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EQUIPMENT FOR REMOVAL OF THE TMI-2 PLENUM ASSEMBLY

M. W. Ales
J. D. Connell
R. V. DeMars
D. A. Nitti

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Babcock & Wilcox
Utility Power Generation Division
Lynchburg, Virginia 24505

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ABSTRACT

The abnormal condition of the TMI-2 reactor requires unique equipment and methods to remove the plenum assembly from the reactor vessel. Detailed inspections of the reactor internals have been planned to assess existing conditions and confirm the proposed plans as of April 1, 1984 for removing the damaged plenum assembly in one piece.

Preliminary examinations have shown that the plenum assembly is distorted and possibly might bind against the reactor vessel and core support shield as it is lifted. Further, fuel assembly components are stuck to the bottom of the plenum assembly and particulate fuel debris is deposited in the plenum assembly. These conditions require special equipment to free the plenum assembly from the reactor internals, to dislodge suspended fuel assembly remnants and to lift, transfer, and store the plenum assembly in the shallow end of the refueling canal.

The special equipment to remove the plenum assembly is being designed and built. This equipment includes an integrated video/communication inspection system; a hydraulic jack system with a 240-ton capacity; specially designed tools to dislodge the end fuel assembly fittings from the plenum assembly; a portable work platform; and final lifting equipment and a transfer contamination barrier that will be used in conjunction with the polar crane to lift and transfer the plenum assembly. Test assemblies necessary to check out the performance of equipment and train personnel are also being provided.

SUMMARY

The severe overheating during the March 28, 1979 TMI-2 accident caused local distortion within the plenum assembly and gross deterioration of the upper region of the core. The resulting abnormal condition of the reactor requires unique tooling and methods to remove the plenum assembly in one piece from the reactor vessel and place it in the shallow end of the refueling canal. The special equipment for removing the plenum assembly is being designed and built by Babcock & Wilcox. This equipment includes an integrated video/measurement inspection system; a hydraulic jack system with a 240-ton capacity; tools to dislodge fuel assembly end fittings from the plenum assembly; a portable work platform; and final lifting equipment that includes a transfer contamination barrier. Test assemblies, necessary to checkout the performance of equipment and train personnel, are also provided.

The program to develop this equipment was initiated in early 1983, following issuance of a Technical Specification by GPU Nuclear's Design Engineering and placement of an order with Babcock & Wilcox for the design and fabrication of the equipment. As of April 1, 1984 much of the equipment had been designed and was in the process of being either purchased or fabricated.

The special equipment needed for removing the plenum assembly is predicated on the assumptions listed below.

1. The plenum assembly is to be removed in one piece.
2. The reactor vessel head has been removed and the internals' indexing fixture (IIF) has been fastened to the reactor vessel flange.
3. The IIF has been flooded with five feet of water shielding.
4. The work platform has been mounted on the IIF.

5. The canal will remain dry during inspection, cleaning, and initial lift of the plenum assembly to allow work to be done from the IIF work platform.
6. To faciliate radiation protection during the transfer of the plenum assembly, the canal will be flooded just before the plenum assembly is lifted out of the reactor vessel with the polar crane.
7. The polar crane will be rigged to the plenum after the initial lift and will be used to remove the plenum from the reactor vessel (through the indexing fixture) and transfer it to the shallow end of the canal.

An inspection plan has been defined that will examine locations and components that (a) will interface with tooling, (b) are points of potential binding that would make lifting the plenum assembly difficult, (c) may unexpectedly separate during lifting, and (d) may require cleaning.

The planned inspection will be done using specially designed long-handled tools and a state-of-the-art video system. Long-handled tools are being fabricated to position video cameras and to measure critical features. The video system consists of three 1.6 in.-diameter Rees R-93 and two 2.88 in.-diameter Diamond ST-5 video cameras and associated lighting, controls, monitors, and recorders. An in-containment system allows the operator to control and monitor the equipment. A supplement video system is located in the command center for monitoring and recording activities.

Since the plenum assembly is distorted and binding can occur, a 240-ton, four hydraulic jack system has been designed to provide a controlled nine inch initial lift of the plenum assembly. Each jack contains a mechanical follower to support the plenum assembly during non-lifting periods. The actual lifting operation will be conducted by personnel located at the 347 ft elevation deck where a control station cabinet will be provided to allow one individual to monitor displacement and load readings for each jack while supervising the operators of the four independent hydraulic hand pumps.

Fuel assembly end fittings and other debris suspended from the bottom of the plenum assembly are planned to be removed. This action will minimize the transfer of radioactive material out of the reactor into the refueling canal and will avoid possible interference from protruding material during movement of the plenum assembly. Special, manually activated, slide hammer-type impact tools have been designed to dislodge the suspended end fittings.

The polar crane, tripod, and lifting pendants will be used to lift the plenum assembly out of the vessel to a storage stand in the shallow end of the refueling canal. The canal will be flooded to act as shielding against radiation from the contaminated plenum assembly. New longer, lifting pendants and new latching devices are being designed to replace the existing lifting pendants. Two of these pendants will include controlled load positioners to aid in aligning and leveling the plenum assembly. A flexible plastic container, supported on a tubular truss frame, is being designed as a transfer contamination barrier to maintain separation of the clean canal water and the contaminated plenum assembly and the reactor water. A new storage stand is being provided to support the enclosed plenum assembly. A channel-supported, thin steel plate structure is being designed as a semi-permanent internals indexing fixture (IIF) cover to prevent long-term mixing of the canal and reactor waters.

A portable work platform has been designed with safety railing to help protect personnel working on the IIF platform when any one of the floor plates is removed.

Four test assemblies are being designed for use in equipment performance checkout and personnel training. These consist of:

1. An interface test assembly that is a full-scale simulation of a section of the TMI-2 plenum assembly, core support cylinder, and internals indexing fixtures.
2. A jack qualification fixture that will be used to load test individual jack assemblies.
3. A jack system test assembly that will be used to evaluate the performance of the entire jack system.
4. A final lift, transfer, and storage test assembly that will be used to verify the operability of the final lift and transfer equipment.

The equipment for removing the TMI-2 plenum assembly is being developed and will be delivered to the site on a schedule compatible with other TMI-2 disassembly and defueling activities.

ACKNOWLEDGMENTS

The equipment designs described herein are the results of the creative efforts of many individuals at General Public Utilities Nuclear Corporation and Babcock & Wilcox. The authors gratefully acknowledge all of these contributions to the plenum assembly removal program. In particular, the technical and administrative efforts of R. L. Rider and the GPU Nuclear Design Engineering staff are recognized and appreciated. The support given to this program by the staff of EGG Idaho assigned to the TMI-2 recovery effort is also gratefully acknowledged. The word processing support provided by L. B. Laughlin and the art work provided by R. H. Rhodes are also greatly appreciated.

INTRODUCTION

The plenum assembly in Three Mile Island Unit 2 (TMI-2) was subjected to severe overheating during the accident on March 28, 1979. Some parts of the 55 ton plenum assembly became hot enough to experience localized melting. In other parts of this 13 ft 11 in. diameter by 12 ft 6 in. high stainless steel structure, the thermal expansions far exceeded the design clearances, thus causing high loads and distortions. Such distortions can cause binding since both the plenum assembly, and core support shield assembly (see Figure 1) were machined to close tolerances and keyed to the reactor vessel to assure proper alignment of fuel and control rod assemblies. Because of this potential for binding, special equipment will be used to free the plenum assembly from the core support shield.

The accident transient also caused severe damage to the fuel assemblies in the reactor core, which in turn, caused large quantities of highly radioactive fuel debris to be circulated throughout the reactor coolant system. As a result, the plenum assembly has a thin, highly radioactive adherent coating in addition to light deposits of fine fuel debris. The accident transient also caused the upper portion of many fuel assemblies to become stuck to and suspended from the bottom of the plenum assembly. Another potential consequence of the accident is the degradation of the structural integrity of key bolted joints. The high preload stress normally applied to bolts combined with the high temperatures created by the accident may have caused bolt failure. Also, the exposure of the highly stressed bolts to the chemical impurities present in the reactor coolant since the accident may have led to stress corrosion cracking of the bolts. The integrity of the lifting lug bolts is of particular concern because the failure of these bolts, should they be used to lift the plenum assembly out of the reactor vessel could result in dropping the assembly. All of these accident effects combine to significantly complicate removing the plenum assembly because they necessitate: (a) inspections for clearance, distortion, and

