

The Distillation and Incineration of 132,000 Liters (35,000 Gallons) of Mixed-Waste Hexone Solvents from Hanford's REDOX Plant

Prepared for the U.S. Department of Energy
Office of Technology and Development



Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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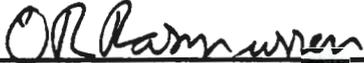
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THE DISTILLATION AND INCINERATION OF 132,000 LITERS (35,000 GALLONS) OF MIXED WASTE HEXONE SOLVENTS FROM HANFORD'S REDOX PLANT

O. R. Rasmussen, W. F. Heine, and R. J. Cowan

ABSTRACT

The Westinghouse Hanford Company has successfully decontaminated 132,000 L (35,000 gal) of radioactive hazardous waste solvents and destroyed the solvents by commercial incineration. The solvents, a mixture of hexone (methyl isobutyl ketone), kerosene, and tributyl phosphate were the extractants in the Reduction Oxidation nuclear fuel reprocessing plant in the 1960's and were stored in carbon-steel underground tanks since the plant shut down in 1967. Westinghouse Hanford Company decontaminated the solvent in a distillation system specially designed to accumulate the radioactive distillation tars in sacrificial vessels for disposal. The distillate, essentially free of radionuclides except for tritium, was shipped in 19,000-L (5,000-gallon) tank trailer loads to a licensed and permitted commercial incinerator that used the solvents' fuel value to produce electric power in a co-generation plant. This successful recovery operation made beneficial use of a material that once posed a significant environmental risk at the Hanford Site. The project was made possible through technology demonstration funding provided by the U.S. Department of Energy's Office of Technology Development and its predecessor, the Hazardous Waste Remedial Action Program.

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ACKNOWLEDGEMENT

The Hexone Remediation Project owes its success to the dedication of many individuals who provided important expertise and tireless efforts in their specialties. The authors would like to thank these individuals for supporting the project through to its successful conclusion. They have made an important contribution to the goal of cleaning up and restoring the Hanford Site.

The authors would especially like to thank five contributors whose support was vital to the project. That the entire bulk hexone inventory has been destroyed is primarily due to the foresight of Gary Bracken of the U.S. Department of Energy, Richland Field Office, who staunchly supported a full-scale remediation effort during the project's definition stage. Project team members JoAnn Brehm, Robert Pavlina, and Eugene Wood were instrumental in translating the project from paper to operating reality. And, last but not least, Richard Lucke of the Pacific Northwest Laboratory performed the pilot scale tests that were essential to the successful decontamination of the hexone waste.

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**THE DISTILLATION AND INCINERATION OF 132,000 Liters (35,000) GALLONS OF MIXED
WASTE HEXONE SOLVENTS FROM HANFORD'S REDOX PLANT****1.0 INTRODUCTION**

Radioactively contaminated solvents from nuclear fuel reprocessing have long posed a severe remediation challenge. In 1987 when the U.S. Department of Energy (DOE) Hazardous Waste Remedial Action Program (HAZWRAP) requested proposals for waste remediation demonstrations, Rockwell Hanford Operations, Westinghouse Hanford Company's predecessor at the Hanford Site, proposed to remediate 132,000 L (35,000 gal) of radioactive hexone waste solvents as an industrial-scale demonstration of waste cleanup technology for use at DOE and commercial sites. The proposal was one of three Hanford Site initiatives originally selected by HAZWRAP and was funded for initial scoping work in late fiscal year (FY) 1987. The HAZWRAP and the DOE's Office of Technology Development continued to sponsor the demonstration through its successful completion in FY 1992. The Environmental Restoration Program, nominal "owner" of the waste solvents, shared 70 percent of the final commercial incineration contract costs.

2.0 THE SOLVENT WASTE SITUATION - 1987

The radioactive solvents were recognized as a problem for many years. The solvents were used in the Hanford Site's Reduction Oxidation Plant (REDOX) nuclear fuel reprocessing plant for extracting plutonium and uranium from dissolved uranium fuel elements. When REDOX was shut down in 1967, the plant's solvent inventory was pumped into two 89,000-L (23,500-gal) carbon steel underground storage tanks built in 1950 for storing freshly manufactured solvents.

Tank 276-S-141 received 77,500 L (20,000 gal) of hexone distilled in the REDOX steam-stripping column before storage. Tank 276-S-142 received 30,000 L (8,000 gal) of hexone and 19,400 L (5,000 gal) of a 2:1 mixture of kerosene and tributyl phosphate. The hexone, a highly flammable solvent with a room-temperature flash point, was the normal REDOX solvent and contained very low levels of radioactivity.

The kerosene and tributyl phosphate had been used in a once-only extraction operation that recovered americium for space applications from Shippingport Reactor blanket-fuel. Some of the solvents initially contained high levels of short-lived isotopes. By the 1980's, most of this activity had decayed away, leaving 0.14 Ci of hard beta activity and 0.108 Ci of alpha activity. The bulk of this radioactivity, 99.8 percent, resided in tank 276-S-142. In addition, spread through both tanks were 0.76 Ci of tritium, a very weak beta emitter that had exchanged with hydrogen in the hexone molecular structure. Tank 276-S-142 also contained 7,750 L (2,000 gal) of solvent-saturated water.

Routine level measurements and internal inspections showed that both tanks were sound, but were not aging well and were internally corroded. It was clear that constructing new storage tanks meeting all current standards would only prolong the waste storage problem and that the most cost effective and responsible action would be to remediate the waste and to close the storage site.

3.0 THE REMEDIATION TECHNOLOGY ANSWER

The Hexone Remediation Demonstration, proposed in FY 1986, was accepted and initially funded in late FY 1987. Early scoping work quickly identified incineration as the most practical means of destroying the waste solvents. Incineration was used extensively in industry for solvents that could not be cleaned for reuse. No commercial or DOE facilities existed to incinerate flammable solvents as contaminated with plutonium, americium, and fission products as was the REDOX waste. Reuse of the material was ruled out from both practical and societal considerations. The funding required to construct and permit a radioactive waste incinerator was well beyond that projected for the demonstration.

Effort therefore focused on removing the radionuclides from the waste solvents and on incinerating the distillate in a commercial incinerator under contract or lease. Samples of the solvents had been boiled down in early disposal studies in the mid-1970's, and while the tests had shown effective decontamination efficiencies, they also had shown massive tar and residual liquor generation in the hexone-kerosene-tributyl phosphate phase.

4.0 DEVELOPMENT TESTS

Laboratory tests were contracted to Pacific Northwest Laboratory (PNL) in Richland, Washington. The PNL technicians withdrew 22 one-liter samples from the underground tanks and launched a new series of waste characterizations and a variety of distillation tests. The distillation results showed that the pure hexone [boiling point 117 °C (243 °F)] and the water phases easily evaporated with very little residue. Contrary to earlier test data, it was shown that the hexone-kerosene-tributyl phosphate mixture could be heated to approximately 204 °C (400 °F) and reduced to a small volume of dry solid tar. The tributyl phosphate partially decomposed below its boiling point, leaving hard phosphate complexes coating all hot surfaces. The major liquid breakdown product, butanol, was readily distilled over. The decontamination efficiencies for plutonium, americium, and hard beta emitters exceeded 99.9 percent for all samples.

5.0 REGULATORY REVIEW AND PERMITTING

An extensive regulatory review was performed in the project's early stages. A *Resource Conservation and Recovery Act of 1976* (RCRA) Part-A permit was submitted to carry out the process under the interim status provisions of RCRA. A Part-B permit was not required because the operating life of the facility was limited. A closure plan currently under preparation and scheduled for submission to Washington State in November 1992 details the closure of the distillation system and hexone tank site. Other documentation prepared for the demonstration included a safety analysis document, and an environmental evaluation, as well as RCRA-compliant plan for personnel training, contingency, waste analysis, and inspection.

6.0 DISTILLATION EQUIPMENT DESIGN

Various distillation equipment options were evaluated, including steam strippers, distillation columns, and different types of evaporators. Special consideration was given to the radionuclide content of the waste and to the tarry nature of the distillation residue. Sacrificial distillation vessels [1,136-L (300-gal) steel pressure vessels with heating coils] were chosen as they offered several important advantages.

- Liquid waste is pumped into the vessels and only vapors exit (although in actual practice the weir design did allow some recirculation to the underground tank). When the vessels are filled with the maximum practicable amount of radioactive tars, they are blanked off and become strong primary storage containers for the radionuclides. The vessels were designed to meet 1988 Waste Isolation Pilot Plant container criteria in the event that the tar was classified as transuranic.
- Very little secondary waste is generated.
- The handling and packaging of radioactive residues is virtually eliminated.
- The heating system remains remote and is not contaminated.
- The requirement for maintaining radioactively contaminated equipment is reduced to an absolute minimum.
- Radioactive exposure to personnel is kept as low as possible. This advantage would be even more significant for wastes with a higher concentration of radionuclides.

