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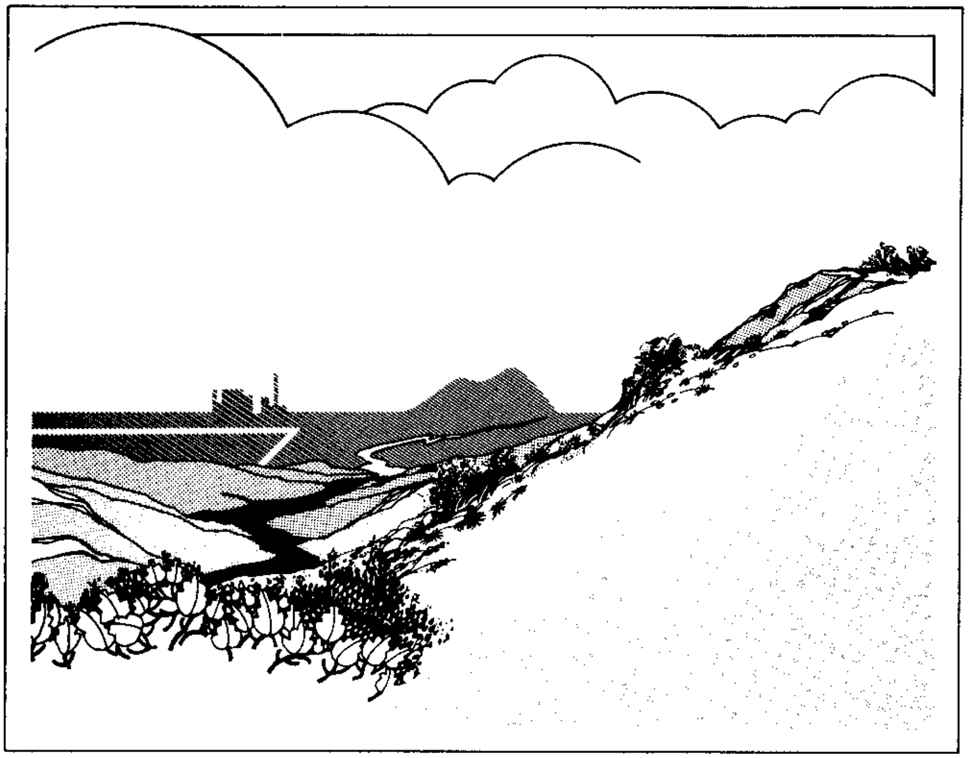
September 1989

Final Report: Decontamination and Decommissioning of Heat Transfer Reactor Experiment Test Assemblies HTRE-2 and HTRE-3

Thomas K. McCusker

FORMAL REPORT



EG&G Idaho

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FINAL REPORT: DECONTAMINATION AND DECOMMISSIONING OF HEAT TRANSFER REACTOR EXPERIMENT TEST ASSEMBLIES HTRE-2 AND HTRE-3

Thomas K. McCusker

Published September 1989

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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Idaho Operations Office
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ABSTRACT

The purposes of this report are to describe the decontamination and decommissioning (D&D) of Heat Transfer Reactor Experiment (HTRE) test assemblies HTRE-2 and HTRE-3 at the Idaho National Engineering Laboratory during 1987, 1988, and 1989, and the conditions existing after completion of D&D activities. The primary objectives of the D&D Project were to remove all accessible radioactive and hazardous contamination from the assemblies, to seal all system openings, and to relocate the assemblies from the Test Area North to the Experimental Breeder Reactor-I area in a safe configuration for permanent public display.

EXECUTIVE SUMMARY

This is the final report on the decontamination and decommissioning (D&D) of Heat Transfer Reactor Experiment (HTRE) test assemblies HTRE-2 and HTRE-3 at the Idaho National Engineering Laboratory. The D&D work was done by EG&G Idaho, Inc., on behalf of the Department of Energy, Idaho Operations Office (DOE-ID).

The HTRE-2 and HTRE-3 assemblies were operated as part of the Aircraft Nuclear Propulsion (ANP) Program, begun in 1951, to test the feasibility of using direct-air-cycle nuclear reactors to propel an aircraft for long periods of time (up to 1000 hr). At completion of the ANP Program in 1961, the test assemblies were drained of most liquids and stored on the rail system at the Test Area North (TAN).

The test assemblies were assigned to the Decontamination & Decommissioning Program in 1978 for ultimate disposal. A 1979 decision analysis concluded that the assemblies should be dismantled and buried at the Radioactive Waste Management Complex (RWMC). A 1984 study concluded that the assemblies should be dismantled at the TAN Technical Support Facility area in the then inactive hot shop. In 1986 efforts were initiated to plan the dismantlement of the assemblies. At this time, preservation was explored and eventually chosen as an alternative decommissioning method. Investigation and planning for preservation involved EG&G Idaho, the DOE-Headquarters, the DOE-ID, the State of Idaho, and the Smithsonian Insititution.

Preparations for display of the assemblies were made in 1987 and 1988. Activities included removal of all asbestos-containing materials from the assemblies, removal of residual mercury from the HTRE-3 assembly, and design of a display pad at the Experimental Breeder Reactor-I area at the INEL. The display pad was completed in November 1988, and the test assemblies were relocated by a subcontractor over INEL roadways to the EBR-I area in early December 1988.

To complete the display of the assemblies, walkways were paved around and between the assemblies, and fences were erected to prevent direct access to the assemblies. Interpretive panels telling the history and significance of the assemblies were mounted on the fences. A gazebo to house the interpretive panels will be constructed in the center walkway between the assemblies by the end of September 1989. Vehicle barriers were constructed for parking control. The assemblies were first available for viewing on May 22, 1989.

CONTENTS

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

ANP	Aircraft Nuclear Propulsion (Program)
CFA	Central Facilities Area
COCA	Consent Order and Compliance Agreement
CTF	Contained Test Facility
D&D	decontamination and decommissioning
DOE-ID	Department of Energy, Idaho Operations Office
DOE-HQ	Department of Energy, Headquarters
EBR-I	Experimental Breeder Reactor-I
ESQ	Environmental, Safety, and Quality (Department)
HTRE	Heat Transfer Reactor Experiments
HTRE-1	Heat Transfer Reactor Experiment No. 1
HTRE-2	Heat Transfer Reactor Experiment No. 2 (assembly)
HTRE-3	Heat Transfer Reactor Experiment No. 3 (assembly)
IET	Initial Engine Test (facility)
MWSF	Mixed Waste Storage Facility
NEPA	National Environmental Policy Act
NRF	Naval Reactors Facility
RWMC	Radioactive Waste Management Complex
TAN	Test Area North
TSF	Technical Support Facility
WERF	Waste Experimental Reduction Facility

FINAL REPORT: DECONTAMINATION AND DECOMMISSIONING OF HEAT TRANSFER REACTOR EXPERIMENT TEST ASSEMBLIES HTRE-2 AND HTRE-3

INTRODUCTION AND BACKGROUND

The purpose of this report is to describe the decontamination and decommissioning (D&D) of Heat Transfer Reactor Experiment (HTRE) test assemblies HTRE-2 and HTRE-3 at the Idaho National Engineering Laboratory. The D&D work was completed during 1987, 1988, and 1989 by EG&G Idaho, Inc., acting on behalf of the U.S. Department of Energy, Idaho Operations Office (DOE-ID).

The HTRE-2 and HTRE-3 assemblies were decontaminated at the Test Area North (TAN) and relocated for permanent public display at the Experimental Breeder Reactor-I (EBR-I) area.

The HTRE power plants were developed and tested during the 1950s as part of the Aircraft Nuclear Propulsion (ANP) Program, operated by General Electric for the U.S. Air Force and the U.S. Atomic Energy Commission. The concept investigated during the ANP work at the INEL was a direct-air-cycle reactor powering turbojets. After testing and refinement of the equipment, the Air Force intended to construct and operate a long-range airplane, powered by a nuclear reactor, that could stay aloft for as long as 1,000 hr. The airplane and the actual reactors to be used to power it were never constructed.

The ANP Program was terminated in 1961 by President John F. Kennedy after 14 years of research and about $1 billion in costs. Three experiments were successfully conducted under the program: HTRE-1, HTRE-2, and HTRE-3.

The first reactor operated in the program was the HTRE-1 reactor. This was a direct-air-cycle reactor that used nickel-chromium, uranium-oxide dispersion fuel elements. Water served the combined function of moderator and structural coolant. The HTRE-1 reactor first operated a modified General Electric turbojet engine exclusively on nuclear power in January 1956. The HTRE-1 reactor was operated throughout 1956, accumulating a total of 150.8 hr of operation at high nuclear power levels, which exceeded the design objective of 100 hr of operation.

The HTRE-2 reactor was a modification of the HTRE-1 core that allowed removal of a center fuel assembly. This removable module allowed experimentation with different core materials and configurations. It provided a core hexagonal center hole, 28 cm (11 in.) across flats, with an active length of 76 cm (30 in.). The center hole was used in testing insert sections for advanced reactors. The HTRE-2 operation started in July 1957 and accumulated 1353 hr at high nuclear power levels. Insert test sections consisted of metallic fuel elements combined with air-cooled hydrided zirconium moderators. Beryllium oxide fuel elements for use in ceramic reactors were also tested. Inserts were operated at material temperatures up to 2800°F for extended periods of time. They were operated at even higher temperatures for short periods of time.

The HTRE-3 reactor was built in a full-scale aircraft reactor configuration using nickel-chromium fuel elements of the HTRE-1 type and an air-cooled hydrided zirconium moderator. To simulate the actual configuration that would be needed to allow mounting on an airplane, this reactor was designed in a horizontal plane rather than the vertical plane used in HTRE-2 and common to most U.S. nuclear power plants. Two modified turbojets were operated by the reactor. Full nuclear power was achieved in 1959. The system operated for a total of 187 hr, exceeding the design objective of 100 hr.

When the ANP Program was cancelled, the designs for the reactor and the airplane had been finalized and work was under way to survey the site for a runway. Although the project was abandoned, much of the research performed became the basis for later designs and technologies. For example, before the ANP Program, reactors were large and bulky (500 to 1,000 tons, or 453,000 to 906,000 kg). The ANP reactors were reduced to 100 tons (90,600 kg). The ANP reactor development contributed to the advancement of the gas-cooled reactor design. Other benefits from the program included the following: development of a new nickel-molybdenum alloy; the development of beryllium fabrication techniques; new technology in the field of high-temperature liquid metal pumps, seals, heat exchangers, and instrumentation; and a vast database of information and operating experience. In addition, the facilities left behind have been in constant use since 1961 to support numerous Government-funded projects conducted at the INEL.

The test assemblies were assigned to the Decontamination & Decommissioning (D&D) Program in 1978 for ultimate disposal. A 1979 decision analysis concluded that the assemblies should be dismantled and buried at the Radioactive Waste Management Complex (RWMC), and a D&D plan[1] was written. A 1984 study concluded that the assemblies should be dismantled at the TAN Technical Support Facility (TSF) area in the then inactive hot shop. In FY-1985 the INEL D&D Program, in conjunction with the Idaho State Historic Preservation Officer, decided that the HTRE test assemblies represented a unique chapter in the history of nuclear power applications and thus should be preserved. At this time the INEL began consultations with the Smithsonian Institution about the possibilities of preserving the assemblies. In 1986 it was decided to decontaminate and transport the HTRE assemblies to the EBR-I area and to place them on permanent public display.

DESCRIPTION OF FACILITY PRIOR TO DECOMMISSIONING

Physical Condition

HTRE-2. The HTRE-2 test assembly consists of the Core Test Facility and the nuclear reactor. This facility included a mobile dolly, turbojet engines, shield tank, ducting, and accessory systems. Figure 1 is a photograph of the HTRE-2 assembly at the near-end of the ANP Program, circa 1960.

All of the Core Test Facility components were mounted on a structural steel platform called the dolly. The platform was supported by four standard railroad trucks, which enabled the assembly to be moved along the four-rail track system at the TAN TSF between the hot shop, the cold shop, and the Initial Engine Test (IET) facility, where the tests were conducted.

The largest component mounted on the dolly was the shield tank assembly, which provided nuclear shielding for the reactor core. The tank contained steel, lead, and borated water as shielding materials. The water was drained from the system when the program was terminated. The tank also contains the core-plug assembly, the pressure vessel (which held the core), and ducting that carried the air from the torus-shaped plenums to the reactor.

HTRE-3. The HTRE-3 test assembly consists of a reactor, side shield, front and rear shield, external auxiliary shielding, engine reactor ducting, a chemical combustor with surrounding auxiliary shield, accessories, controls, and two turbojet engines. Figure 2 is a photograph of the HTRE-3 assembly circa 1960. The turbomachinery and much of the ducting were removed prior to 1978. The assembly was located on a rail-mounted dolly to allow servicing in the TAN hot shop facilities and testing at the IET facility.

Following the termination of the ANP program, the HTRE-2 and HTRE-3 assemblies were made available for salvaging of components by other programs. The diesel engines for fan/auxiliary power were removed, the instrumentation was taken, and the HTRE-3 turbojets were removed and buried at the RWMC. Figures 3 and 4 show the HTRE-2 and HTRE-3 assemblies, respectively, in 1978 after salvaging of components and prior to D&D efforts.

Radiological Conditions

Radiation measurements and calculations indicated that the region inside each core shield probably had a radiation level too high to allow disassembly of the core shield. Because of the radiation hazard presented by the reactor system internal structures, the D&D Plan[2] called for all internal system openings to be permanently sealed. Table 1 lists the maximum radiation levels, prior to D&D activities, at given distances for the HTRE-2 and HTRE-3 assemblies.

Hazardous Material Conditions

The HTRE-3 had a shield augmentation system to provide additional gamma shielding after reactor shutdown by replacing the water in the primary shield outer tank with mercury. During augmentation, the primary shield contained 24,000 kg (53,000 lb) of mercury, which provided the necessary mass around the reactor to facilitate contact maintenance. Following completion of the testing program the shield systems were drained, but small amounts of mercury remained in the shield and associated piping.

Both HTRE test assemblies had small amounts of asbestos-containing pipe insulation on system piping.

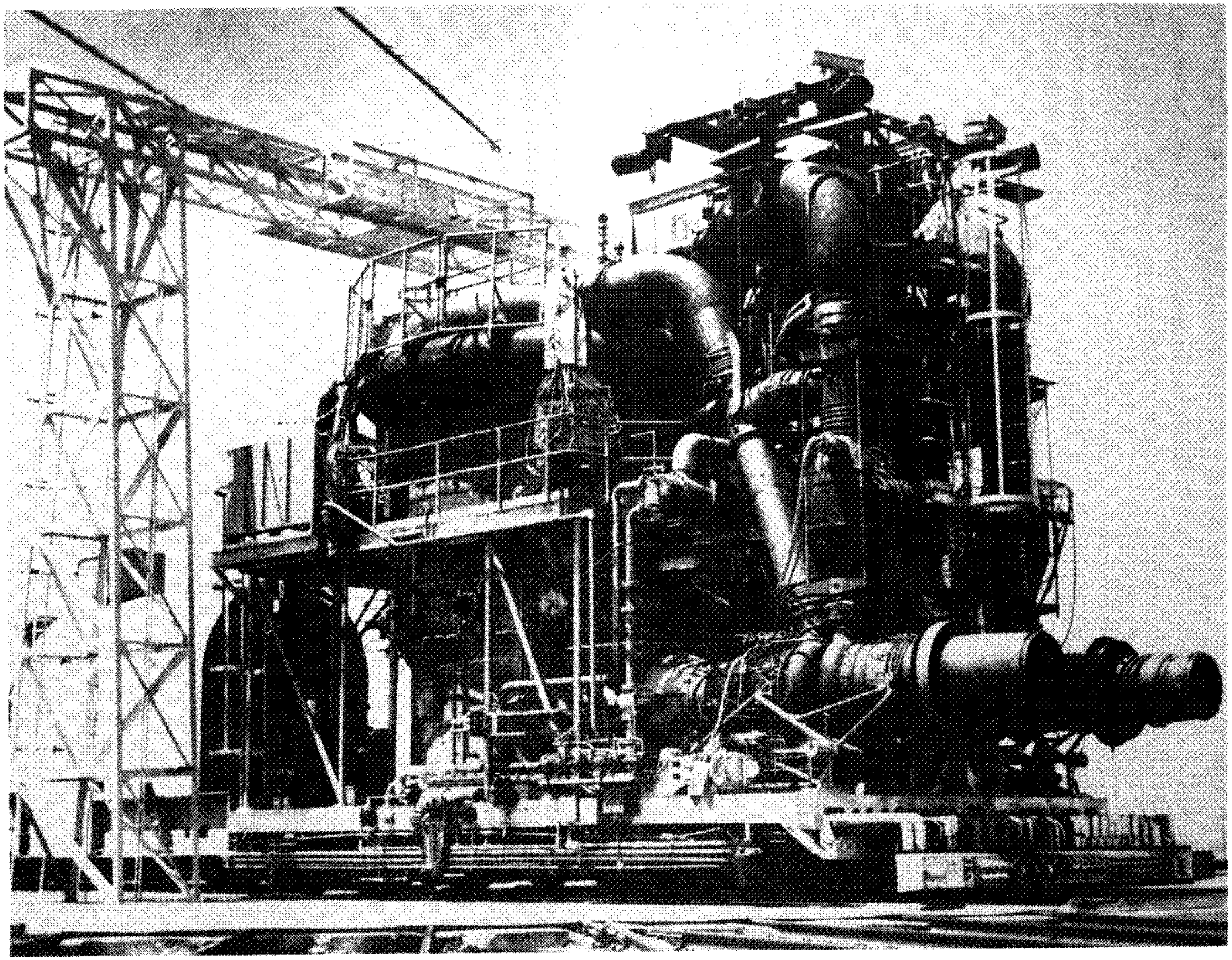

Figure 1. The HTRE-2 assembly at the near-end of the ANP Program, circa 1960.

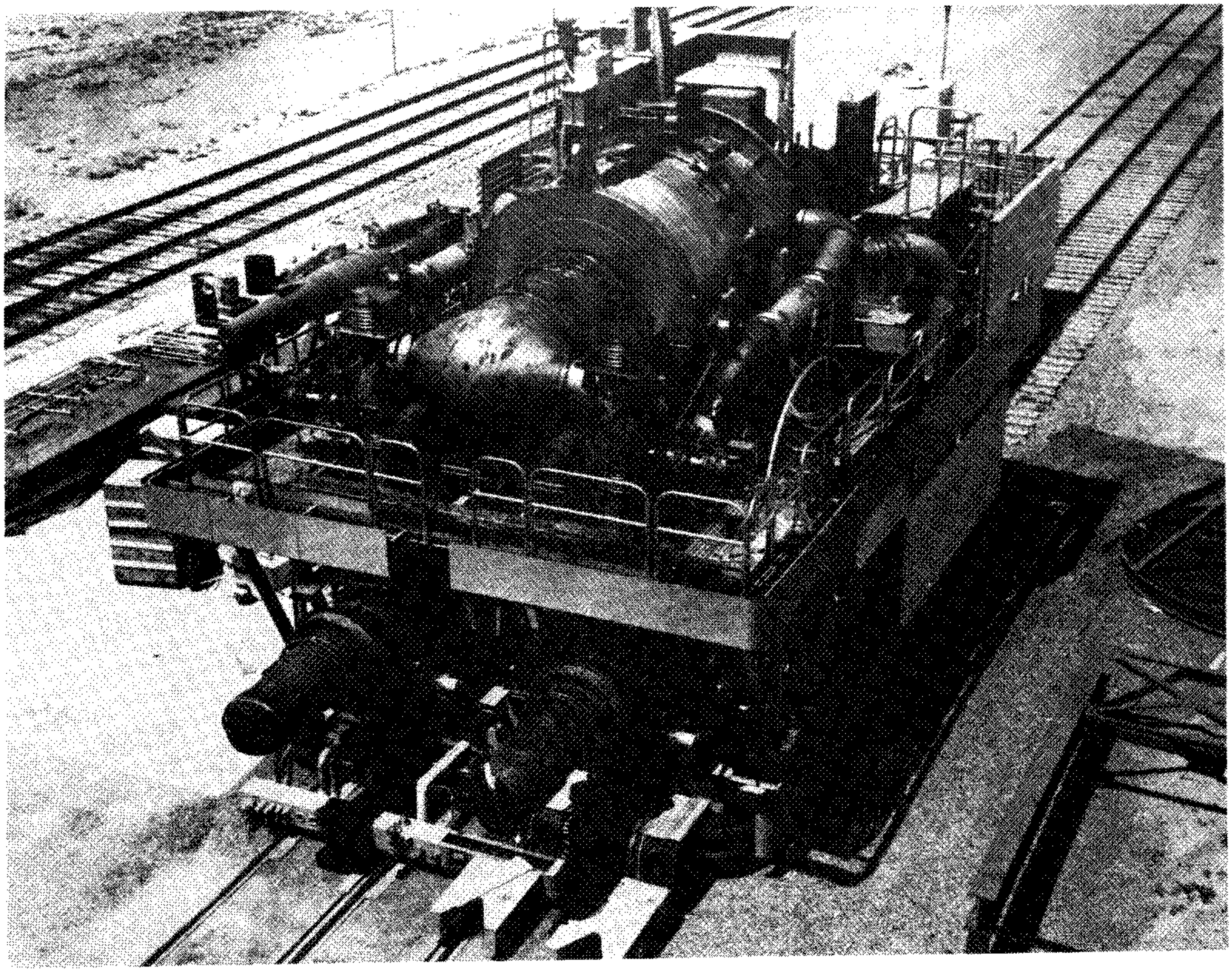

Figure 2. The HTRE-3 assembly at the near-end of the ANP Program, circa 1960.