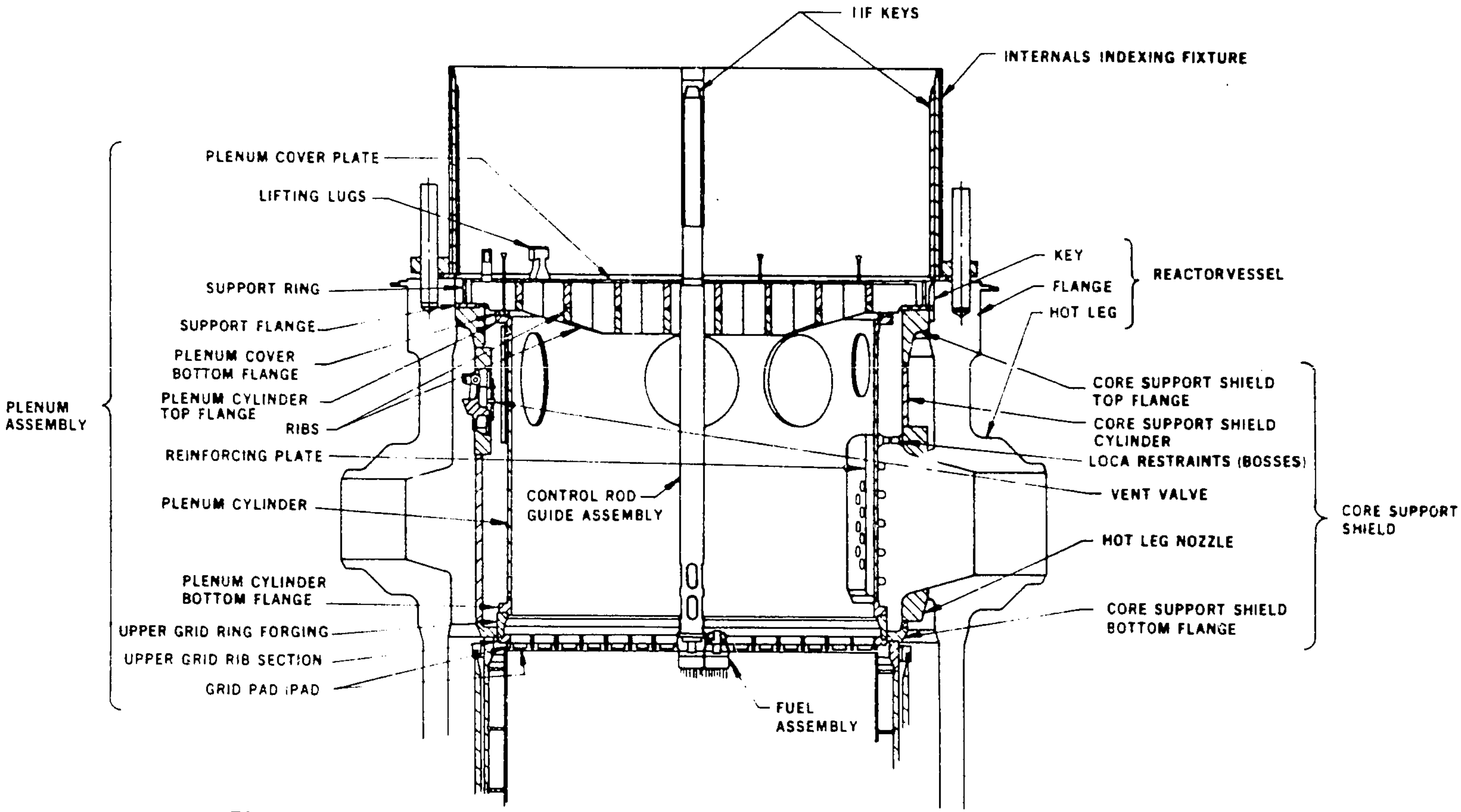

Figure 1. Cross-sectional view of plenum assembly and adjacent reactor components, including nomenclature

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damage; (b) special high-capacity lifting capability to overcome potential binding between the plenum assembly and the core support shield; (c) water and lead shielding to avoid excessive radiation exposure to personnel; (d) alternate lifting pendants to reach the plenum assembly through the water shielding in the refueling canal and to attach to a structurally sound portion of the plenum assembly; and (e) contamination control barriers to prevent the uncontrolled spread of radioactive debris.

This report summarizes the status, as of April 1984, of the design and development of the special equipment to remove the plenum assembly from the reactor vessel at TMI-2.

Background on the Plenum Assembly Removal Task

Removing the fuel debris from the reactor vessel is essential to the long-term safety and stability of the TMI-2 plant; thus, the TMI-2 Reactor Dissassembly and Defueling Program was organized to plan and accomplish the defueling operations. Key tasks of this program are:

1. Removing the reactor vessel head;
2. Removing the plenum assembly;
3. Defueling the core region;
4. Cleaning and removing the remainder of the reactor internals (the core support shield assembly);
5. Removing the fuel debris from the bottom of the reactor vessel and the other components of the reactor coolant system; and
6. Packaging and shipping the fuel debris to a disposal site.

The reactor vessel head must be removed to gain access to the plenum assembly. Removing the plenum assembly will provide free access to the core region so that the fuel debris can be removed effectively. Planning for removing the plenum assembly began in 1980 when Bechtel North American Power Corporation (BNAPC), acting as the agent for General Public Utilities Service Corporation, requested that Babcock & Wilcox (B&W) prepare a technical plan for removing the plenum assembly. The plan was initially issued in November 1980; it was revised and re-issued in July 1981. A "Plenum/Fuel Removal Preliminary Design Study" (PDS) was then performed by General Public Utilities Nuclear Corporation (GPU Nuclear). Based on the PDS and information from the TMI-2 Quick Look and Quick Scan video inspections inside the reactor vessel, B&W prepared and issued a Planning Study for Plenum Assembly Removal in January 1983. This study considered both removing the plenum assembly as an intact structure and destructively dissassembling it. Subsequent evaluations showed that relative to the "intact" approach the destructive approach would take approximately 50 to 100% longer and would be approximately 50% more costly in both dollars and man-rem exposure. Based on this extensive planning, (in early 1983) GPU Nuclear's Design Engineering group prepared and issued a Technical Specification for the plenum assembly removal system and B&W was contracted to develop the special equipment needed to inspect and non-destructively remove the plenum assembly from the reactor vessel.

In accordance with the requirements of the Technical Specification, B&W is designing and developing the special equipment in three phases -- preliminary design, detailed design, and fabrication and checkout. GPU Nuclear has primary responsibility for the fourth phase, relating to the site operation of the equipment.

The special equipment needed for removing the plenum assembly is predicated on the assumptions listed below.

1. The plenum assembly is to be removed in one piece.
2. The reactor vessel head has been removed and the internals' indexing fixture (IIF) has been fastened to the reactor vessel flange.
3. The IIF has been flooded with five feet of water shielding.
4. The work platform has been mounted on the IIF.
5. The canal will remain dry during inspection, cleaning, and initial lift of the plenum assembly to allow work to be done from the IIF work platform. (A backup approach involves performing work from the refueling bridges should the radiation levels be excessive.)
6. The canal will be flooded just before the plenum assembly is lifted out of the reactor vessel with the polar crane to facilitate radiation protection during the transfer of the plenum assembly.
7. The polar crane will be rigged to the plenum after the initial lift and will be used to remove the plenum from the reactor vessel (through the IIF) and transfer it to the shallow end of the canal.

The sequence of events considered in the planning of the special equipment needed for plenum assembly removal is:

1. Inspecting the plenum assembly for deformation, damage, and debris;
2. Initial lifting of the plenum assembly using jacks;
3. Separating fuel assemblies and fuel assembly end fittings from the upper grid plate, which is on the bottom of the plenum assembly (see Figure 1);
4. Removing the IIF work platform;
5. Final lifting and transferring of the plenum assembly using a transfer contamination barrier;
6. Installing a semi-permanent cover on the IIF.

To help synchronize the schedules for equipment development and planned use, the special equipment to remove the plenum assembly has been organized into the following equipment groups:

1. Inspection Equipment -- includes both the inspection tools and the video support system.
2. Initial Lift System -- includes the jacking system to separate the plenum assembly from the core support shield and the monitoring equipment to support the jacking operation.
3. End Fitting Separation and Cleaning Tools -- includes the end fitting separation tools and the tools for localized cleaning.
4. Final LIft, Transfer, and Storage Equipment -- includes the equipment that will be used to attach the PA to the crane rigging, the transfer contamination barrier, the PA storage stand, and the semi-permanent IIF cover.
5. Portable Work Platform -- includes only the portable work platform that will be used on top of the IIF work platform to provide personnel protection and support.

6. Test Assemblies -- includes the assemblies that will be used to test the special equipment and will be available for training the personnel who will be removing the plenum assembly. Specifically, these assemblies are: (a) the interface test assembly that will be used to assure the accessibility to the required parts of the reactor internals; (b) the jack qualification fixture that will be used to load test individual jacks; (c) the jack system test assembly that will be used to test the function and control of the four jack system, (d) the final lift and transfer test assembly that will be used to test the deployment and function of the contamination barrier.

Each of the six subsequent sections of this report will be devoted to describing the design and development activities of each of these equipment groups. This is an interim report which summarizes the current state of the design and development of this special equipment. Another report will be prepared after fabrication and checkout of the special equipment to document the changes that were made in the requirements and design features based on new information that became available as the TMI-2 defueling activities proceeded.

INSPECTION EQUIPMENT

Introduction

The plenum assembly and interfacing reactor internal components of TMI-2 must be inspected to assess the existing conditions within the reactor vessel and verify the method for removing the plenum assembly. These examinations must be performed remotely and therefore require the integration of two equipment systems: a cadre of specialized long-handled inspection tooling, and a state-of-the-art video system, which together can be used to examine, and thus assess, select areas of the reactor internals. As of April 1, 1984, this equipment was being procured and assembled. The following sections describe the areas to be inspected, the inspection tooling, and the supporting video system.

Inspection Plan

A study was made to define the inspections necessary to support removing the plenum assembly. The locations of and components for inspection have been identified as those that: (a) will interface with tooling, (b) are points of potential binding that would make lifting the plenum assembly difficult, (c) may unexpectedly separate during lifting, and (d) may require cleaning. Additional inspections may be made should they be envisioned as leading to fewer subsequent activities and less associated man-rem exposure. Visual observations or measurements are planned for three areas: the plenum cover, the core support shield (CSS) to plenum assembly (PA) annulus, and the plenum assembly interior/bottom.

Plenum Cover

The top surface of the plenum cover assembly, the keys and keyways, and the lifting jack locations will all be video-scanned. The general character (i.e., size, quantity, distribution) of accumulated debris will be observed to determine if cleaning will be required.