The distillation equipment layout is shown in Figure 1. Piping and instrument schematics are shown in Figures 2 and 3. A 0.5 hp gear pump transfers waste from the underground tanks into a feed weir that maintains a constant liquid level in the coil-heated distillation vessel. Excess feed

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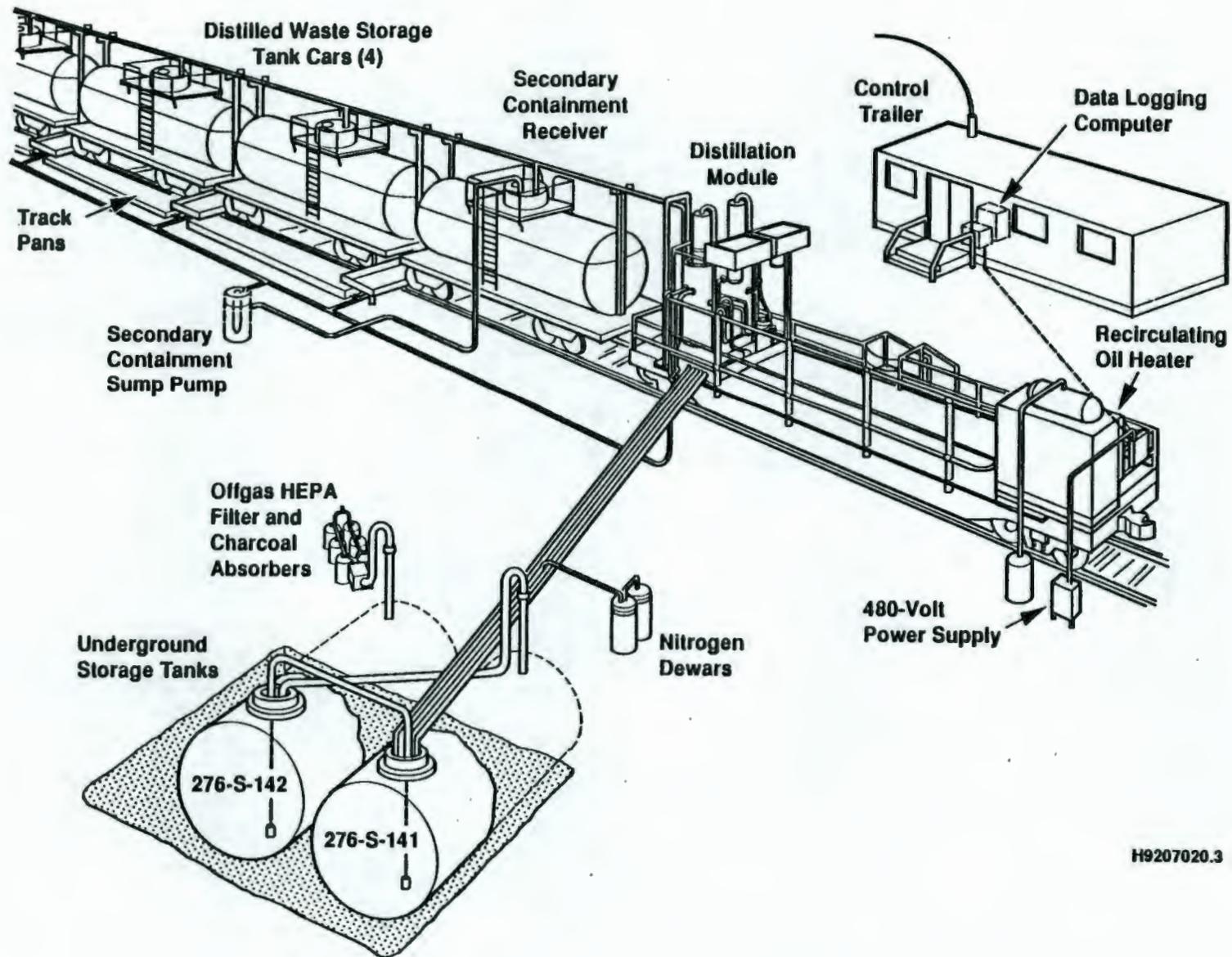
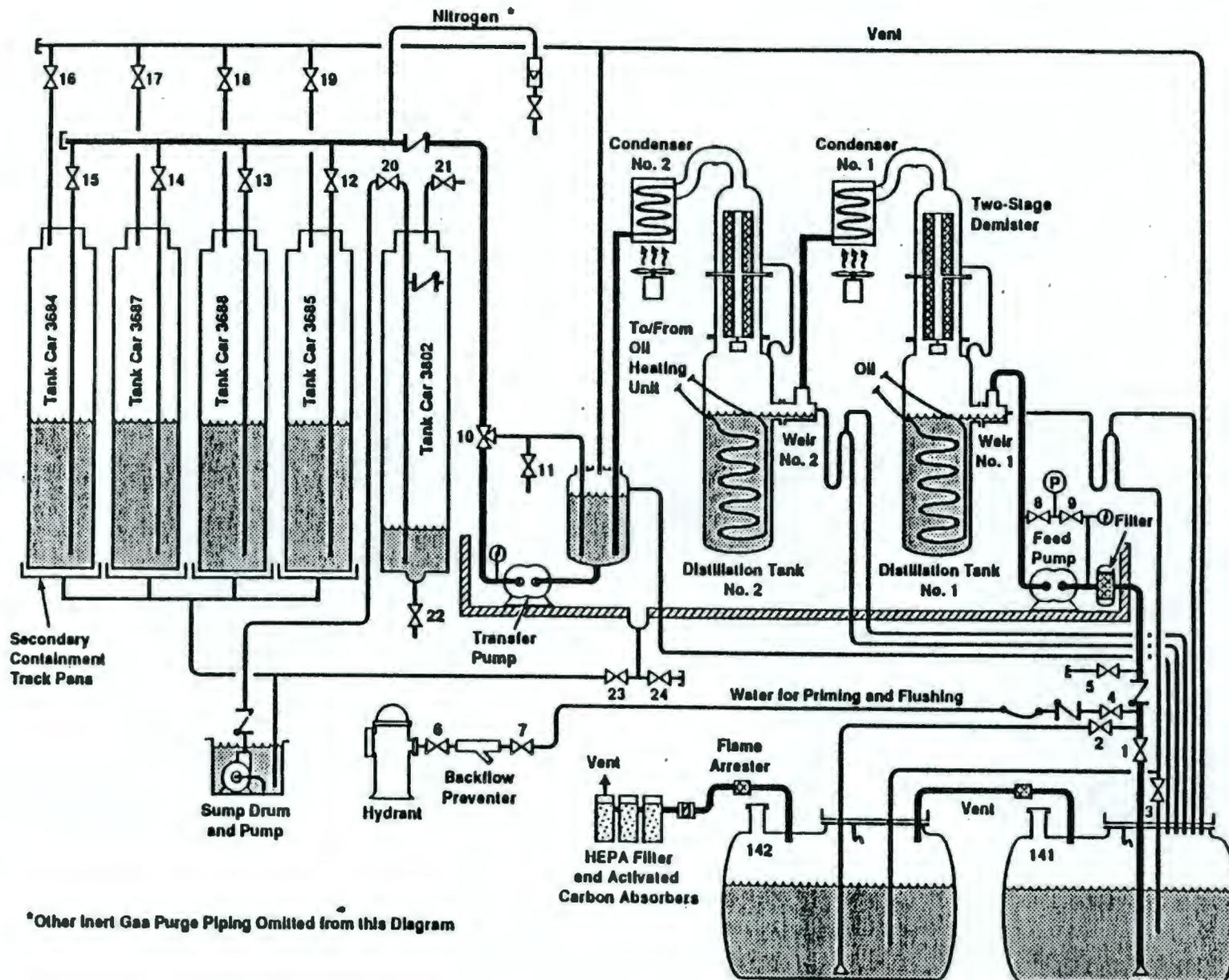


Figure 1. Hexone Distillation Arrangement.