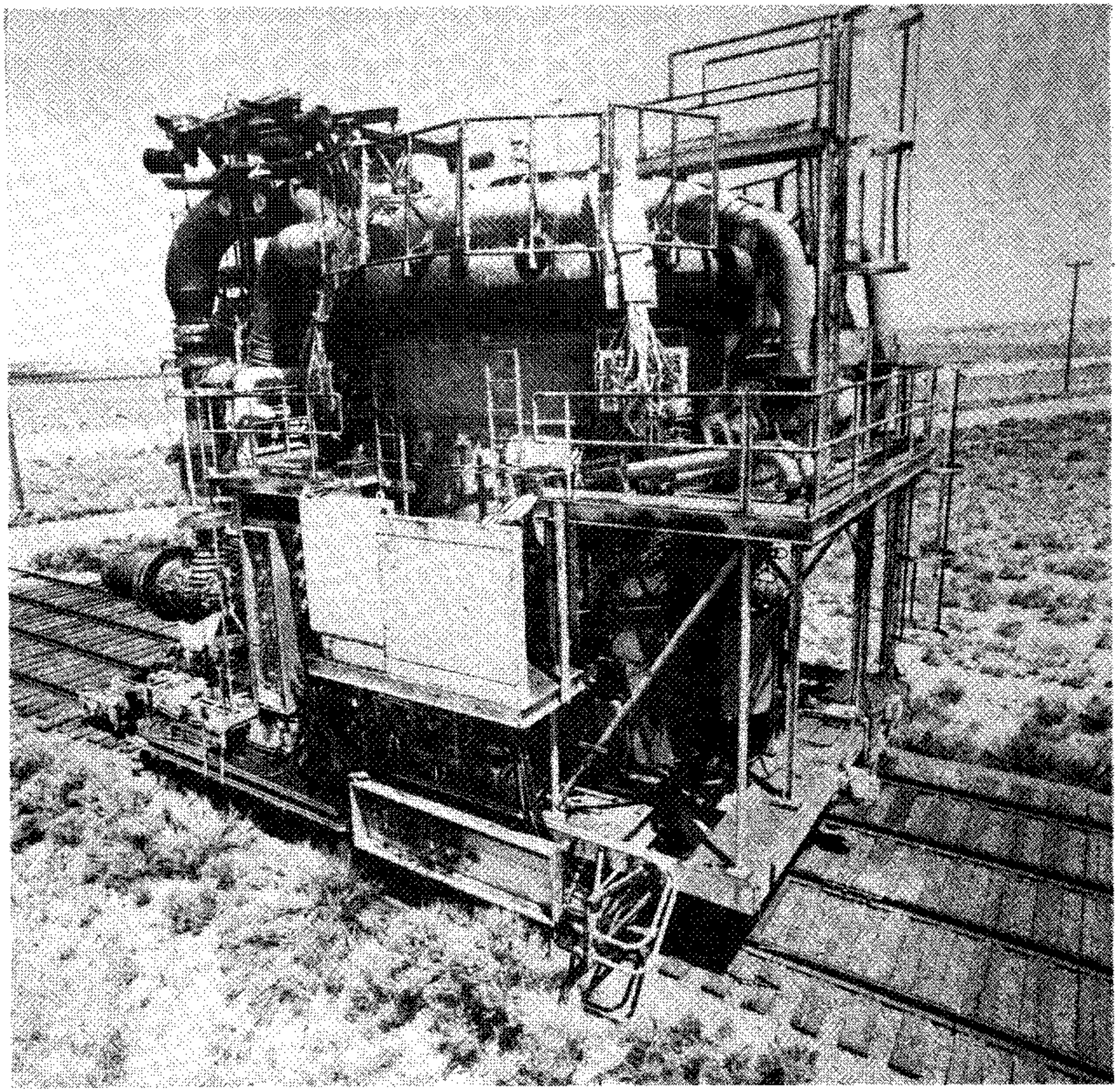

Figure 3. The HTRE-2 assembly in 1978 after salvaging of components and prior to D&D efforts.

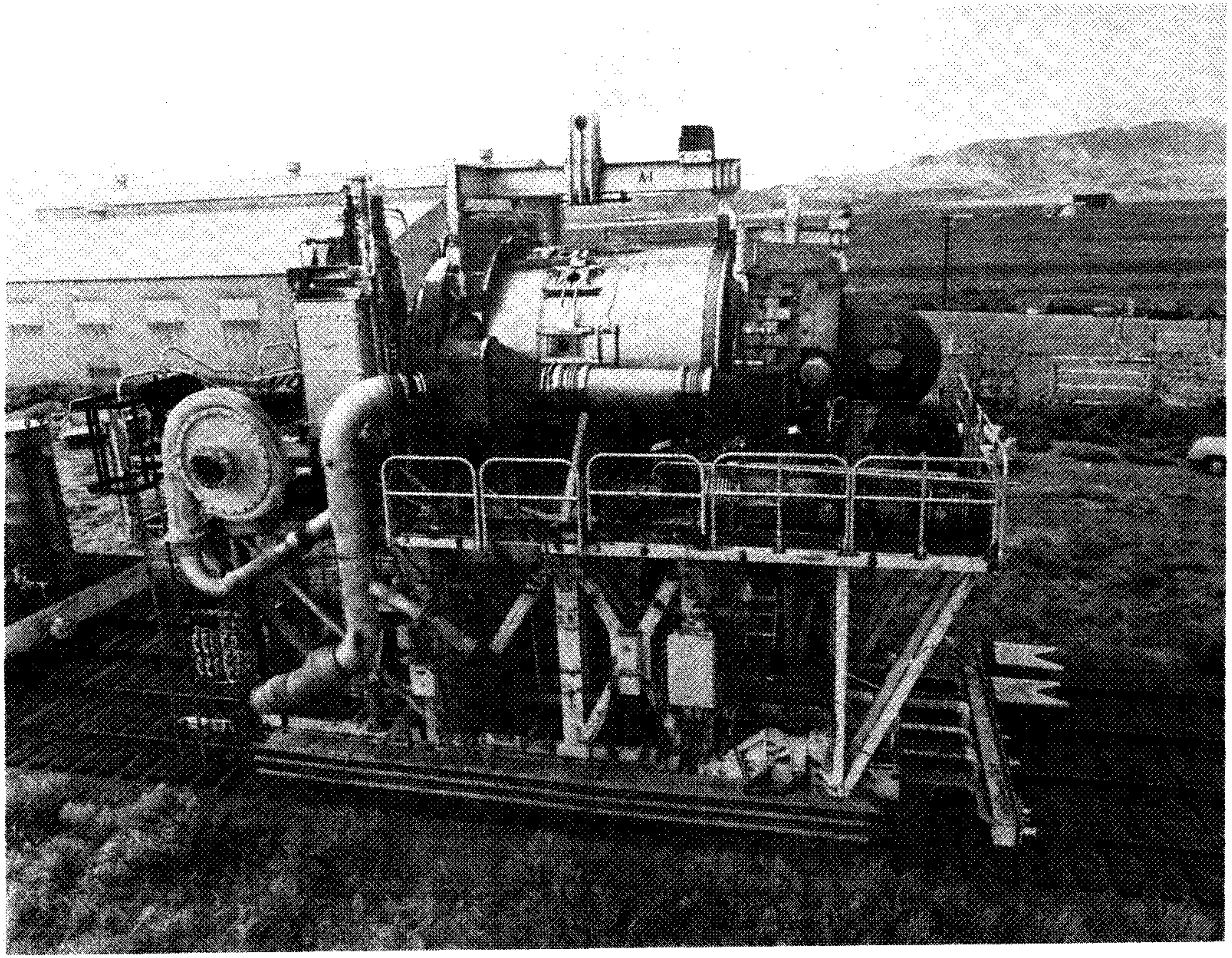

Figure 4. The HTRE-3 assembly in 1978 after salvaging of components and prior to D&D efforts.

Table 1. Maximum radiation levels, prior to D&D activities, for the HTRE-2 and HTRE-3 assemblies

Assembly	Distance (ft)	Maximum Radiation Level (mR/h)
HTRE-2	1/2	0.4
HTRE-2	3	0.3
HTRE-2	20	0.3
HTRE-2	40	0.15
HTRE-3	1/2	0.15
HTRE-3	3	0.15
HTRE-3	20	0.1
HTRE-3	40	0.1

OBJECTIVES

The objectives of the HTRE D&D Project were to decontaminate and move two excessed, contaminated nuclear power plants, HTRE-2 and HTRE-3, from their location near the TAN TSF area to the EBR-I area, and to place them in a safe configuration for permanent public display. Figure 5 shows the HTRE-2 and HTRE-3 assemblies at the TAN TSF area at the beginning of the HTRE D&D Project.

The project met the requirements of various rules and regulations regarding protection of workers and the environment. The general objective of the conduct of the D&D operations was to take all reasonable measures to minimize worker exposure to radiological, chemical, and industrial hazards and to prevent the release of contaminants to the environment.

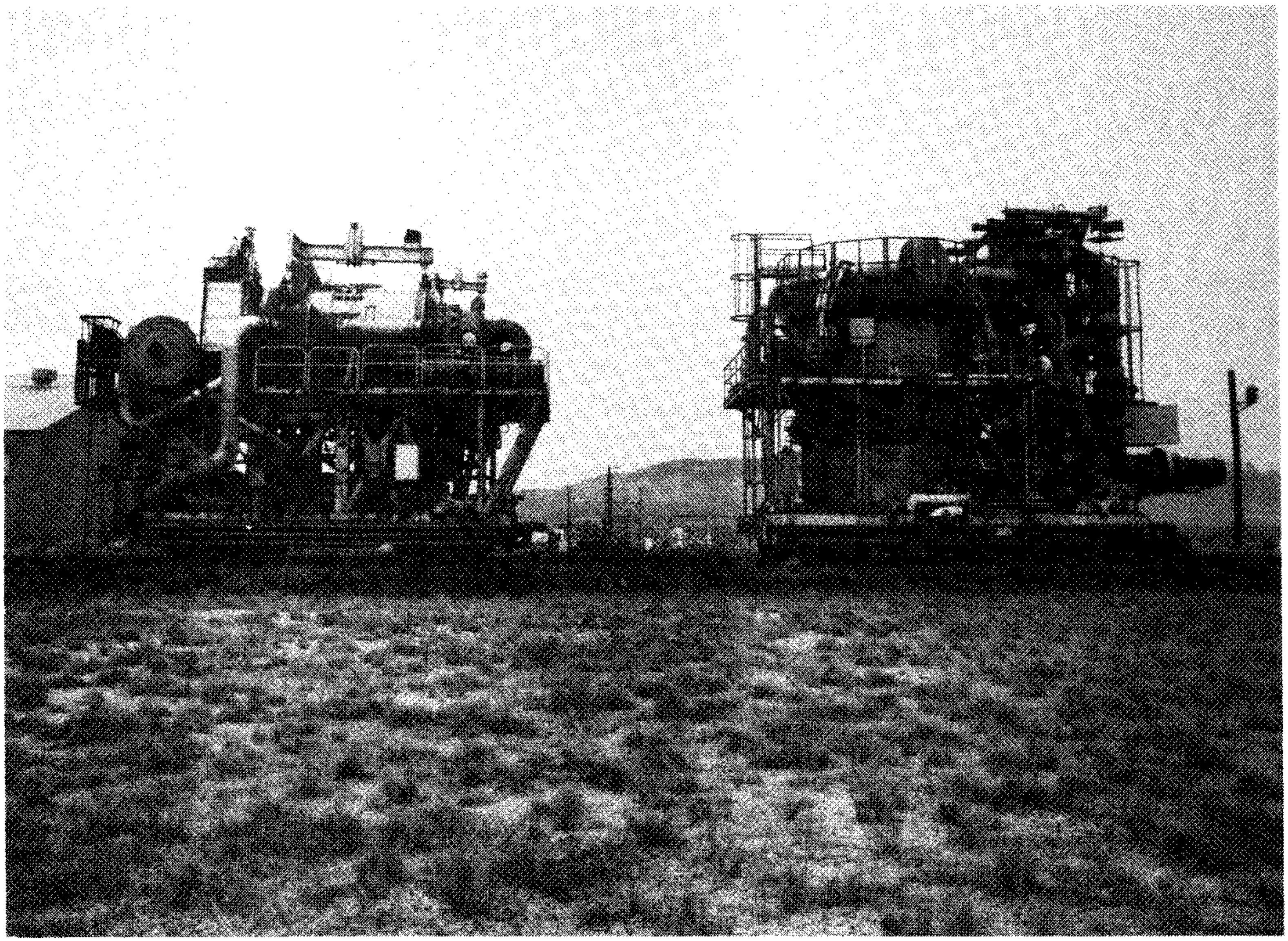

Figure 5. The HTRE-2 and HTRE-3 assemblies at the beginning of the D&D Project.

Project Management/Engineering

Project management was provided by the Environmental, Safety, and Quality (ESQ) Department. A project engineer was assigned full time to the project and was responsible for the planning, coordination, and overall direction of the project. He was responsible for the budget, schedule, and reporting of the project. The project engineer was supported by the technical staff of the ESQ Department in the preparation of activity specifications, operating procedures, a relocation report, and the final D&D report. Engineering support was obtained on an "as needed" basis through work releases.

Prior to 1986, plans called for dismantling the test assemblies and burying them at the RWMC.[1] At this time, preservation was explored and eventually chosen as an alternative decommissioning method. Investigation and planning for preservation involved EG&G Idaho, the DOE-Headquarters, the DOE-ID, the State of Idaho, and the Smithsonian Institution. The D&D Plan was revised accordingly.[3]

The D&D Plan provided a work breakdown structure (see Figure 6) and specified project management responsibilities, including control of budget, schedule, and work. It also specified reporting requirements and contained an environmental assessment and a safety evaluation.

The D&D Plan was used to develop the necessary work packages. Safety review and approval of the D&D Plan, work packages, and safety engineering criteria were provided by the appropriate EG&G Idaho and DOE-ID organizations.

The D&D Plan was revised again in June 1988[2] to reflect the intent to relocate the HTRE-2 and HTRE-3 assemblies at the EBR-I area.

In November 1988 a transportation plan was written and approved[4] for moving the assemblies from the TAN to the EBR-I area.

In preparation for the planned workscope, the necessary notifications and documents were prepared and submitted to the appropriate organizations. These included an asbestos removal notification and National Environmental Policy Act (NEPA) documentation. For this project, NEPA documentation was prepared for the restoration activities as well as for the construction of the display pad area. Work was not initiated until the appropriate notification was made and/or the NEPA documentation was finalized.

The HTRE-3 was included in the INEL Consent Order and Compliance Agreement (COCA). As required, a closure plan was submitted and approved by the State of Idaho and the Environmental Protection Agency Region X.

Site Preparation

To present these assemblies as a public display, EG&G consulted with the Smithsonian Institution about the format of the display. In June 1988 a designer from the Smithsonian came to the INEL to view the assemblies and potential display sites and arrangements. At the close of this visit it was decided that the assemblies would be moved from the TAN and placed adjacent to the EBR-I National Historic Landmark. The configuration of the test assemblies was restored to as close to original condition as possible through the remounting of loose hardware, ductwork, etc., and removal of miscellaneous debris.

A pad was designed to support the assemblies and show an example of the unique four-track railroad system that was used to move the assemblies at the TAN TSF area. This concrete pad was constructed (see Figure 7) and made ready to accept the test assemblies.

Decommissioning Operations and Waste Disposal

The D&D operations began with the transportation of the test assemblies to the Contained Test Facility (CTF) for decontamination. Figure 8 shows the HTRE-3 assembly being transported to the CTF, wrapped in plastic to prevent the spread of asbestos and mercury during transport. The decontamination operations took place within a temporary enclosure built within the CTF (see Figure 9). The enclosure provided a controlled environment for asbestos removal and mercury flushing operations. The enclosure had a high-efficiency particulate air exhaust system (see Figure 10), which created a negative pressure within the enclosure and exhausted into the CTF exhaust system.

All asbestos-containing insulation material was removed from both assemblies and disposed of at the CFA Landfill. Figures 11 and 12 show a worker

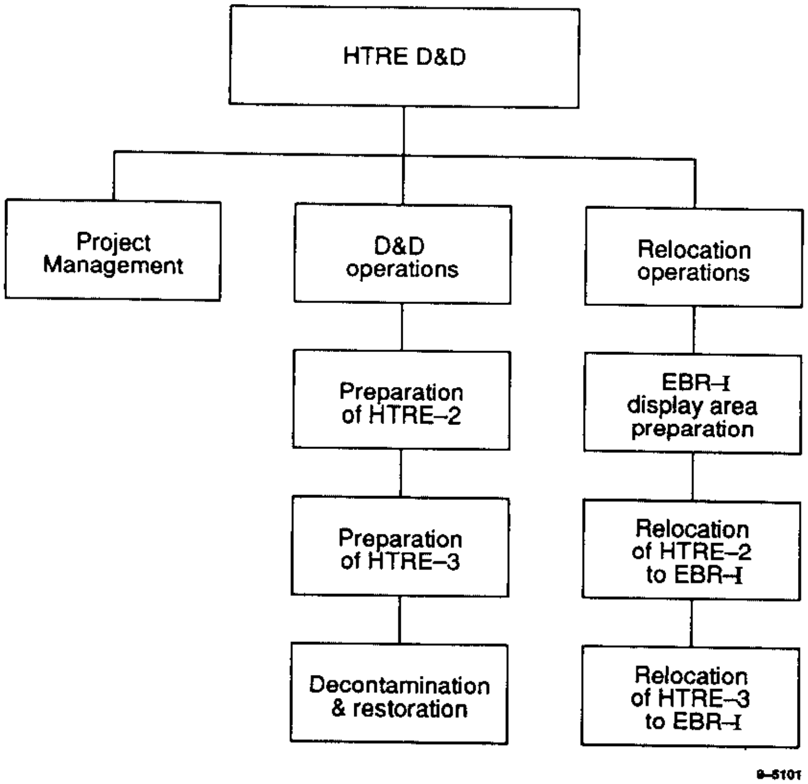

Figure 6. Work breakdown structure for the HTRE D&D Project.

