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7. Abstract

This SAD addresses an activity to be performed under the Hazardous Waste Remedial Action Program as a technology demonstration by WHC to eliminate the underground storage of hexone waste, which has been classified as a mixed hazardous chemical/ radioactive waste. The remediation plan consists of double distillation to remove radionuclides, followed by incineration. This SAD addresses only the distillation phase of the remediation demonstration.

The SAD concludes that the number of curies of radioactive materials contained in the waste hexone is sufficiently low that the calculated radiolgical doses for the worst case accident are far below the radiological risk acceptance criteria discussed in the Nonreactor Facility Safety Analysis Manual (WHC 1988). On this basis, the remediation project is classified as a nonnuclear facility with respect to DOE Orders and the WHC guidance provided in the Nonreactor Facility Safety Analysis Manual.

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1.0 SUMMARY

This Safety Assessment Document (SAD) addresses an activity to be performed under the Hazardous Waste Remedial Action Program (HAZWRAP) as a technology demonstration by the Westinghouse Hanford Company (Westinghouse Hanford) to eliminate the underground storage of hexone waste, which has been classified as a mixed hazardous chemical/radioactive waste. A remediation plan has been written (Rasmussen 1988) which proposes a scheme consisting of double distillation to decontaminate the hexone to remove radionuclides, followed by destruction in an incinerator. This SAD addresses only the distillation phase of the remediation demonstration. Later phases of the technology demonstration will be covered by separate safety analysis documentation.

This SAD concludes that the number of curies of radioactive materials contained in the waste hexone is sufficiently low that the calculated radiological doses for credible accidents are far below the radiological risk acceptance criteria discussed in the Nonreactor Facility Safety Analysis Manual, WHC-CM-4-46, (Westinghouse 1988). On the basis of this, the remediation demonstration is classified as a nonnuclear facility with respect to DOE Orders and the Westinghouse Hanford guidance provided in the Nonreactor Facility Safety Analysis Manual. It was also concluded in Chapter 6 that hexone vapor pressure is sufficiently high, even at freezing temperatures, that the environmental airborne concentration limit of 50 ppm would be exceeded for any spill. The SAD also shows that fires, explosions, and spills are the only accident scenarios of any consequence. It is shown that hexone/nitric acid explosions and hexone peroxide explosions are relatively easy to prevent through control of solution chemistry. Computer calculations are done to demonstrate that the effects of either hexone fires or spills are limited to the immediate facility. Discussion is given of various configurational controls which are used to prevent fires. These include inert gas blanketing, use of appropriate electrical grounding, and use of class I, division I explosion proofing for all electrical equipment within 25 ft of the hexone system. Methods used to prevent spills include pressure testing all piping before use, proper surveillance, use of level indication instrumentation, and the use of catch pans to prevent soil contamination in the event that a leak does occur. The catch pan on the distillation module is equipped with an interlock which shuts down the feed to the distillation pot if the liquid in the catch pan gets to a prescribed depth.

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2.0 INTRODUCTION

The problem of disposal of hexone solvent from the shutdown of the Reduction-Oxidation (REDOX) facility has been under consideration since 1972. While this document refers to the solvent as hexone, it should be recognized that this is the common name, and the compound is actually methyl isobutyl ketone which is also known as 4-methyl-2-pentanone. The inventory of surplus hexone includes approximately 20,000 gal of relatively pure hexone presently stored in tank 276-S-141. Tank 276-S-142 contains a total of approximately 16,000 gal of a mixture which includes 100 gal of sludge, 2,000 gal of water, and 14,000 gal of a separate organic phase which is a mixture consisting of 60% hexone, 39% normal paraffin hydrocarbons (NPH), and 1-2% of metal/tributyl phosphate (TBP) complexes (Rasmussen 1988). According to data given by Strachan (1976), the total amount of alpha activity held in the two tanks is quite comparable with about 0.07 Ci in each tank. The total beta/gamma activity in tank 276-S-142, 0.91 Ci, is a factor of 40 higher than the beta/gamma activity in tank 276-S-141. From the standpoint of accident analysis, release of the contents of tank 276-S-142 represents the worst case radiological release with a total of 0.072 Ci of total alpha and 0.76 Ci of total beta/gamma activity available for release.

