TMI Unit 2 Technical Information & Examination Program

UPDATE

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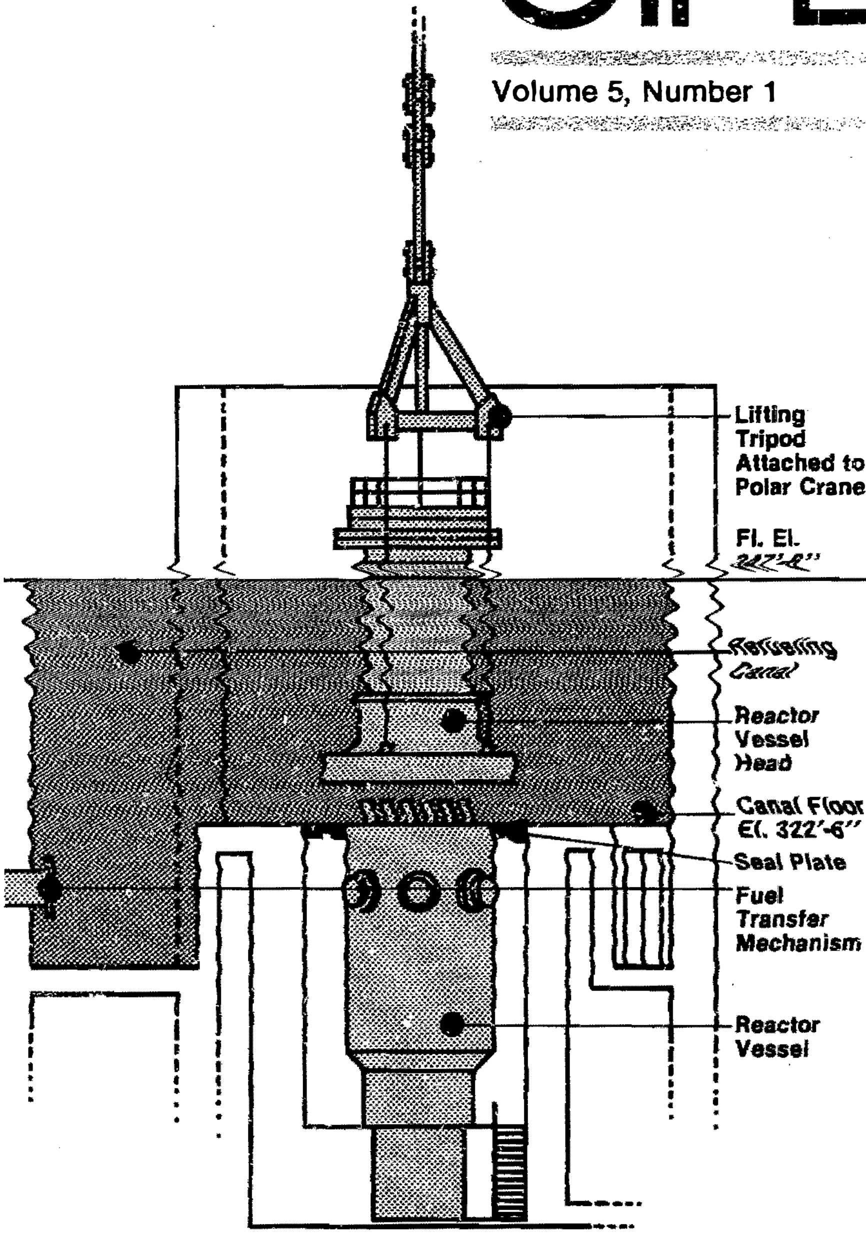

TMI-2 Head Safely Lifted

Two teams of more than 40 workers labored around-the-clock to successfully lift the head from the damaged Three [illegible] The completion of this stage in the cleanup effort provides ready access to the internal components and fuel of the Unit 2 reactor.

The head was lifted on the evening of *July 24 and was seated on its storage stand shortly after midnight the next day. The head, including the service structure, lead blanketed shielding, and lift rigging, weighs approximately 159 tons. The head* consists of two major components: the domed cap of the reactor vessel and the head service structure (see Figure 1).

Figure 1. **Section view of reactor vessel head removal.**

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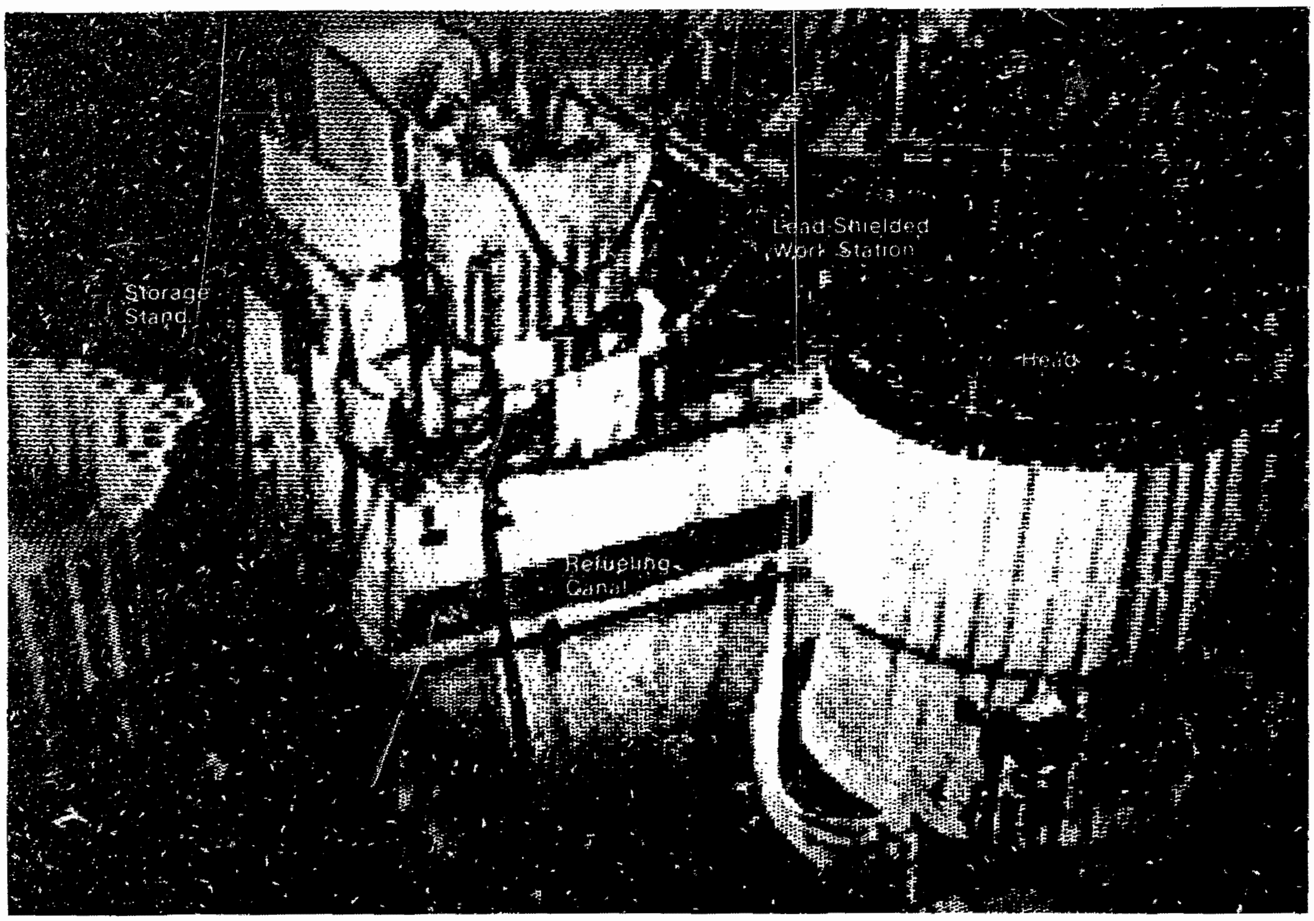