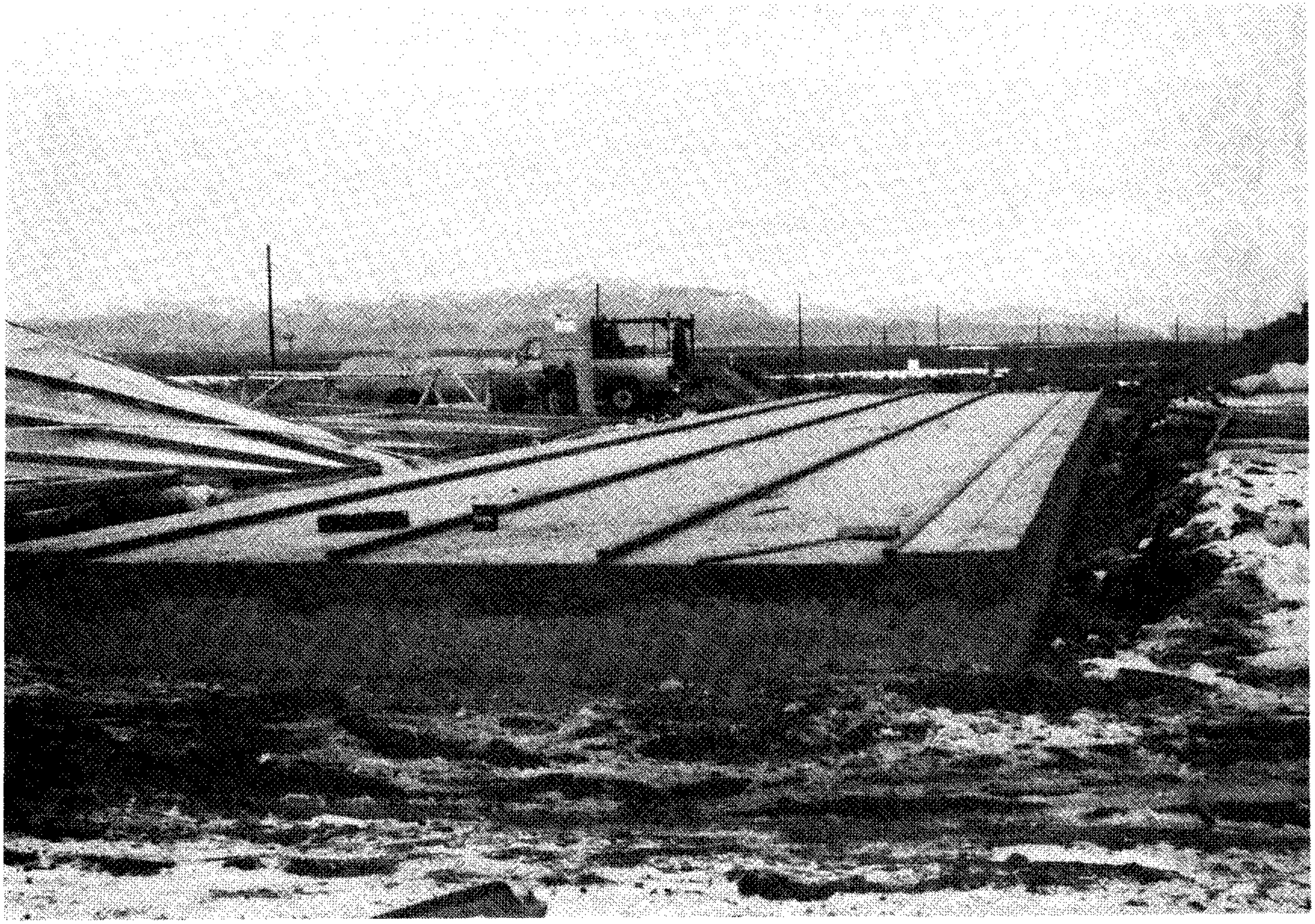

Figure 7. Construction of concrete pad for displaying test assemblies at the EBR-I area.

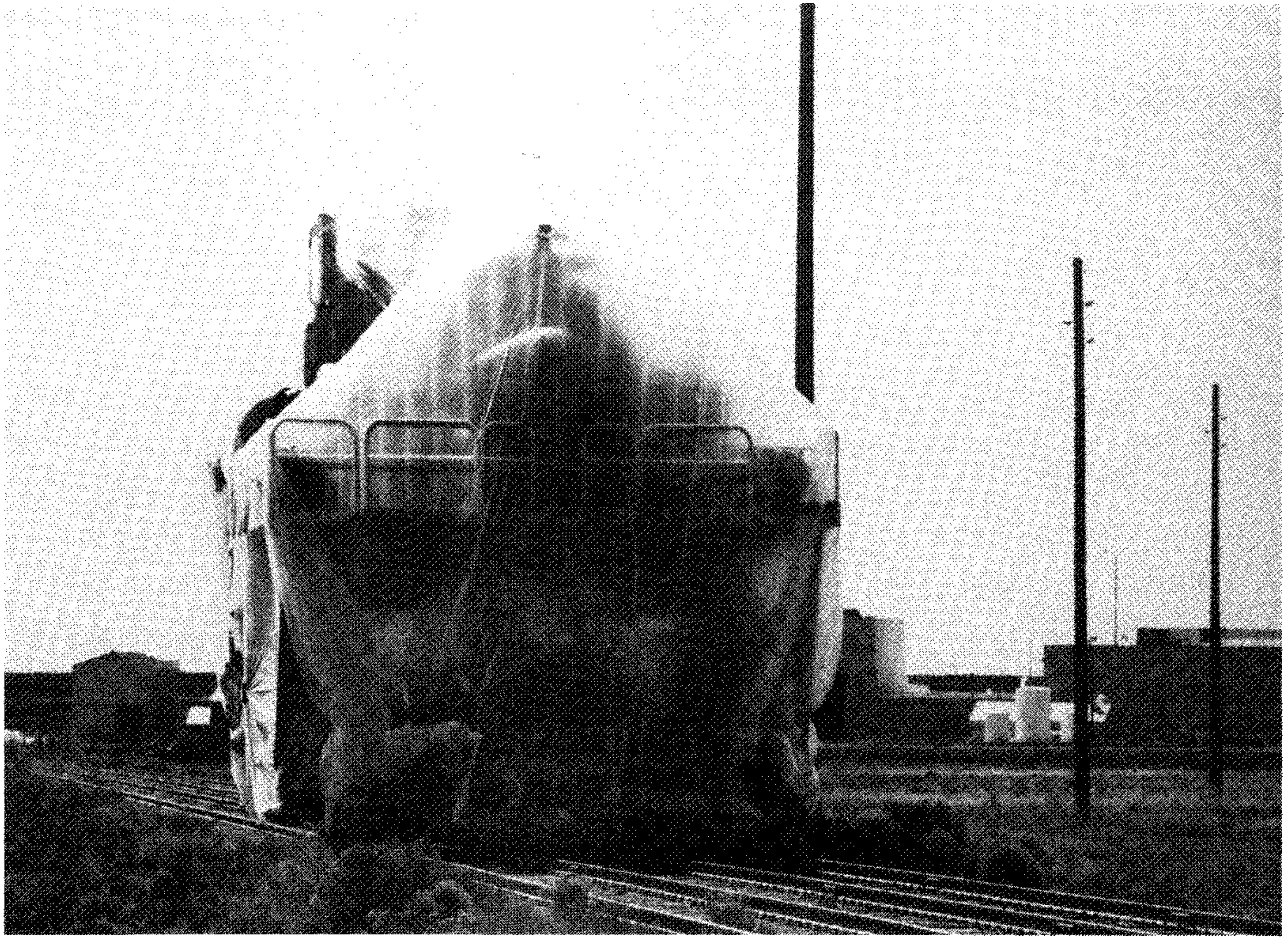

Figure 8. The HTRE-3 assembly being transported to the CTF for asbestos and mercury removal operations. It was wrapped in plastic to prevent the spread of asbestos and mercury during transport.

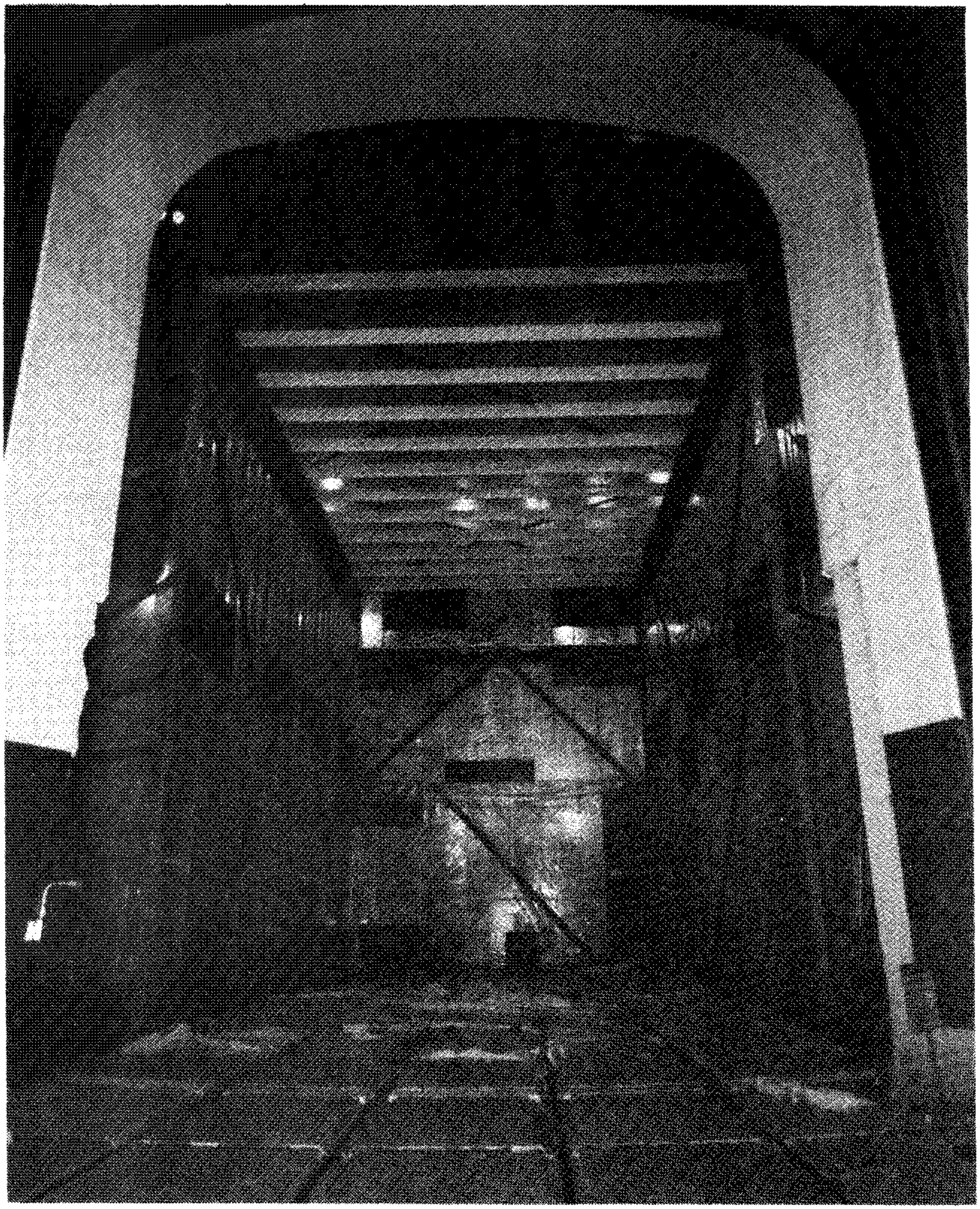

Figure 9. Enclosure that was constructed inside the CTF to provide a controlled environment for asbestos removal and mercury flushing operations.

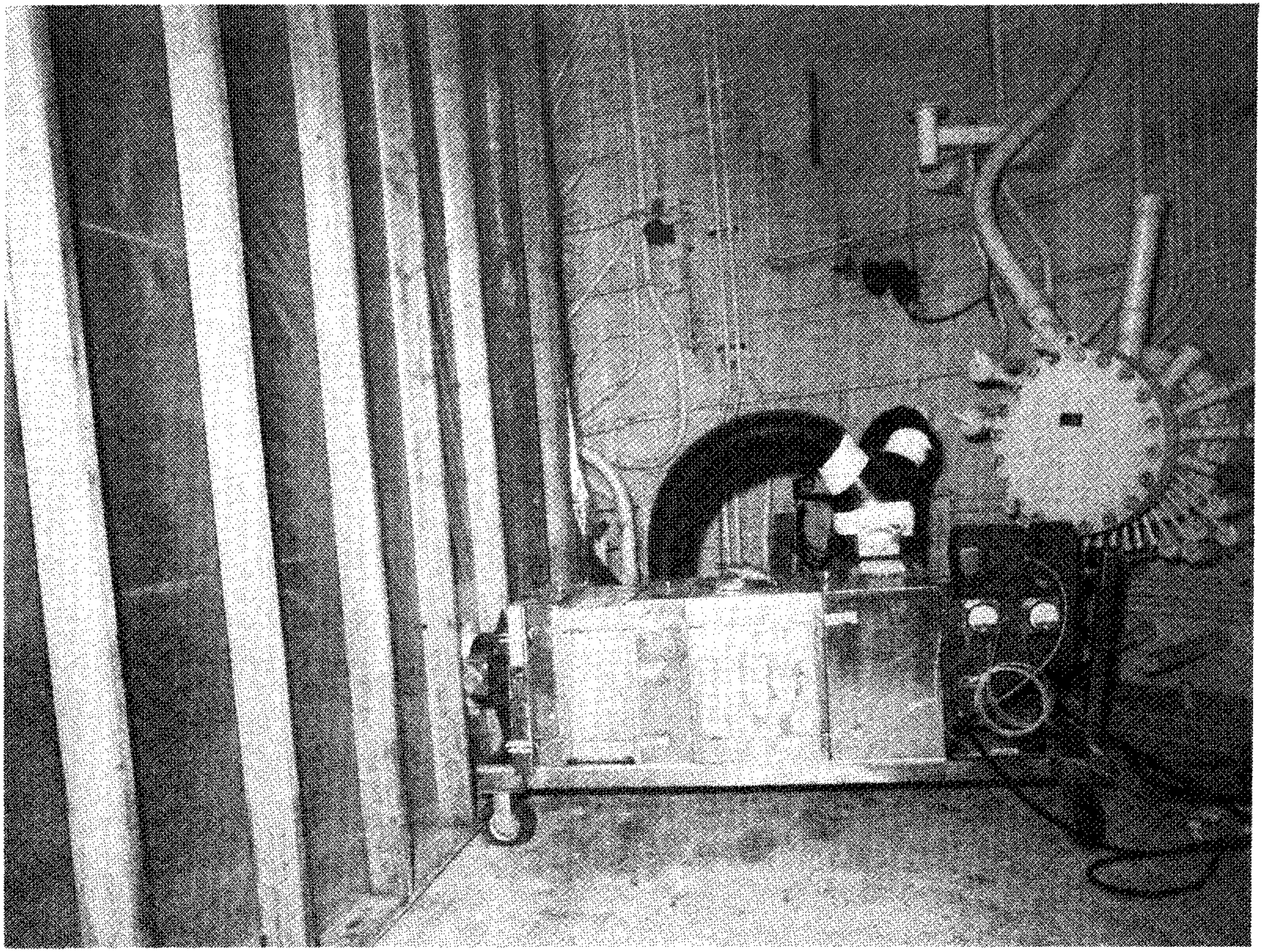

Figure 10. The HEPA exhaust system for the CTF work enclosure. The system created negative pressure within the enclosure and exhausted into the CTF exhaust system.

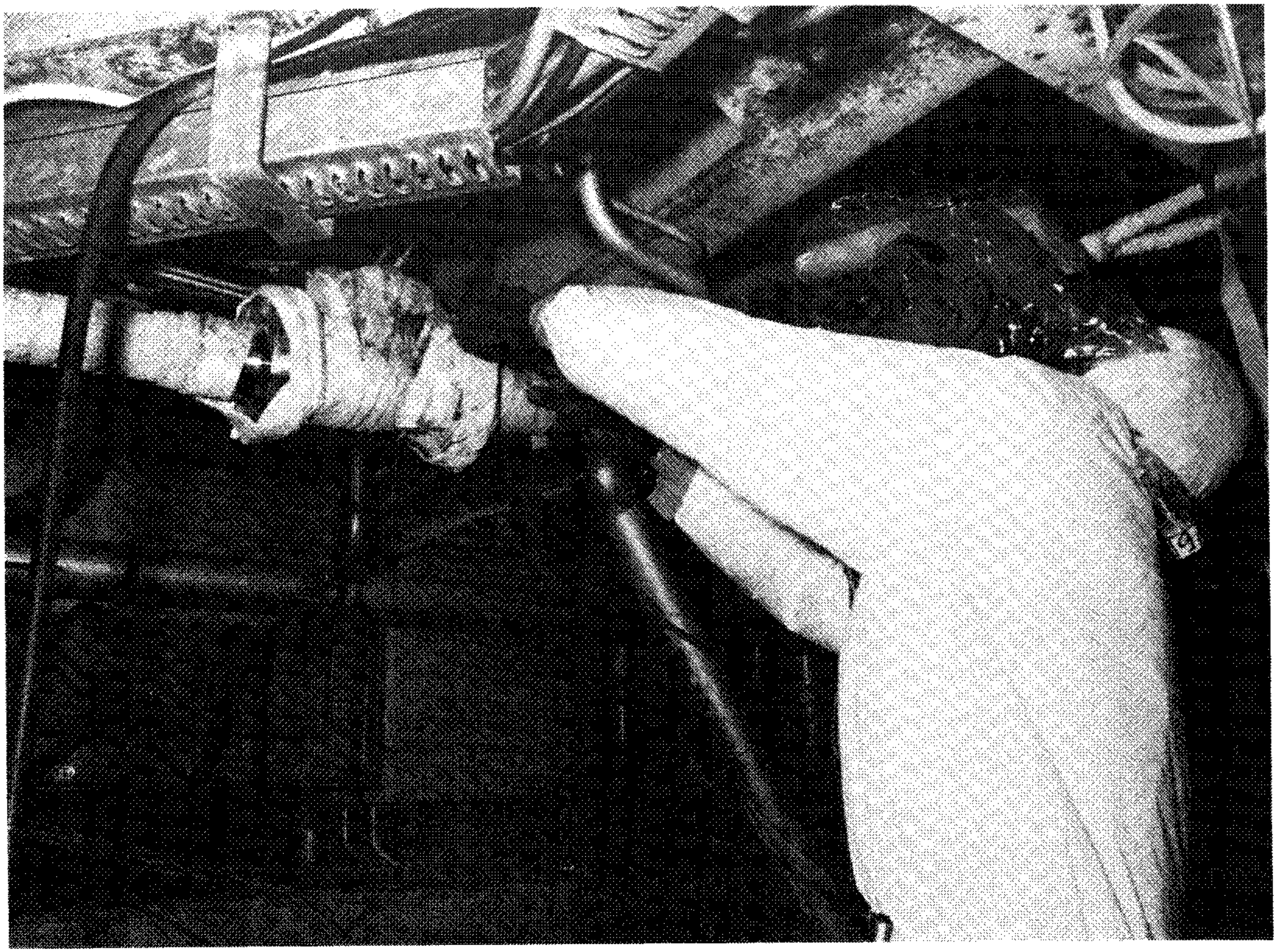

Figure 11. Worker removing asbestos-containing materials from the HTRE-3 assembly within the CTF work enclosure.

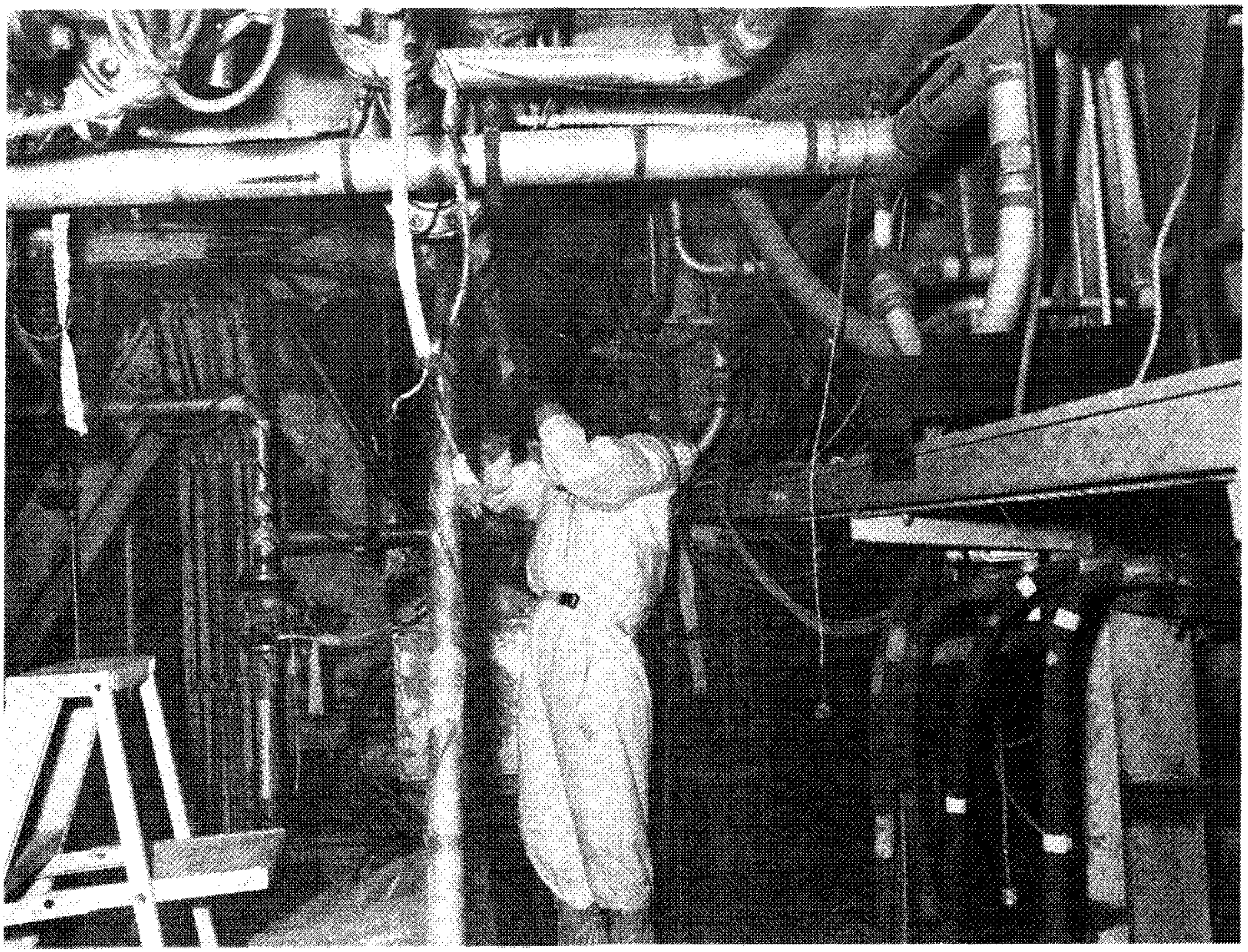

Figure 12. Worker removing asbestos-containing materials from the HTRE-3 assembly within the CTF work enclosure.

removing asbestos from the HTRE-3 assembly. All loose radioactive contamination was removed from both assemblies and shipped to the RWMC for disposal in accordance with radioactive waste transportation procedures. The radioactively contaminated materials were shipped on a timely basis to avoid accumulation of waste in the work area. These materials were packaged in accordance with low-level waste acceptance criteria. After decontamination, radiation and contamination surveys were conducted.