CSS to PA Annulus

Measurements and observations will be made within the CSS to PA annulus. The LOCA restraint boss gaps will be measured to assess structural distortion and evaluate misalignment and potential interferences. The bottom of the annulus will be video-scanned to view the existing debris conditions. Further, the depth of debris will be measured to determine if the debris will hinder subsequent operations. The vent valves will also be visually inspected to detect any structural anomalies that may cause interference with LOCA bosses during the plenum lift.

Plenum Assembly Interior/Bottom

Several areas within the plenum cylinder and control rod guide assemblies (CRGAs) will be examined. The upper grid ring and control rod guide assembly bolted joints will be visually inspected at several locations in the area of the hot legs to confirm the structural integrity of the plenum assembly. In addition, the force required to move the axial power shaping rods will be measured to decide whether they should be removed or left in place. The lower portion of the plenum assembly will also be examined from inside both the plenum cylinder and the core cavity; these examinations will indicate the extent of foreign material (fuel assembly end fittings, fuel debris) that may need to be removed during subsequent operations.

Inspection Tooling Description

The planned inspections will be performed remotely by workers operating from both the platform situated on the internals' indexing fixture (IIF) just above the reactor and from the modified auxiliary refueling bridge that is at a higher elevation. The tools can be operated from either location depending on operator efficiency and the expected man-rem exposure.

Video cameras and tool ends will be positioned for inspection using special long-handled manipulators. Most of these tool arrangements will be connected to an overhead crane through a load counter balancer. This arrangement will give the operator freedom to properly position the tool without having the added burden of supporting the 70 to 120 pound tool(s).

All inspection tooling consists of a tool handle and a tool end. All tool handles and tool ends are interchangeable with one another except for the APSRA depth-gauge/handling tool, which is a special design due to its load requirements. Two sets of tool handles are provided: one set is sized to work from the refueling bridge; the other set, to work from the IIF work platform.

Additional equipment is provided to support inspection tool operation. This equipment consists of a dynamometer, a gauge-sighting device, temporary tool racks, a permanent tool storage rack, and tool strong-back for upending the long, horizontally assembled tools.

Camera Manipulators

There are two ways to position the cameras used in the inspection activities. They can be manipulated with either a camera cable and draw wire or a camera-handling tool assembly with the type of positioning dictated by specific viewing requirements.

The cable design consists of the camera cable and a draw wire. The camera is free-hanging from its cable with the draw wire attached to the camera. This design allows the camera to be positioned in areas unaccessible by a pole. However, proper placement of this flexible arrangement will depend on the operator's skill in manipulating the cables and in interpreting the visual feedback from the camera as it is being positioned.

The camera handling tool assembly consists of a camera handling tool end, camera winch assembly, camera cable, Rees R-93 camera, and a tool handle. With this setup, the operator can remotely position the camera in predefined locations without heavily depending on visual feedback from the camera. The twenty foot-long camera handling tool end is 1 3/4 in. OD x 1/8 in. wall stainless steel tube with a pivoting camera clamp welded to the bottom end of the tube. A bottom plug is welded to the top of the tube for coupling with the tool handle.

The tool handle assembly is a 2 in. square x 1/8 in. wall aluminum tube, with a removal hoist ring attached to the top end of the handle. Cutouts are provided in the top handle for routing the camera cable and camera draw wire. The smaller cutout has a pulley assembly welded across its opening for operating the camera draw wire. Two rings are welded at specific locations on the handle for mounting the handle in a tool storage rack.

Measurement Tools

Rigid, long-handled tools are used to perform inspections requiring direct measurements to assess plenum assembly distortion. All tools are designed to work within given physical constraints and provide the appropriate accuracy.

The LOCA boss gap measurement tool assembly consists of a tool handle (previously described), tool end, gap measurement device, camera cable, and Rees R-93 camera with a fixed right angle lens. The tool end consists of a 14 ft section of 1 3/4 in. OD x 1/8 in. wall stainless steel tubing with a 1 3/4 in. bend to offset the end of the tube and properly align the camera lens with the LOCA boss gaps. A non-pivoting camera clamp is welded to the lower portion of the tube, and a bottom plug is welded to the top portion of the tube for coupling to the tool handle. The gap measurement device consists of a scale welded to a special clamp designed to position the scale in front of the Rees camera right angle lens. With the scale and LOCA restraint gaps both in the field of view, the gaps can be measured to within an accuracy of ±1/32 in.

The fuel assembly end fitting probe assembly consists of a tool handle, tool end, and slide hammer. The tool handle is the same as that described above. The tool end comprises a 16 ft section of 1 1/4 in. OD x 0.188 in. wall stainless steel tube. A nine inch stainless steel tip is fitted and welded to one end of the tube. A bottom plug fits on the outside diameter of the other end and is welded in place. The bottom plug is square on the outside for coupling into the tool handle. The slide hammer assembly consists of a stainless steel hammer, a stainless steel hammer slide, cap, socket, and hoist ring. The hammer weighs approximately three pounds and has four inches of travel on the hammer slide. This slide hammer assembly mounts in place of the hoist ring on the tool handle.

The APSRA depth gauge/handling tool consists of a tool handle, extension, tool end pole, modified APSRA male coupling, and slide hammer assembly. The tool handle is a 1 1/2 in. OD x 0.188 in. wall stainless steel tube. Two 1 1/8 in. OD x 0.188 wall stainless steel tube sections are pinned and welded to each end of the tool handle for coupling with the slide hammer assembly and the extension piece or tool end pole. A modified APSRA male coupling is fitted to the tool end pole and is pinned and welded in place. The slide hammer assembly is mounted to the top of the tool handle and is held in place with a positive locking pin. The slide hammer assembly is the same as that described above.

The debris probe tool assembly consists of a tool handle and a debris probe tool end. The tool end (debris probe) comprises a 16-foot section of stainless steel rod (debris rod), one end of which is bored out to accommodate a stainless steel point which is welded in place. The other end of the debris rod fits into a bottom plug and is welded in place. The bottom plug is square on the outside to couple to the tool handle.

There are several auxiliary pieces of equipment in addition to these long-handled tools. A gauge-sighting device, which consists of a rail clamp with a leveling/sighting device welded to it, is used with the APSRA depth gauge to obtain readings accurate to within ±1/16 inch. A temporary tool rack consisting of two support legs, a rack, latch, and guide plate is designed to mount to standard round-hand rails and hold up to two inspection tools. A permanent tool storage rack assembly, comprising a rack and six latches, is designed to hold up to six inspection tools. An 8000 pound capacity Dillon dynamameter is used with the APSRA depth gauge/handling tool to control the amount of force applied during attempts to lift a stuck APSRA. A tool strongback assembly consisting of two sections of 5 x 5 x 1/2 in. aluminum angle spliced together is used to up-end the long-handled tools after they are assembled horizontally in the reactor building.

Video System

The video system designed for TMI-2 has two basic parts -- the in-containment equipment portion and the command center equipment. The in-containment system primarily acquires the information and provides immediate monitoring and control of the video equipment by the operator manipulating the tools. The command center provides control for monitoring and recording operations from outside the reactor building.

Although the video system was developed specifically for plenum assembly removal activities, general provisions have been incorporated into its design in anticipation of their use in subsequent reactor recovery operations. Several sets of selection criteria were used in choosing the video cameras and supporting equipment. Initially, specifications relating to the technical aspects of the cameras were written and camera designs from various manufacturers were compared with the specifications. The specifications dealt with such areas as sensitivity, shades of gray definition, resolution, scan linearity, and signal-to-noise ratio. Those units meeting the specifications were subjected to proof tests to ascertain the adequacy of their performance in reactor vessel environments. Both the cameras and potential auxiliary lighting units were tested underwater for their abilities to view prototypical hardware in turbid water. Turbidity ranged from clear to virtually opaque when viewed from outside the container with the naked eye. The camera units found satisfactory after this proof testing were compared with one another on the basis of past experience with the manufacturer and availability of peripheral equipment and controls.

In-Containment System

The in-containment initial inspection equipment comprises three cabinets to house the in-containment video systems -- two to hold the camera controls and associated electronic equipment, and another to store the cameras and cables when not in use. (There is also a portable rack with three, six-inch video monitors should the stationary system not be within easy access of the operators.)

The two control cabinets are each 22 x 47 x 22 in. (w x h x d) and will hold all camera controls, light controls, monitors, and the audio base repeater unit (Figure 2). The entire system comprises five cameras/control units; eight lights, some with reflectors; six nine-inch monitors; and one audio base repeater station. The camera system has three Rees R-93 units and two Diamond ST-5 units. These cameras are all completely sealed, stainless steel housed underwater units.