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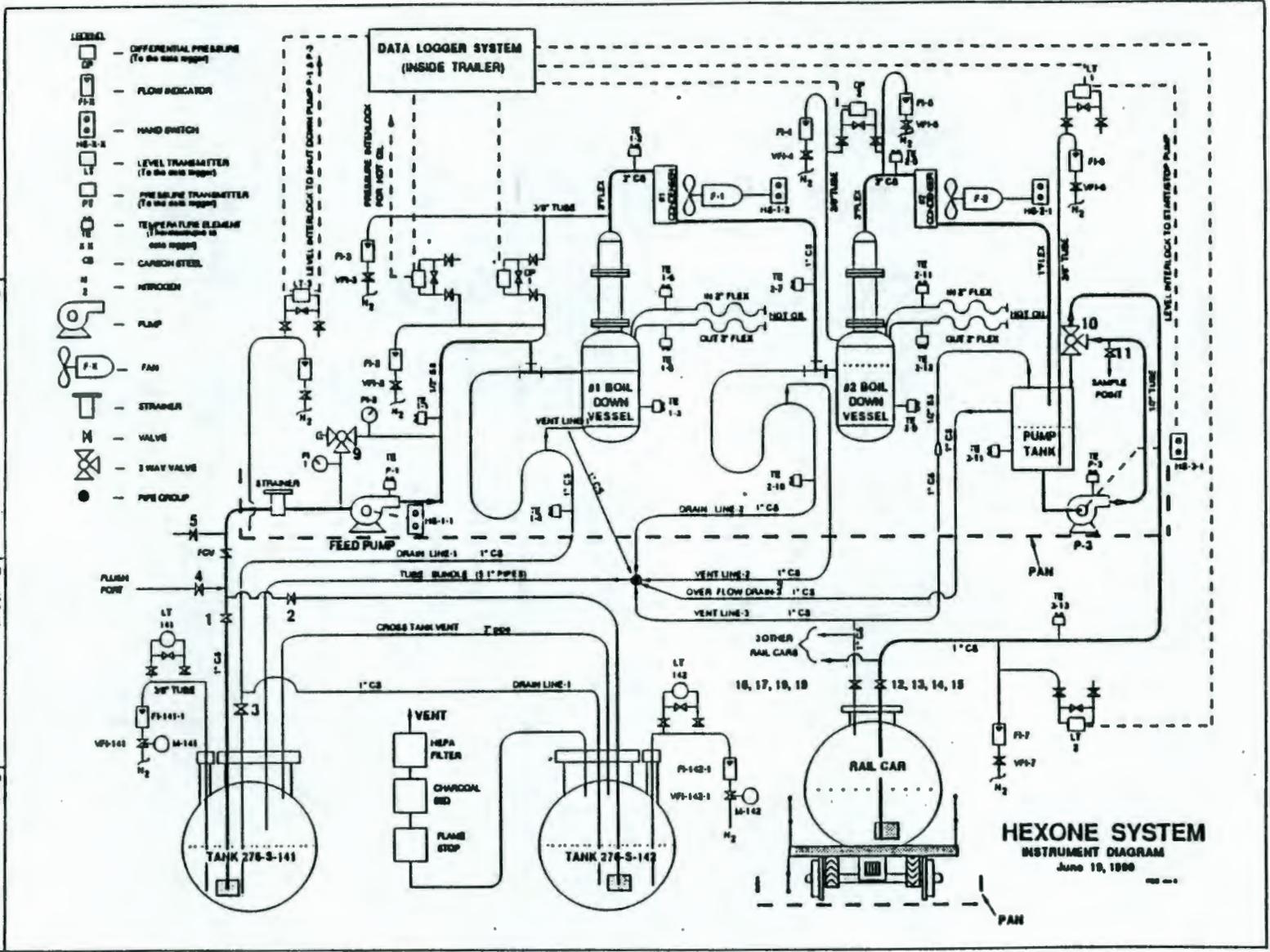


*Other Inert Gas Purge Piping Omitted from this Diagram

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Figure 2. Hexone Distillation System Piping Schematic.

Figure 3. Hexone System Instrument Diagram.



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overflows via a 1-m (40-in.) seal loop and returns to the underground feed tank. Vapors pass through two high-efficiency demister elements, are condensed, and are again treated by the identical process in the second stage before transfer to the rail tank cars for storage.

The distillation system was constructed as a modular unit by installing all major components on a 100-ton-capacity railroad flatcar (Figures 4 and 5). Use of the railcar reduced fabrication costs as the system could be assembled in the shops and then moved as a complete unit to the site with a minimum of costly field work.

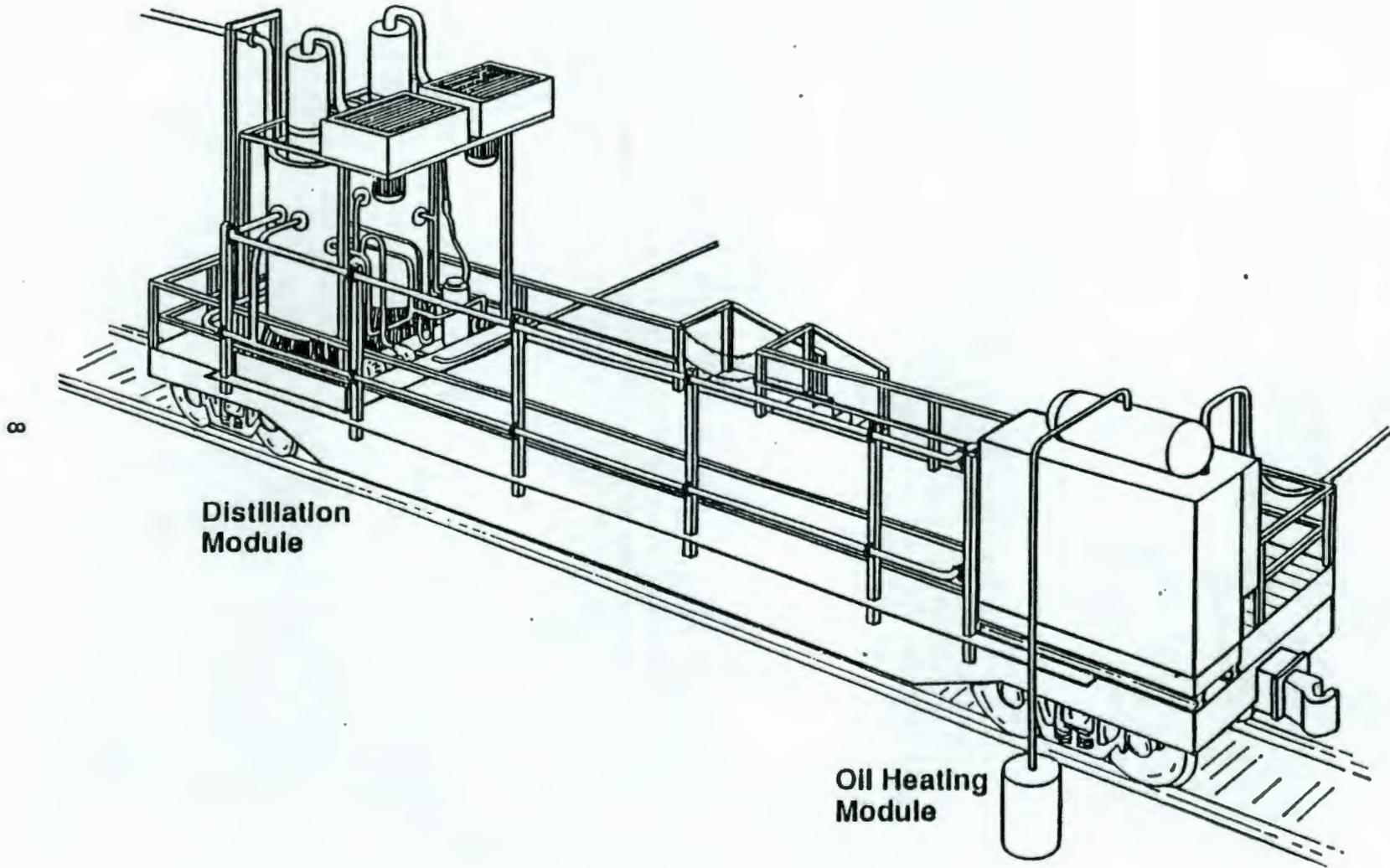
The distillation occurred in two 0.9-m-dia. by 2-m-tall (3-ft-dia. by 6.5-ft-tall) cylindrical distillation vessels (Figures 6 through 8) in series. Each vessel was surmounted by a 2.5-m (8-ft) -tall, two-stage demisting unit and a fan-cooled condenser. A 120-L (30-gal) transfer tank received the double-distilled hexone product (Figure 9). Four Department of Transportation (DOT) 103-W 3,800-L (10,000-gal) railroad tank cars were connected with transfer and vent piping to the transfer tank pumping system. The distillation system had a nominal process capacity of 5 L (1.3 gal) of hexone per minute, although in actual practice this rate declined as the first-stage distillation vessel gradually filled with tar. When processing water, the rate averaged 2 L (0.5 gal)/min. Three spare distillation vessels were fabricated to replace units filled with radioactive tar residues, although only one spare vessel actually was used.

