R
MASTER

MEMO

NAA-SR-15503

IMPROVED DESIGN FOR FUEL HANDLING

ON

SODIUM GRAPHITE POWER REACTORS

By

T. F. EDZIAK, R. O. CROSGROVE, and J. F. STOLZ

ATOMICS INTERNATIONAL
A Division of North American Aviation, Inc.
Canoga Park, California

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

ABSTRACT

Operational experience at the SRE and evaluation of alternate methods have resulted in the development of an optimized fuel-handling system for the Hallam Nuclear Power Facility Reactor. Increased reliability, easier maintenance, improved safeguards, and broader flexibility are some of the characteristics of this system, which features a manually-operated, shielded cask with reactor atmosphere seals, for use in a conventional unshielded building with an air atmosphere.

INTRODUCTION

The HNPF Reactor (Figure 1) is a sodium-cooled, graphite-moderated reactor with a right cylinder core, including graphite reflector, 17 ft in diameter and 17 ft in height. Helium is used as a cover gas over the sodium pool and a seal is maintained at the top shield. The fuel elements are supported by hanger rods which are suspended from shielded plugs sealed at the top shield. Control rods, temperature measuring devices, sodium level indicators, and source element are contained in thimbles, which are sealed at the top shield and also contain shielding plugs. All core components are loaded through the top shield.

Figure 1. HNPF Reactor

A fuel handling machine is required to replace the spent fuel and other components in the reactor, and to transport them to the wash cells and storage cells, where they will ultimately be loaded into shipping casks for processing and disposal. All of the operations are performed in a controlled atmosphere at the reactor, the wash cells, and storage cells. Shielding is required to protect operating personnel. Before the design was finalized, the following four alternate methods were studied and evaluated:

CASE I. A manually-operated, shielded cask with reactor atmosphere seals for use in a conventional unshielded building with an air atmosphere.

CASE II. A remotely-operated unshielded cask with reactor atmosphere seals for use in a shielded building with an air atmosphere. Normal access to the building for maintenance is possible only when fuel handling is not in progress. Dual drive systems are provided throughout.

CASE III. A manually-operated shielded cask without reactor atmosphere seals for use in a gas-tight building containing an inert atmosphere. A gas lock for equipment and personnel, an air supply for operating personnel, and constant air monitoring are required.

CASE IV. A direct- or remotely-operated building crane with adapters and special grapples for use in a shielded and gas-tight building. A gas lock for personnel and equipment, an air supply for operating personnel, constant air monitoring, and dual drives are required. After the fuel handling, decontamination procedures must be performed prior to any maintenance operations.

A consideration of construction and development costs, a comparison of attendant operational difficulties, and an analysis of SRE fuel-handling experience, much of which was directly applicable to the cask design, led to the choice of Case I.

DESCRIPTION OF FUEL HANDLING SYSTEM

The fuel-handling machine (Figures 2 and 3) consists of a shielded cask, two grapple mechanisms contained in diametrically-opposed, full-length guide tubes, with turntables at top and bottom, capable of 180° rotation, and grapple hoisting. A gas lock and reactor seal, indexing and viewing devices, a movable shield at the bottom of the cask, and a cooling system are provided.

Figure 2. Fuel Handling Machine

Figure 3. Sectional Diagram of Fuel Handling Machine

Crane

The machine is transported by a trolley and gantry crane, which straddles the reactor loading face. The cask is 54 ft high, and the gantry is 26 ft 6 in. long, and has a span of 44 ft; the total weight is 240 tons. The gantry travel speed varies from 1/4 ft/min to 100 ft/min. The trolley wheel base is 14 ft 6 in., has a maximum travel of 20 ft 6 in., and has a variable speed of 1/4 to 30 ft/min. The machine will handle a component 6-1/2 in. in diameter, 40 ft in length, and weighing 1000 lbs.

Grapples

There are two grapples, each suspended between two continuous roller chains. The grapples operate in individual guide tubes, both of which extend the full length of the machine and are diametrically opposed. The tubes are continuous, except for two lengthwise slots, and are suspended from the top turntable attached to the rotating cask top and stabilized by a bearing-supported bottom turntable. A bar supporting the grapples passes through the slots and is attached to the two chains outside of each guide tube. Sprockets at the top and bottom turntables drive the chains in either vertical direction. The grapples are provided with fingers which are operated by a internal piston contained in the grapple center body and pressurized with helium. Air cylinders at the bottom of the cask are also provided for alternate grapple actuation.