The Rees units are smaller (1.6 in. in diameter) than the Diamond cameras (2.88 in. in diameter) and will be used in instances that make it necessary to place the cameras in very space-restricted areas, i.e.,

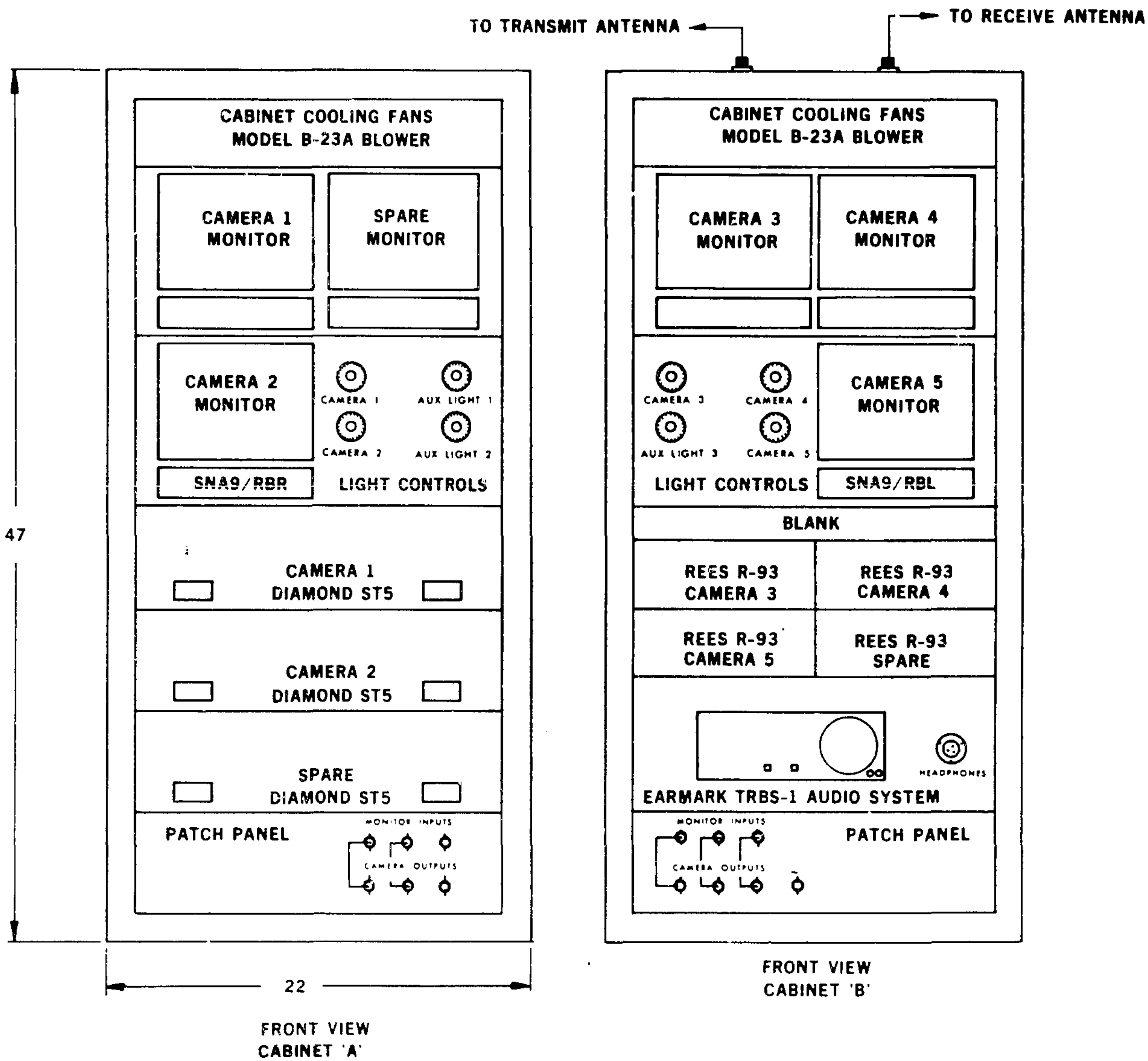

Figure 2. In-containment video control and monitor cabinet arrangement.

through the control rod guide assemblies or through the narrow annular space between the plenum cover and the core support shield (see Figure 1 for nomenclature). Both types of units have focus and iris controls and are capable of either straight or right-angle viewing. All five cameras have integral lighting, although auxiliary lighting is also provided.

The control cabinets also contain spare Diamond and Rees camera controls, should a unit unexpectedly fail. Each of the five camera controls feed a Conrac SNA nine inch monitor and automatically assigns a permanent camera identifying number. The sixth monitor is a spare. The output signals to the command center will come directly from the six video monitors.

The lighting portion of the in-containment system provide for up to eight lights with individually controlled intensity. Three of the lights will be standard Hydro Products SQ-500 units; five will be modified lights that will illuminate areas with access of less than 2.3 in. in diameter. These modified lights will be provided with a reflector that will limit the light beam to a 180° pattern.

The audio communications between the camera/tooling operators and the command center will be handled by the Earmark Duplex Portable Base Repeater Station. This unit will receive the RF signal from the operators' mikes via the antennas on top of one of the cabinets and transfer it to the command center through two, twisted-shielded pairs. Should the control consoles not be near the tool operators, a rack with three, six inch monitors can be attached to the hand rails of the modified auxiliary refueling bridge or the portable work platform. This monitor rack, though more portable than the large control cabinets, has no controls for the video cameras or lights. It provides a repeat of selected images monitored at the control cabinets and is provided to aid the tool operator manipulate tools.

Provisions for in-building storage and decontamination are provided by a stainless steel equipment locker with storage space for all camera cables, camera light cables, and lights. The storage cabinet is approximately 72 x 48 x 18 in. (w x h x d).

Command Center System

The command center system consists of a desk top console with three side-by-side racks each 22 x 28 x 22 in. (w x h x d). The console contains a direct viewing monitor, camera signal distribution amplifiers, camera signal identifiers, and two video cassette recorders (VCRs) with record/playback monitors that can be switched to view camera signals with picture identification information. The system includes all camera selection switchers for each monitor and VCR. (Figure 3).

The system can accommodate four camera signals, each feeding a distribution amplifier module which in turn feeds both the switcher of the live monitor and the video identifier/switcher combination. Also coming from these video distribution amplifiers will be two spare, unidentified, high-resolution signals available for display on other monitors. The identifier/switcher will add a time/date/camera number and a 16-character message to the video signal. The outputs of the switcher/identifier will be fed to four additional distribution amplifier modules. These modules will, in turn, feed a six-position switcher for each of the two nine inch monitors and a four-position switcher for each of the two VCRs. The VCRs will feed one position on the six position switchers for record/playback viewing on the nine inch monitors. There will be two video outputs available from the switcher/identifier for display on other monitors.

One viewing monitor, the Conrac SNA-17, will be switchable to any of four camera input signals. This monitor will have a direct input from the amplified high-resolution signal of the camera that will be unaffected by high-frequency roll-off in either the video identifiers or the video recorders and thus will provide the highest quality picture. Picture identification will be provided by the lighted number displayed on the switcher of this monitor.

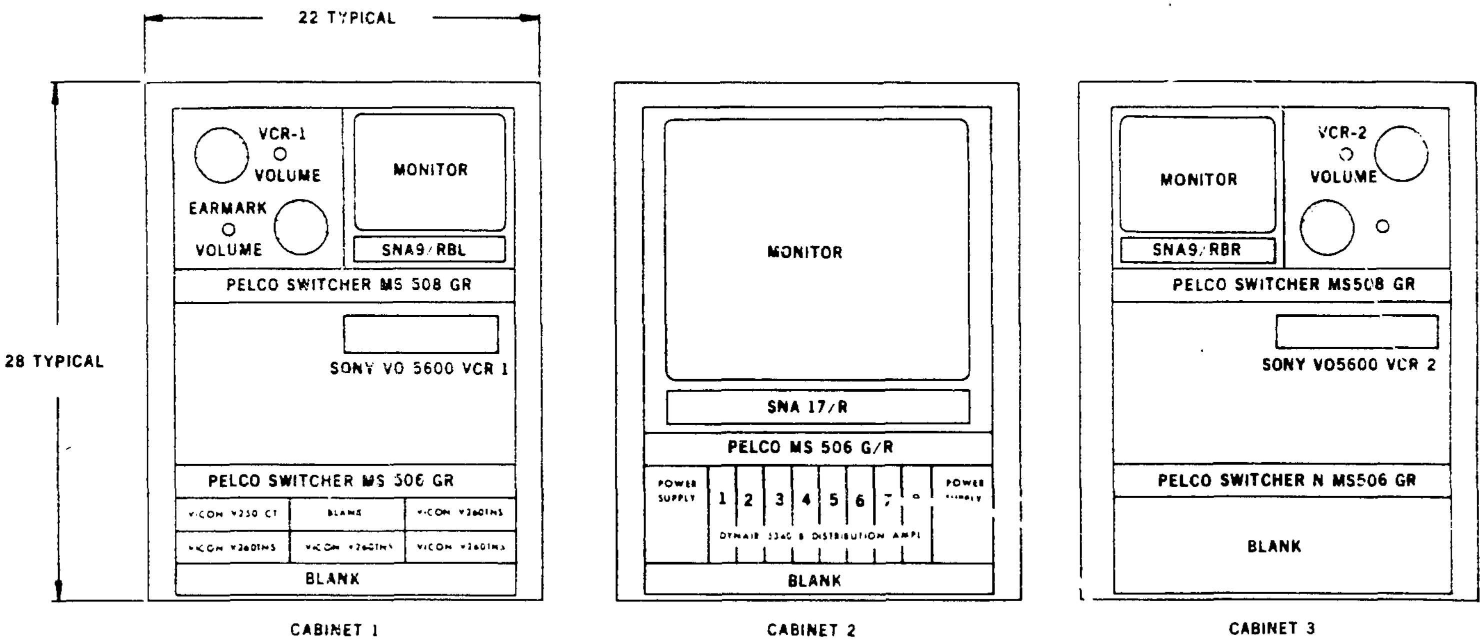

Figure 3. Command center video monitor cabinent arrangement.

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INITIAL LIFTING EQUIPMENT

Introduction

Ordinarily, the polar crane is used to remove a plenum assembly from normal reactors. However, the severe conditions resulting from the accident at TMI-2 have caused the plenum assembly to be distorted, which in turn, has restricted the way in which the assembly can be lifted (e.g., the clearances provided for free movement may be closed, causing the plenum assembly to be bound in the core support shield). To provide a controlled lift under such conditions, a high-lift capacity jack system has been designed to lift of the plenum assembly the first nine inches from the core support shield.