The distillation vessels were heated with a heat-transfer oil circulating through pipe coils. A standard commercial oil heating unit (Figure 10) was located at the opposite end of the flatcar and was connected to the distillation module with insulated 7.6-cm (3-in.) piping. All electrical equipment on the distillation module were constructed with explosion-proof components. The electrically-fired oil heating system, which is not designed to explosion-proof standards, was located more than the required 8 m (25 ft) from the distillation module to maintain safe separation. All components of the distillation system, including piping, tank cars, and secondary containment facilities, were fully grounded. A 12-m (40-ft) light pole with four sodium vapor lights was bolted to the frame of the flatcar for visibility at night.

Four DOT 103-W rail tank cars suitable for transporting flammable solvents were obtained at no cost from the Department of Defense for storing the distilled solvent waste. All of the cars were rinsed, hydrostatically tested, internally inspected and photographed, and equipped with new fill and vent piping as well as new relief valves.

A secondary containment system (Figure 11) was designed to meet RCRA requirements and consisted of steel pans under the distillation module, the four hexone receiver cars, and under all threaded fittings on hexone-carrying pipe. Four 12-m (40-ft) track pans were placed under each hexone storage tank car, and the gaps between cars were spanned by bridge pans. The 16 track pans and the distillation module pan were connected via a header system to a sump vessel equipped with an automatic transfer pump. A 43,000-L (11,360-gal) -capacity tank car, large enough to receive 110 percent of the volume of the largest vessel in the system, acted as the drainage receiver vessel. Rainwater pumped to the receiver car was sampled routinely before disposal to the ground.

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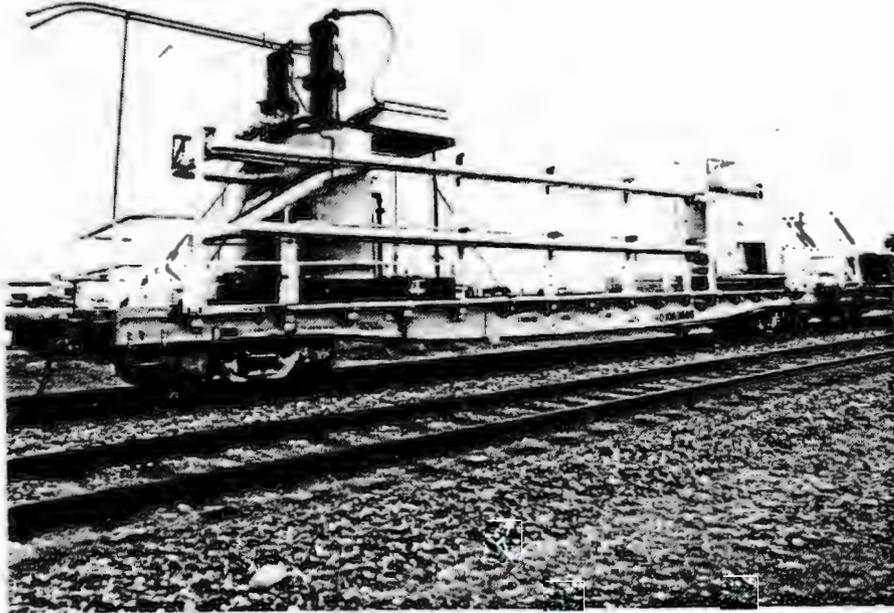
Distillation
Module

Oil Heating
Module

Figure 4. Distillation System Mounted on Flatcar.

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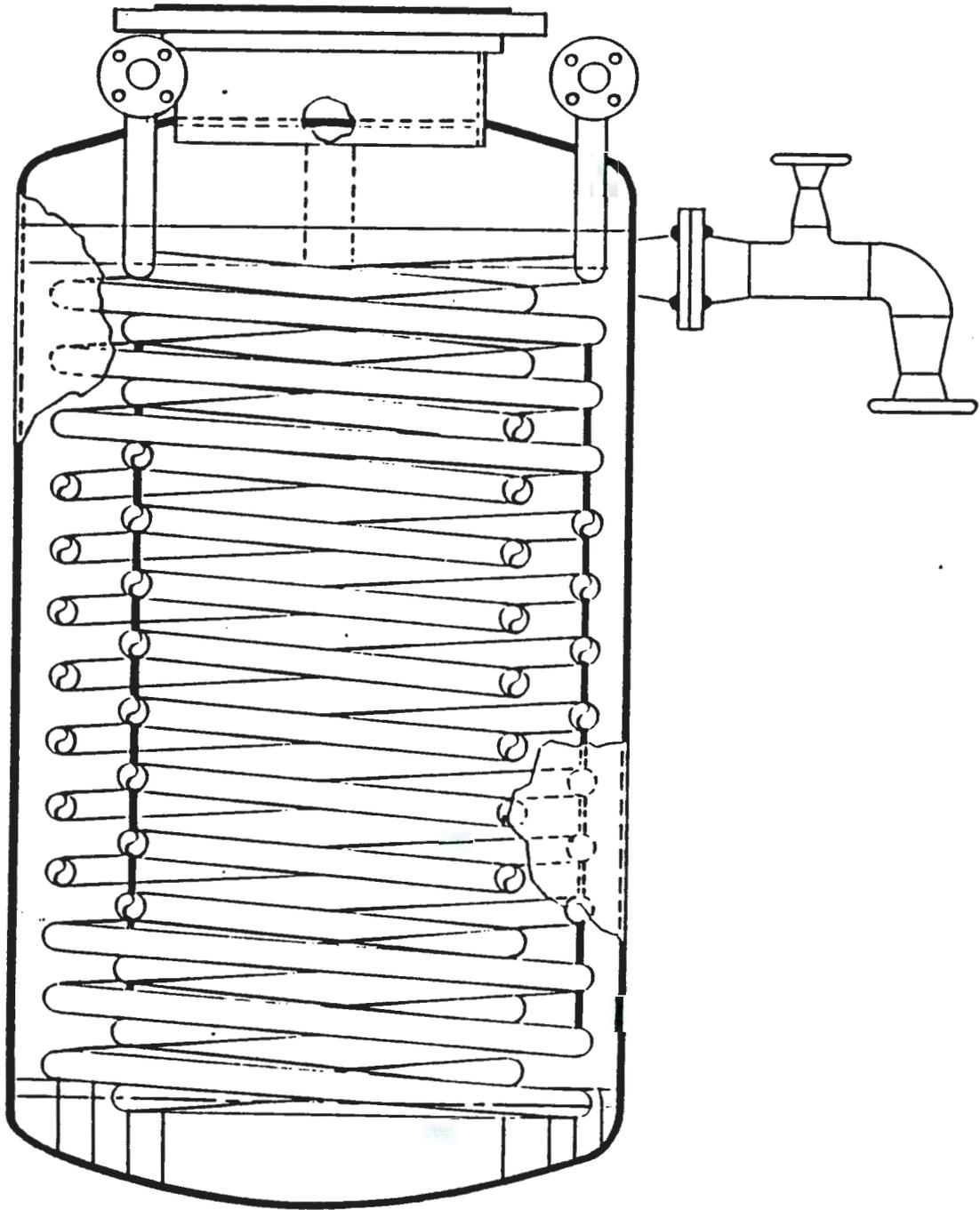
Figure 5. Distillation System on Flatcar.



The distillation system is shown before transport to the site and before the installation of insulation blankets on the demister housings. The boxy structure is the electrically fired oil heater. It is connected to the distillation system at the other end of the car via insulated piping.