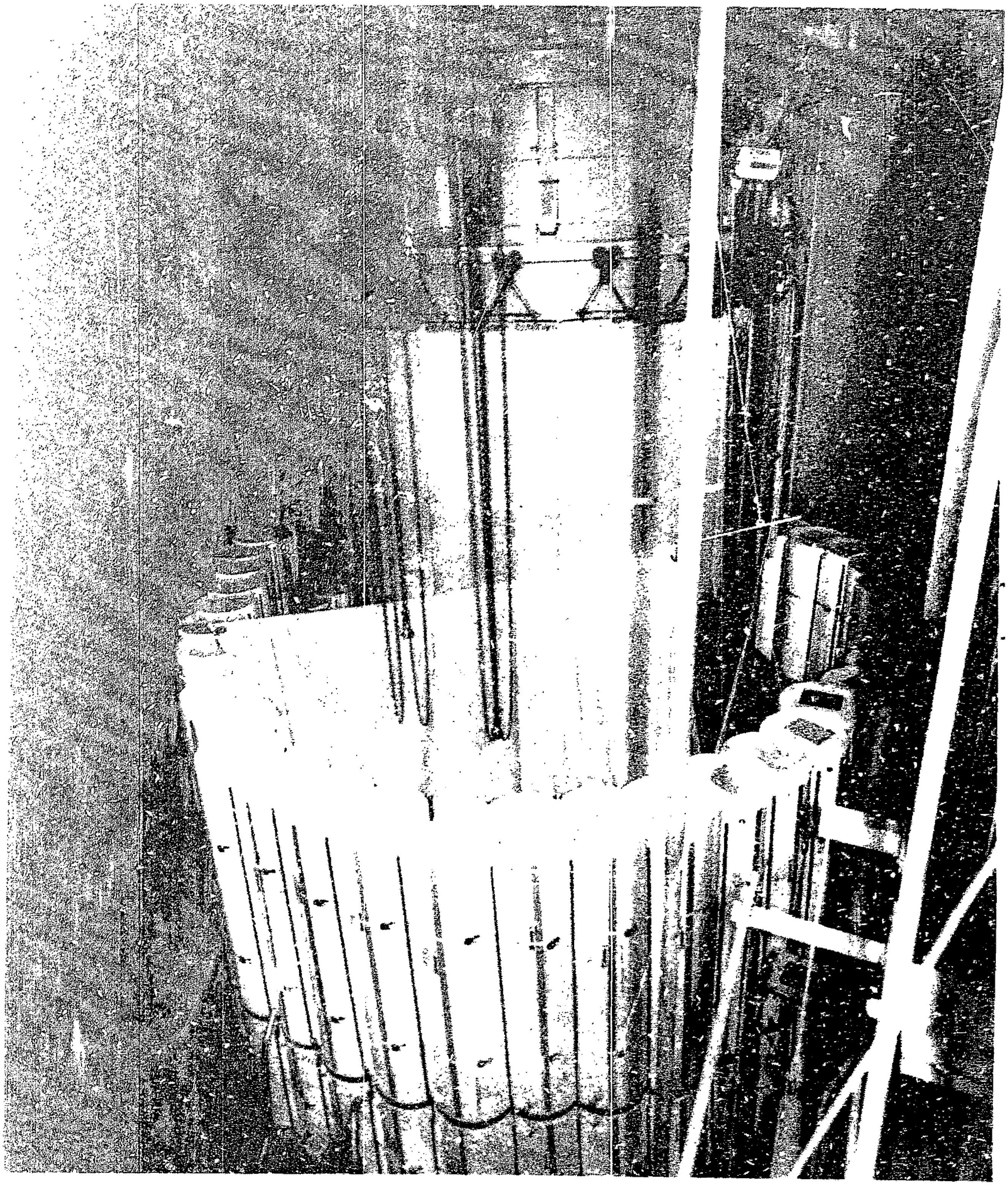
Figure 2. **Photo taken from television monitor of the head traveling toward the head storage stand.**

Attached to the polar crane with three cables and lifting tripod, and covered with 13 tons of lead blankets, the head was first lifted a fraction of an inch so that workers could ensure that the head was level. With the head then raised 3 feet above the reactor vessel, workers wrapped a plastic "diaper" underneath to prevent contaminants there from being spread during travel. Moving at a rate of 1 to 2 feet per minute, the head was raised 38 feet and then moved south and east towards its storage stand (see Figure 2).

During the entire process, engineers and technicians were located in a command center in the TMI-2 Turbine Building and monitored the head lift activities by closed-circuit television and mobile radio. The workers inside the Reactor Building worked most of the time inside a lead-shielded work station to minimize exposure. The Reactor Building was isolated during the lift, and radiation monitors placed inside the building showed no radiation releases during the entire operation.

The final lowering of the head was delayed while the guide holes in the head were aligned with the guide pins on the storage stand. Surrounding the head storage stand are 12-foot-high columns filled with sand that act as radiation shields. The columns were originally filled with water but were drained and refilled with sand because of leakage. Figure 3 shows the head seated on the storage stand.