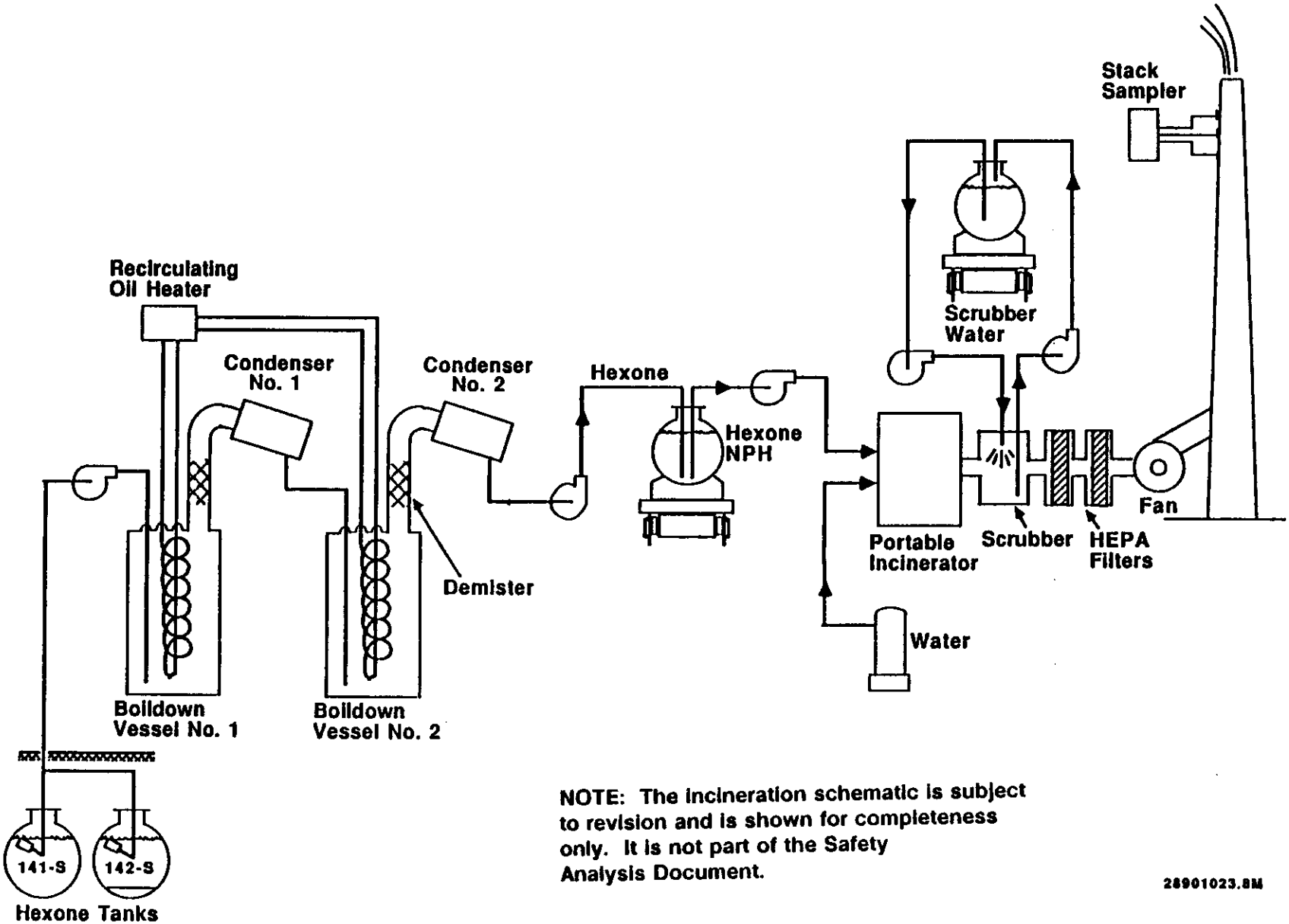
The source term for use in doing dose calculations for tank 276-S-142 is based on multiplying Strachan's (ARH-CD-685) concentration data by the waste volume of 14,000 gal for the organic phase, and by 2,000 gal for the aqueous phase radionuclide inventory. Accurate measurement of the source term is quite difficult because the activity is distributed in three different phases and the taking of representative samples is quite difficult. The data from ARH-CD-685 were used, instead of the more recent data given in Appendix I of the Hexone Remediation Demonstration Plan for Tanks 276-S-141 and 276-S-142, because of the higher concentrations of radionuclides shown in the earlier study. The ARH-CD-685 data provide a more conservative basis for this safety assessment.