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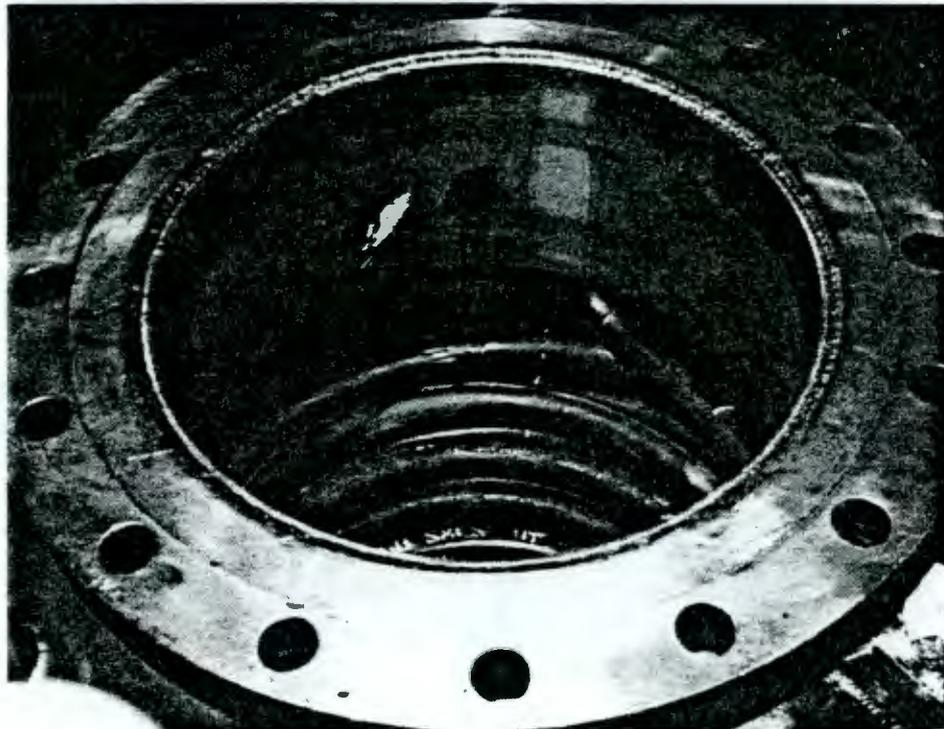
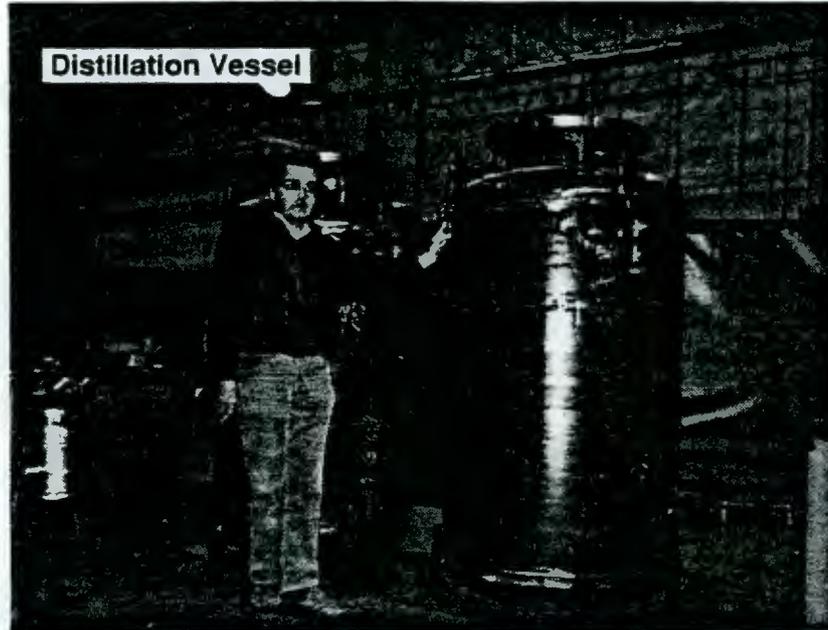
Figure 6. Distillation Vessel.



The distillation vessels are 0.9 m (3 ft) in diameter and 2.5 m (6.5 ft) tall. The vessel is fabricated from 0.95 cm (3/8 in.) carbon steel. The 7.6-cm (3-in.)-dia. feed weir is shown at upper right.

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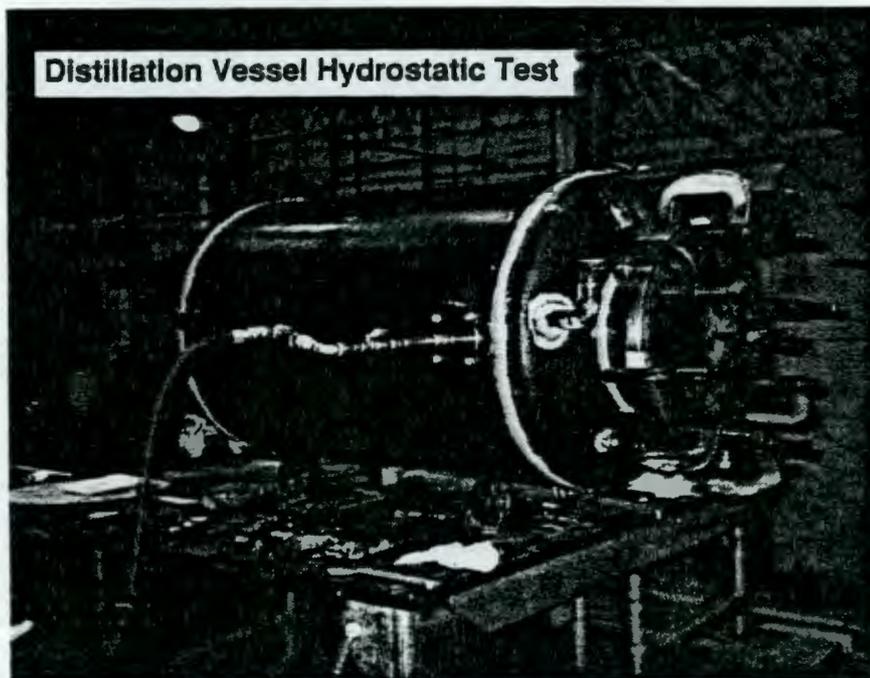
Figure 7. Distillation Vessel Assembly.



A completed distillation vessel (top) ready for installation in the distillation module. The double row of internal heating coils (above) provide the necessary heat transfer surface area for boiling tarry feed material.

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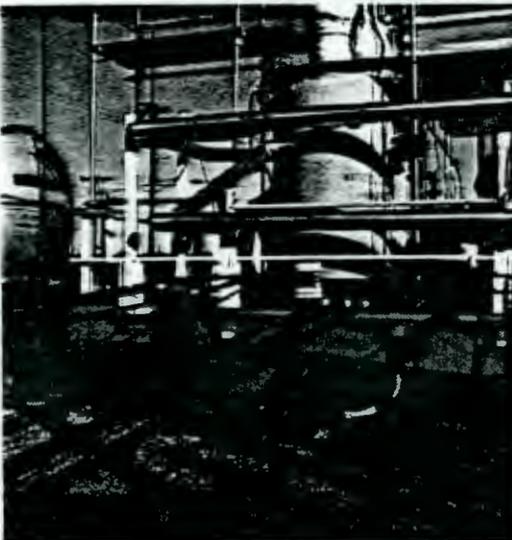
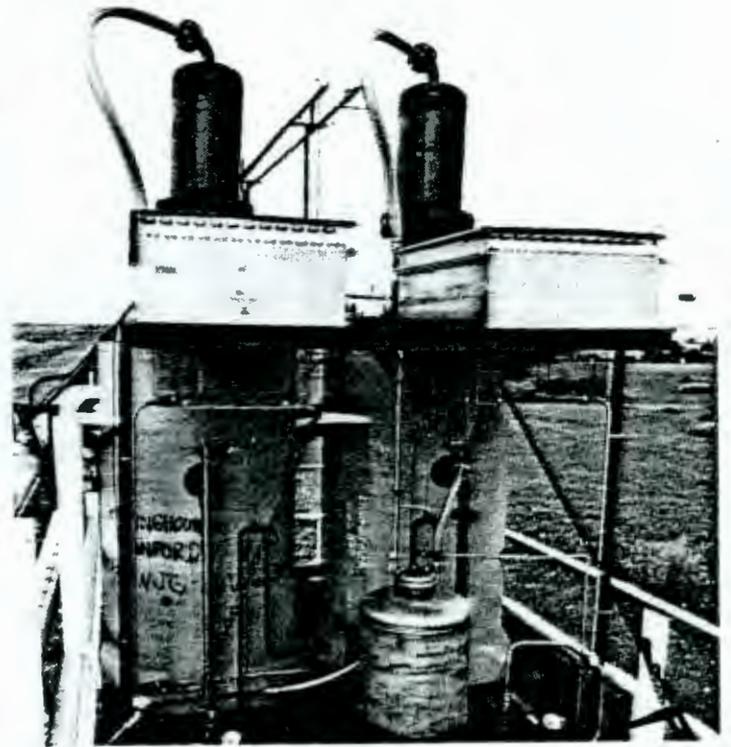
Figure 8. Distillation Vessels.



The top photo shows one of the distillation vessels undergoing hydrostatic testing before final certification. The lower photo shows the three spare distillation vessels fabricated for the hexone cleanup effort. Only one spare vessel was actually used.