A visual inspection was made of all shield system components, including dismantling connections, to determine the extent of mercury contamination. Mercury was found to be present in all shield system components. The mercury was removed and disposed of as mixed waste (waste that is both hazardous and radioactive) at the Mixed Waste Storage Facility (MWSF). Figure 13 shows acid rinse mercury removal equipment adjacent to the CTF. Figure 14 shows barrels containing mercury rinse waste stored in the CFT prior to shipment to the MWSF. Mercury-absorbent material was placed in the shield tank of HTRE-3, and all openings to shield system components were permanently sealed (see Figure 15). Following decontamination operations within the CTF, the assemblies were high-pressure washed to remove minute particles of asbestos, mercury, and loose radioactive contamination prior to transport to the display site (see Figure 16).

After decontamination, the assemblies were restored to conform with the configuration required by the DOE and the Smithsonian Institution.

In preparation for relocating the test assemblies from the TAN to the EBR-I area, a transportation plan was prepared and issued. In the plan, estimates were made of the efforts necessary to allow passage of the assemblies at all obstacles. A request for proposal was prepared and issued for a contractor to perform the move, and bids were obtained from interested contractors. Upon receipt of funding, a contract for relocation was awarded to Premay Equipment, Inc., of Edmonton, Canada, through its Pocatello, Idaho, office. Premay moved the sections of the special transporter to the INEL and began assembly of the transporter. The transporter consisted of six subassemblies that were hooked up to form one assembly. The transporter had 12 axles with 12 tires each for a total of 144 tires to carry the load. Each axle was capable of being steered to minimize turning radius or of being pinned to prevent loading that axle.

The large size and weight of the test assemblies made the prospect of relocation a formidable task. The assemblies are each approximately 7.2 m (24 ft) wide, 7.5 m (40 ft) long, and 7.5 m (25 ft) high, and the HTRE-3 weighs about 222,000 kg (490,000 lb) and the HTRE-2 about 267,000 kg (590,000 lb). Thus, normal road transport was impossible. In addition, the TAN four-track railroad system is a closed system that was built specifically for the ANP Program, and the standard two-track INEL rail system extends only as far as the Naval Reactors Facility (NRF), approximately 32 km (20 mi) away. Thus, rail transfer of the assemblies to the EBR-I area was also impossible.

To resolve the transportation problem, discussions were held with specialty transport companies and a method was developed for transport. The method chosen was to load the assemblies onto a special transporter and to pull this load across the INEL roadways during a low-usage period.

Due to the size and weight of the test assemblies, the method of loading the assemblies onto the transporter involved the excavation of a downramp at the turntable at the TAN. A similar ramp was excavated at the display pad for off-loading.

To determine by performance that the move was technically feasible, a test run was made on November 23, 1988. During this test run, test weights of approximately 272,000 kg (600,000 lb) were loaded on the transporter at the CFA. The transporter was then taken to the EBR-I area and turned around at the EBR-I parking lot. The load was then taken to the TAN TSF area along the route that would be used during the test assembly moves. During the test run, the transporter was lowered and two axles pinned to minimize the amount of weight being carried on the bridge north of the NRF. Engineering analyses had indicated that this was needed due to the design of this bridge. To determine the effect of the load on this bridge, instrumentation was installed under the bridge. These instruments were monitored during the passage of the test weights in both directions and during the actual moves of the test assemblies. Figure 17 shows the transporter moving the test weights across the NRF bridge.

The test runs were completed satisfactorily and minimal bridge deflection was observed.

To accommodate the transfer of the assemblies onto the transporter, modifications were made to the transporter deck and at the loading and offloading sites. The transporter bed was modified by the addition of I-beams and 5-cm^2 (2-in^2) bars to match up with the four-rail system. The rails and

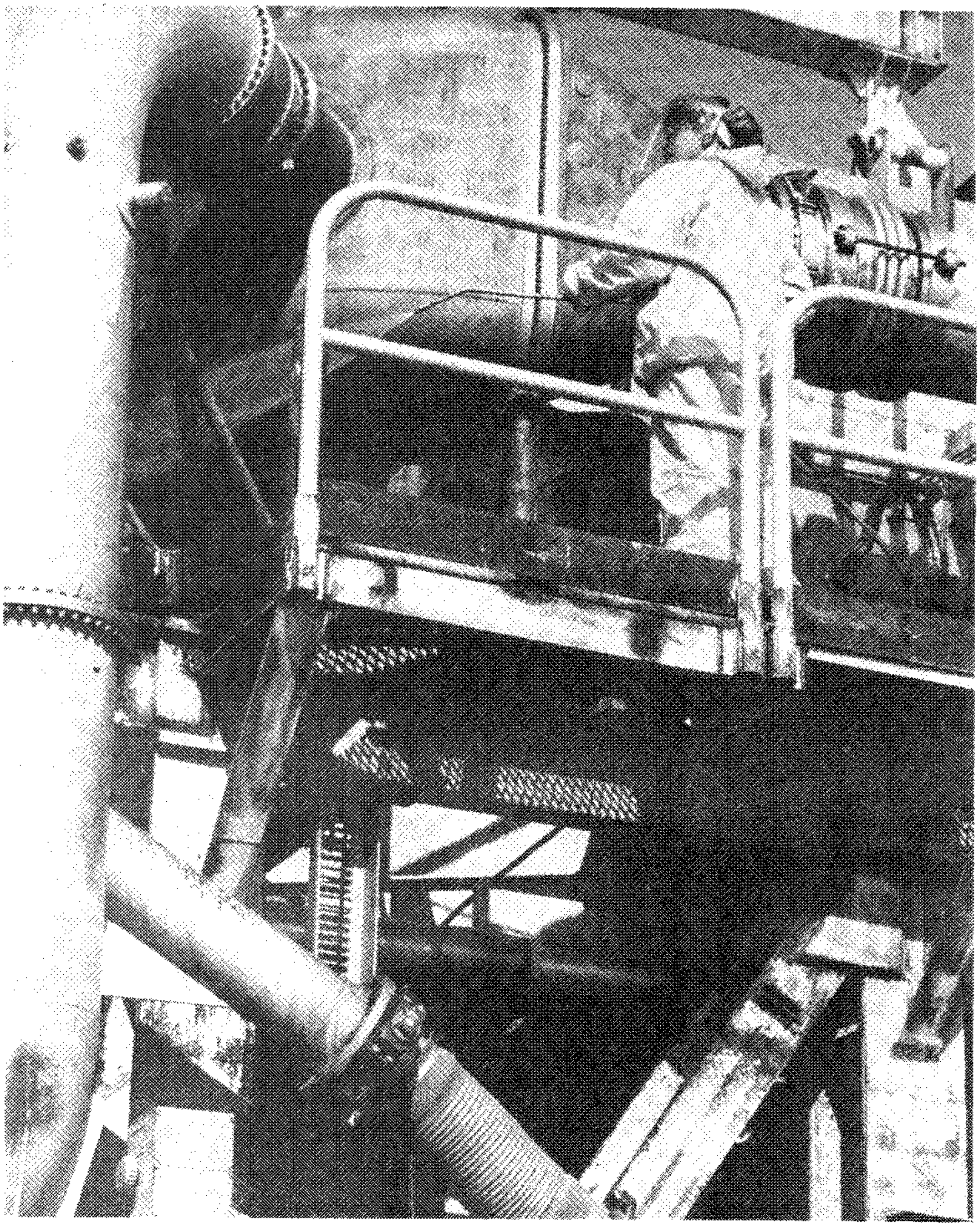

Figure 13. Acid rinse mercury removal equipment adjacent to the CTF work enclosure.

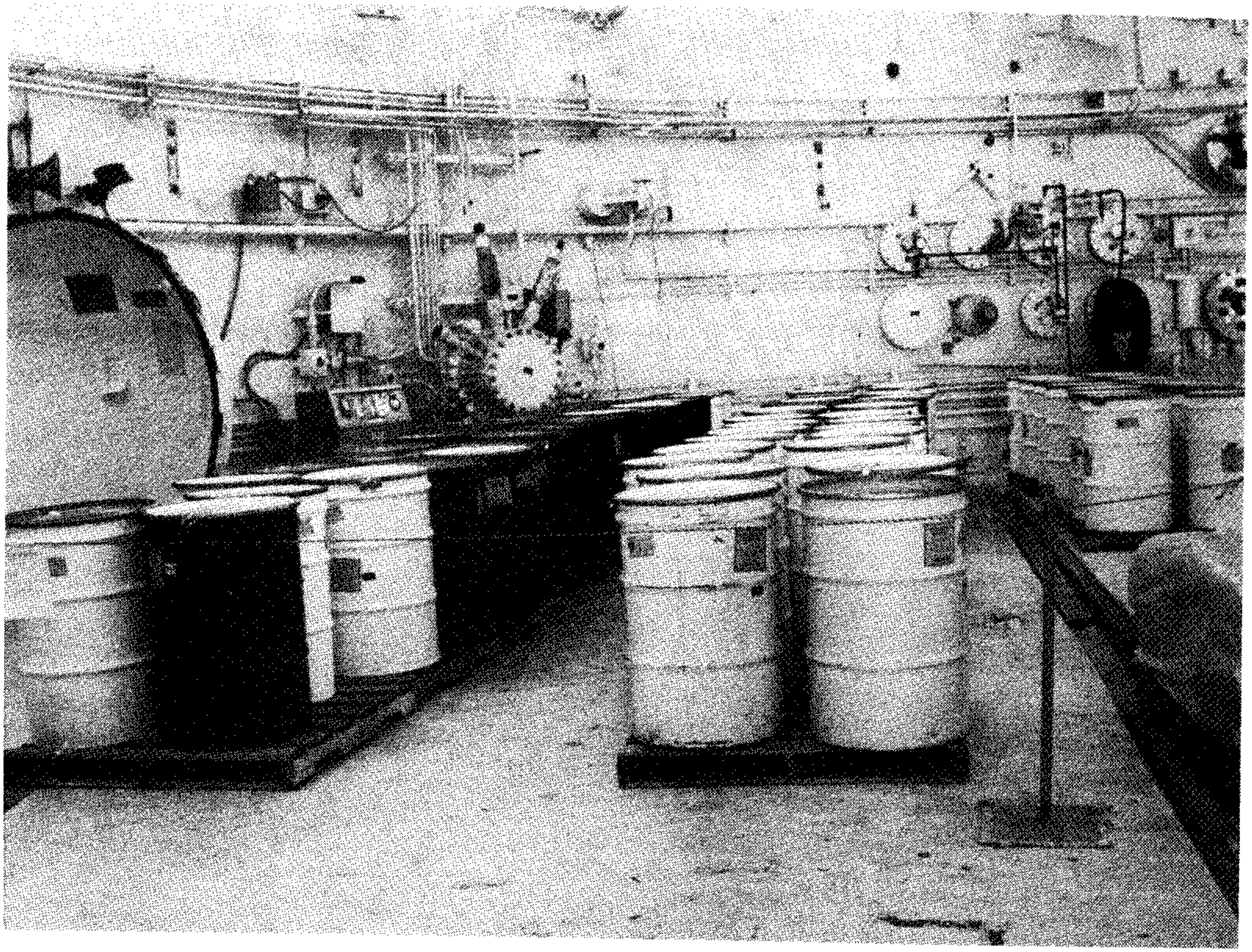

Figure 14. Barrels of mercury rinse waste stored in the CTF prior to shipment to the MWSF.

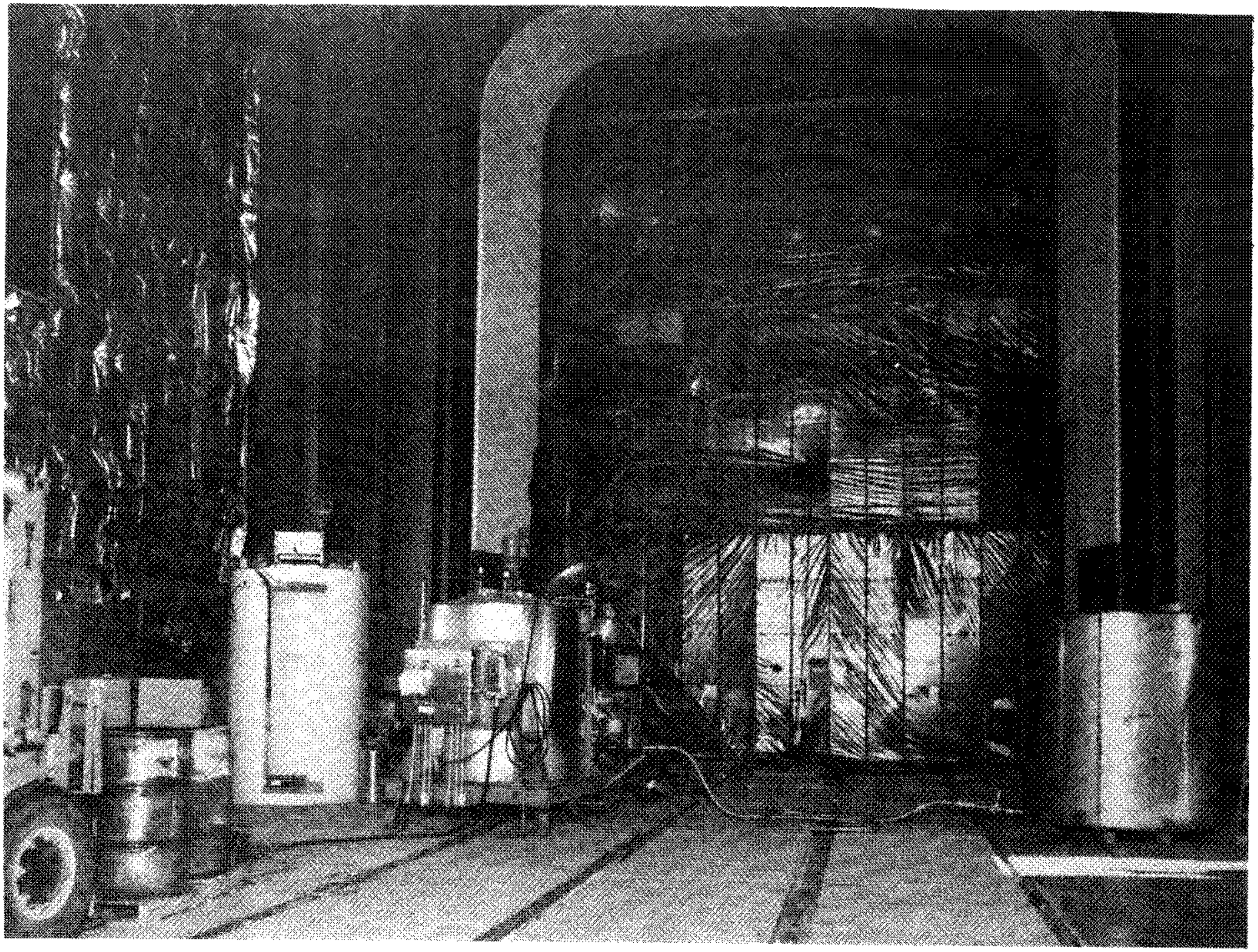

Figure 15. Welding of pipe ends to prevent leakage of residual mercury.

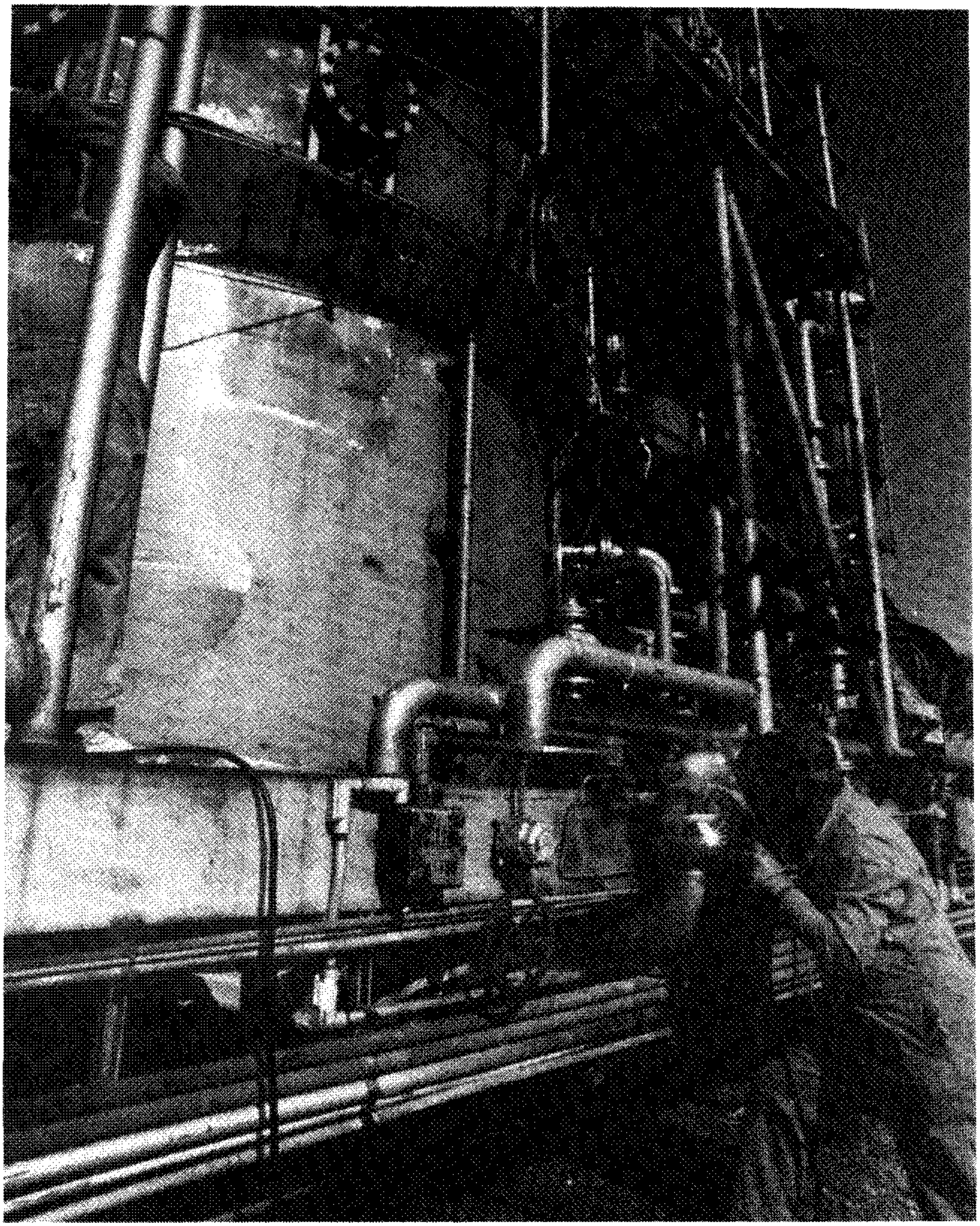

Figure 16. Worker conducting a high-pressure wash of the HTRE-3 to remove minute particles of asbestos, mercury, and loose radioactive contamination prior to transport to the display site.

