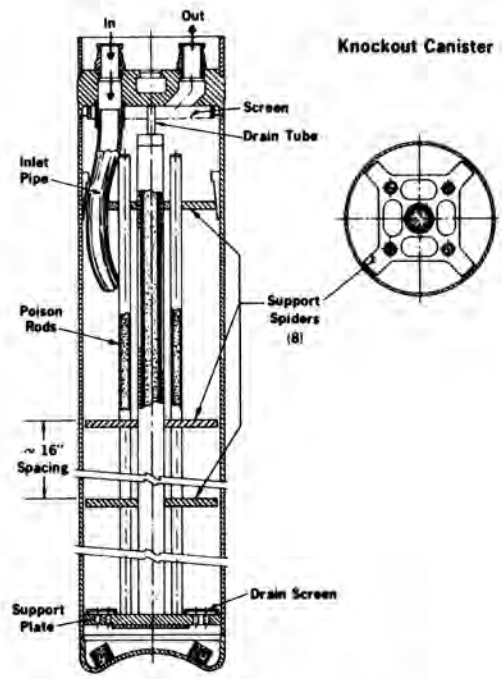

Fig. 2. Knockout Canister

Filter Canister

The filter canister, Fig. 3, is used both as a part of the vacuum system and the Defueling Water Cleanup System (DWCS). In both capacities, the inlet flow will contain primarily small fines.

The slurry from the vacuum system or DWCS enters the filter canister through a 2-1/2 inch cam-loc fitting in the upper head and is dumped into a full diameter mixing chamber ~12 inches long at the top of the canister. It then flows down and around a filter bundle which consists of 17 filter elements, 1 centrally positioned poison rod/strongback tube and 1 drain tube. Each filter element has the 316L sintered filter media (0.5 micron) in corrugated pleats around a perforated core tube which directs the filtered flow down into a sump below the bottom support plate. The flow then goes up the drain tube and out a 2-1/2 inch fitting on the upper head. When the ΔP limit on the canister inlet/outlet lines is reached, the system will be shutdown. After the filter canister is filled, the hose connections will be removed and plugs will be inserted into the bore of the cam-loc fittings.

The filter bundle and payload rest on a bottom support plate welded to the outer shell. The filter bundle is positioned by welded chock blocks at the upper support plate. The center absorber rod (2.125 inch OD, 0.063 inch wall) is filled with vibrapacked B_4C powder and has a flanged bottom end cap which is attached to the underside of the bottom support plate with a fillet weld. It is protected full length by a strongback tube (2.5 inch OD, 0.125 inch wall) which is welded to the upper and lower support plates.

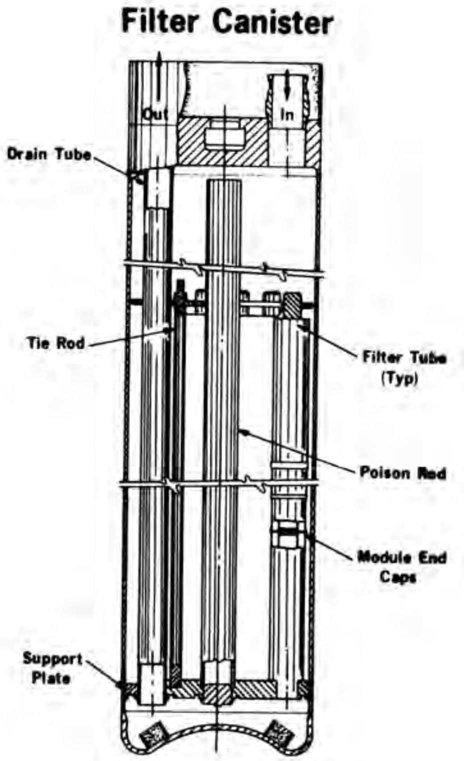

Fig. 3. Filter Canister