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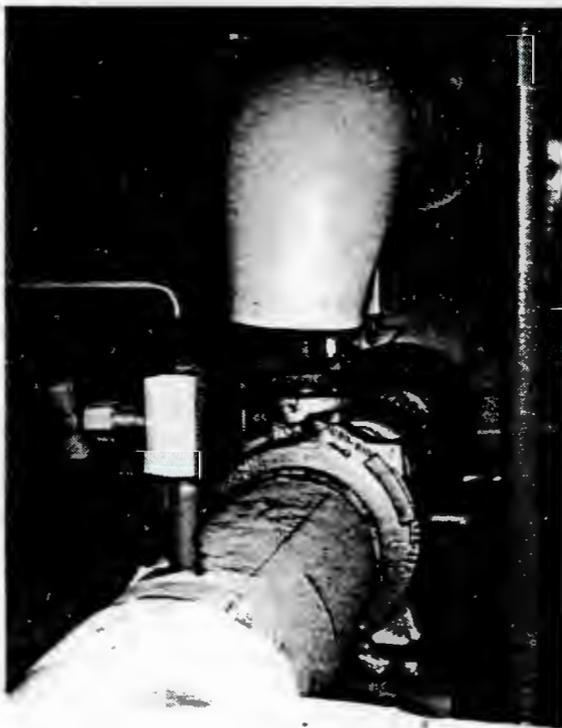
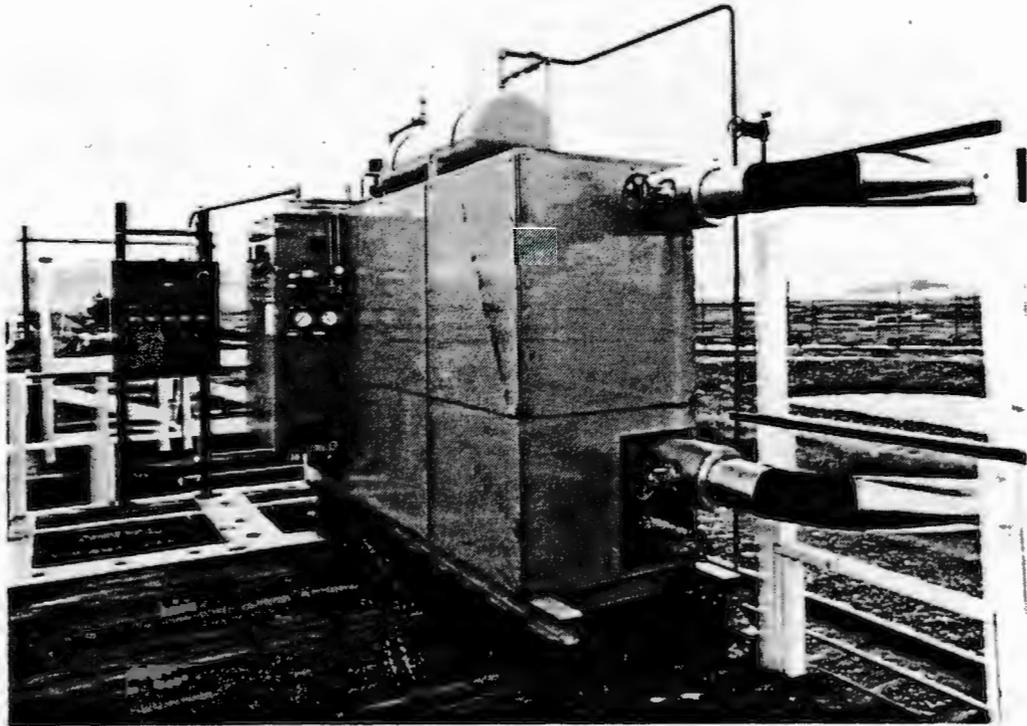
Figure 9. Distillation System Details.



The photo at upper left shows the feed pump and the feed weir/seal loop system. The photo at upper right provides a broader view, with the product accumulation tank, and product transfer pump at lower right. The piping connecting the distillation system to the underground storage tank is shown in the photo at left.

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Figure 10. Oil Heating System.



A commercial oil heating system was purchased to heat and recirculate oil through the distillation vessel coils. The oil system was mounted at one end of the flatcar (top). A pump (left) recirculated the oil through two electric heaters and the vessel coils.

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Figure 11. Construction of the Secondary Containment and Grounding Systems.



Track pans were installed for the event of tank car or piping leakage (upper photo). Bridge pans, installed after the tank cars were in place, spanned the gap between pans. Piping connected the pans to a sump vessel, equipped with a transfer pump to the secondary containment tank car. An extensive grounding system was installed as a fire protection measure (lower photo).

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Pressure, temperature, and liquid-level sensors from the distillation system and associated tankage were connected via explosion-proof electronic transmitters to a datalogger for recording process and operating data. An office trailer (Figure 12) was installed at the site to house the datalogger and to maintain logbooks and operating documentation.

Power for the distillation system pumps, heaters, and fan motors was obtained from a 200 amp, 480-v 3-phase breaker located in the 276-S Building.

7.0 INERTING AND OFFGAS CONTROL

Two 113m³ (4,000 ft³) gas capacity liquid nitrogen dewars (Figure 13a) provided gas for inerting the four distillate receiver tank cars, the distillation module vessels, and the underground hexone tanks. The nitrogen gas also served as the medium for the continuous purging of all pressure sensors and for operating the weight factor dip tube bubblers used for liquid-level measurements. A demand regulator (Figure 13b) on the nitrogen supply system added nitrogen gas as required to maintain the hexone system pressure about 0.5-cm (0.2-in.) water above ambient pressure to prevent air infiltration. Inert conditions in the distillation system were essential, as at times the system operated above the self ignition temperature of the solvent vapors.

Purge nitrogen gas from the distillation system as well as noncondensable gases vented first to tank 276-S-141 and flowed via a flame arrester to tank 276-S-142 before entering the offgas filtration system. This arrangement allowed the two underground tanks to be used as backup vapor condensing pots. Gases vented from tank 276-S-142 passed through a flame arrester, a high-efficiency particulate air (HEPA) filter, and then two parallel systems of three activated-charcoal absorption units in series (Figure 13c).

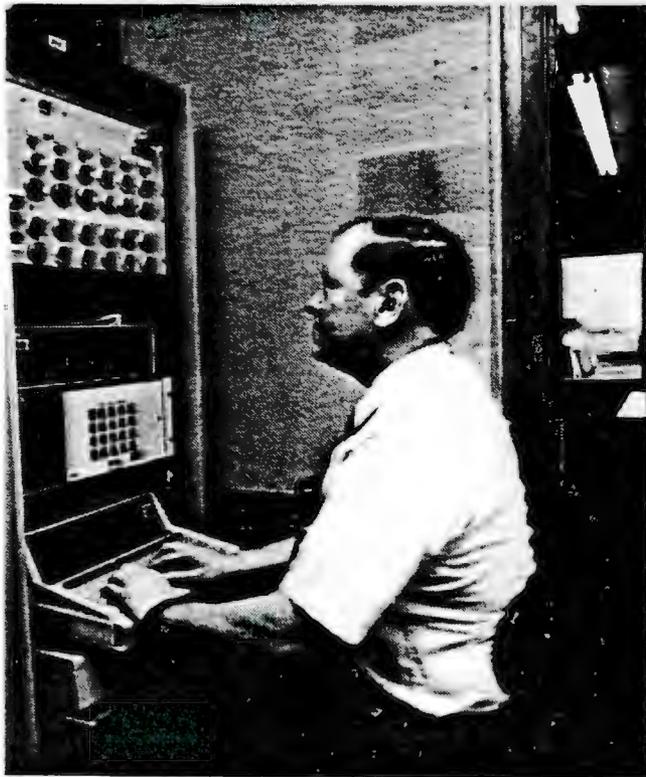
8.0 DISTILLATION OPERATIONS

The distillation system was moved to the site on a seven-car train in February of 1990 (Figures 14 and 15). After completion of piping and utility connections, operability testing, training, and readiness review, the system started up in July of 1990.

As expected, distillation operations proceeded very smoothly for the 77,500-L (20,000-gal) tank batch of nearly pure hexone. Process rates of 5 L (1.3 gal)/min were easily maintained without approaching the 1-m (40-in.) hydrostatic pressure limit imposed by the weir overflow loops. Problems with plugging of the feed gear pump with rust flakes were overcome by reducing the inlet screen opening from 40 to 80 mesh and installing a larger screen housing.

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Figure 12. Control Trailer and Datalogger.



A control trailer (upper photo) was installed 8 m (25 ft) from the distillation system. All temperature, pressure, and other operating data were accumulated, displayed, and recorded on a datalogger (left)..

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Figure 13. Inert Gas and Vent System.



a. **Liquid Nitrogen Tanks.** Dewar tanks provided the nitrogen for inerting all vapor spaces.



b. **Demand Regulator.** A demand regulator controlled the nitrogen flow and maintained the tanks and distillation system under 0.5-1.0 cm (0.2 - 0.4 in.) of water pressure to prevent air intrusion and a fire hazard.



c. **Offgas System.** The tanks vented through a flame arrester, a HEPA filter and a set of six activated charcoal drums to the outside.