Figure 17. The transporter moving the test weights across the NRF bridge, with the instrumentation van at right.

cross bracing were constructed on December 2 and 3. Down ramps were excavated adjacent to the turntable at TAN and the display pad at the EBR-I area. The down ramps were needed to accommodate the direct transfer of the assemblies onto the transporter.

On December 3, 1988, the transporter was positioned at the TAN TSF turntable in preparation for the relocation of the HTRE-3 assembly to the EBR-I area (see Figure 18). After preparations were completed, the HTRE-3 was hooked onto the winches of the tractors positioned at the opposite end of the transporter. The winches were operated simultaneously to pull the assembly up to the edge of the turntable. At this point the cables were repositioned and the pull onto the transporter proceeded. As the assembly started to travel onto the transporter and bridging pieces, the progress was visually monitored very closely. No deflection was detected and the pull was continued until the assembly wheels were hard against the chocks that had been installed on the transporter. At this time, temporary chocks were placed behind the wheels, and welders attached rigid chocks behind the rear wheels. During loading, the slight upslope of the transporter bed provided the needed braking force.

The transporter and assemblies were left in this condition until the following morning due to darkness. On December 4, the tractors were hooked onto the transporter in series for the pull out of the ramp area. When the transporter was moved out of the ramp area, the lead tractor was unhooked from the load. The load was then moved onto Snake Ave. and the spare tractor was hooked onto the transporter's trailing end. This was to allow backing the transporter down Snake Ave. towards the CTF to the point at which there is a crossover to Nile Ave. The transporter was then moved to the crossover and the spare tractor was unhooked once again.

At this time, the transporter was ready to complete the move without any further repositioning of tractors. The transporter and escort vehicles then moved onto Nile Ave. and up to Lincoln Blvd.

Prior to making the turn onto Lincoln Blvd., the load had to pass under the de-energized Specific Manufacturing Capability power lines and over alarm cables that had been lowered to the ground. This section of the move, like that at all other power and communication line crossings, was done with utmost care to prevent damage to the lines or transporter and its load. Commercial and INEL power and communication crews were on hand to ensure that clearances were adequate and lines de-energized where necessary.

The load was then moved on Lincoln Blvd. toward the CFA at less than 16 km/h (10 mph). Figure 19 shows the HTRE-3 assembly on the special transporter as it leaves the TAN TSF area. At the CFA the load was turned west onto W. Portland Ave. and then onto Van Buren Blvd. to the display area at the EBR-I area. Figure 20 shows the transport route.

The 50-km (31-mi) move took most of the day. During the move over the NRF bridge, the installed instrumentation was monitored by INEL technicians. As was the case with the test load, there was minimal deflection of the bridge during the move. The transporter reached the EBR-I area late in the afternoon and the assembly was left in the parking lot until the following morning.

On December 5, preparations were made for off-loading the assembly onto the display pad. When preparations were completed, the transporter was parked adjacent to the display pad and the fixed chocks were removed. One of the tractors was positioned on the pad and hooked onto the test assembly. The other tractor was also connected to the assembly but on the opposite end to provide braking capability. The off-loading was accomplished in a manner similar to that for the loading. The display pad was closely watched for signs of degradation during the transfer.

The HTRE-3 assembly was placed on the pad (see Figure 21) and temporary chocks held the load in place until the next assembly was moved.

Following the HTRE-3 move, all equipment was returned to the TAN for use in the HTRE-2 move. The transporter was again positioned at the turntable and HTRE-2 was moved onto the transporter. When this assembly was secured in place, the transporter was moved out onto Snake Ave. and up to the crossover to Nile Ave on December 8. At this time, the transporter was made secure until the scheduled move time on December 11.

The same procedure was followed for this move as was used for the HTRE-2 assembly. Figure 22 shows the HTRE-2 assembly being moved onto the transporter. When all conditions were ready, the transporter proceeded as planned.

A significant difference during this move was the procedure used at the NRF bridge. Because of the weight of this load with respect to the capacity of the bridge structure, the transporter was stopped and lowered to the end of the hydraulic cylinder travel. The center two axles were then incapacitated by placing pins in the cylinders to prevent loading

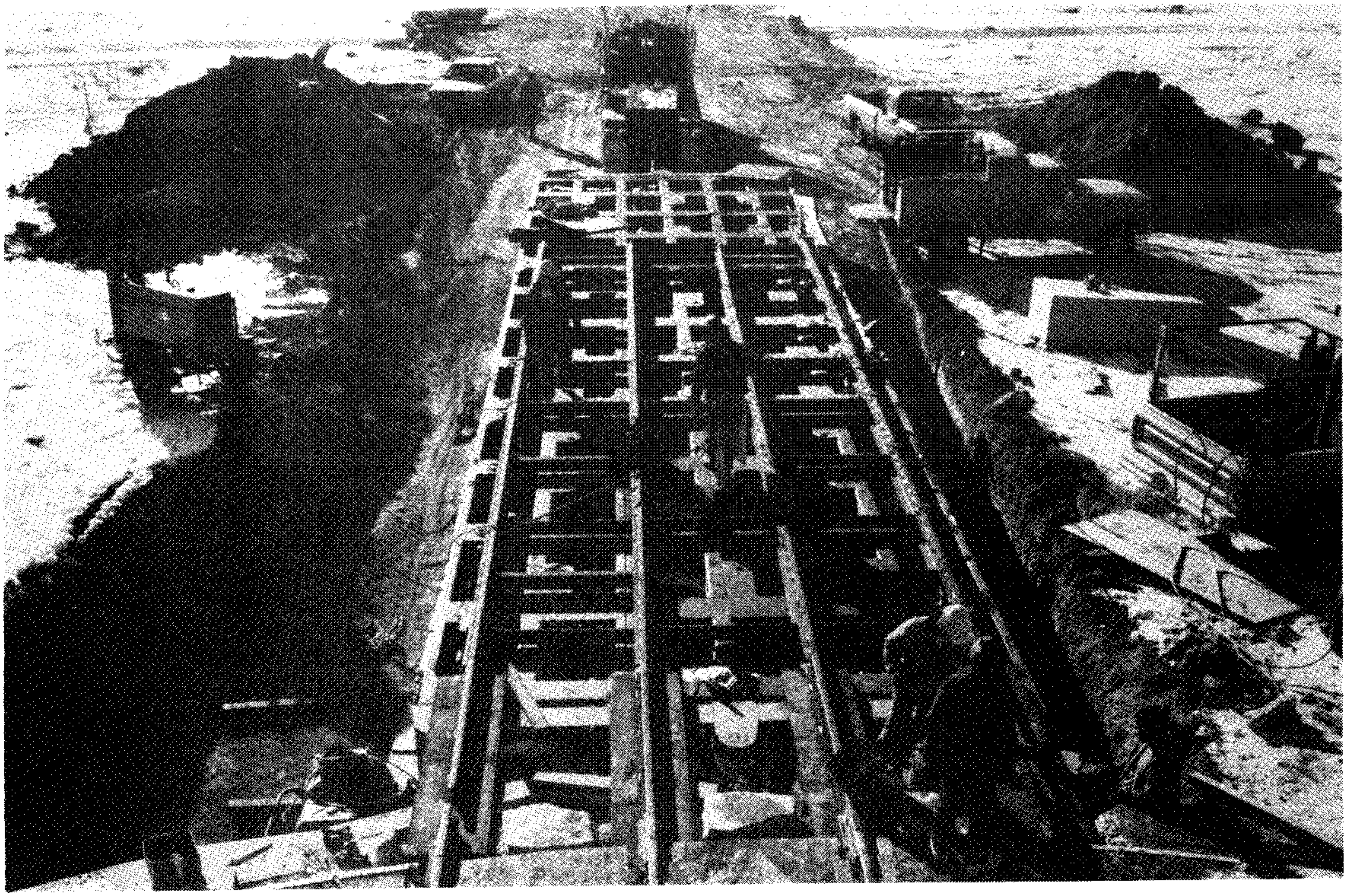

Figure 18. Final preparation of transporter in position at the TSF turntable.

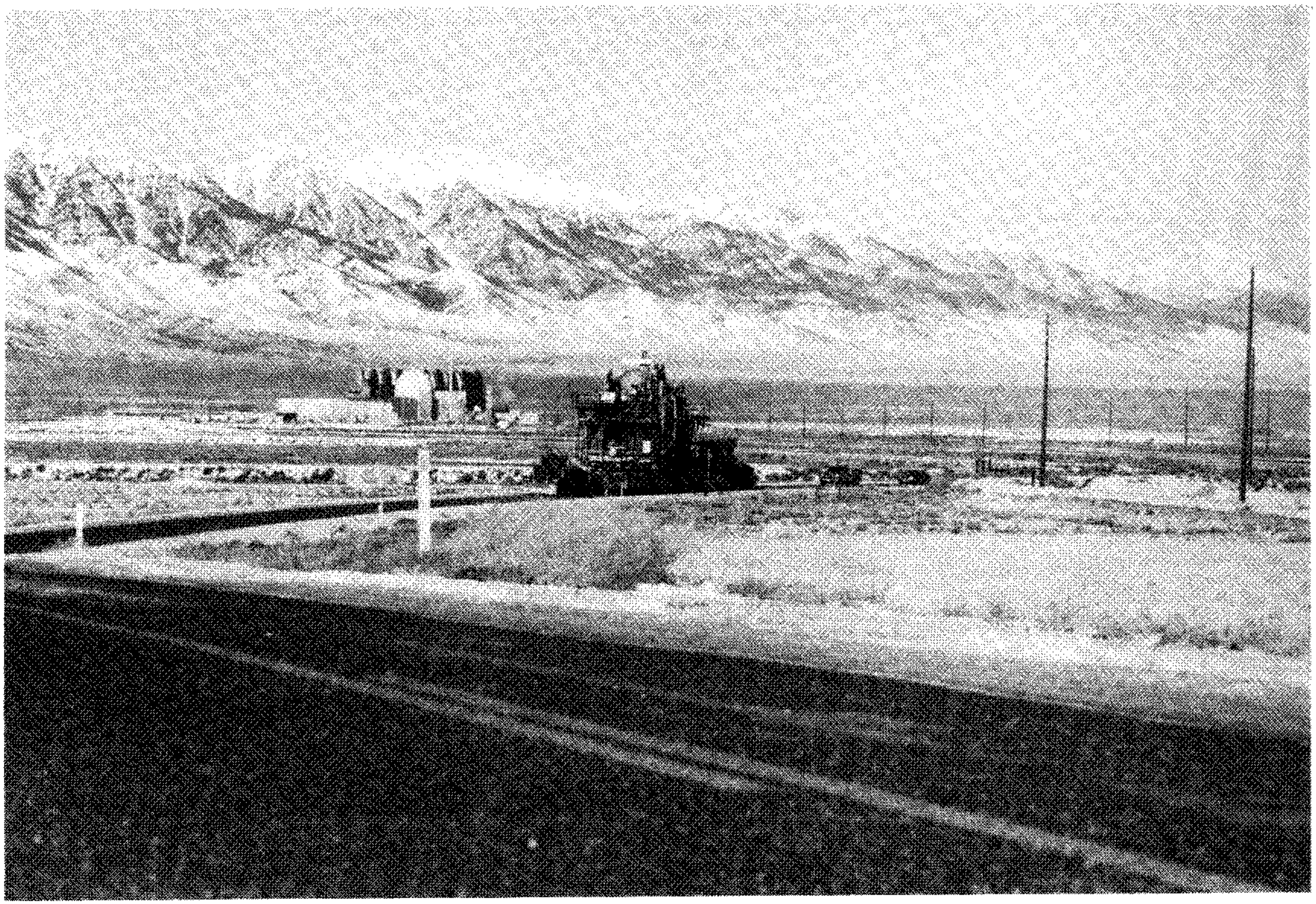

Figure 19. The HTRE-3 on the special transporter leaving the TAN area.

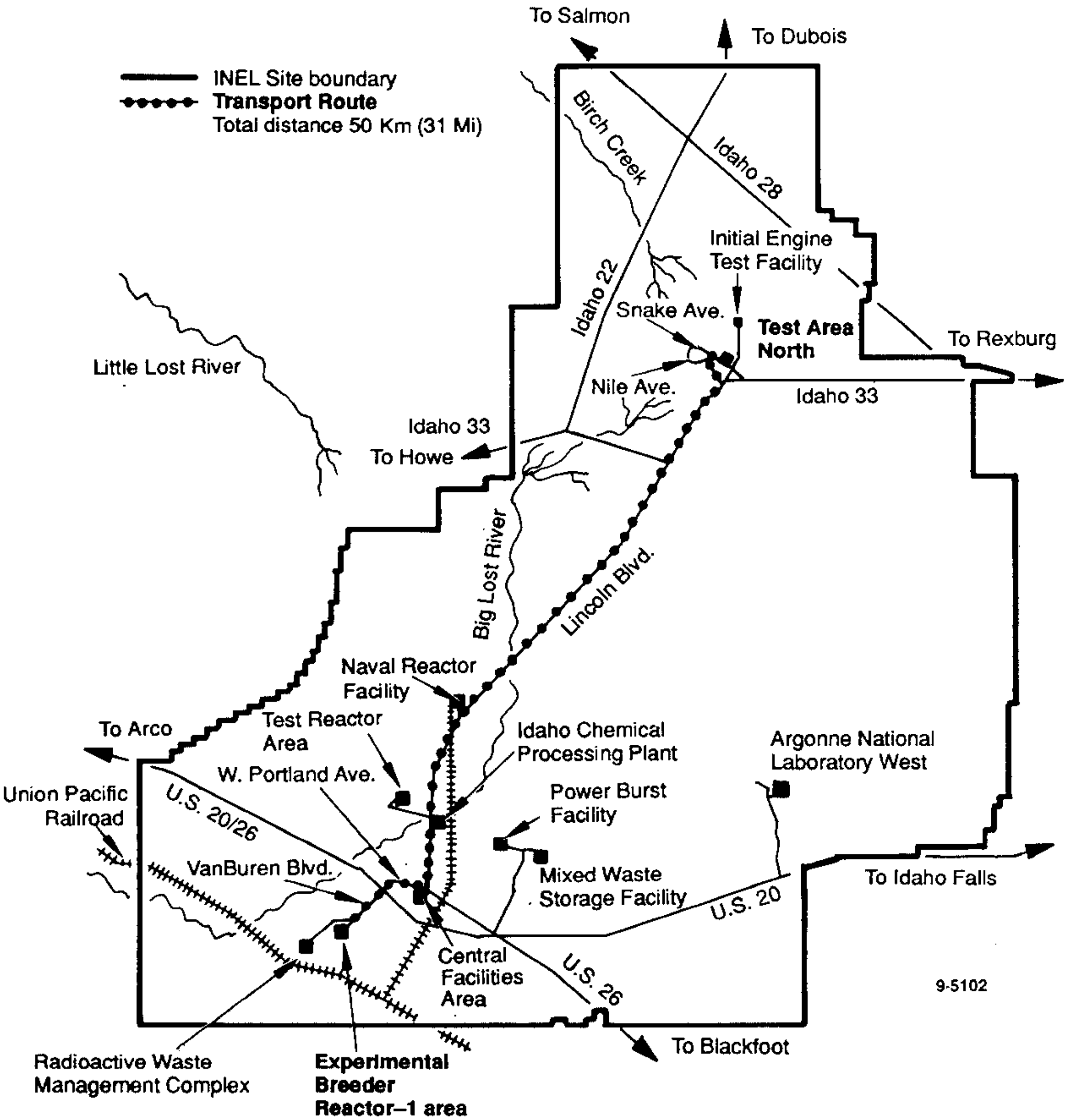

Figure 20. Map showing transport route for the HTRE-2 and HTRE-3 assemblies.

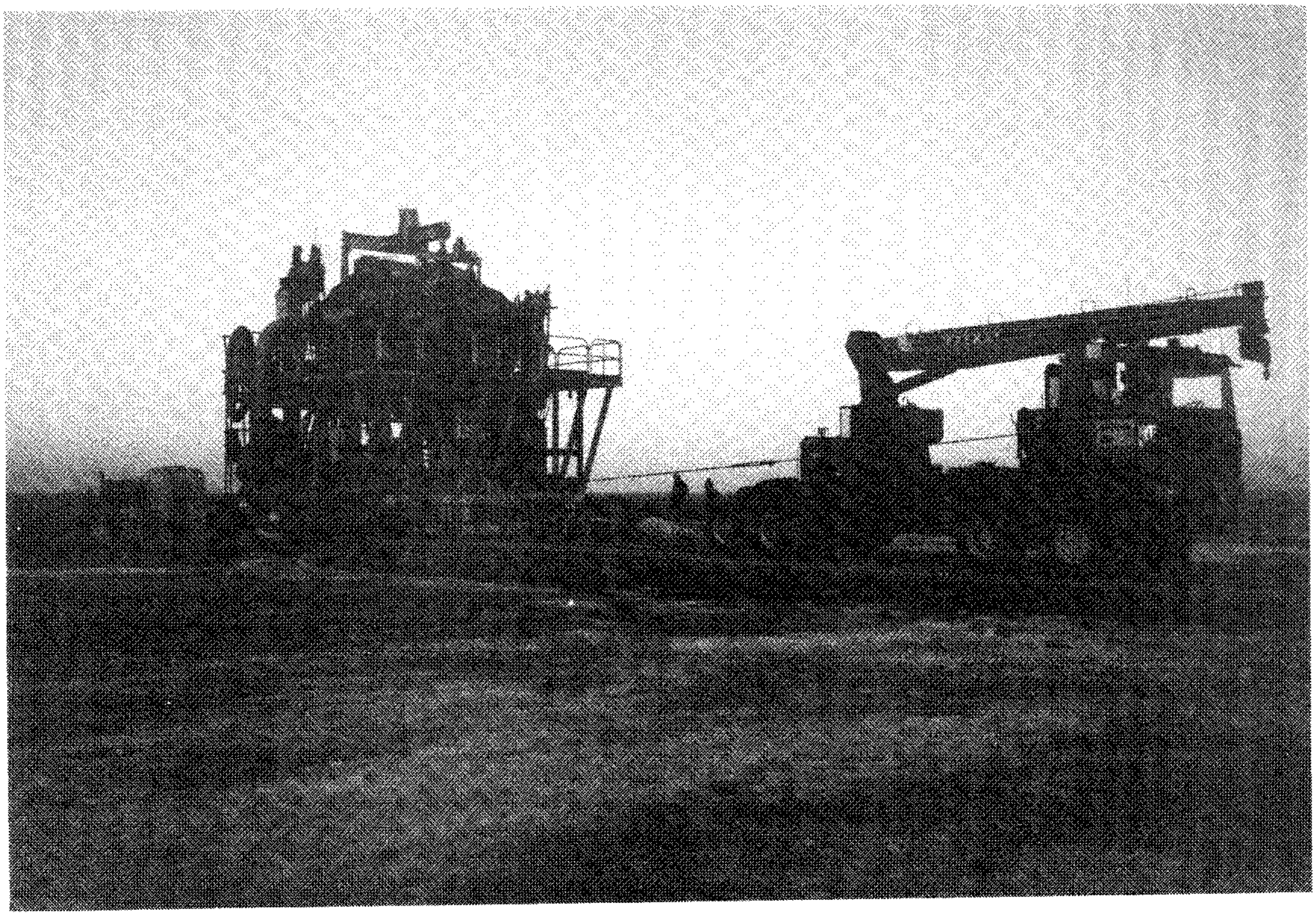

Figure 21. Placement of the HTRE-3 assembly on the display pad.