Figure 3. **Reactor vessel head seated on storage stand.**



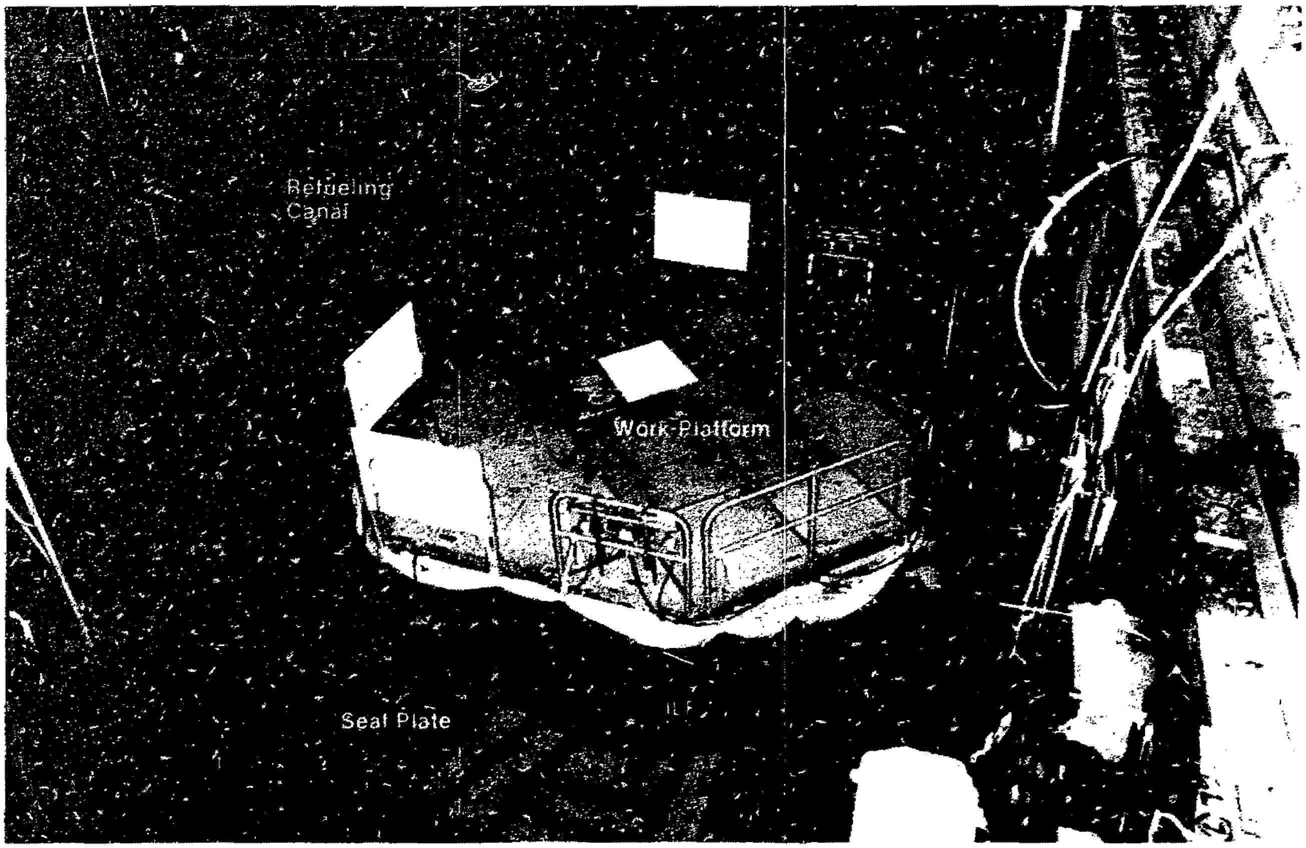


Figure 4. **IIF and work platform in place on the reactor vessel.**

After the head was successfully landed on the storage stand, workers released the lifting rig and attached it to the Internals Indexing Fixture (IIF) located on the operating floor of the Reactor Building. This 6-foot-high steel cylinder, used during normal refueling operations, was placed on top of the open vessel where the cylinder will remain throughout the entire defueling process. Once the IIF was attached, water was added to the Reactor Coolant System, filling the IIF to a depth of about 5 feet. This configuration provides shielding from radioactivity and will allow the plenum and fuel to be extracted through the IIF without flooding the refueling canal. Once the IIF was filled with water, workers installed a 1-3/4-inch-thick lead-lined steel work platform on top of the IIF, completing the head removal/IIF installation procedure. Figure 4 shows the IIF and platform in place on the reactor vessel.

During placement of the work platform, a minor malfunction of one of the switches on the polar crane caused it to stop when the work platform was within an inch of the IIF. Workers manually lowered the work platform the rest of the way by turning the turnbuckles on the crane's lift rigging.

Throughout the head removal process, the radiation levels were less than originally anticipated. Readings taken at the refueling canal were 3 R/hour, which was 10 to 15 times lower than projected. In the lead-curtain cubicle, workers experienced radiation levels of 30 mR/hour, lower than the 50 to 150 mR/hour anticipated. While removing their protective clothing, six workers experienced minor skin contamination, which was subsequently washed off with soap and water.

With the head lifted and the IIF in place, the first major phase toward successful cleanup has been accomplished. Currently, the schedule calls for initial plenum jacking in December 1984 and defueling to begin the following July.□

Months of Preparation Lead to Safe Head Lift

The successful head lift in July 1984 climaxed months of preparatory work in and out of the TMI-2 Reactor Building. Safety played a key role throughout the operation, from underhead characterization to placement of the head on the storage stand.

One of the early objectives of the TI&EP's Reactor Evaluation Program was to determine the best approach to safely remove the reactor vessel head. The approach chosen was to remove the head dry, without flooding the refueling canal. This is essentially the same technique used in normal refueling operations and was considerably less time consuming than removing the head wet, which would have required subsequent decontamination of the refueling canal and processing of the canal water.