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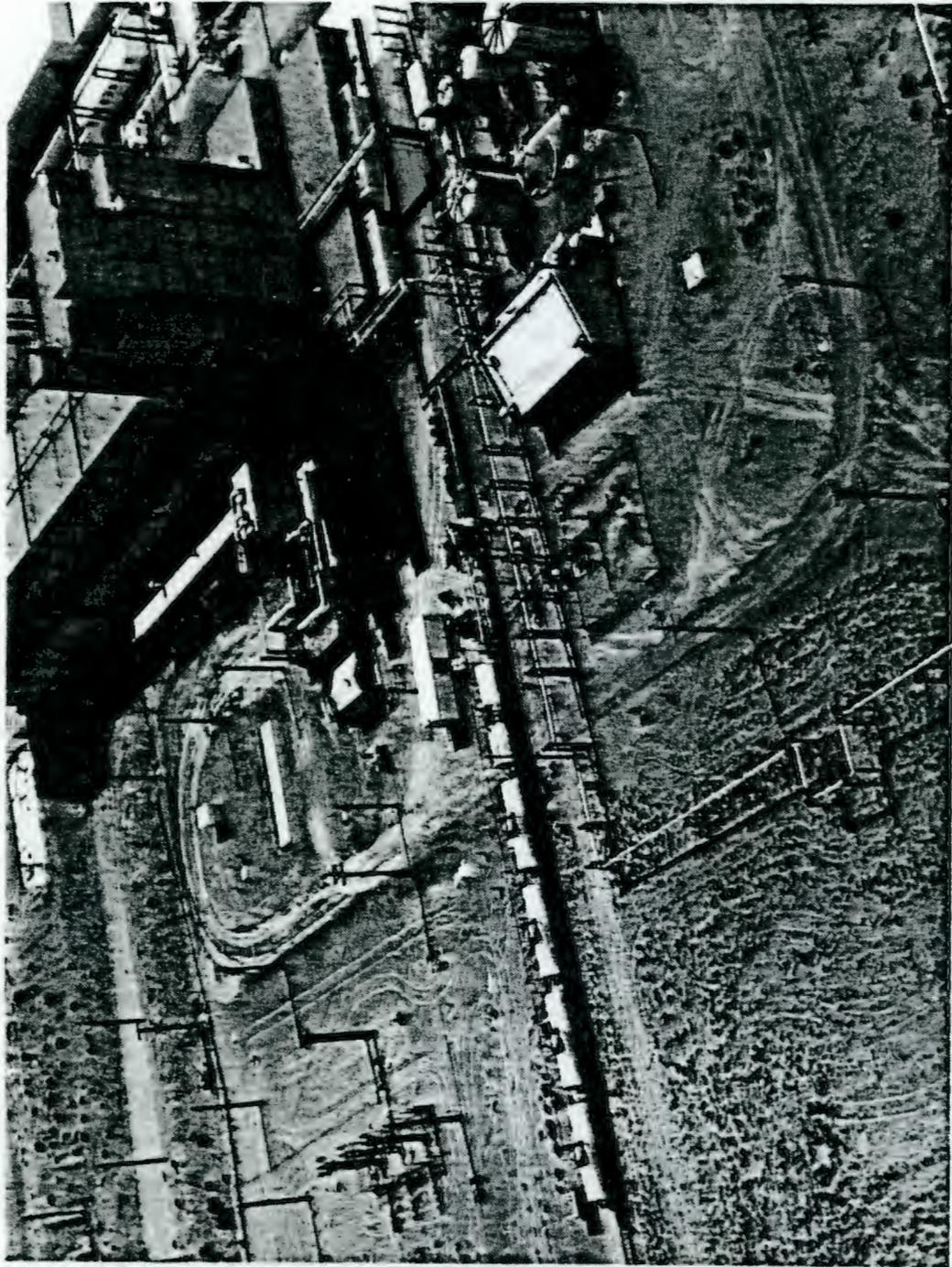
Figure 14. Moving the Hexone Train to the Site.



Pre-assembly of the distillation system and distillate storage tankage allowed the equipment to be fabricated at various shop facilities at the Hanford Site, and moved to the site in a single train movement upon completion. The first car is the spare equipment car, followed by the distillation car, the secondary containment tank car, and the four distillate receiver tank cars.

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Figure 15. Aerial View of the Hexone Site.



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This aerial view shows the REDOX plant at upper right. The distillation system and associated storage tank cars are shown in the center of the photograph. The underground tank enclosure is located just below the distillation flatcar.

The next material processed was 7,750 L (2,000 gal) of water, where process rates dropped to 2 L (0.5 gal)/min due to the high heat of evaporation of water. The system was operated conservatively and no attempt was made to raise processing rates by increasing the oil temperature, as volatile organics could be expected to enter the system at any time.

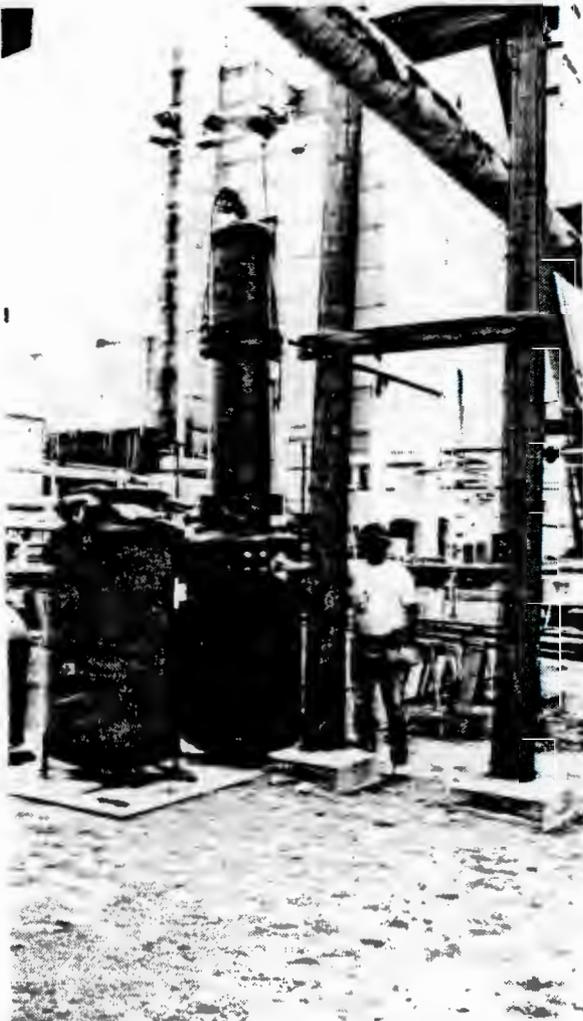
The challenging phase of the operation began with processing of the 54,000 L (14,000 gal) mixture of hexone, kerosene, and tributyl phosphate. The overflow weir recirculation system allowed much of the hexone phase to be boiled out of the organic liquids early on. As temperatures were increased to distill the higher-boiling fractions, tributyl phosphate breakdown tars became a problem. Thick tars started accumulating in the first-stage distillation vessel. While all of the tar had been expected to remain in the distillation vessel, soft tar also started building up in the feed weir and in the overflow seal loop, partially plugging the loop and causing cycling in the vessel liquid level.

The first stage vessel was replaced with a spare vessel (Figure 16) after 77,500 L (20,000 gal) of hexone and 31,000 L (8,000 gal) of the mixed organics had been processed, and process rates fell. At the same time the feed weir was cleaned out because it was two-thirds filled with tar as well as rust flakes from the underground tanks. The long fiber-mesh first-stage demister was replaced with a short wire-mesh pad to reduce demister pressure drop.

The last 27,000 (7,000 gal) of mixed organics (Figure 17) proved the most troublesome. Several process outages were required to remove tar from the feed weir (Figure 18) and to flush the overflow drain line. As the end of processing approached, oil temperatures were raised to 260 °C (500 °F) and held for several shifts to wring out the maximum amount of distillate. Bulk distillation operations were completed in October 1990. Flushing and rinsing of the piping and underground tanks, along with distillation of the rinsate were completed in early December 1990.

By the time all possible distillate had been recovered, the first stage distillation vessel (replacement unit) also held 475 L (125 gal) of tar as well as 265 L (70 gal) of high-boiling kerosene residuals. The second-stage vessel contained about 57 L (15 gal) of tar and 4 L (1 gal) of residual kerosene. The distillate radionuclide content totalled less than 223 μCi of penetrating alpha and beta activity for a decontamination factor of greater than 1,100 across the distillation system. (In this calculation, detection limits were used as the actual number where radionuclides were nondetectable.) Decontamination results are summarized in Table 1. No decontamination was measured for tritium as this very low-energy isotope is exchanged into the hexone molecular structure and cannot be extracted.