The storage of the waste hexone is being done under the authority of a Resource Conservation Recovery Act (RCRA) Part A Permit application that includes the underground storage tanks, the distillation system tank cars, and incineration. Because the material is classified as both "hazardous" and "radioactive," it cannot be disposed of in its current form. Hexone is classified as a land disposal restricted material. The disposal scheme must meet prescribed treatment standards prior to disposal because of the radioactive hazardous character of this waste.

Figure 2-1 shows the overall remediation scheme. This SAD addresses only the activities leading to storage of decontaminated hexone in rail tank cars. Later project phases, if carried out the Hanford Site, will be covered in separate safety analysis documentation. Current plans for remediation of the waste hexone storage problem involve distillation of the organic chemicals to effect a decontamination to remove the radionuclides, followed by incineration to destroy the hexone, NPH, and TBP. The radionuclides would be left behind in the distillation vessel as a black, tarry, still bottom. The residues from distillation of the contents of tank 276-S-142 will be considered to be radioactive mixed waste. The waste may also be

classified as transuranic (TRU) waste. If it is classified as TRU waste, it will be stored onsite until eventual ultimate disposal which is yet to be determined. Ultimate disposal will probably involve shipment to the Waste Isolation Pilot Plant in New Mexico. The residues will also be analyzed for residual hexone content to determine disposal options as a hazardous or non-hazardous waste.

Figure 2-1. Overall Hexone Remediation Scheme Including Distillation, Rail Car Storage, and Incineration.



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3.0 SITE CHARACTERISTICS

This chapter describes the environmental characteristics, specific to the Hanford Site, that would be affected by operation of the hexone distillation equipment. Further environmental information about the Hanford Site is available [Jamison 1982; Rogers and Rickard 1977; Stone et al. 1983; U.S. Department of Energy (DOE) 1982a, 1982b, and 1984; U.S. Energy Research and Development Administration (ERDA) 1975; and U.S. Nuclear Regulatory Commission (NRC) 1982].

3.1 HANFORD SITE LOCATION AND REGIONAL POPULATION

The Hanford Site occupies approximately 15,000 ha (570 mi^2) of a semiarid region in southeastern Washington State (Figure 3-1). In 1944, the U.S. Army Corps of Engineers (ACE) selected the Hanford Site as the location for nuclear reactors, chemical separation facilities, and related activities for the production and purification of plutonium for use in nuclear weapons (Manhattan Project). Nine graphite-moderated reactors were built along the Columbia River. The last reactor built was N Reactor, which began operation in 1963 and is located in the 100-N Area (see Figure 3-1).

The Hexone Remediation Demonstration is located immediately to the northwest of the REDOX Plant (202-S Building) in the 200 West Area (Figure 3-2). While the REDOX Plant is shut down and awaiting decommissioning, the REDOX Plant complex includes active office facilities and the 202-S laboratory.

The nearest population center, Richland, Washington, with a population of 33,578 (Census 1981), is approximately 5 km (3 mi) south of the southernmost site boundary and approximately 35 km (22 mi) southeast of the REDOX Plant facilities. The 1980 combined population of Benton, Franklin, and Grant counties was 192,991 or an increase of approximately 108% since the previous census in 1970 (DOE 1982b). The estimated 1980 population within an 80-km (50-mi) radius is 341,000 (Sommer et al. 1981). This estimate includes populations living in portions of Yakima and Walla Walla counties, and many other smaller communities, as measured from the Hanford Meteorological Station (HMS) (Figure 3-3). For the same 80-km- (50-mi-) radius area, the projected 1990 population is 417,000 (Sommer et al. 1981). Recent (1983) employment, construction activity, and population influx has been less than postulated initially in the 1980 population forecast.

Figure 3-1. Hanford Site.