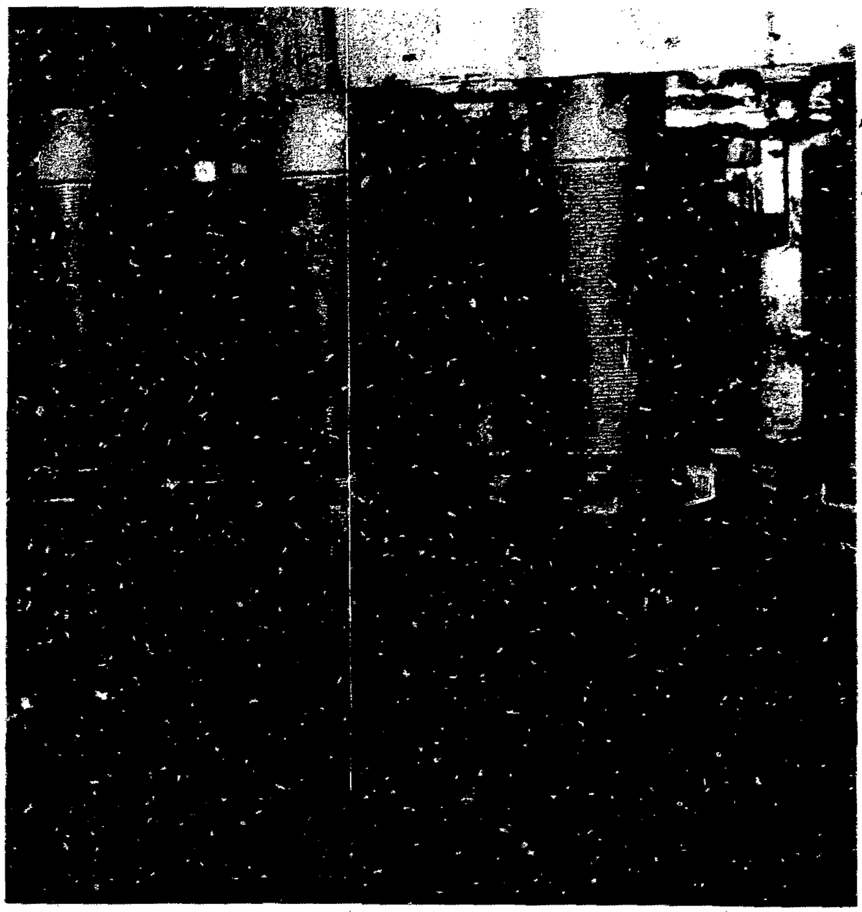
The Underhead Characterization Program confirmed the decision to remove the head dry. This program included the closed-circuit television examinations of surfaces under the head and on top of the plenum, radiation measurements inside the vessel, and analyses of debris samples from the plenum's upper surface.

While cameras saw much debris hanging from the underside of the plenum, its top surface—between the plenum and the head—showed no apparent damage or distortion and little debris. After obtaining gamma and beta radiation readings of this debris, technicians removed some samples which were tested for pyrophoric reaction. The test, conducted at Battelle Pacific Northwest Laboratory's TMI facility, demonstrated the debris posed no pyrophoric hazards.

The next major step in head removal preparations followed in February 1984, when the polar crane was successfully load tested and qualified to lift the reactor vessel head and service structure. The crane lifted and maneuvered a 214-ton load of missile shields, the lifting frame, and assorted rigging assemblies.

Major preparations were conducted in the five months preceding the actual lift. The 60 studs that fastened the head to the reactor vessel were partially detensioned to identify the studs that might have been stuck as a result of corrosion. Studs are detensioned by first stretching the studs and then loosening the nuts on them (see Figure 5). As expected, workers encountered some difficulty turning the stud nuts but succeeded using penetrating oil and a striking bar and hammer. Two of the studs were removed at that time, leaving holes in the head flange that later were lined up with the two guide pins on the storage stand on which the head was seated. In a later entry, the workers fully detensioned and removed the other 58 stud and nut assemblies, each weighing 670 lb, and placed them in storage racks. Finally, the stud holes were filled with a preservative and sealed, preventing them from corroding.

Figure 5. **This closeup shows some of the 60 studs that fastened the TMI-2 reactor head to the reactor vessel. The nut on the lower portion of each stud maintains tension on that stud.**



After the head studs were partially detensioned, the reactor vessel was refilled and pressurized. Processing of the Reactor Coolant System water could then resume. By sending the water through the Submerged Demineralizer System, its radioactivity was reduced. Also, the water's boron concentration was increased from 3700 to about 5000 ppm, thus increasing the safety margin for prevention of criticality (nuclear chain reaction) during later defueling operations. After the processing was complete, the reactor vessel was depressurized and water partially drained to below the reactor vessel flange before head lift.

Clearing a path for the head to be transported through the south end of the refueling canal, the auxiliary fuel handling bridge was dismantled and moved to the north end of the canal. The bridge is a crane that straddles and trolleys over the refueling canal.