Figure 16. Distillation Vessel Changeout.



The original first stage distillation vessel was replaced after it had accumulated approximately 475 L (125 gal.) of solid tar. The left photo shows the original vessel and demister assembly. The spare vessel is about to receive the double-demister assembly that was re-used. The photo at right shows the vessel/demister unit being hoisted into the distillation system with a crane.

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Figure 17. Feed and Product Comparison (left).

The distillation system converted the contaminated tank waste into a clear distillate free of radionuclides (except for tritium).



Figure 18. Feed Weir Plugged with Tar (below).

During the final phase of operation the 11-cm (3-in.)-dia. feed weir had to be cleaned out two times to remove phosphate tars generated by the decomposition of tributyl phosphate. Similar complete or partial pluggages occurred in the weir seal loop. For prolonged operation a larger weir/seal loop system with backflush capabilities would have been desirable.

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Table 1. Decontamination/Removal Efficiencies.

	Alpha	Beta, μCi^*	Total, μCi
Initial radionuclide inventory, μCi	108,000	140,000	248,000
Final radionuclide inventory, μCi	<30.5	<192.6	<223.1
Removal efficiency, %	>99.972	>99.86	>99.91

*Does not include tritium exchanged into hexone matrix.

9.0 INCINERATION

The distillation operation decontaminated the waste solvents to a level low enough to be acceptable for destruction in a fully licensed commercial incinerator. Transportation and incineration services were bid competitively and awarded to a consortium of Chem Nuclear Environmental Services, Diversified Scientific Services (DSSI), and Kindrick Trucking.

The distilled solvents were hauled in nominal 18,500-L (4,900-gal) shipments by tanker truck (Figure 19) from the Hanford Site to DSSI's incinerator in Kingston, Tennessee (Figure 20). The same 19,300-L (5,100-gal) trailer was used for all shipments. The trailer tank was purged with nitrogen gas before loading and rinsed with ethanol after each shipment. At DSSI the solvents were unloaded, sampled, and blended with other waste materials for incineration. The final truck shipment was combined with 3,000 L (800 gal) of mixed organics from Hanford's 618-9 burial ground.

The DSSI incinerator is a co-generation steam electric plant that produces electricity for the DSSI facilities and feeds surplus power into the local power grid. The incinerator is fully licensed by the Nuclear Regulatory Commission, the U.S. Environmental Protection Agency (EPA), and the State of Tennessee to burn and destroy radioactive hazardous waste solvents. The plant's incineration rate achieves a nominal 8 L (2 gal)/min. The offgas stream is cleaned rigorously with scrubbers, charcoal absorbers and high efficiency filters to meet all regulatory requirements. The tritium (0.76 Ci) is released as a gas to the atmosphere in accordance with DSSI's license that allows discharge of 22 Ci of tritium per year.

10.0 TAR DISPOSAL AND HEXONE SITE CLOSURE

Three 1,135-L (300-gal) sacrificial distillation vessels have been removed from the distillation system. The vessels will be sampled and analyzed, and then stored at a permitted mixed waste storage facility at the Hanford Site for ultimate treatment and disposal. All interconnecting piping between the distillation unit and the empty underground storage tanks has been cut up and shipped in lined 208-L (55-gal) galvanized steel drums to the mixed-waste storage facility. The distillation system is being offered for

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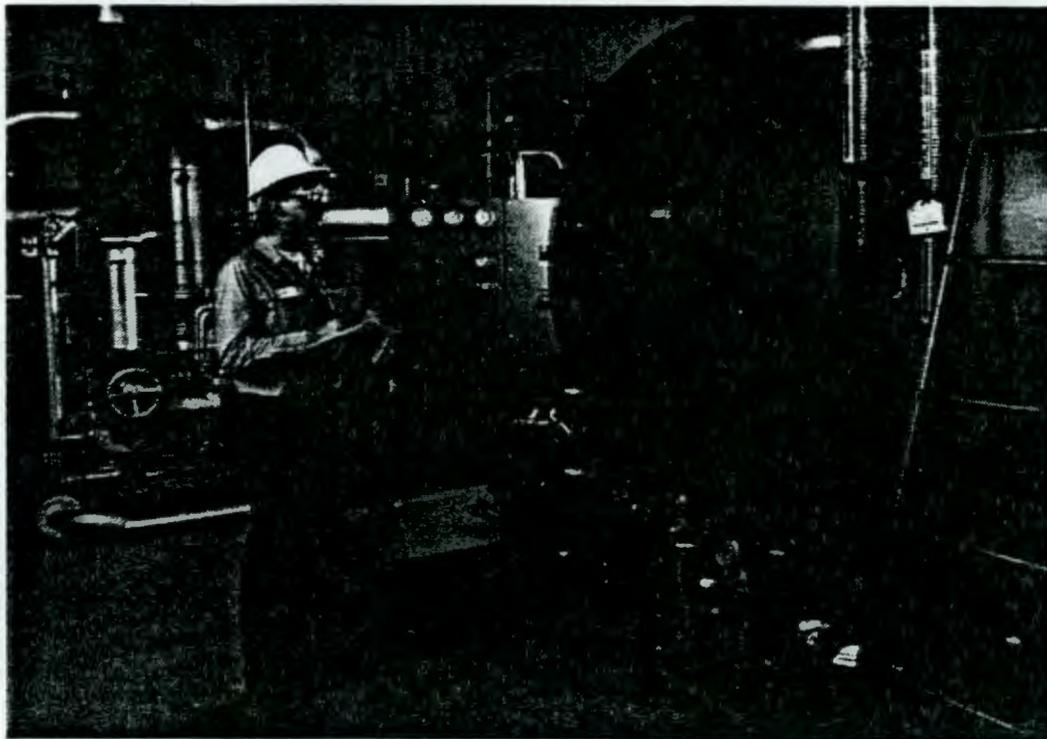
Figure 19. Trucking Distillate to DSSI.



A single tractor/trailer rig made eight round trips to Tennessee to transport the distilled hexone waste. The trailer (top photo) was a standard 19,300-L (5,100-gal.) capacity vehicle licensed for flammable liquid. The hexone was loaded via a diaphragm pump, rigid piping and hoses into the trailer (lower photo).

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Figure 20. DSSI Incinerator Facility.



The DSSI incineration plant is shown in the top photo. The lower photo shows the co-generation boiler and electrical generating system,

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future use. Spare distillation vessels are available and the condensers and other components have been rinsed with detergent solutions. If no other Hanford Site needs are identified, the system will be dismantled and the components reused elsewhere or excessed. The tank cars have been rinsed and are expected to be released for other Hanford Site service.

The underground tanks will be cleaned by dry blasting (grit or dry ice), removed from the ground, and hauled to a permitted Hanford disposal site. It is expected that the hexone site can be clean closed. A closure plan is scheduled for submittal to the State of Washington and the EPA in November 1992.

11.0 COST

The cost of the hexone remediation demonstration is expected to total \$4.0 million, which is a relatively modest cost for resolution of a radioactive and hazardous waste problem of this nature.

Decontamination expenses, including characterization, technology development, and solid waste disposal, consumed 71 percent of this cost. Shipping and incineration of the distillate accounted for the remainder. Commercial shipping and incineration charges totalled \$5.07 per L (\$19.20 per gal).

12.0 CONCLUSION

Onsite distillation/decontamination followed by commercial incineration has proved to be a practical and cost-effective means of remediating industrial-size volumes of hazardous, flammable, and radioactive waste solvents. The use of sacrificial distillation vessels virtually eliminated the need to handle the intractable distillation tars and provided a convenient and secure storage/disposal container for the radioactive still bottoms. Use of concrete shields around the vessels reduced personnel radiation exposure to essentially nil. The operations were carried out safely without personnel injuries, chemical exposures, fires, spills, or radioactive-contamination events.

Small-scale distillation systems using sacrificial distillation vessels are expected to have future applications when radioactive organic and aqueous liquids require safe disposal.

The Hexone Remediation Demonstration pioneered the use of commercial incineration facilities for the destruction of DOE radioactive solvents. The commercial incineration success has generated significant interest. Numerous inquiries have been received from other Hanford functions and from other DOE sites. Another Hanford project, the 618-9 Solvent Drum Retrieval, has contracted for commercial incineration, and the Plutonium-Uranium Extraction (PUREX) Plant is preparing a request for proposal. Other DOE sites have also initiated request-for-proposal and procurement actions.

13.0 REFERENCES

Resource Conservatoin and Recovery Act of 1976, 42 USC 4321 et seq.

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