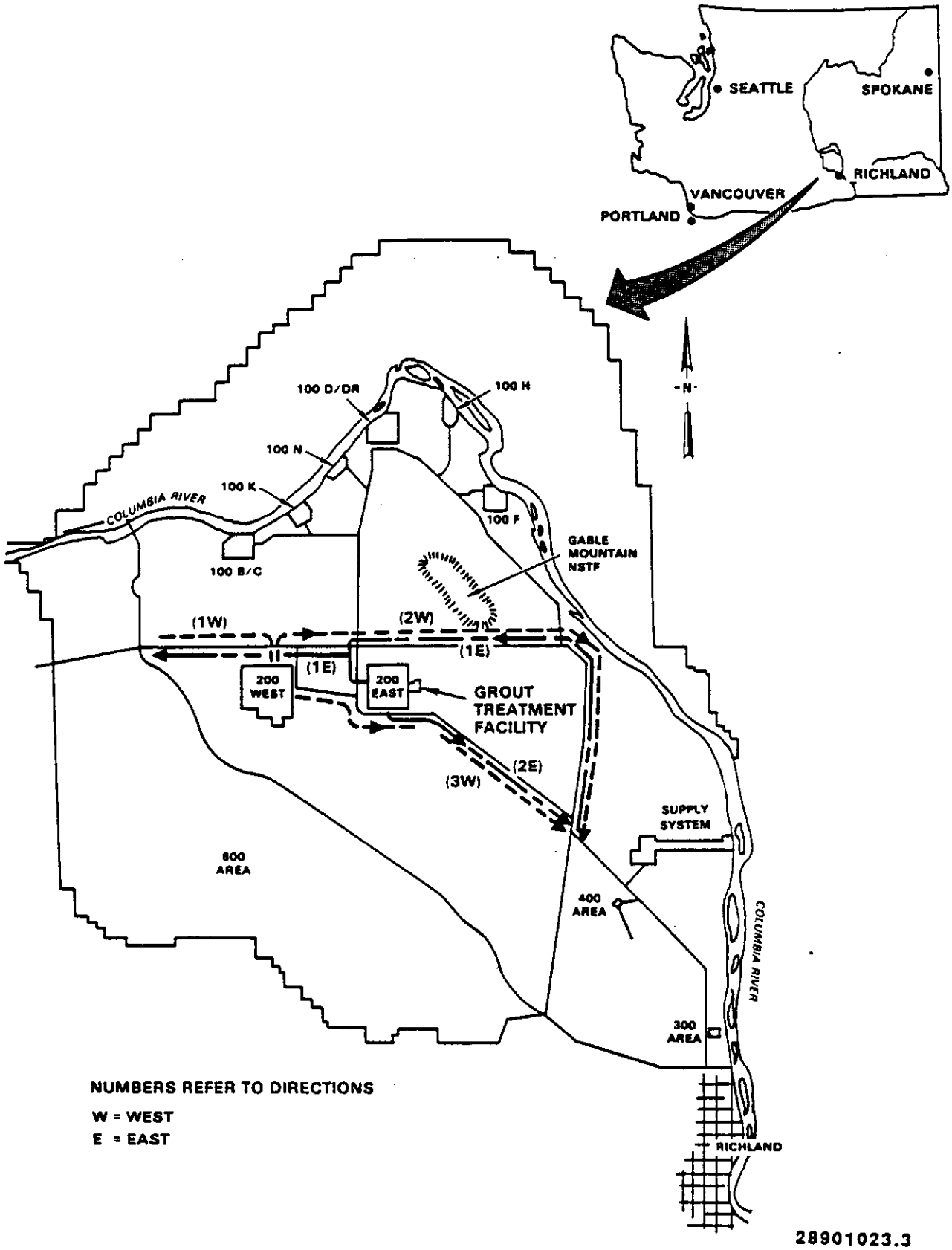

Figure 3-2. 200 West Area.