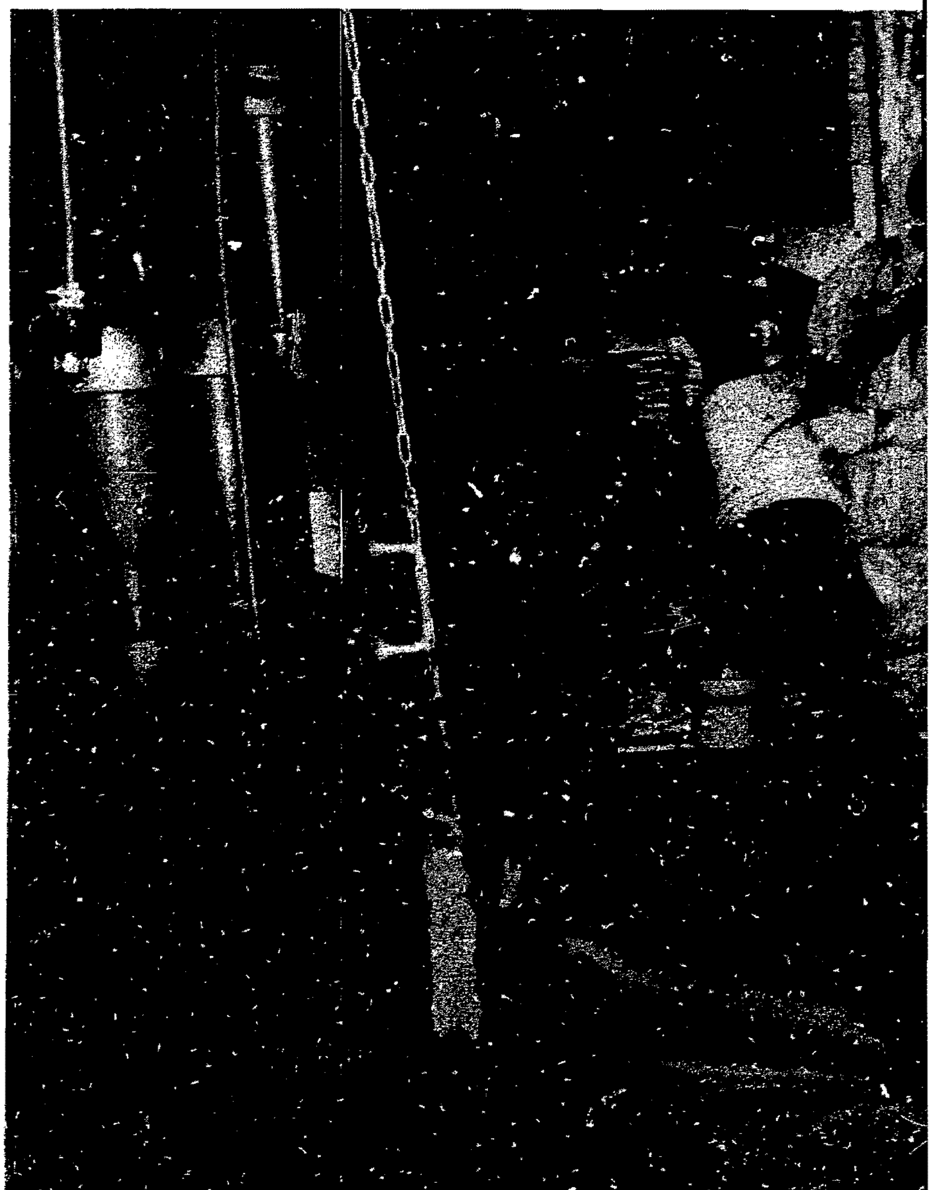


Figure 6. **A TMI-2 worker pours a sealant around the canal seal plate. The sealant and a metal seal plate were placed between the refueling canal and the reactor vessel so the canal could have been flooded, if necessary, for shielding.**

A few days before head lift, the remaining 66 lead screws were parked, or raised from inside the reactor vessel up into the reactor head service structure. Other important prelift jobs included installing cameras to monitor the head to maintain alignment as it was lifted; stripping the head of remaining insulation, wiring, piping, and equipment for adequate accessibility; preparing the IIF for placement on the reactor vessel after head removal; assembling in the Reactor Building the IIF work platform; and installing a system to process the Reactor Coolant System water within the reactor and IIF. The water is being pumped through this system to remove radioactivity from the reactor coolant system water, thereby keeping radiation levels low in work areas above the vessel.

Head lift planners were aware that head lift could have resulted in an air particulate radioactivity buildup or radiation intensity in the area around the top of the vessel, possibly requiring the refueling canal to be flooded. They therefore took precautions for such a contingency, fully inspecting the canal, sealing all penetrations in the canal walls and floors, and modifying the water systems so the canal could have been flooded with borated water—and subsequently drained.

A seal plate was installed, closing the gap between the reactor vessel and the refueling canal. On a partial mockup of the canal seal plate, workers practiced various techniques to apply the sealing compound that was to be used in the cavities and joints of the seal plate. Figure 6 shows a TMI-2 worker actually pouring the sealant around the reactor vessel.

Training was, in fact, a critical part of the head removal effort. By rehearsing in the Unit 2 Turbine Building on mockups of the reactor head, IIF, IIF work platform, and other components and apparatus, workers were prepared to enter the Reactor Building and carry out their functions safely and efficiently. Consequently, they were able to reduce their time in the building and minimize their exposure.

Training was one of a number of items established to make head lift a safe activity. Some other controls included the use of shielding, protective clothing and respirators, personal dosimeters, radiation monitors, and television cameras, the combination of which were designed to keep radiation exposures to a minimum.

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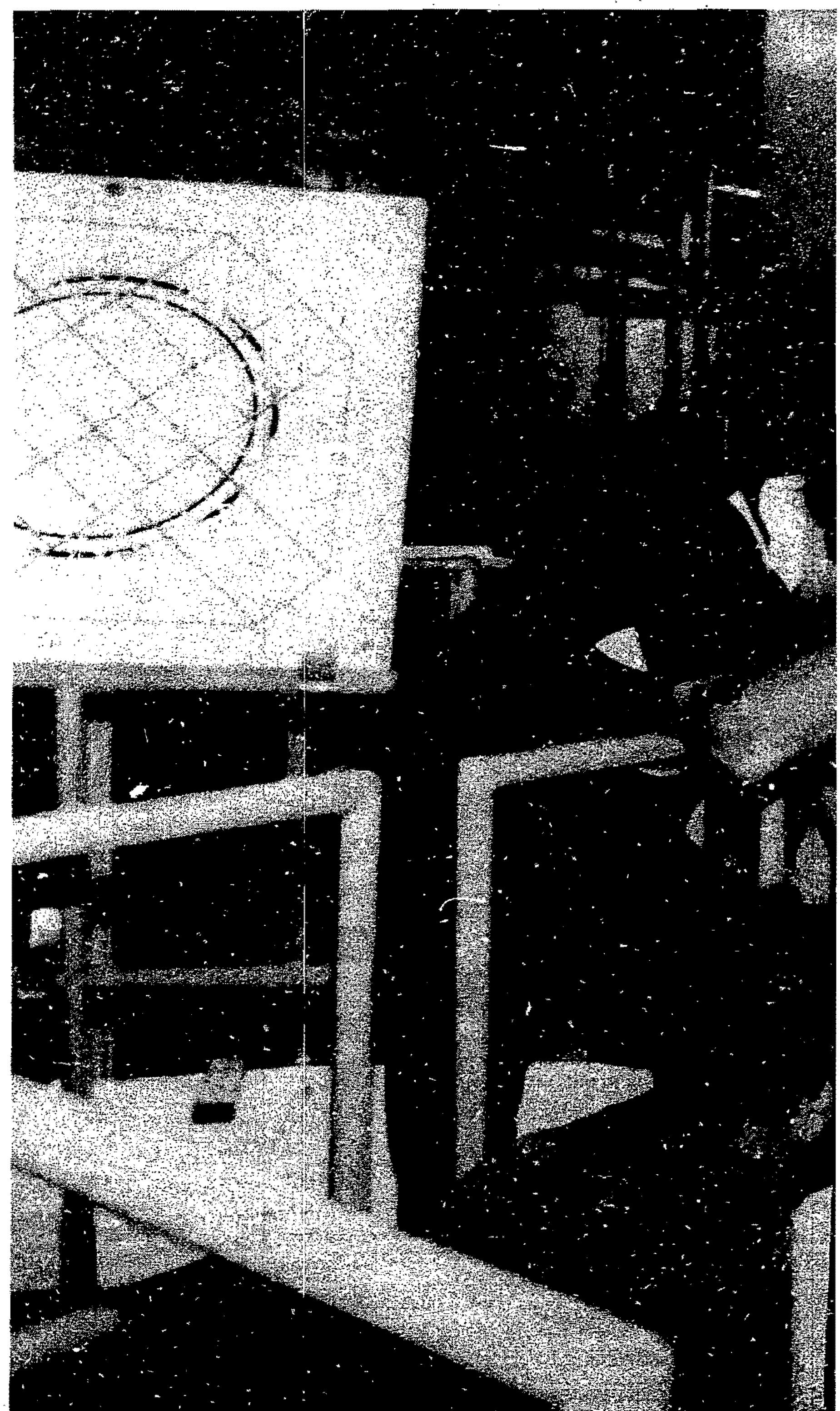
Next Step:

Plenum Jacking, Removal Planned



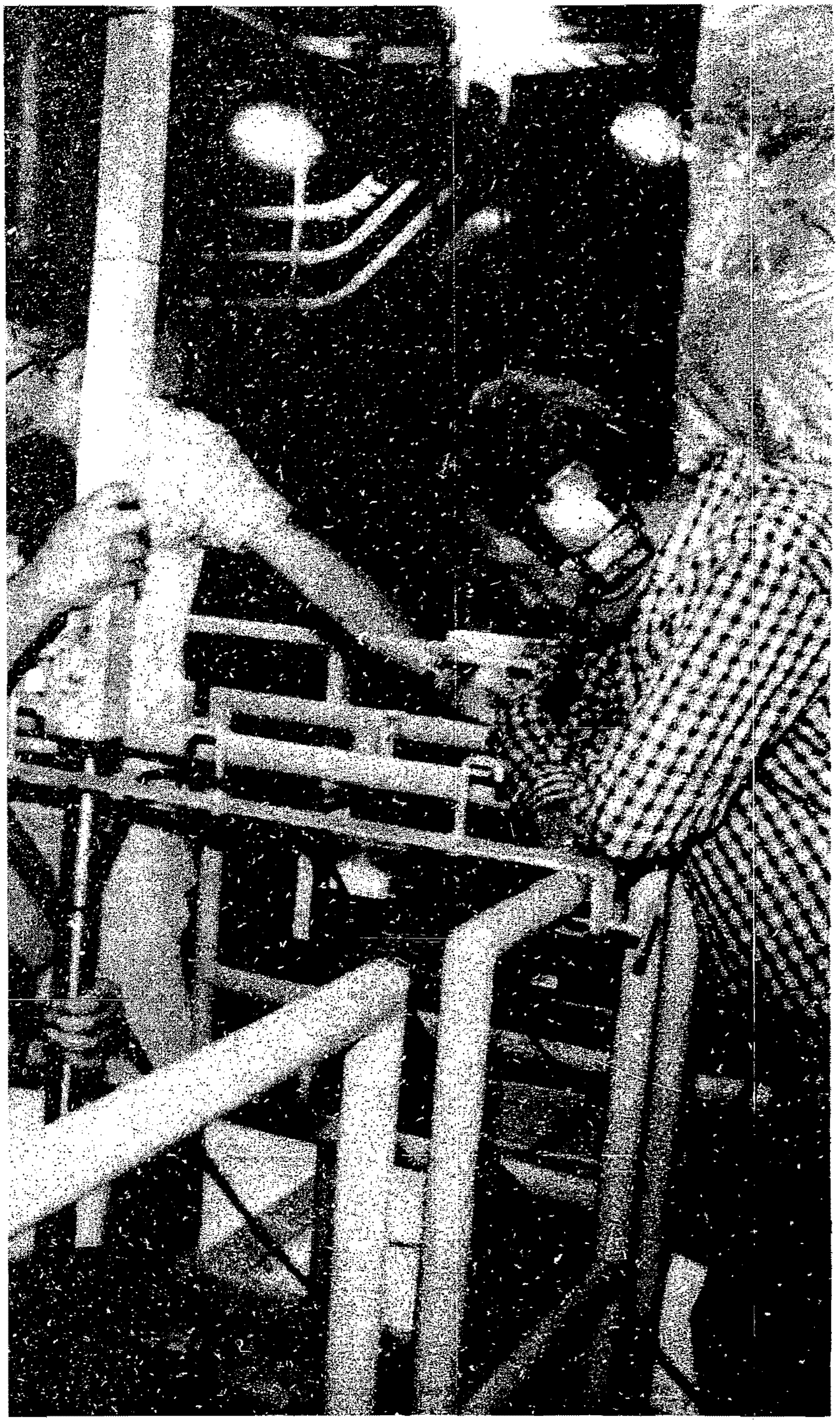
No sooner was the head removal project completed when the TMI-2 recovery program turned its primary focus to the next major stage in reactor disassembly: plenum removal.

The plenum assembly, a 55-ton cylindrical structure above the reactor core, houses the control rod guide tubes. It is scheduled for initial jacking in December and placement in the deep end of the refueling canal in May 1985. Over the past couple of months, the TI&EP and GPU Nuclear have been getting the plenum assembly ready for its initial jacking.

As a preparation, technicians are visually inspecting the plenum, using specially designed underwater cameras, recorders, lighting, and long-handled camera-positioning tools, to determine the amount of debris on the underside and peripheral surfaces of the plenum, as well as on top of the fuel assembly end fittings (see Figure 7). If a great amount of debris is found and considered to be a possible hindrance to the plenum lifting operation, the technicians may remove it by water lancing or vacuuming.

Also during the inspection, workers will attempt to separate unsupported end fittings using newly designed end fitting separation tools. If some end fittings remain attached, they may leave them since the plenum would still be able to sit evenly on a stand in the refueling canal.

End fitting separation is considered to be the first intentional movement of significant quantities of fuel in the damaged reactor core. This action can not cause



core criticality because the nearly 5000 ppm of boron in the Reactor Coolant System water in the vessel prevents criticality, regardless of fuel geometry.

The visual inspection of the plenum is not designed solely to check for debris and to test the knock-off tools, but also to see how much clearance remains in certain normally tight areas between the plenum and the core support shield that encircles the reactor vessel. Technicians want to establish whether the plenum has been damaged or distorted in these vital areas.

In December, workers operating four 60-ton hydraulic jacks will initially lift the plenum about 2-1/2 inches. The workers will then check for fuel separation, after which they will jack the plenum another 6-1/2 inches to be sure the plenum has a free path out of the reactor vessel.

The work will then be completed in early 1985, when a dam will be installed to hold water in the deep end of the refueling canal, a plenum storage stand will be put in place, the deep end will be flooded, and the plenum will be lifted, placed on its stand, and covered.