Before the jack system was designed, studies were conducted to determine the optimum number, arrangement, size, and type of jacks. These studies concluded that:

1. Four jacks could be installed at each of the "W", "X", "Y", and "Z" axes of the plenum cover.

2. Up to 60-ton standard hydraulic jack cylinders could be incorporated into a jack assembly that could be installed and operated in the available space between the plenum assembly and the core support shield.

3. The 240 ton combined lift capacity of the four jack assemblies, at more than four times the design weight of the plenum assembly, should be adequate. If the plenum assembly cannot be freed with a 240 ton vertical force, means other than increased lift force, such as high energy impactors, would be required to supplement the jacks.

As of April 1, 1984, the final design of the jack system had been completed and procurement activities initiated.

Description

Lifting Jack System

The lifting jack system comprises four lifting jack assemblies installed on the plenum assembly and a control station located at the south end of the refueling canal on the 347 ft elevation of the reactor building. Hydraulic, air, and electrical lines connect the jacks to the control station. The video system, described previously, is used to assist the operators in installing the jacks and monitoring select areas of the plenum assembly while it is being lifted. Installation tools and miscellaneous cable and camera mounting equipment round out the system.

The lifting jack assemblies are installed on the plenum cover in the triangular area formed by the intersecting plenum ribs at each of the four vessel axes. The jack assembly extends down into the 2 3/4 in. annulus between the plenum cylinder top flange and the core support shield and lifts under the plenum ribs. (See Figure 1 for reactor component arrangement nomenclature.) As the jack lifts the plenum assembly, it pushes down on the top of the core support shield flange. The hydraulic, air, and electrical lines are grouped by jack and are carefully routed to simplify maintenance and avoid interference with subsequent operations.

The actual lifting operation will be conducted by personnel located on the 347 ft elevation deck. The equipment will be arranged so that one individual can monitor the various jack assembly instruments while supervising each of the operators of the four independent hydraulic hand pumps. No personnel will be located on the internals indexing fixture work platform during the lifting operation.

Lifting Jack Assembly

The lifting jack assembly consists of a hydraulic jack cylinder, a special mainframe structure, a mechanical follower, and two displacement transducers. (See Figure 4 for a pictorial view of the lifting jack assembly.)

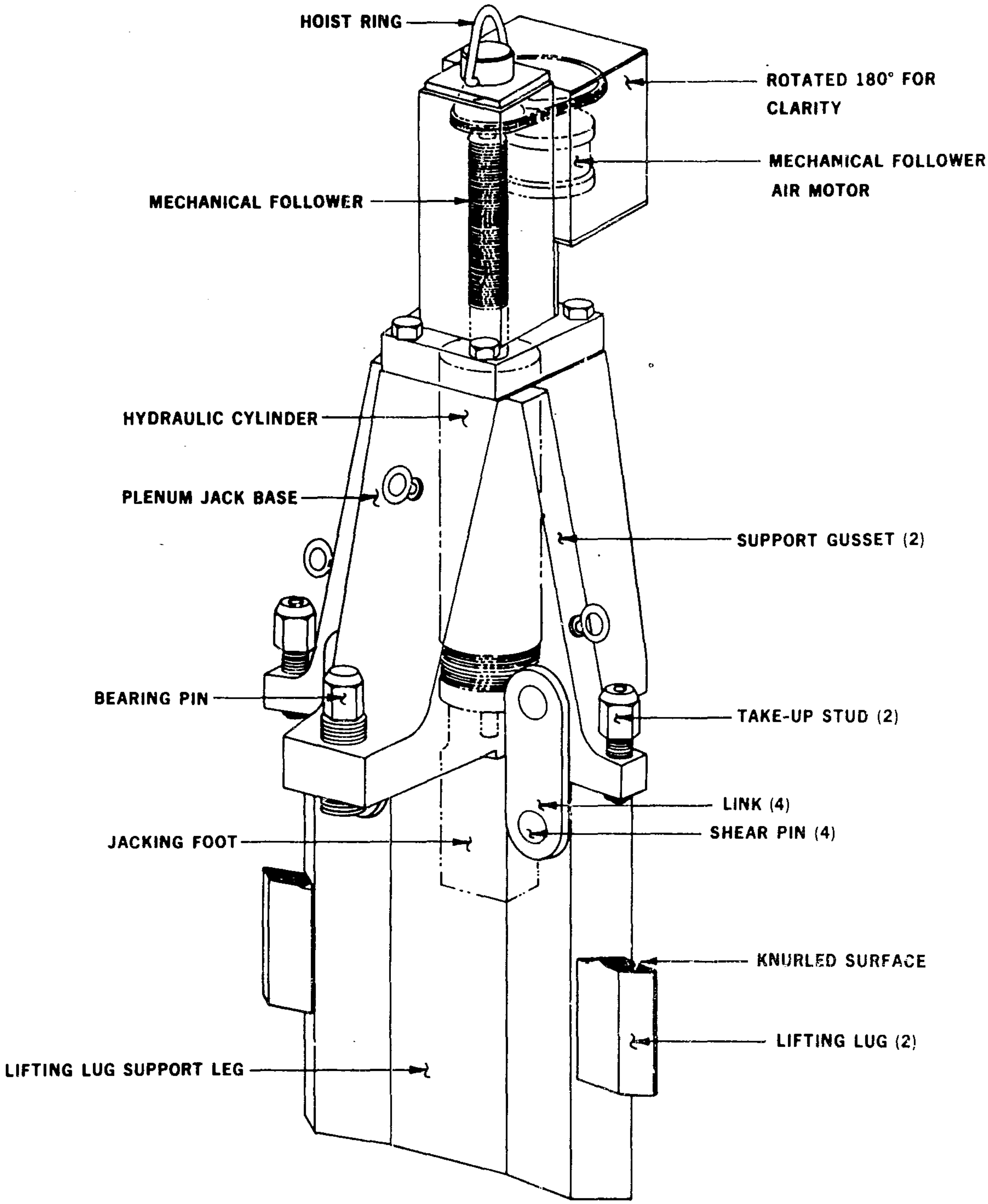


Figure 4. Lifting jack assembly.

The hydraulic jack cylinder is a double acting, hollow plunger design, with a rated load capacity of 60 tons and a stroke of 10 1/8 in. The 17-4 PH stainless steel jack cylinder is 6 1/4 in. in diameter and 18 1/16 in. in length. The hollow plunger has an inner diameter of 2 1/8 in. The jacking foot is attached to the bottom of the hollow plunger and extends downward to push against the top of the core support shield flange. The lower end of the jack cylinder threads directly into the base of the special mainframe of the jack assembly.

The stainless steel special mainframe is an intermediate structure that transmits the force from the hydraulic cylinder to the plenum assembly. The jack base houses the jack cylinder. Suspended from the jack base through heavy links and shear pins is the lifting lug support leg. This 22 in. long by 2 1/4 in. thick leg is shaped to conform to openings defined by the plenum support ribs and the 2 3/4 in. annulus between the plenum assembly and the core support shield. Two opposing, extendable lifting lugs are located in the support leg. These lugs are hydraulically extended to form jack lifting surfaces under each of the adjacent plenum ribs. Above each plenum rib, in the jack base, is a threaded take up stud that, when tightened, will lock the jack assembly to the plenum cover.

A mechanical follower is incorporated into each jack to provide mechanical support of the plenum assembly when the hydraulic jack pressure is relieved. Such hydraulic depressurization is planned during various lift "hold" point activities, such as end fitting separation, to minimize the potential for leakage of hydraulic fluid from the high pressure system. The follower is a two inch diameter Acme threaded shaft extending through the hollow plunger of the jack cylinder. An air driven motor is located on top of the jack. During operation, the motor will continuously hold the mechanical follower against the jacking foot, advancing as the hydraulic cylinder is extended. Thus, as the hydraulic pressure to the jack is relieved, the load of the plenum assembly will be transferred to the mechanical follower.