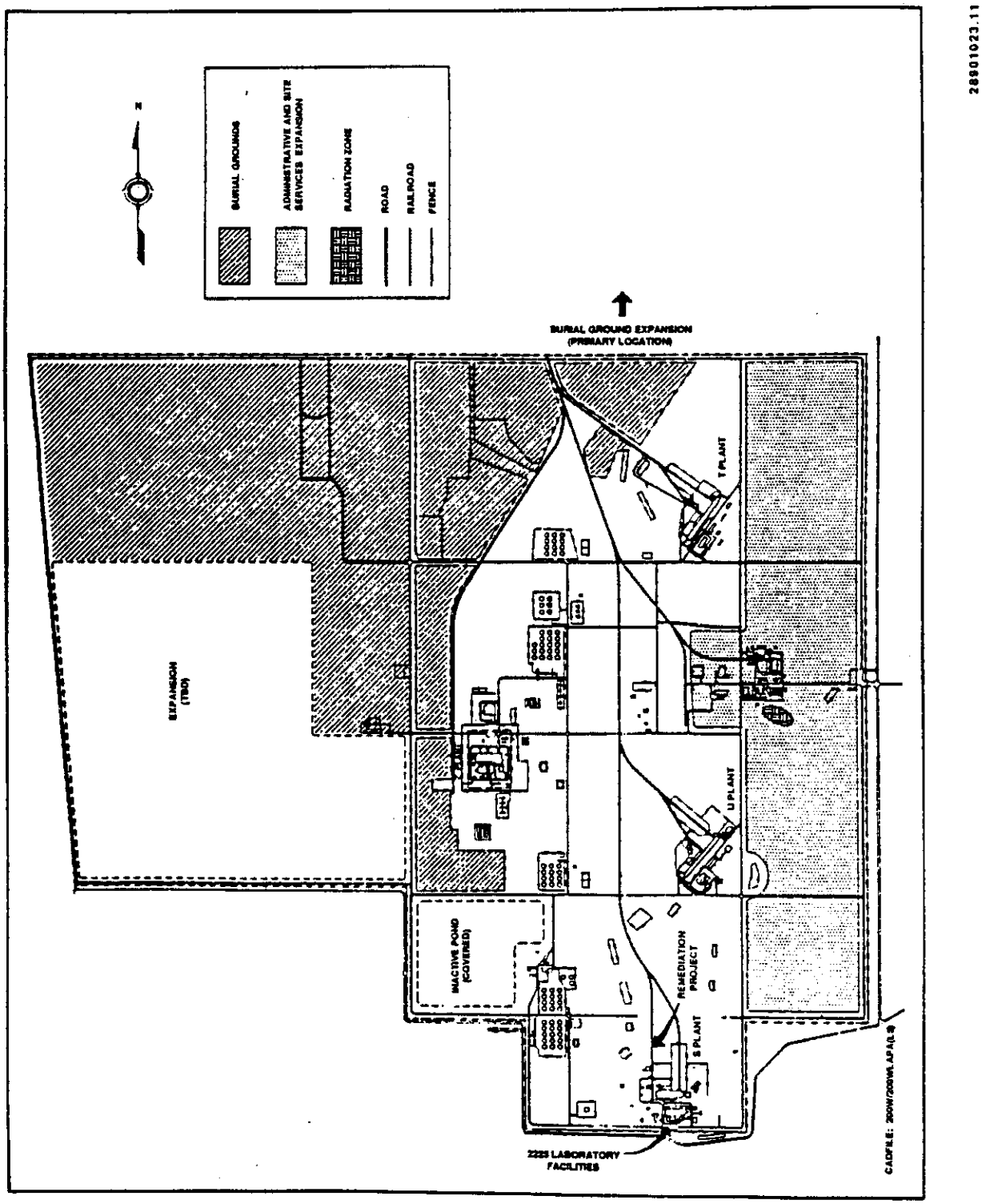

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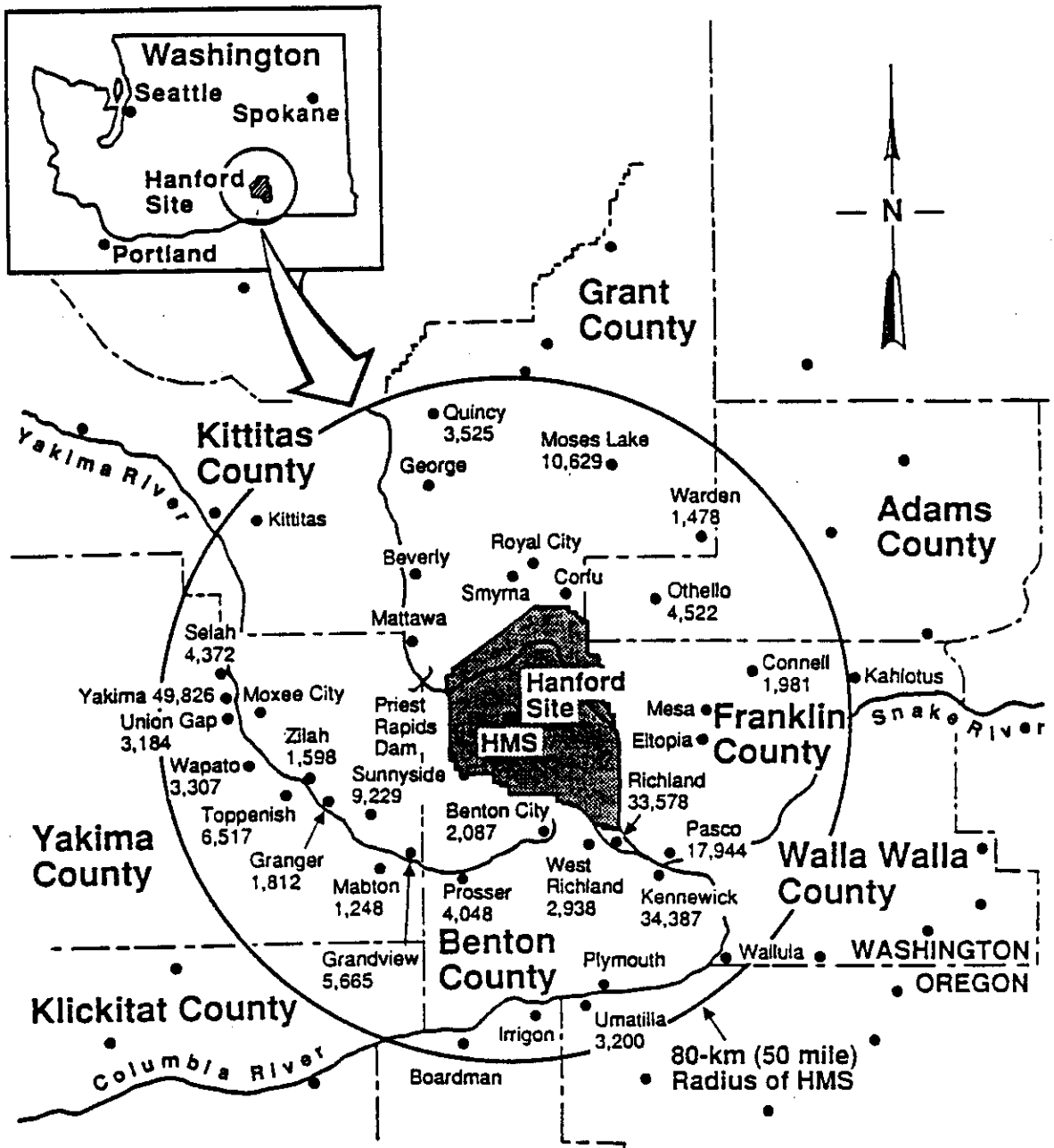
Figure 3-3. U.S. Census Populations for 1980 of Cities within 80 km of the Hanford Meteorological Station.



County	Population
Adams	13,267
Benton	109,444
Franklin	35,025
Grant	48,522
Kittitas	24,877
Klickitat	15,822
Walla Walla	47,435
Yakima	172,508

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3.2 REGIONAL AND SITE ACTIVITIES

Major industrial facilities in the region include a meat-packing plant, food-processing facilities, fertilizer plants, pulp and paper mill, chemical plant, and small manufacturing firms. A variety of support and supply facilities serve this industrial base. Agriculture also provides major support to the regional economy and includes a variety of dryland and irrigated crops. Major roads in the region are State Highways 14, 24, and 240; U.S. Highways 12 and 395; and Interstate Highways I-82 and I-182. Rail service is also available. Air transportation is available through three local airports, including two (Pasco and Yakima) suitable for small commercial jet aircraft. In addition, commercial traffic on the Columbia River may travel to the north Richland dock area nearest the southern Hanford Site boundary. This area is considered as the upper limit for commercial navigation.