The outcome of this entire phase of the reactor disassembly project will be detailed in a future *Update* issue. ☐

Figure 7. **Workers lower new plenum inspection equipment into a large model of the TMI-2 reactor as they receive training in the plant's Turbine Building. The grid on the map of the plenum (left) provides guidance.**

The TI&EP— What Has it Accomplished? What is in the Future?

The safe removal of the TMI-2 reactor vessel head marked the successful completion of Phase 1 of the defueling sequence. Many TI&EP sponsored activities, along with intensive head lift preparations, contributed to the achievement of this major milestone. These activities began in 1980 when the DOE Technical Integration Office (TIO) was established.

The first major step toward defueling the damaged reactor occurred in July 1980 when the first manned entry into the Reactor Building occurred. To support this activity, the TI&EP established a Citizens' Radiation Monitoring Program, which proved to be one influential factor in alleviating the fears of local residents regarding adequacy of monitoring during

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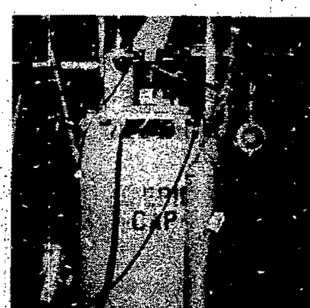
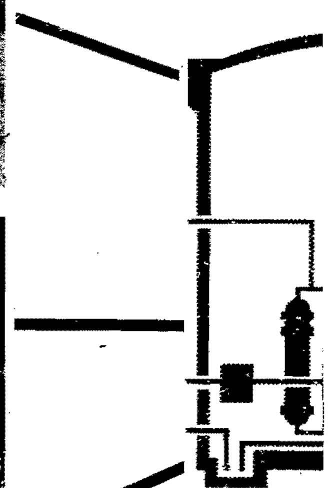
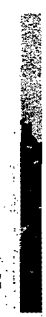
Polar Crane Inspection

Gross Decontamination



Basement Water Processing





SDS & EPICOR Waste Shipments

the venting of ^{85}Kr from the Reactor Building—a prerequisite for manned entries. The program was designed to provide a credible source of information about radiation levels to the citizens in the communities adjacent to TMI during ^{85}Kr venting. The program represented a unique effort to build citizen confidence in public information and remains active in six communities today.

As manned entries into the Reactor Building increased, the TI&EP sponsored early inspections of the polar crane. These inspections provided recovery engineers with vital information on the extent of damage to the crane so that a safe, cost effective refurbishment of the necessary crane components could be conducted as expeditiously as possible. TI&EP engineers also provided technical electrical engineering evaluations to support the polar crane recovery—a critical path milestone for head removal that was completed in February 1984.

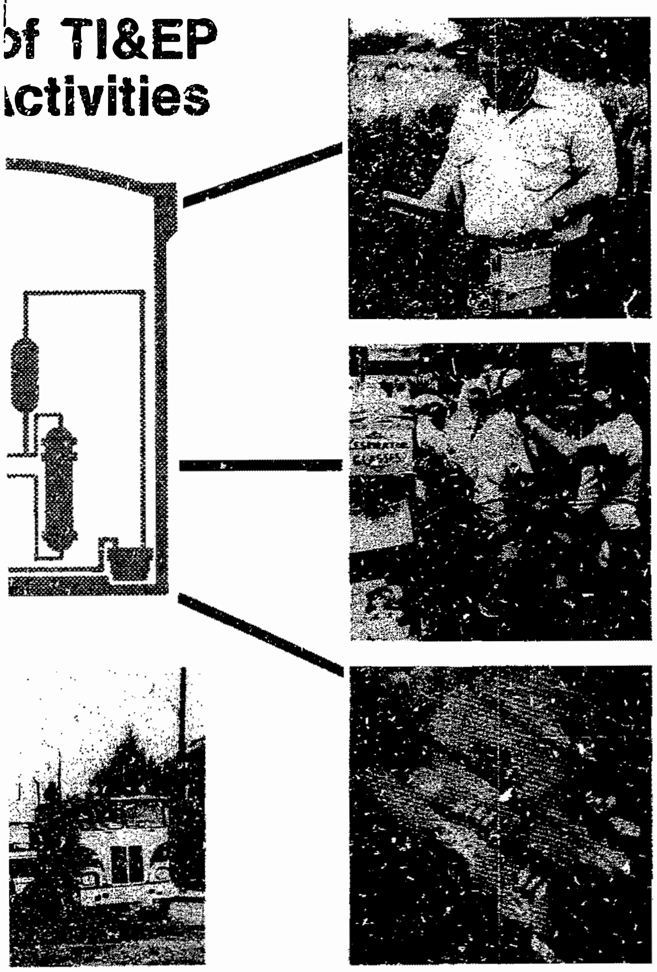
Probably the single TI&EP sponsored event that provided the greatest impact on the cleanup occurred in July and August of 1983 when the first inspections inside the reactor were conducted. Not only did this activity provide the first pictures of the actual conditions of the core, but it conclusively demonstrated that work in and around the reactor itself could be performed safely and efficiently. The activity, called "Quick Look," also proved that reactor internal components could be safely removed and handled and it paved the way for future underhead and in-vessel (core) characterization programs.

Other TI&EP activities also provided valuable contributions to the cleanup, but were not nearly as visible as Quick Look or head lift. Some of those activities included the gross decontamination experiment designed to determine the most effective means of reducing loose surface contamination, fission product deposition and mass balance, Reactor Building characterization, and shipping and disposal of accident generated wastes.

A major milestone in the Waste Immobilization Program was reached in the summer of 1983 when the last ion-exchange wastes used to decontaminate accident water were shipped from the Island for research and development projects and disposal. The two ion-exchange media systems, called EPICOR II and Submerged Demineralizer System (SDS), decontaminated more than a million gallons of accident generated water and captured approximately 95% of the radioactive elements released from the Reactor Coolant System as a result of the accident. (See articles published in previous editions of the *Update*.)

Another major cleanup milestone, elution of cesium from the plant's Makeup and Purification System demineralizer resin, is scheduled for completion in late 1984. Completion of this activity will essentially complete the Waste Immobilization Program's role in the TMI-2 cleanup.

of TI&EP Activities



Community Monitoring Program

First Manned Entry

Quick Look

Now that the head has been removed, the major thrust of the TI&EP is toward plenum removal. In addition, the defueling and core shipping phase is gaining momentum.

The plenum inspection equipment has already arrived on the Island, and training for the actual plenum inspections is well underway. The inspections, scheduled to begin in October, will be followed by removal of fuel rod stubs that are adhering to the plenum's underside. Once this step is complete, the plenum will be raised some 2-1/2 inches using hydraulic jacks to check for intact fuel assembly separation. This operation is currently scheduled to be completed by the end of 1984 and will be followed by transport of the plenum assembly to a storage stand located in the deep end of the refueling canal in the spring of 1985.