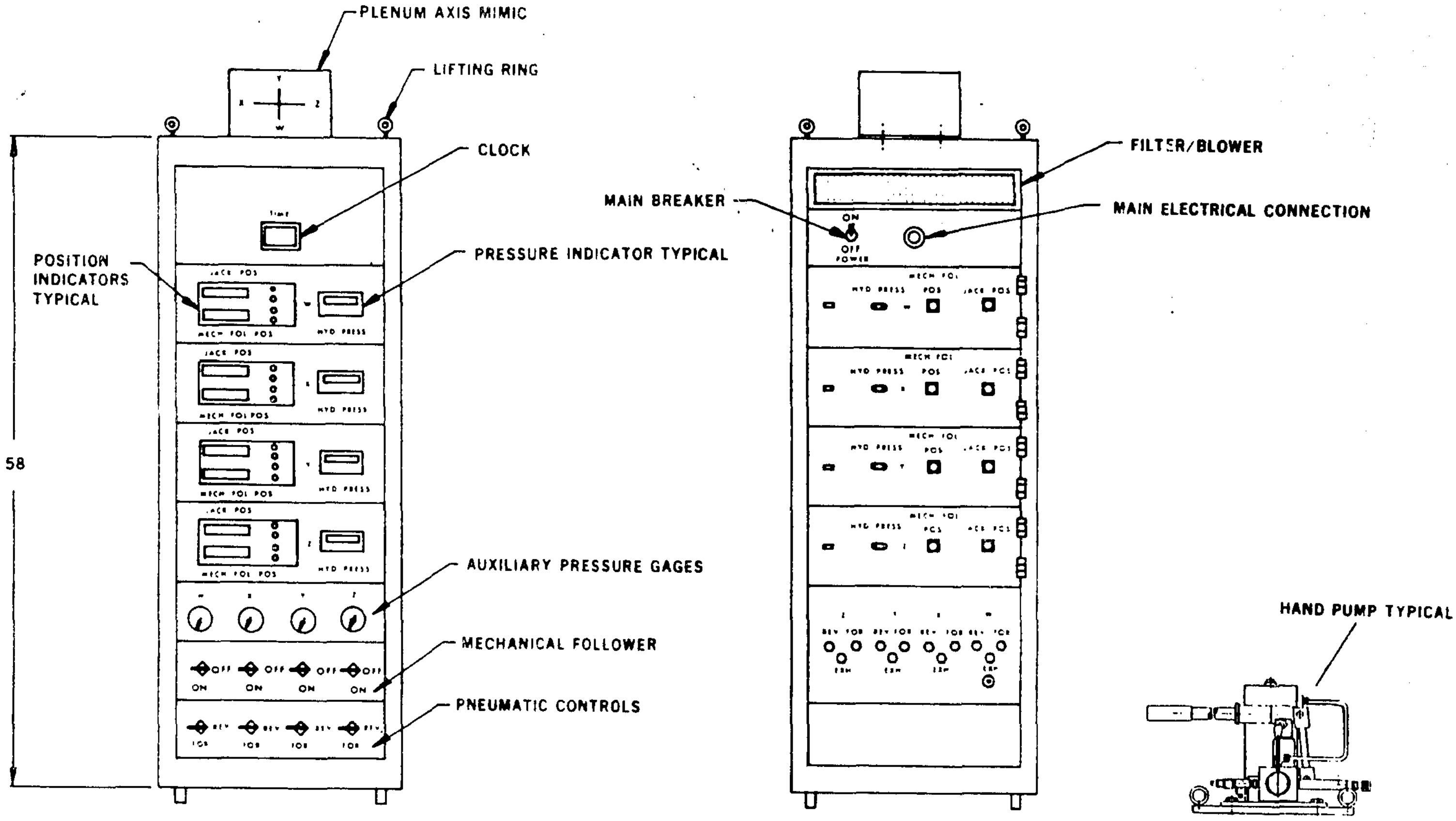
Each lifting jack assembly has two displacement transducers for remote readout of the jack lift position. Both transducers are mounted on the mainframe with one measuring plunger movement and the other indicating corresponding displacement of the mechanical follower. These transducers are accurate to within ±0.015 in. and consist basically of a cable wrapped around a mandrel that is connected to a potentiometer. A digital output is supplied to the control station.

A bull's eye level supplements the displacement transducers, providing a direct measure of the plenum assembly's levelness during both initial and final lifting. This level is mounted on a frame installed on top of one of the plenum assembly control rod guide tubes. The frame also supports a video camera that transmits a visual image of the level to the video monitor at the control station.

Control Station

The control station consists of the necessary remote control and monitoring equipment for the initial lift of the plenum assembly. The control cabinet (Figure 5) contains individual jack readouts for jack displacement, mechanical follower position, hydraulic pressure, and air pressure. The cabinet also contains the on/off and forward/reverse valves for controlling the air motors on the mechanical followers. Adjacent to the cabinet are the individual, manually operated hydraulic pumps that control the lift force and displacement of lifting jack assemblies.

The in-containment video system, described previously, provides support for the initial lift operations. Video cameras and lights will be suspended from the plenum assembly to view select locations within the plenum assembly and core cavity. The controls and monitors for this equipment will be located adjacent to the control station.



CONTROL STATION CABINET ASSEMBLY

REAR VIEW

Figure 5. Lifting jack control and monitoring equipment arrangement.

END FITTING SEPARATION AND CLEANING TOOLS

Introduction

During the TMI-2 accident, the upper half of most of the fuel rods overheated and deteriorated, creating a cavity in the upper region of the core. Remote video examinations of the cavity show that several fuel assembly upper end fittings either fell or were highly ablated leaving numerous empty locations in the bottom of the plenum assembly. However, the video examinations also show that many fuel assembly end fittings and fuel rods remain suspended from the underside of the plenum assembly, and in some areas, many rows of fuel rods extend well into the cavity. The amount of radioactive fuel, both within the suspended fuel rods and the deposits of fine particulate debris, is not insignificant. To minimize the amount of radioactive material transported out of the vessel and prevent the suspended material from interfering with the planned transfer of the plenum assembly, special tools are being developed to separate the end fittings from the plenum assembly.

The cleaning equipment, originally included in the scope of work for moving deposits of loose debris from the plenum assembly to the rubble bed, is not being developed. This decision was based on video inspections (limited) that showed that there were no deposits of debris on the plenum assembly. Further, cleaning equipment of the type originally being considered would not have been very effective on many of the contaminated surfaces and its operation could cause turbidity that would inhibit subsequent operations involving video support. As a result, the cleaning equipment has been limited to pole-mounted, brush and scraper-type tools that may be required to support inspection and jack installation activities.

Before designing end fitting separation tools, proof-of-principle tests were conducted to quantify design requirements and test initial tool concepts. A test fixture representing a control rod guide assembly and a 2 x 3 grid array for suspending fuel assembly end fittings was designed and fabricated. Tests were conducted on end fittings that were force fit, silver brazed, and welded into the grid array. A long-handled, slide hammer tool was used to impart a controlled energy impact to the end fitting. This test demonstrated that force-fit and silver-brazed end fittings could be separated by applying force in the center of the end fitting with a manually activated long-handled impact tool. However, if an end fitting is effectively welded to a grid pad (a much more severe condition than expected to exist in the TMI-2 plenum assembly), a chisel type tool would be required to cut the weld. Based on the results of these tests, development of manually activated impact tools (without the chisel feature) were initiated.

A second proof-of-principle test was done to assess the viability of a preliminary tool design intended to reach end fittings adjacent to control rod guide tubes (CRGTs). One of the tools is designed to be operated through the CRGT. This tool has an "h" shaped tool end that will impact the end fitting at the CRGT location and then be moved laterally so that the leg extends through the three-inch wide flow slot in the CRGT to access the adjacent end fitting. The test showed that physical constraints within the CRGT prevented the fixed-leg, "h" tool from consistently dislodging end fittings in locations adjacent to CRGTs. Information from this test was used to develop a pivoting leg "h" shaped tool to overcome the problem.

The end fitting separation and cleaning tool group consists of three types of impact tools and a long-handled cleaning tool with two types/sizes of interchangeable brush and scraper tool ends. In addition to the pivoting leg impact tool previously mentioned, there is a straight tool and an offset tool, both used to separate end fittings located around the periphery of the core that cannot be effectively reached through the control rod guide tubes. These tools are described in subsequent paragraphs.

As of April 1, 1984, the above tools had been designed and were undergoing review by GPU Nuclear personnel.

Description

End Fitting Separation Tools

These 22 to 23 ft long and 55 to 65 pound tools will be installed and operated from the internals' indexing fixture (IIF) work platform. An overhead crane will assist the operators during the repositioning on the tools.

Each of the three impact tools are similar and consist of a ram, a main body that includes the tool end, and an indexing tube. A removable pin holds the components together during handling, but once the tool is installed, the pin is removed to allow manual operation of the ram.

The ram for the "h" tool is a 20 ft length of 5/8 in. diameter stainless steel rod with a hand grip with a lifting bail. The ram for the two other tools is a foot longer. These 25 pound rams, when lifted three feet and manually pulled downward, can impose up to 150 foot-pounds or more of energy on the tool end. This energy level has been shown in a proof-of-principle test to dislodge end fittings that are force-fit and silver-brazed to the plenum assembly grid pads.

The ram slides up and down in the main body which is a 20 ft long, 7/8 in. diameter by 0.11 in. wall stainless steel tube. A large tee handle is located at the top of the tube as an aid to the operator during tool positioning and operation. Graduated marks, applied to the top of the tube are used, in conjunction with the indexing tube, to indicate the actual position of the end fitting relative to the plenum assembly and measure its displacement following each impact. The tool end is welded to the bottom of the tube. Welded to the side of the "h" tool main body is a 1/4 in. diameter tube which guides and protects the draw wire cable used to actuate the pivoting leg of the tool end.

The tool ends are designed to be positioned in the center of the end fittings, mating with either the coupling assembly of control components or the holddown latch feature of those end fittings that do not have control components. The tool end of the "h" tool, as the name implies, has two legs: one, a fixed leg, that mates with the control rod coupling within the CRGT; the other, a pivoting leg, that extends through a flow slot in the CRGT and mates with the burnable poison rod coupling assembly in the adjacent fuel assembly location. The tool end legs are machined from 7/8 in. thick stainless steel plate to transmit a high percentage of the impact energy to the end fitting. The tool end of the straight tool is a one inch diameter rod with a truncated cone end. This tool end can be used to dislodge end fittings either with or without control components.

The offset tool is used to impact and dislodge the ten peripheral fuel assembly end fittings adjacent to the reactor outlet nozzles. The reinforcing plates that are welded to the inside of the plenum cylinder interfere with the straight tool, thus requiring the offset tool to be used. This tool end uses a one by two inch stainless steel bar to provide a 5 1/2 in. offset.

The aluminum index tube surrounds the top of tool's main body and extends from just below the tee handle to plenum assembly. The index tube on the "h" tool rests on the top spacer in the CRGTs, while the index tube on both the straight and offset tools rests on the plenum cover.