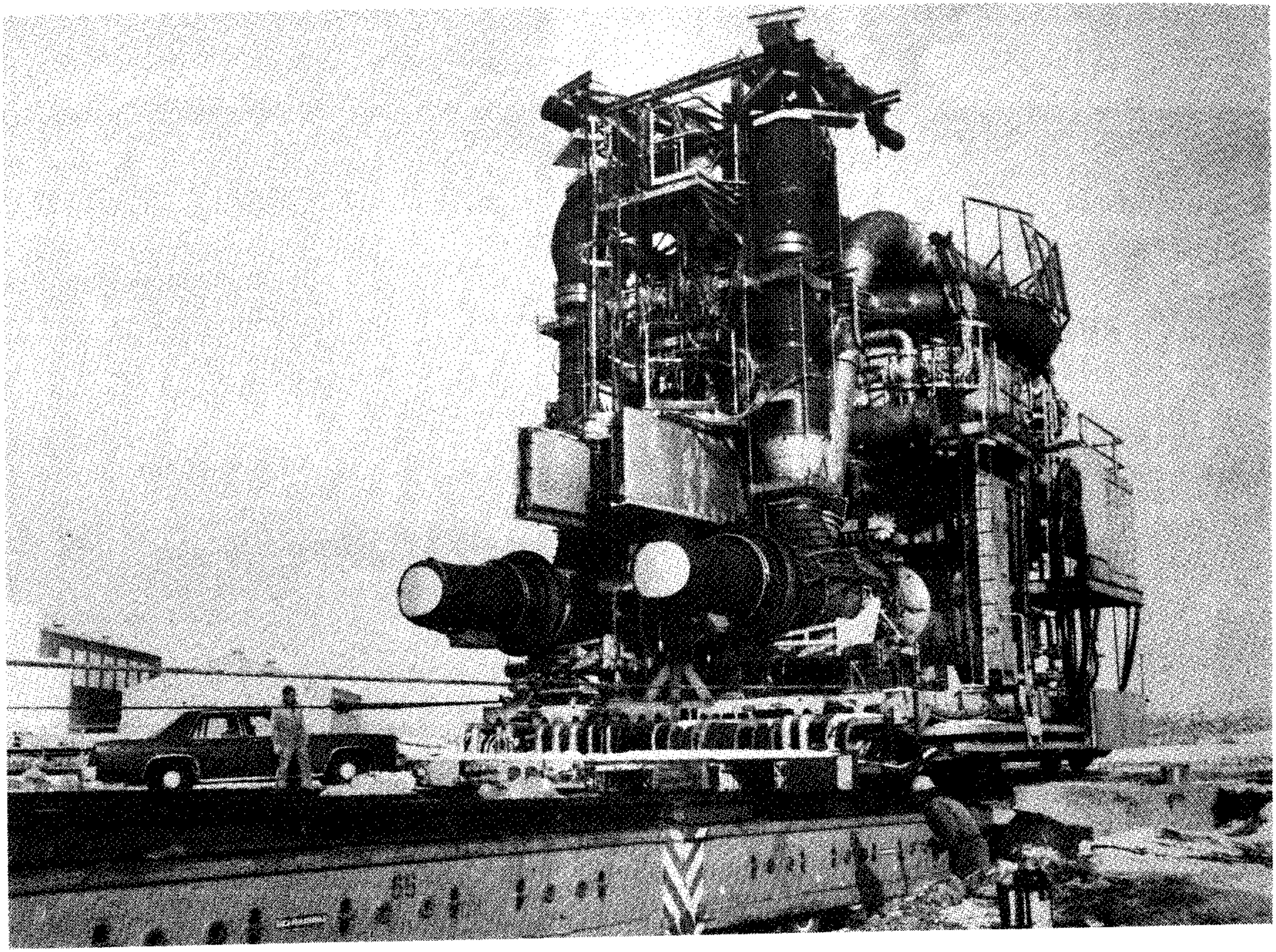

Figure 22. The HTRE-2 assembly being moved onto the transporter.

of these axles. The hydraulics were then recharged and the trailer was lifted with the pinned axles being held stationary. This caused the center two axles and wheels to be suspended above the road surface. The result of this modification was that the bridge would support only a fraction of the load at a time. This reduced load was calculated to be well within the design limits of the bridge structure. The instrumentation confirmed this, as the load passing over the bridge caused even less deflection than the HTRE-3 load had.

During the move, the state Transportation Department had two representatives from Boise present as observers because these loads were the heaviest loads permitted to travel across Idaho or INEL roadways to date. The HTRE-2 total load weight including the transporter was approximately 362,000 kg (800,000 lb). Figure 23 shows the HTRE-2 assembly passing under power lines at the CFA enroute to the display area.

The HTRE-2 assembly was placed in the parking lot at EBR-I on December 11, 1988. The transporter was then placed in position at the display pad in preparation for the off-loading. The plan was to position HTRE-3 and off-load HTRE-2 the following morning.

As planned, the HTRE-3 assembly was moved to the west end of the display pad and the tractors were positioned for winching HTRE-2 onto the pad. The HTRE-2 was winched onto the display pad and placed in its final position at the east end of the pad.

Representatives from the Idaho Falls newspaper and two local television stations were in attendance during these final relocation efforts December 12, and they reported to the public the relocation efforts and the plans for public access to these assemblies in the future.

After placement of the assemblies on the pad, the walkways, fencing, and vehicle barriers were constructed, and interpretive display panels were placed on the fencing (see Figures 24 and 25). Figure 26 shows the assemblies on the display pad, with the EBR-I monument in the background and the special transporter at the right.

Post-Decommissioning Radiological Survey

The results of the post-decommissioning radiological surveys of external parts of HTRE-2 and HTRE-3 are given in Figures 27 through 35.

Post-Decommissioning Hazardous Material Survey

No hazardous materials were detected during surveys by industrial hygienists either before or after the moving of the HTRE-2 and HTRE-3 assemblies.

Project Data Package

At the completion of the project, a project data package was compiled in accordance with Defense Facilities Decommissioning Program guidance and INEL project directives. This data package contains all data relevant to the performance of this project and will be stored along with other project data packages at the INEL indefinitely.

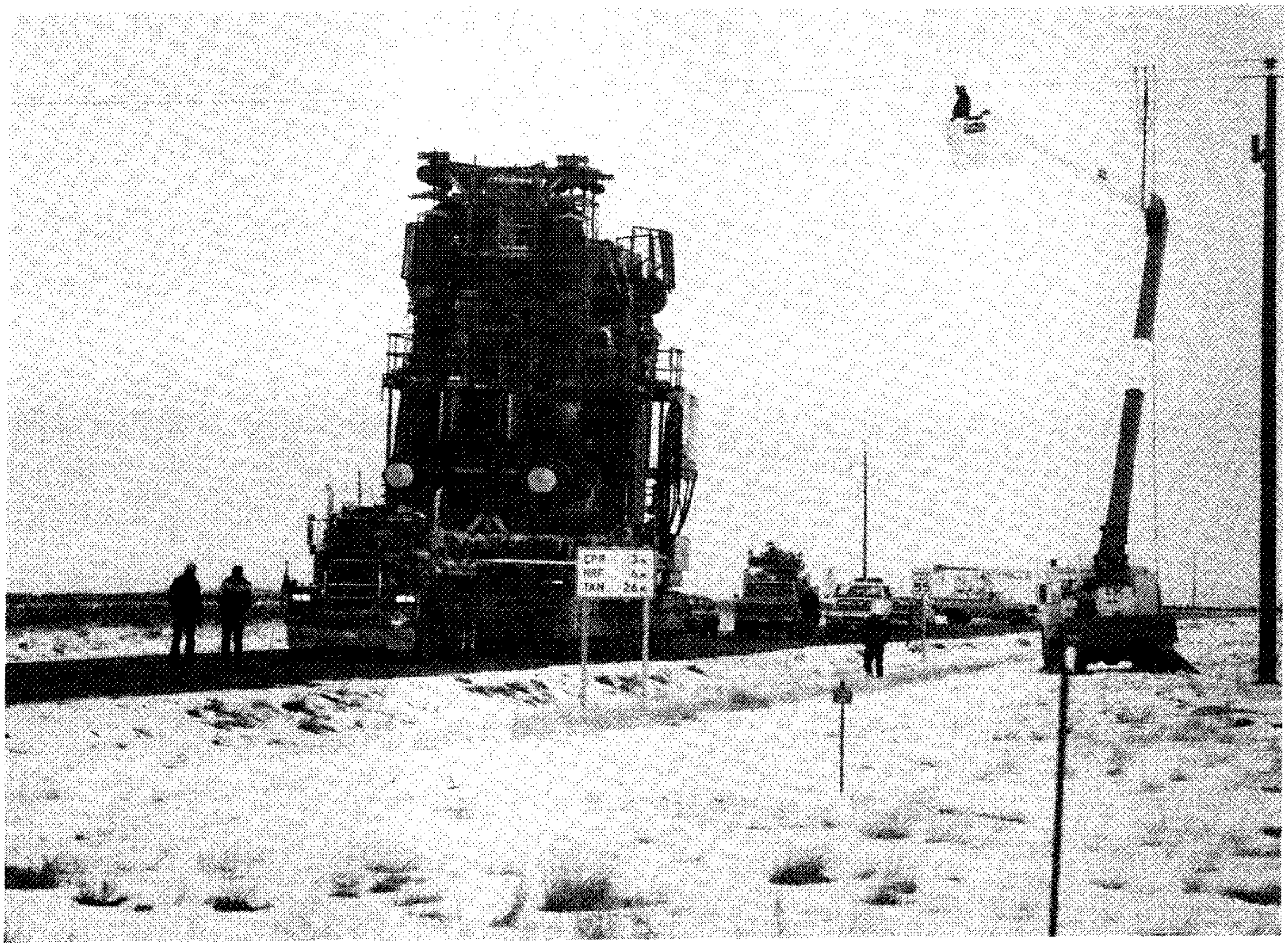

Figure 23. The HTRE-2 passing under power lines at the CFA enroute to the display area.

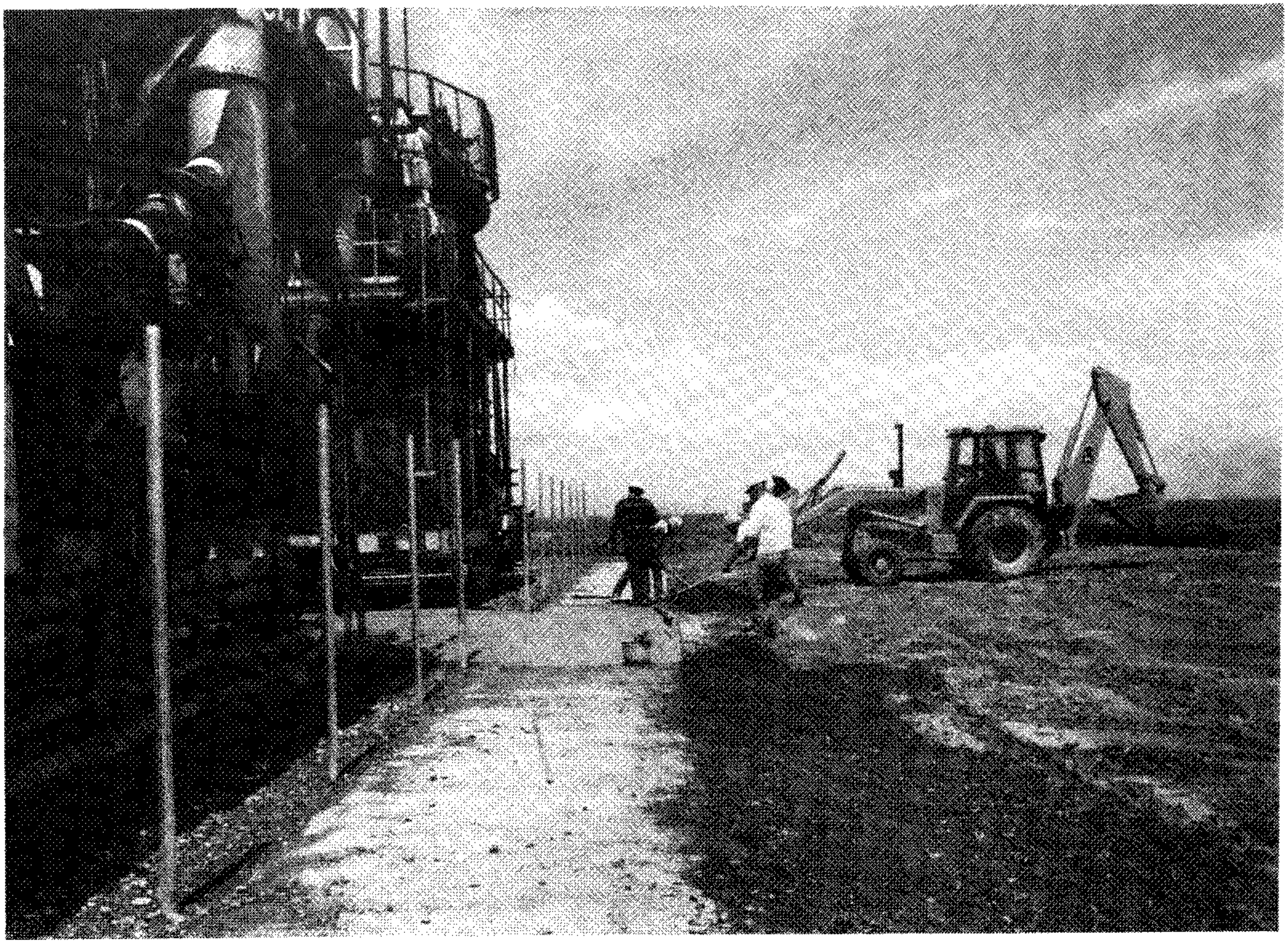

Figure 24. Construction of walkways and fencing around the assemblies at the display area.

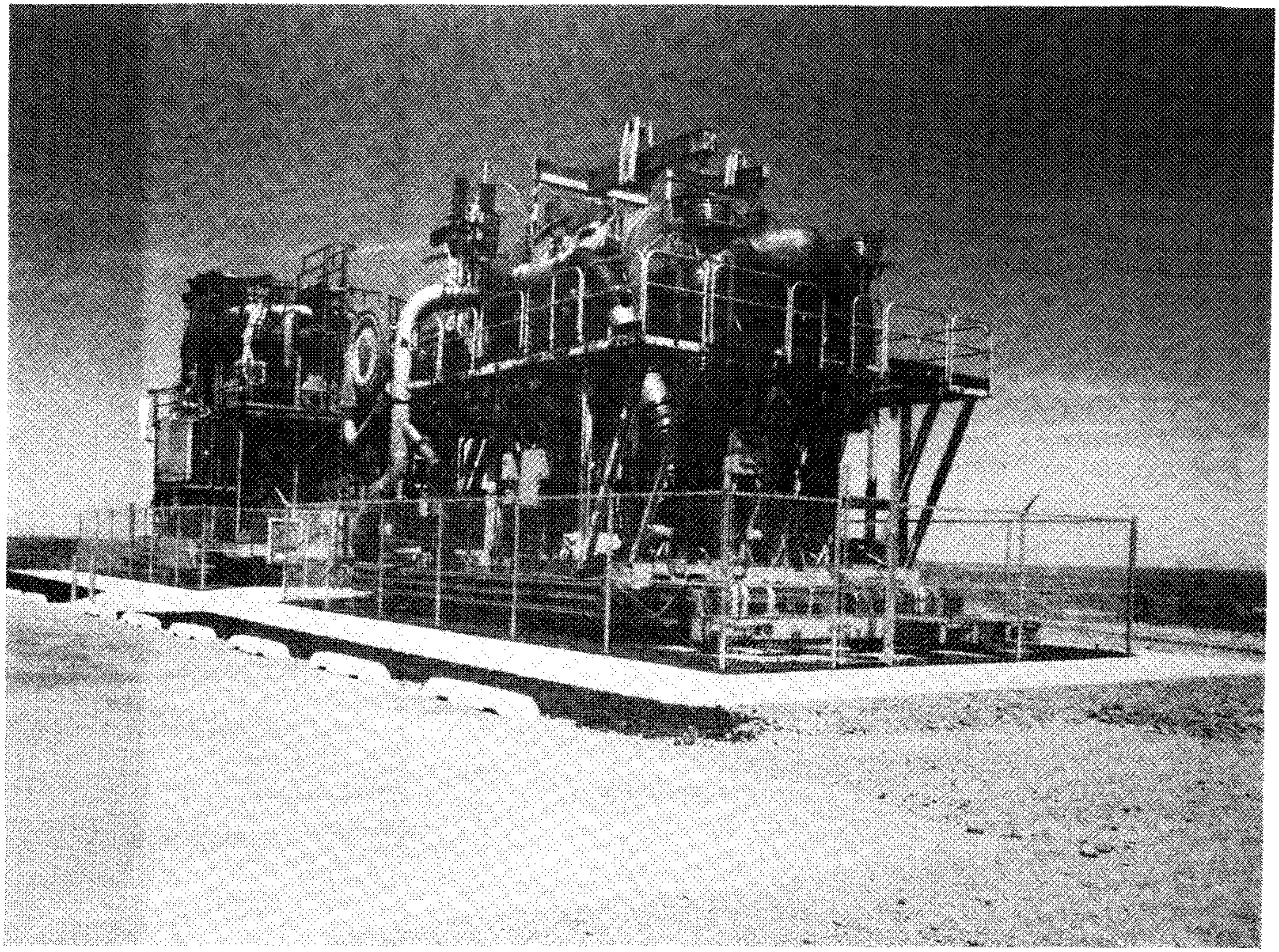

Figure 25. Sidewalks, fencing, vehicle barriers, and display panels in place at the display area.

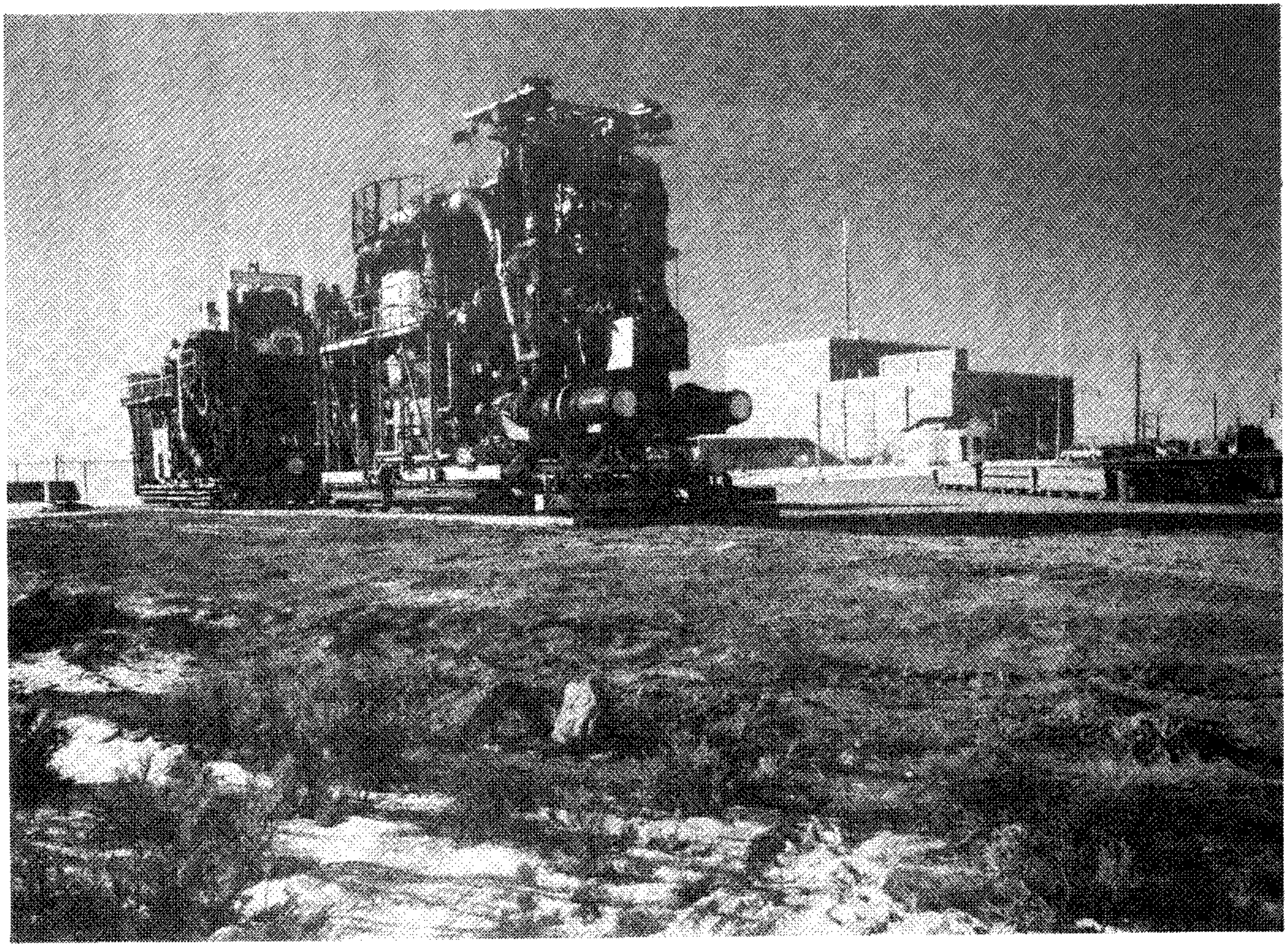

Figure 26. The HTRE-2 and HTRE-3 test assemblies on the display pad following relocation. The EBR-I monument is in the background and the special transporter is at right.