The defueling and core shipping activities have made significant progress. Westinghouse Electric Corporation, the defueling equipment contractor, has completed the preliminary design for the defueling tooling. The tooling final design and fabrication are expected to be completed before July 1985, when early defueling is currently scheduled to begin. Early defueling, which basically consists of a vacuuming technique, is projected to be completed by early fall of 1985 and will be followed by bulk defueling. Preliminary design of the fuel shipping/storage canisters is essentially complete. The first canisters are scheduled for delivery in early spring.

After completing many months of engineering evaluations and studies, TI&EP engineers selected the cask designed for rail shipping as the best method for transporting the TMI-2 core to the Idaho National Engineering Laboratory (INEL). Based on this concept, engineers have begun the preliminary cask design.

In addition to the plenum and core activities, the TI&EP is continuing to support the cleanup effort by analyzing samples of core materials and internal components. These efforts, as well as similar efforts in the past, will provide GPU Nuclear recovery engineers with the necessary data to formulate the best approach in solving complex recovery problems. □

Videotapes Detail Head Removal Operations and Successful Waste Disposal System

The TI&EP recently completed two videotapes, now available for loan without charge. One of the programs, titled "TMI-2 Head Removal—One Step Closer to Recovery," details the head removal operation carried out July 24 through July 27, 1984, in Unit 2 at TMI. With actual footage from inside the Reactor Building, this videotape takes the viewer step-by-step through the lift, transport, and storage of the reactor vessel head. The program also discusses the followup work of shielding and covering the opened reactor vessel and some of the preparatory work done in the months previous to the major event.

"EPICOR II: The Evolution of a Successful Waste Disposal System," also recently released, examines how this demineralizer system processed contaminated water through three stages of organic and inorganic ion-exchange media. The videotape specifically discusses EPICOR II system processing of the water, development of a prototype gas sampler that sampled and purged the EPICOR II liners of radiolytic gas, shipments of the liners to the INEL for major research and development studies, and preparations for liner burial in high integrity containers. □

These videotapes may be obtained by contacting Kim Haddock, EG&G Idaho, Inc., TMI Site Office, P.O. Box 88, Middletown, PA 17057, telephone FTS 590-1019 or (717) 948-1019.

TMI-2 TOPICS

TWO DEBRIS CHARACTERIZATION TECHNIQUES FIELD-PROVEN

Engineers at TMI and the INEL have completed an extensive study of various nondestructive assay methods to locate and characterize debris distributed in the TMI-2 primary coolant and connecting piping systems. As a result of this work, they have found two techniques to be highly feasible.

The first technique, ultrasonic detection, uses ultrasound beamed through the pipe wall, then reflected back from the surface being examined. From the reflected ultrasound, or echo, a small computer constructs a contour map of the pipe's inner surface and the debris. Using this technique, engineers are capable of locating a full range of debris, including complete and fragmented fuel pellets, pieces of nonfuel material, and fine powder.

The second technique, passive gamma-ray detection, uses measurements of the gamma rays associated with the decay of certain fission products in fuel to detect and characterize fuel debris in the piping. A high-resolution gamma spectrometer was used in experiments to detect the fission product ^{144}Ce, chosen for its chemical inertness, low volatility, long half-life, and associated high-energy gamma rays.

Each technique has its disadvantages, but both are field-proven, and test engineers believe the advantages far outweigh the disadvantages. Among the disadvantages, the ultrasonic method cannot distinguish between fuel and nonfuel debris, and the shell walls of piping insulation degrade acoustic signals, so the insulation must be removed for the ultrasonic technique to be effective. The passive gamma-ray technique cannot detect nonfuel debris.

However, the advantages are the gamma-ray technique is especially appropriate for assaying fuel debris in piping, whether or not the pipe is insulated. Also, the two techniques are complementary; used together, engineers can locate fuel and nonfuel debris, determine fuel and nonfuel fractions, and measure the amount, thickness, and physical distribution of all forms of debris in reactor plant piping systems. And both techniques use commercially available equipment.

BIAS VOLTAGE MEASUREMENTS OF LPM CHARGE CONVERTERS MORE RELIABLE

In all pressurized water reactors licensed since 1976, the proper operation of the loose parts monitoring (LPM) system of the reactor vessel and related reactor coolant components must be demonstrated on a regular basis. In some reactors, the system's performance is a limiting condition for continued operation. But the normal routine surveillance procedures, which rely on audio output, will not detect when the system is degrading. A more reliable method of monitoring the state-of-health of an LPM system is by taking regular dc bias voltage measurements of the converters. This is the conclusion of the DOE Instrumentation and Electrical (I&E) Program, which has been researching selected instrumentation and electrical components used in TMI-2 and other nuclear power facilities.

After studying LPM system charge converters removed from the TMI-2 and Sequoyah-1 nuclear power stations, I&E engineers found that the converters, which use field effect transistors of metal oxide silicon, degraded as a function of accumulated radiation dose. These converters, however, were not designed to be radiation tolerant, nor does the manufacturer, Endevco, claim them to be. The TMI-2 instruments had been mounted in low radiation dose areas but failed after being exposed to unusually high radiation after the accident. The Sequoyah-1 charge converters had been mounted under the reactor vessel where they failed as a result of high accumulated radiation dose after 156 effective full-power days.

Plants that use charge converters that are not radiation qualified are recommended to take regular measurements of converter dc bias voltage, which will shift upwards as radiation dose is accumulated until the limit of the power supply rail voltage, normally 30 volts, is reached. By measuring the charge converter dc bias voltage and looking for a higher-than-normal level, plant operators can effectively monitor radiation degradation. The normal bias voltages for the TMI-2 and Sequoyah-1 charge converters were 13.5 and 13 volts, respectively.

In monitoring the converter's audio output, the only normal indication of degradation is a decrease in the usual background vibration levels; this output is not a constant that would indicate to personnel that the converter degraded since its last test. Consequently, a plant could be operating in violation of technical specifications and U.S. NRC Regulatory Guide 1.133 R1, with control room personnel unaware of the condition.

In response to its failed charge converters, Sequoyah-1 replaced its units with temperature and radiation hardened converters. All nuclear power plants are recommended to consider installing charge converters with temperature and radiation tolerant components able to withstand normal plant conditions. Strategic location and shielding of converters can also significantly reduce radiation damage, prolong the service life, and increase the reliability of radiation sensitive equipment installed in a reactor building.

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