Cleaning Tools

The cleaning tool consists of a telescoping aluminum tube handle and four interchangeable brush or scraper tool ends. The tube handle which weighs 12 pounds can be extended from 12 ft to 24 ft so that surfaces from the top to bottom of the plenum can be cleaned by personnel operating from the IIF platform.

The stainless steel scraper tool ends consist of a one inch-wide inclined blade for scraping vertical surfaces and a three inch-wide straight blade for horizontal surfaces. There are two wire brush attachments for cleaning horizontal surfaces. Both attachments use a four inch-long by 5/16 in.-wide brush, having two inch-long, 0.03 in. diameter stainless steel wire bristles and differ only in offset from the centerline of the tool. The differing offset increases the variety of surfaces that can be reached and cleaned by the brushes.

FINAL LIFT, TRANSFER, AND STORAGE EQUIPMENT

Introduction

Under normal conditions, the plenum assembly is lifted from the reactor vessel by its lifting lugs and transferred to its storage stand with no water shielding in the refueling canal. However, the lifting lug bolts of the TMI-2 plenum assembly may have been damaged during the reactor transient. Furthermore, the plenum assembly is highly contaminated with radioactive debris that requires shielding and contamination control. Therefore, the final lift, transfer, and storage equipment must be designed to cope with these unique conditions while providing adequate safety margins and radiation protection.

Since the refueling canal will be filled with water to shield the TMI-2 plenum assembly as it is lifted from the reactor vessel, new extra long pendants are needed to reach the plenum assembly through the canal water without submerging and contaminating the crane rigging. The new pendants must also be equipped with new lifting attachments for grasping the plenum assembly without using the potentially weakened lifting lugs. And, to minimize radiation exposure and comply with ALARA practices, contamination control barriers and covers are needed to prevent radioactive material from excessively contaminating the refueling canal water. A new storage stand is also needed to support the plenum assembly without interfering with or puncturing the contamination control barrier.

The final lift, transfer, and storage equipment has been divided into the following subgroups of equipment: lifting equipment, transfer contamination barrier and associated equipment, storage stand, and semi-permanent cover for the internals indexing fixture. (The arrangement of this equipment is shown in Figure 6.)

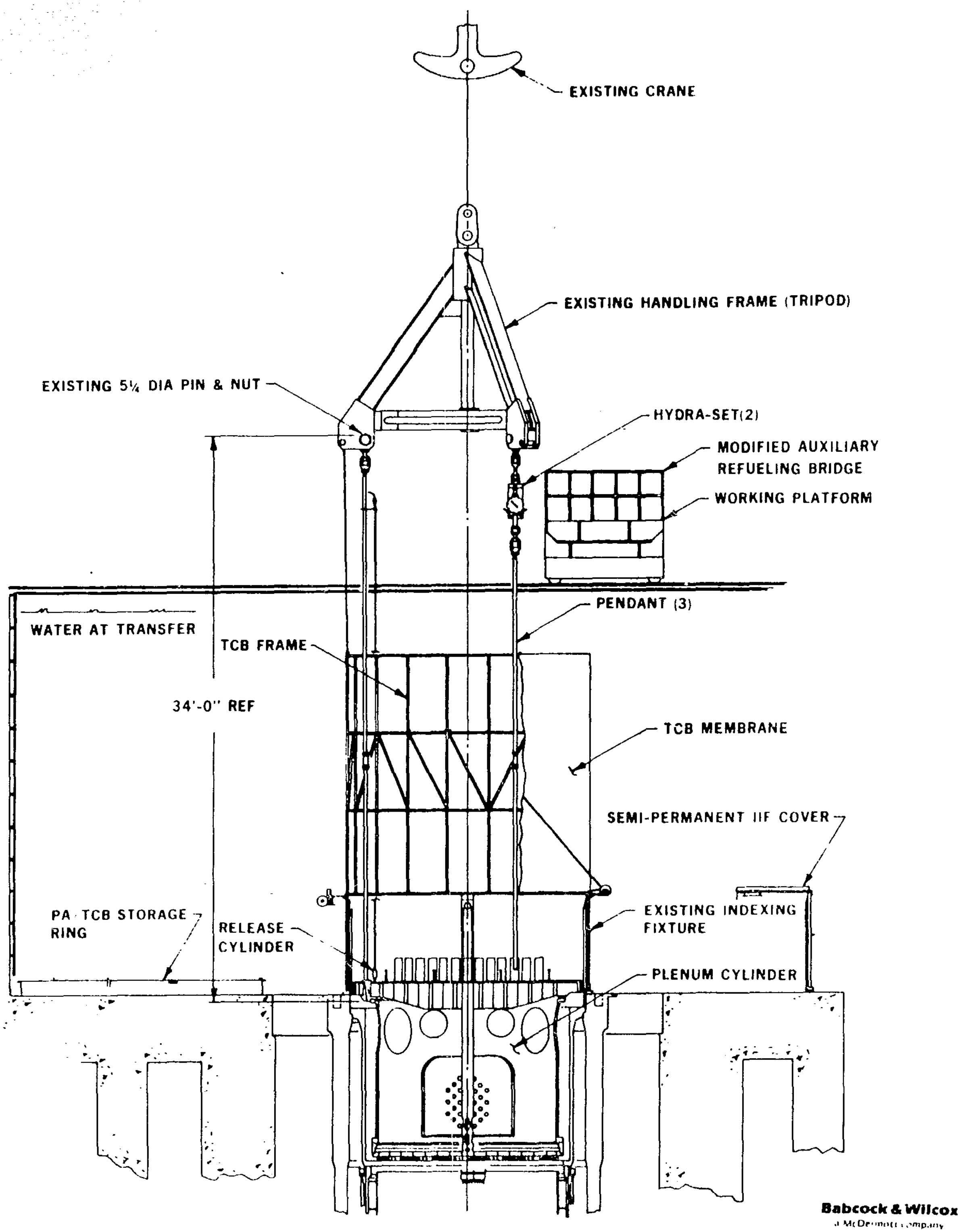


Figure 6. Final lift, transfer and storage equipment arrangement.

As of April 1, 1984 a preliminary design of this equipment had been completed.

Equipment Description

Lifting Equipment

The normal plenum assembly handling equipment was reviewed to determine whether or not it could be used in removing the TMI-2 plenum assembly. The existing pendants were found to be too short (only 7 1/4 ft) to be used with a flooded refueling canal. Furthermore, the questionable structural integrity of the plenum lifting lug bolts necessitate that the pendants have lifting attachment devices that can grasp and lift the plenum assembly without using the lifting lugs. Thus, new extra long pendants with special lift attachment devices (lifting block assemblies) are being designed.

Three new pendant assemblies are required to attach to the existing internals' handling fixture (tripod). One pendant is a fixed-length pendant, 34 ft long. The other two pendants are designed with load positioners (Hydra-Set, Model E) so that their length can be varied from 33 1/2 ft to 34 1/2 ft. The adjustable pendants are needed to keep the plenum assembly level as it is being lifted from the reactor vessel. Each load positioning pendant includes a set of commercial carbon steel swivel links to allow rotation so that the load gauge can be easily read.

The upper end of each pendant will have a forged carbon steel connecting link that will be pinned to the tripod clevis plates with 5 1/2 in. pins. The pendants will be attached to the tripod in the TMI-2 reactor building using centering sleeves or spacers to keep each pendant link in the center of its clevis. The fixed-length pendant is attached to the tripod leg that will be positioned 15° from the W-axis toward the X-axis. The other two pendants will be 120° on either side of the fixed pendant. The lower end of each pendant has a stainless steel lifting block assembly that automatically locks under the plenum cover assembly and can be pneumatically disengaged only when it is not under load.

The preliminary design of the lifting block assemblies consist of a main block, reaction blocks, spherical nut, minor parts, and fasteners.

The pendant load is carried through the spherical nut and main block into the bottom side of the plenum flange. The tapered reaction block matches a taper on the main block and adjusts to fill the radial opening between the two plenum upper flanges, locking the lifting block in place. The lifting block assemblies are connected to the upper portion of the pendants with two lengths of stainless steel bars connected with a single threaded stainless steel coupling. Thus, all parts of the pendant that will be submerged in the contaminated refueling canal water will be made of stainless steel.

The preliminary design of the pendant and lifting block assemblies are designed and stress analyzed to the requirements of ANSI-N14.6. Also, the lifting block assemblies are designed so that stresses in the plenum assembly comply with the allowable stresses of the ASME Boiler and Pressure Vessel Code Section III, Subsection NG.

Transfer Contamination Barrier

A transfer contamination barrier (TCB) has a dual purpose: to minimize mixing between the contaminated water in the reactor vessel and plenum assembly with the clean water used to fill the refueling canal, and to minimize the spread of radioactive debris during plenum lift, transfer, and storage. The TCB is a cylindrical structure about 14 ft 5 in. in diameter by 14 ft 6 in. tall. This large, truss-like structure will be assembled in the reactor building from a collapsed condition small enough to pass through the personnel hatch. Self-locking pins will be used in the final assembly of the tubular stainless steel truss structure that will then be covered with an inverted bag made of flexible reinforced plastic. The assembled TCB is suspended from the tripod with the lifting pendants hanging through openings in the top of the TCB.

The bottom of the TCB and the top of the internals indexing fixture (IIF) will be closed with sheets of reinforced plastic rolled from a spool. The two cover sheets will be rolled on a common spool that will be installed on one side of the IIF (see Figure 6). A take-up spool will be installed on the opposite side to allow the cover sheets to be drawn between the TCB and the IIF after the plenum assembly has been lifted 1/2 in. above the IIF to allow passage of the plastic sheets. The feed and take-up spools are part of the 15 ft 3 in. square stainless steel closure frame assembly which fits on and is clamped to the top of the IIF; they are remotely operated while submerged in the canal water. After the plenum assembly is lifted into the TCB, draw cables will be used to remotely close and secure the bottom closure to the TCB membrane and frame. The IIF closure sheet stays in place forming a temporary barrier over the reactor vessel.