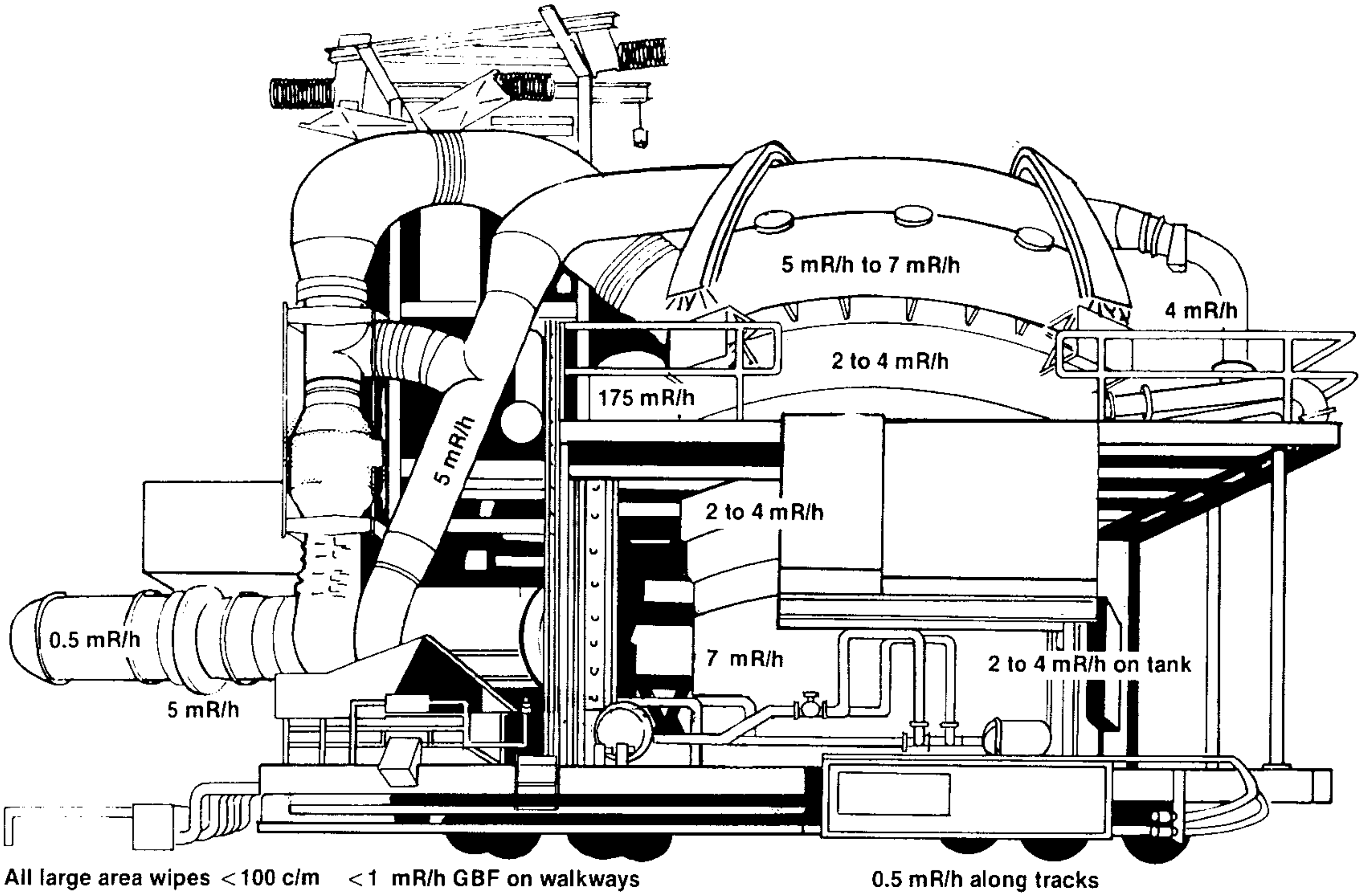

Figure 27. HTRE-2 post-decommissioning radiation and contamination levels, right side view.

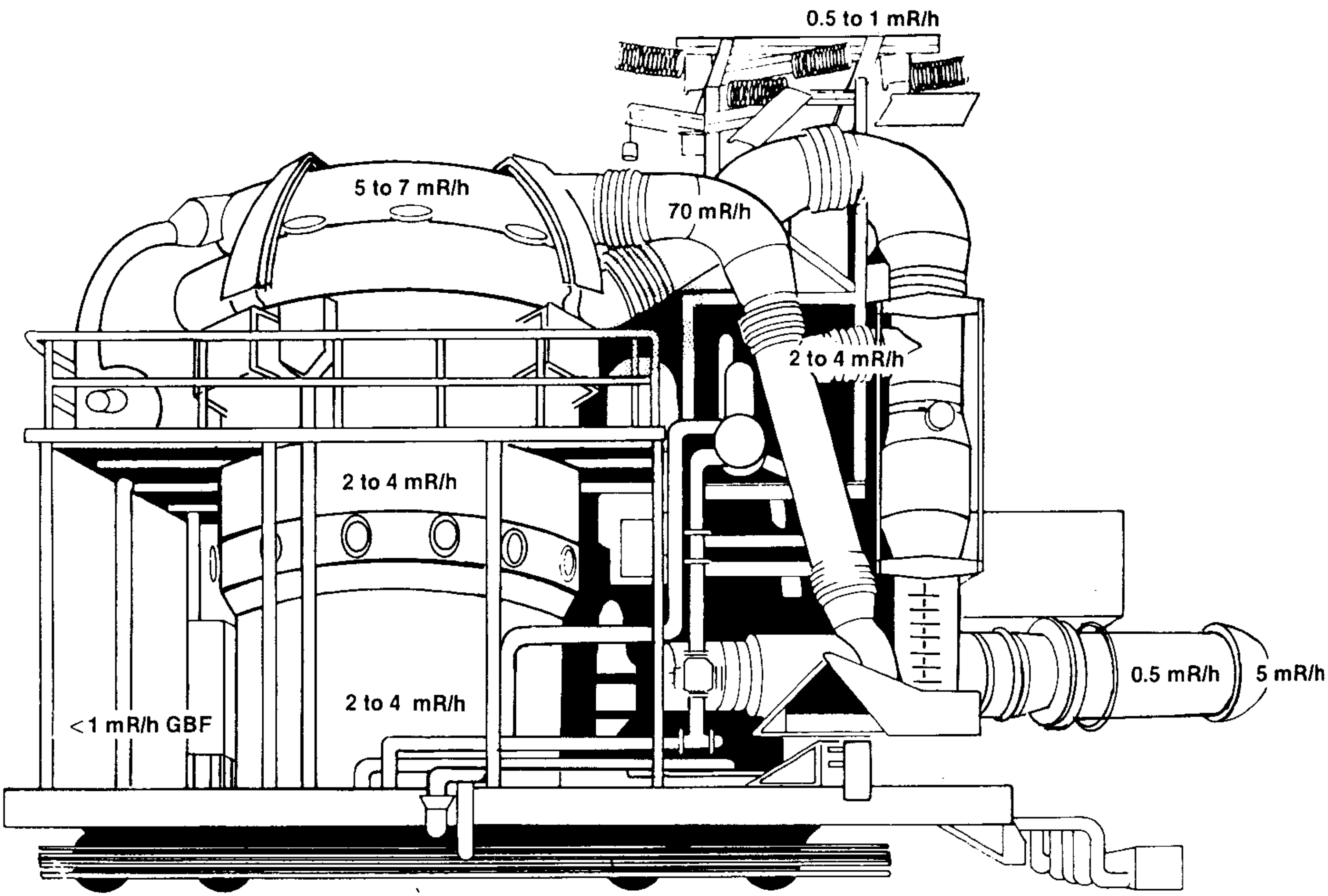

Figure 28. HTRE-2 post-decommissioning radiation and contamination levels, left side view.

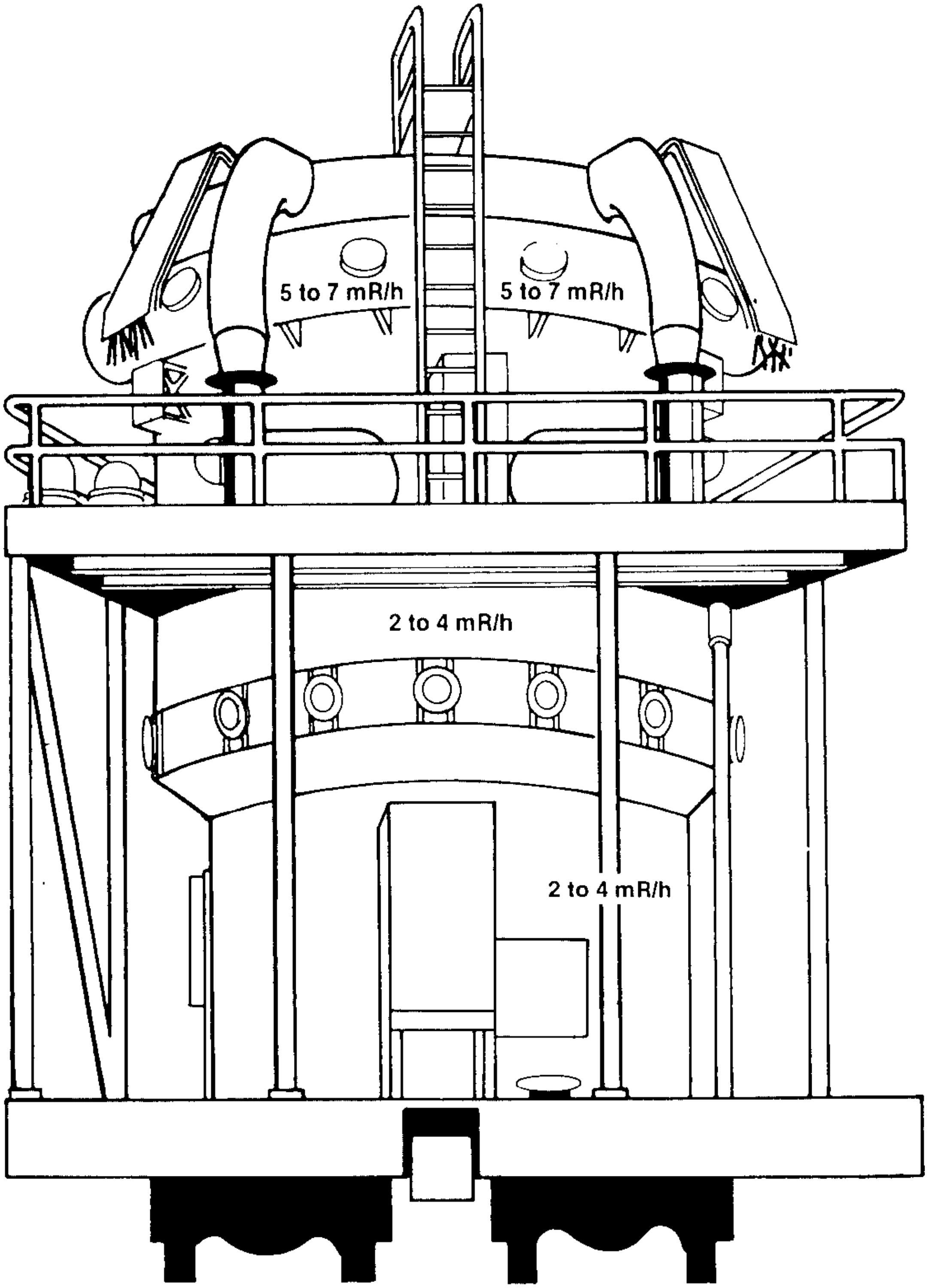

Figure 29. HTRE-2 post-decommissioning radiation and contamination levels, front view.

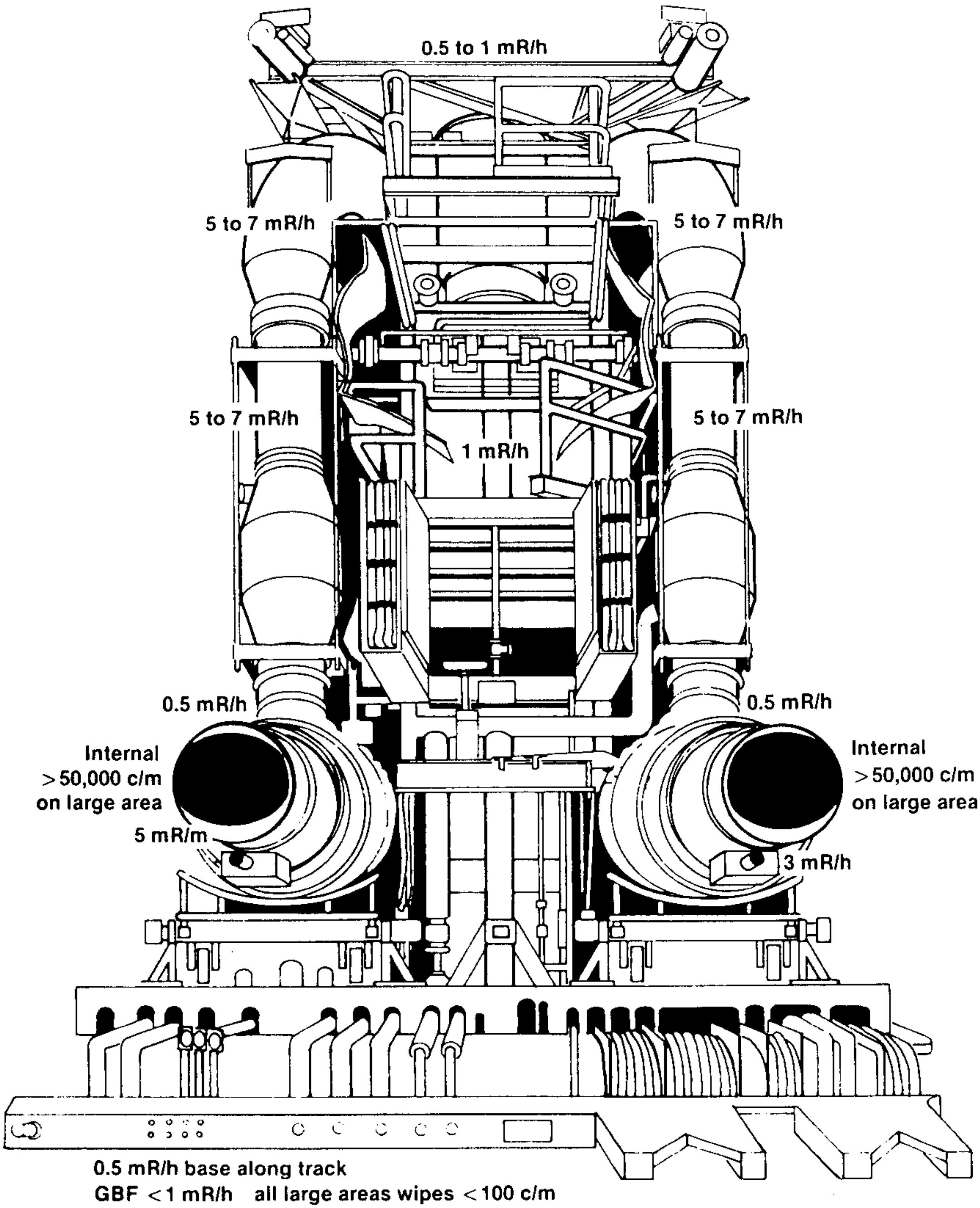

Figure 30. HTRE-2 post-decommissioning radiation and contamination levels, aft view.

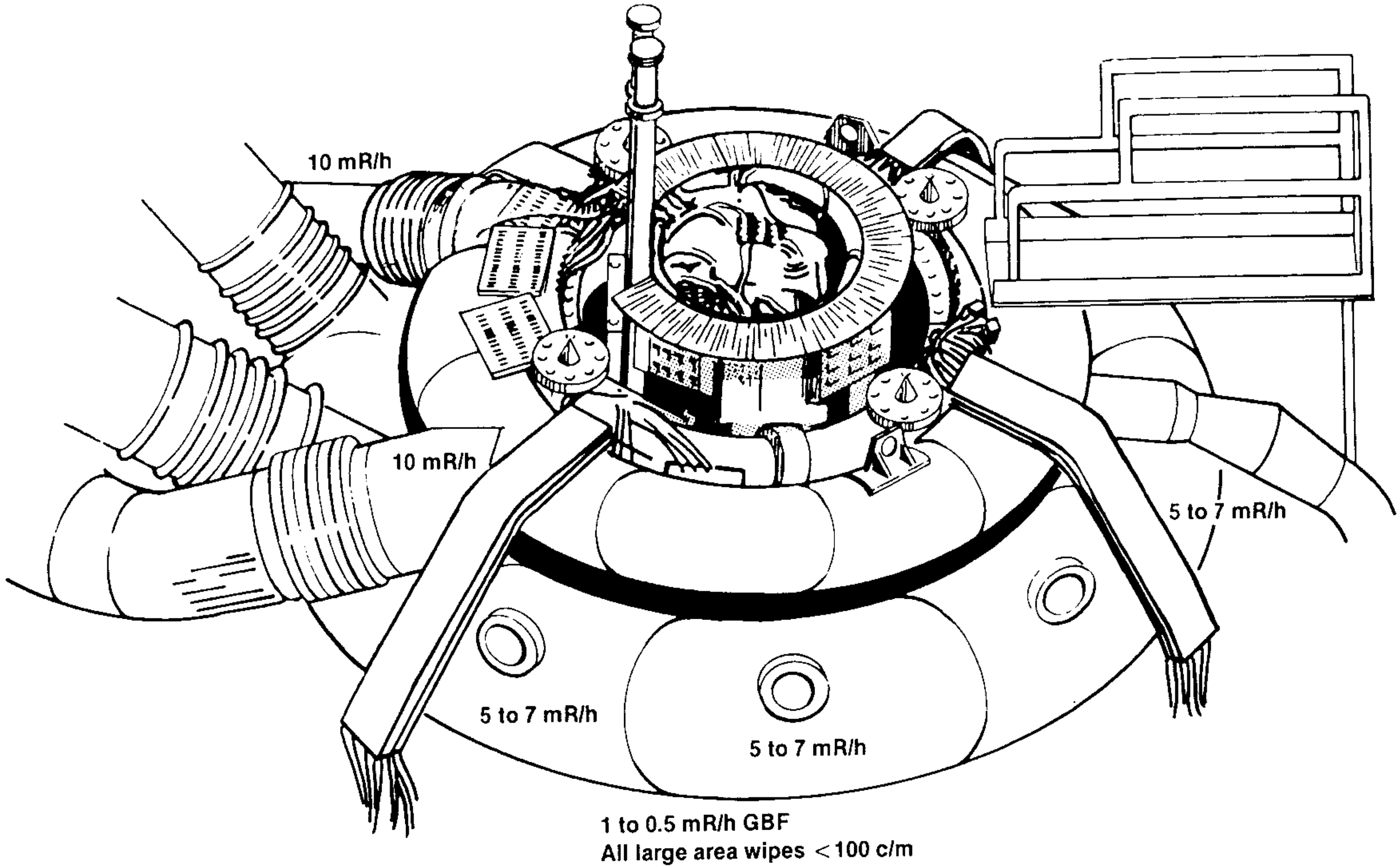

Figure 31. HTRE-2 post-decommissioning radiation and contamination levels, top view.