Drives

Two drives, one for each grapple, are located on the rotating top of the machine (Figure 4). The complete drive mechanism is outside the machine. The drive shafts for the grapple sprockets pierce the cask wall and are provided with seals. A variable-speed electric motor equipped with a brake supplies the power through a slip clutch, gear box, and torque load cell for each grapple. The hoist lifts at a speed of 0.8 to 16 ft/min. The guide tube assembly rotates 180° in 30 seconds. A hand crank may be attached to the input side of the gear box for manual operation. A limit switch assembly and a selsyn with a counter, which is driven from the output side of the gear box, indicates the grapple position on the control panel. A mechanically-driven counter at the hoist mechanism is also provided as a check and for adjustment purposes. The torque load cell indicates

Figure 4. Diagram of Top of Fuel Handling Machine

Figure 5. Top of Fuel Handling Machine

the load on the grapples. The rotating top of the machine rests on a thrust bearing and is sealed to the upper body by a Wilson seal. All wiring, switches, drives, and critical components are located outside the machine for easier maintenance.

Lower Body

The bottom of the machine (Figure 6) contains three television cameras: one for viewing objects being handled, one for indexing, and one spare in the indexing position. Indexing is accomplished with the downward-facing camera. A photoelectric cell at the gas lock indicates presence or absence of components on the grapple. The gas lock sleeve, which is normally carried about 6 in. above the floor, is driven down by a hydraulic cylinder onto an indexing ring to make the reactor seal. The indexing ring is previously positioned and sealed to the reactor face. The drip pan valve, which is operated by an air cylinder, seals the gas lock, providing total containment while transporting. A vacuum pump and a helium supply are provided for gas lock and cask atmosphere control.

Figure 6. Bottom of Fuel Handling Machine

Shielding

The movable shield (Figure 7) provides shielding when an element is entering or leaving the machine. The shielding, which consists of lead shot between concentric cylinders, varies from 3 in. in thickness at the top, to 17-1/2

in. at the bottom. It is raised and lowered by four hydraulic cylinders with the required flow control valves for protection against free fall. While the machine is transporting, the movable shield is locked in the "up" position by manually-inserted pins.

Figure 7. Fuel Handling Shield

Cooling

The helium blower (Figure 8) is located outside the machine body, but inside the movable shield, and has a nozzle protruding into the machine in line with either of the guide tubes. After a fuel element has been raised into the machine and rotated 180° from the pick-up position, it is lowered into the blower nozzle. The helium within the cask is blown upward through the fuel element, and transfers the heat to the internal wall cooling coils. Circulating water and a finned heat exchanger dissipate the heat to the atmosphere.

In order to prevent operational errors, interlocks are provided on all drives, electrical or hydraulic, and on all critical grapple positions.

Figure 8. Diagram of Bottom Fuel Handling Machine

SAFEGUARDS

Advantage has been taken of recent fuel-handling experience with the SRE to further increase the reliability and safety of the HNPF fuel-handling machine. The external installation of all critical drive components, and the use of full-length guide tubes, prevents damage by hang-up and entanglement on the removal mechanisms. Wiring, switches, critical drives, and components are not exposed to reactor atmosphere and corrosion, and entanglements are eliminated. Television camera indexing has proven superior to contact indexing, which required constant adjustment because of impact, and observation of the component while entering the cask provides confidence during operation. The cooling system provides insurance against excessive fuel element temperatures in the event that the element must be kept in the cask indefinitely. Containment during fuel transfer and transport is achieved by sealing grapples, a drip pan valve, and upper drive seals. Since the machine has its own gantry and trolley, it is independent of the building crane operations.

Maintenance and inspection have been improved by the external location of wiring, switches, and drives, and the movable shield permits inspection and maintenance of the mechanisms at the bottom of the cask. The internals can be removed as a unit for overhaul and decontamination.

Shielding has been simplified and streaming is reduced by the use of lead shot over lead pours and machined slabs.

PRESENT STATUS

The fuel handling system is presently undergoing tests at the Fuel Handling Test Facility at Santa Susana, California. Upon completion of testing and after incorporation of any resulting developmental improvements, the machine will be shipped to the HNPF site for installation.