Storage Stand

The new storage stand is designed to support the plenum assembly enclosed within the TCB. The storage stand will be a segmented ring 14 ft 5 in. in diameter fabricated of 1/2 in. thick stainless steel plate approximately 10 in. high with integral bearing pads to support the plenum assembly. A soft plastic seal will be provided between the segmented ring and the liner of the canal floor to form a secondary seal for the bottom of the plenum assembly.

Semi-Permanent IIF Cover

After the plenum assembly has been removed from the reactor vessel and placed on the storage stand, the temporary plastic sheet covering the IIF will be replaced by a semi-permanent IIF cover. The purpose of the stainless steel cover is to minimize the mixing of the contaminated water in the reactor vessel with the clean water in the refueling canal. This cover will be fabricated in sections to allow it to be carried through the personnel hatch. It will have connections for a water cleanup system to process the contaminated water in the reactor vessel.

Monitoring Equipment

In addition to the major equipment items, as described above, support or accessory equipment items such as monitoring, viewing, and lighting equipment will be used for the plenum assembly final lift and transfer to canal storage. In many instances, equipment used in previous operations will continue to be used for the final lift operations.

During the final lift of the plenum assembly, this equipment will monitor component levelness, load, and movement in order to minimize the possibility of binding and to aid in its correction if some binding should occur. Plenum assembly levelness will be monitored by the level described in the section of this report on initial lift equipment. Load and movement will be monitored by observing the load positioners described above. Video observations, if required, will use the video systems and lighting described in the section of this report on initial inspection equipment.

PORTABLE WORK PLATFORM

Introduction

A portable work platform equipped with safety railing will be used to help protect personnel working on the IIF platform when any one of the floor plates is removed. The specific operations performed from the IIF platform will depend on the existing radiation levels and may include performing initial inspections, installing initial lift equipment, separating suspended fuel assembly end fittings, and removing loose debris (if required). As of 1 April 1984, the portable work platform had been designed and was being procured.

Description

Because of the various sizes and shapes of the IIF work platform floor plates, several unique guardrail structures were originally envisioned. This concept of several work platforms has evolved into a single universal design platform compatible with any location in the IIF.

The portable work platform consists of a large steel plate having a central access hole surrounded by guard railing. All of the platform's components are made of 304 stainless steel. The plate exterior is sized to span the largest opening in the IIF platform. The platform's base provides a place for the operator to stand while working over an open hole in the floor of the IIF platform. The secured safety railings can support tooling and operator's leaning against them to perform various operations. The center hole is large enough to permit equipment to be installed and operated, but still small enough for the operators to comfortably reach and maneuver tools. An overhead crane is required to move the portable work platform; however, once moved, the platform does not need to be locked into position.

The portable work platform is designed without shielding on the expectation that radiation levels will be tolerable. However, the structure can support one in. of lead on the plate and railing (but design changes would be necessary to affix the shielding). Four lifting lugs are used in moving and positioning the portable work platform on the IIF platform.

The base of the portable work platform consists of a 3/8 in.-thick steel plate with a 2 ft 9 in. by 7 ft 6 in. access hole. The overall dimensions of the base plate are 6 ft wide by 10 ft 9 in. long. The corners of the base plate are cut at 45° angles to make it compatible with the orientation of the steel framing of the IIF platform.

Four-inch high rectangular structural steel tubing is welded all around the perimeter of the access hole to serve as a stiffening member and help resist bending of the platform; it also serves both as a toe plate to prevent any miscellaneous tools or equipment from being inadvertently kicked through the access hole into the reactor internals and as a support for mounting the handrails. The four lifting lugs are welded to the top of the rectangular tubing.

Three, 3/8 in.-thick cover plates are included in the design as a contingency in the event that a smaller hole is desired either for shielding or closer access, or when the hole must be completely covered should work be stopped. These plates can support lead shielding, as well as worker and equipment weight. Each plate has four lifting handles.

The perimeter of the portable work platform access area is equipped with safety railing. This railing is made of 1 1/4 in. diameter Schedule 40 pipe and comprises separate sections for each side of the existing hole. There are two end pieces each spanning 39 in., and six side pieces each spanning 21 1/8 in. All sections consist of two, 42 in.-high posts connected by cross pieces at 2 ft and 3 ft 6 in. above the platform floor level. Each railing post is welded to a 5/8 in.-thick mounting plate that is then connected to the base plates on the tubing with 5/8 in. bolts. The end railings are interchangeable and each side railing is compatible with the other by using this connection arrangement. A 16-gauge plate is welded to each end railing to act as a toe plate in the event that the rail section is moved to an interior position. All railing sections must be detached from the platform base to transport the base plate into the reactor building through the personnel air lock.

TEST ASSEMBLIES

Introduction

Test assemblies are necessary to support the various activities required to remove the plenum assembly. They are used for checking out equipment, training personnel, and demonstrating techniques. Significant man-rem exposure savings can be realized by training personnel before they actually work in the reactor building. The geometries through which special tooling and inspection equipment must pass are complex, and although every effort is made to design tooling and equipment to be compatible with these geometries, checking out the tooling on test assemblies that realistically simulate actual components will allow errors to be found at a point when remedial action will not impact the critical work path. Furthermore, test assemblies are required for load-testing critical components, such as lifting jacks, and for full-capacity tooling checkout of complex systems.

There are four major test assemblies: the Interface Test Assembly (ITA), the Jack Qualification Fixture, the Jack System Test Assembly, and the Final Lift Transfer and Storage Test Assembly. The following sections provide the status and description of the various test assemblies required to support plenum removal activities.

Description

Interface Test Assembly

As of 1 April 1984, the interface test assembly (ITA) was in the process of being fabricated.

The ITA is a full-scale simulation of a section of the TMI-2 plenum assembly, core support cylinder, internals' indexing fixture (IIF), and stationary work platform. The configuration of this test assembly accurately represents the constraints that will be encountered in plenum removal operations, such as inspecting and removing debris; installing the initial lifting jack, level monitor and video monitors (for plenum integrity and plenum separation); performing end fitting separation activities and final cleaning (if required); verifying the final free-path; and attaching the lifting equipment for the final lift and transfer. The ITA is primarily made of grey-colored plastic and grey painted aluminum to simulate the anticipated surface conditions of the actual components. The ITA is designed for underwater use and will be installed in the Defueling Test Assembly tank at the TMI-2 facilities where it will be used to both check out tooling and train personnel.

Jack Qualification Fixture

As of 1 April 1984, this fixture had been designed and was in the initial stages of procurement.

The jack qualification fixture is a rigid boxlike frame that simulates the initial lifting jack seating surfaces on the plenum cover, plenum cover ribs, and the top surface of the core support shield flange. This fixture is used to load-test and functionally check out individual plenum lifting jacks. The jacks are loaded by actuating an opposing hydraulic jack. This opposing jack is positioned under the simulation of the upper surface of the core support cylinder section on which the plenum lifting jack foot rests.

Jack System Test Assembly

As of April 1, 1984, fabrication of this test assembly had just been initiated.

The purpose of this test assembly is to check out the entire system of four lifting jacks, the control station, hydraulic pumps, level monitor, and interconnections comprising the entire initial lifting system. The test assembly is a large steel structure fabricated from structural shapes and plate sections, that simulates not only the plenum assembly diametral and angular spacing into which the jacks will be installed, but also the restraints on lateral movement of the plenum assembly during the initial lift period of the plenum removal. The jacks on this test assembly may be operated as a system up to the full (100%) capacity of the jack cylinders. Load is applied through massive steel plates stacked on the test assembly as needed.

The tooling checkout operations on this test assembly will be performed at the Babcock & Wilcox Mt. Vernon facilities where the ability to produce a smooth, level lift with four independent jacks will be demonstrated. As currently planned, TMI-2 supervisory personnel will participate in the final jack checkout as part of their training program. Following checkout, the test assembly will remain at Mt. Vernon and will not be shipped to TMI.

Lift, Transfer, and Storage Test Assembly

As of April 1, 1984, this assembly had undergone only preliminary design.

The final lift test assembly is needed to verify operability of the final lift equipment and the transfer contamination barrier and associated equipment before it is sent to the site. It will also serve as a limited training facility for site shift supervisors. As will be evident in the following paragraphs, this test assembly cannot be transported to the TMI-2 site.

This test assembly is, in effect, more of a set of facilities than a separate piece of equipment. It will consist of a large vessel filled with water; overhead crane and support equipment; and a simulation of the plenum assembly. This simulation will comprise a carbon steel cylinder approximately the same diameter and length as the TMI-2 plenum cylinder with a steel structure attached to the top to simulate the attachment points for the final lifting equipment. Weight will be added to the cylinder to make the entire assembly weight equal to the 55-ton design weight of the plenum assembly. Additionally, there will be a shortened simulation of the internals' indexing fixture (IIF).

Assembling and setting up the transfer contamination barrier, storage ring, closure mechanism, semi-permanent IIF cover, and lifting equipment will be practiced in an adjacent assembly area. The entire final lift, transfer, and storage sequence, including attaching the lifting equipment and placing the semi-permanent IIF cover will then be performed in the flooded vessel. This test assembly will use Babcock & Wilcox's Mt. Vernon facility which has a large quench pit suitable for these underwater operations.