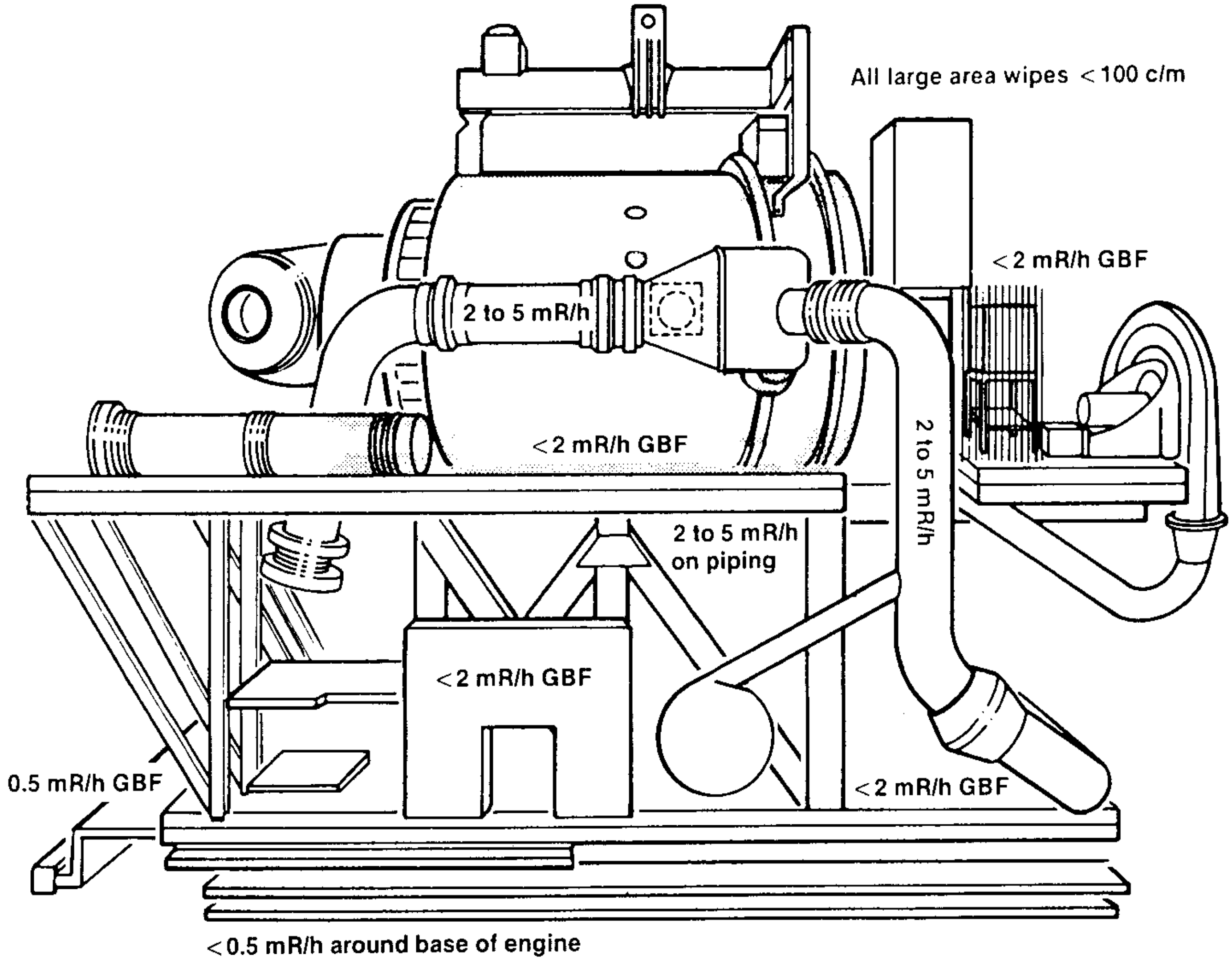

Figure 32. HTRE-3 post-decommissioning radiation and contamination levels, right side view.

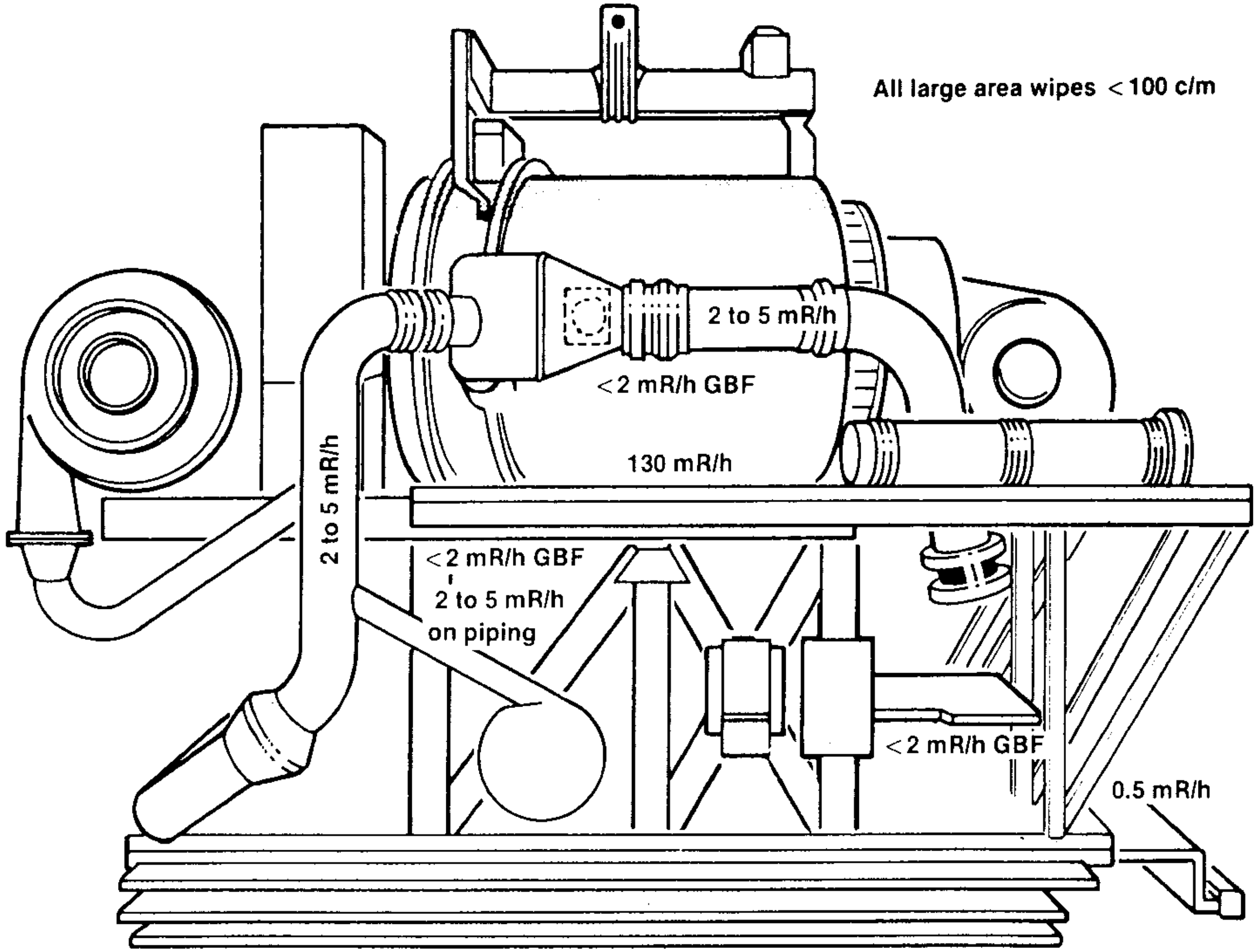

Figure 33. HTRE-3 post-decommissioning radiation and contamination levels, left side view.

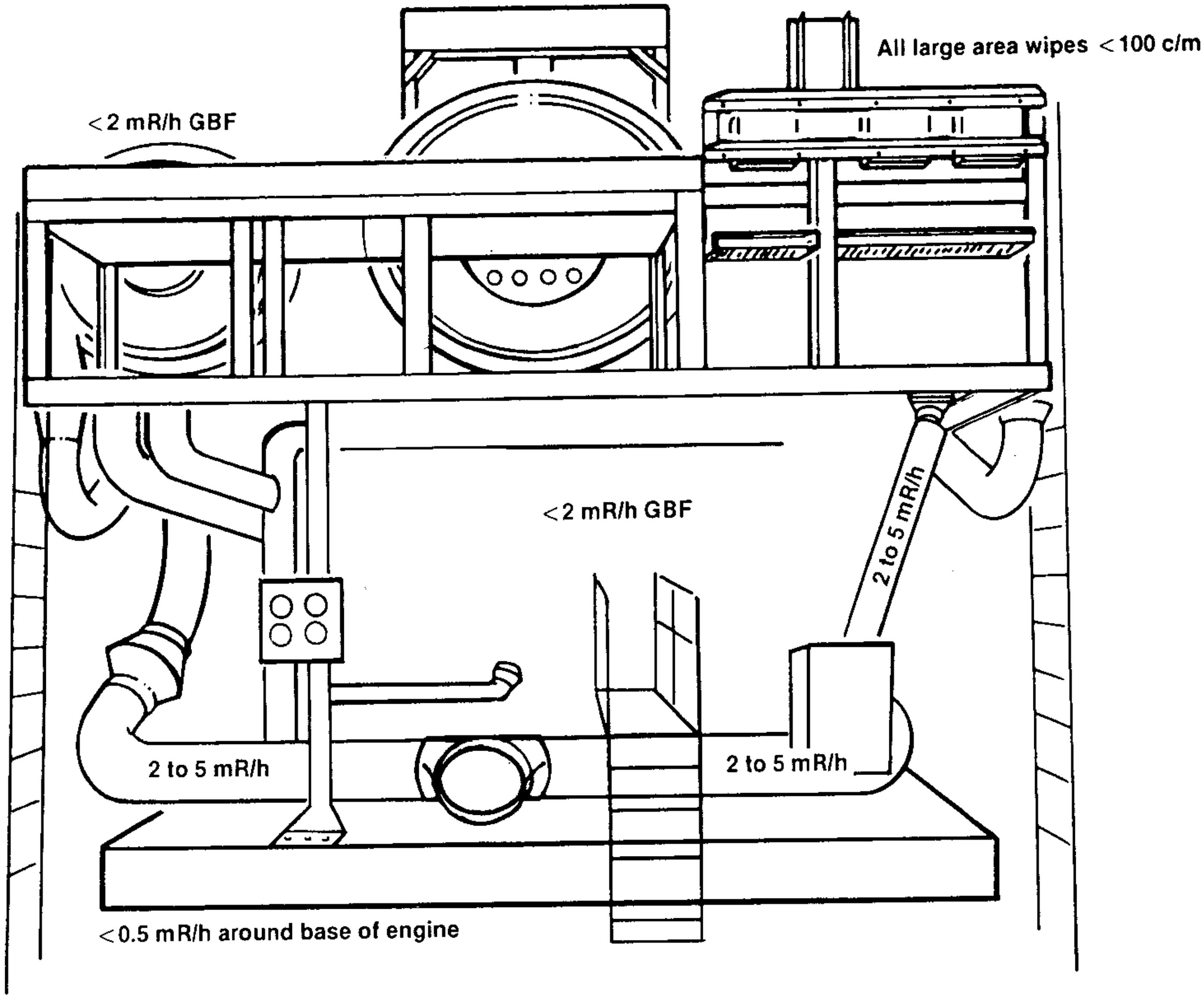

Figure 34. HTRE-3 post-decommissioning radiation and contamination levels, front view.

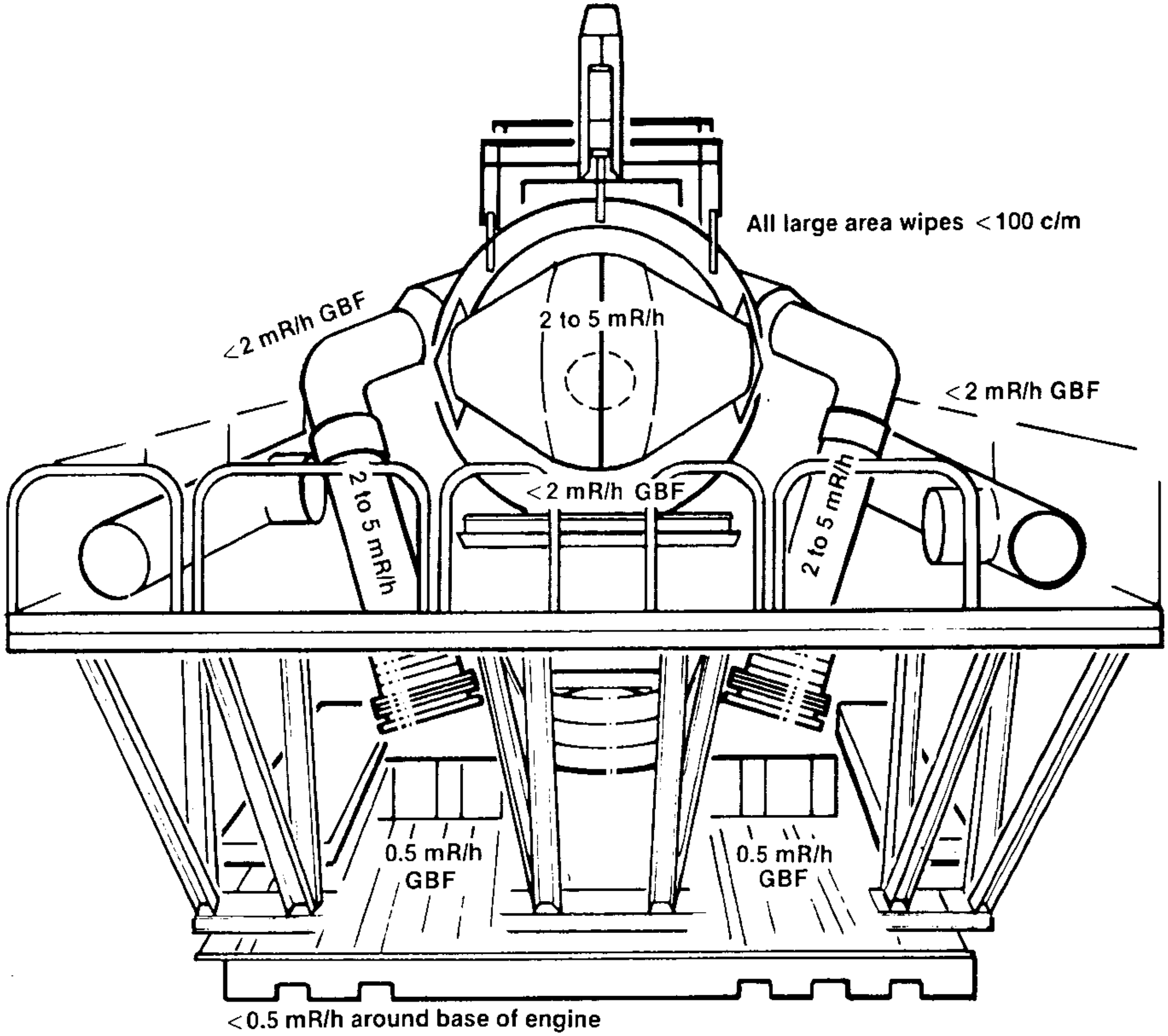

Figure 35. HTRE-3 post-decommissioning radiation and contamination levels, aft view.

COST AND SCHEDULE DATA

The projected and actual costs associated with the characterization and decision analysis, D&D Plan development, and D&D operations including project management are shown in Table 2. The project operations were carried out from October 1986 to September 1989.

Due to the changing work scope associated with this project, the D&D Plan was revised twice to reflect major changes in project direction and scheduling. The most significant change was the decision to preserve the assemblies rather than dismantle them as originally planned. This change resulted in a reduction of approximately $1,000,000 in the total estimated cost. The savings were realized through the elimination of the many labor-intensive dismantlement procedures that would have been required for dismantlement. The reduced workscope cut about two years from the project schedule. Preservation of the assemblies did create additional costs for decontamination planning and work execution related to preparing the assemblies for display. Table 2 lists the costs of preservation ("actual cost") and of dismantlement ("projected cost").

Additional, unplanned costs totaling approximately $43,000 resulted from the implementation of an INEL policy to charge waste generators for storage, handling, and disposal of hazardous wastes.

The project's total estimated cost was $2,580,000 in the FY-1988 field task proposal/agreement and $1,502,000 at the beginning of FY-1989. The final project cost was approximately $1,364,000.

Table 2. Detailed cost breakdown for the HTRE D&D Project

Task	Projected Cost ($K)[a]	Acutal Cost ($K)
Characterization and Decision Analysis	50	50
Decontamination & Decommissioning Plan	30	50
Decontamination & Decommissioning Operations		
Asbestos removal and mercury rinsing	—	524
General decontamination and integrity tightening of the assemblies	—	180
Assembly relocation including subcontracting (pad construction, move, support manpower, engineering)	—	500
Dismantlement operations (labor, materials, waste disposal, facility use fees)	2,440	—
Final report, photo books, and data package[b]	60	60
Total	2,580	1,364

a. Based on total dismantlement.

b. These costs have not been fully costed and are estimates.

WASTE VOLUME GENERATED

Wastes generated during this project included industrial (clean) waste, hazardous waste, mixed waste, and radioactive waste. Table 3 shows the quantity, source, and point of disposal/storage for each of these waste types.

Table 3. Quantities, sources, and points of disposal/storage of waste generated during HTRE D&D Project

Waste Type	Quantity	Source	Disposal/Storage Point
Industrial	10 yd^3	Work enclosure	INEL clean landfill
	5 yd^3	Misc. equipment	INEL clean landfill
Total	15 yd^3		
Hazardous	1,450 gal	HTRE-3 rinsing	Hazardous Waste Storage Facility (HWSF)
	55 gal	Residual oil	HWSF
Total	1,505 gal		
Mixed	940 gal	HTRE-3 rinsing	Mixed Waste Storage Facility
Radioactive	2.5 m^3	Contamination control	Waste Experimental Reduction Facility incinerator
	7.24 m^3	Misc. equipment, piping, etc.	Radioactive Waste Management Complex
	3.62 m^3	Rinsate barrels	WERF compactor/RWMC
Total	13.36 m^3		

PERSONNEL EXPOSURE

Based on the decision to preserve the test assemblies rather than to totally dismantle them, and on the fact that only low radiation fields were present, the area health physics personnel did not require the use of individual, job-specific radiation monitoring devices. Continuous monitoring of the work area by health physics personnel did not detect any abnormal radiation fields. The workers assigned to the HTRE D&D Project showed no exposures above what they normally receive at their usual work locations on the INEL.

Industrial hygiene monitoring of job sites and individual workers indicated that no workers were exposed to hazardous or toxic substances while assigned to this project.

POST-DECOMMISSIONING CONDITION

The HTRE-2 and HTRE-3 assemblies are displayed at the EBR-I area in a safe configuration for public viewing (see Figure 26). Walkways have been paved around and between the assemblies, and fences have been erected to prevent direct access to the assemblies. Interpretive panels telling the history and significance of the assemblies have been mounted on the fences. A gazebo to house the interpretive panels will be constructed in the center walkway between the assemblies by the end of September 1989. Vehicle barriers have been constructed for parking control. The assemblies were first available for viewing on May 22, 1989, which coincided with the seasonal opening of the EBR-I National Historic Landmark.

Post-relocation radiological surveys indicated that radiological conditions were unchanged from the pre-move conditions.

The previous storage location at the TAN TSF is part of a larger INEL COCA site and will receive continued surveillance and ultimate remediation through the Remedial Actions Program. There will be no surveillance costs associated with this location after FY-1991. Routine radiological surveys will be performed once or twice a year in FY-1990 and FY-1991.

LESSONS LEARNED

The increasing importance of hazardous waste handling caused delays and regulatory compliance concerns. Current and future projects will need to investigate and address this issue in depth.

During the planning for the mercury removal from the HTRE-3 assembly, the effects of having the system open for more than 25 years was not factored into the condition of the materials present. In this case, the mercury was altered through biological action and amalgamation of metals from system components. Future projects should evaluate, during the planning stages, the interactions of materials that are left in place for long periods of time.

During the acid rinse operation, two nipple connections (out of a total of eight) on a manifold were corroded to the point of failure. Investigations revealed that these components were constructed of carbon steel instead of the stainless steel specified and utilized in all other components. Extra care should have been taken to verify that the materials supplied were as specified. This is especially true when highly corrosive materials are involved (in this case a 30% acidic solution). Adequate safety planning prevented worker injury and environmental release of materials.

System conditions were not fully verified following rinse operations due to deadlines imposed by other programs wanting to use the facility. This caused a loss of control of materials by forcing a decision to plug the system openings after relocation. Similar pressures should be resisted as they eventually lead to problems.

REFERENCES

1. D. L. Smith, *Decontamination and Decommissioning (D&D) Plan for the Heat Transfer Reactor Test Assemblies HTRE-2 and HTRE-3*, PR-W-79-001, Rev. 0, January 1979.

2. S. T. Fenn, *Decontamination and Decommissioning (D&D) Plan for the Heat Transfer Reactor Test Assemblies HTRE-2 and HTRE-3,* PR-W-79-001, Rev. 2, June 1988).

3. S. T. Fenn, *Decontamination and Decommissioning (D&D) Plan for the Heat Transfer Reactor Test Assemblies HTRE-2 and HTRE-3*, PR-W-79-001, Rev. 1, September 1987.

4. O&CIE Mechanical Engineering, *Transportation Plan for Movement of Heat Transfer Reactor Experiment (HTRE) Assemblies HTRE-2 and HTRE-3 from TAN to EBR-I*, Rev. A, November 1988.