There are three regional power dams located on the Columbia River near the Hanford Site, and a fourth dam on the Hanford Site has been proposed; however, construction is considered unlikely at this time (Harty 1979). The Hanford Site has several government facilities, including N Reactor, PUREX and UO_3 facilities, the Fast Flux Test Facility, plutonium reclamation and processing facilities, a fuel fabrication plant, waste management facilities, nuclear materials storage, and research laboratories. Hanford Site commercial activities include an operating commercial nuclear power station (construction on two other nuclear power stations on the site has been discontinued), and a low-level waste burial area. The fuel fabrication plant is located just south of, and adjacent to, the site boundary.

3.3 PHYSICAL ENVIRONMENT

This section summarizes the physical characteristics (geology-topography, hydrology, climatology, and seismicity) of the Hanford Site. More extensive and detailed technical information about the Hanford Site and surrounding region is available (Brown 1959 and 1960; Cline et al. 1985; Jamison 1982; McKee et al. 1977 and 1981; Mitchell and Bergstrom 1983; Myers et al. 1979 and 1981; Napier 1981; Price et al. 1984 and 1985; Rogers and Rickard 1977; Stone et al. 1983; Sula and Blumer 1981; Sula et al. 1982; Tallman 1979; ACE 1969; DOE 1982a, 1982b, and 1984; ERDA 1975; and Watkins and Baksi 1974).

3.3.1 Geology-Topography

The Hanford Site is located in southeastern Washington in the Pasco Basin, part of the Columbia Plateau. The earthen materials beneath the site consist of a thin mantle of wind-blown silts and sands that cover layers of coarse sands and gravel of the Hanford Formation. The Hanford Formation is up to 61 m (200 ft) thick and resulted from Pleistocene catastrophic floods (Tallman 1979) that occurred during the last ice age. Sands, silts, and gravels of the Ringold Formation lying beneath the Hanford Formation gravels were deposited to approximately 300 m (1,000 ft) thick during the Pliocene. The basaltic lava of the Columbia River Basalt Group (extruded throughout

periods extending from 16- to 6-M yr ago) lies beneath the younger sediments. The total basaltic lava accumulation beneath the Hanford Site is known (from borehole measurements) to be greater than 3,650 m (12,000 ft) thick. The water table in the REDOX Plant area lies in the Ringold Formation 50 to 100 m (150 to 300 ft) below the land surface (Tallman 1979).

The sedimentary deposits in the 200 Areas are moisture-deficient and have a high capacity to absorb and retain cations from waste streams, spills, or leaks. Precipitation penetrates to a maximum of approximately 5 m (13 ft) and is lost to the atmosphere by evaporation during the summers.

Detailed stratigraphic and geologic data are available to characterize the Hanford Site environment [Atlantic Richfield Hanford Company (ARHCO) 1976; Myers et al. 1979; and Tallman 1979] and have allowed subdivision of the basalts into a number of formations, members, and flows. Details concerning these flows are available (Fecht 1978; Geoscience Research Consultants 1978; Goff 1977; Jones and Landon 1978; Reidel 1978; and DOE 1984). Details of the sedimentary layers and soils at the Hanford Site are also available (Baker 1973; Hajek 1966; Routson and Fecht 1979; Tallman 1979; and ERDA 1975).

3.3.2 Hydrology

The Columbia River, the dominating factor in Hanford Site hydrology, flows through the northern part of the site and along the eastern boundary. Under probable maximum flood conditions, the REDOX Plant Facilities would be 60 to 75 m (200 to 250 ft) above the highest probable water elevation (ACE 1969). Studies of a hypothetical 50% breach of the upstream Grand Coulee Dam (which would result in the devastation of downstream cities including Pasco, Richland, Kennewick, and Portland) show a flood elevation at 45 to 60 m (150 to 200 ft) below the REDOX Plant Facilities (ERDA 1976).

The annual average flow rate of the Columbia River at the Hanford Site is 1.1×10^{11} m^3/yr (2.9×10^{13} gal/yr). The Hanford Site export water system withdraws water currently for the 200 Area operations at a rate of approximately 2.6×10^7 m^3/yr (7×10^9 gal/yr).

Precipitation in the 200 Areas does not generally penetrate deeply into the soil and only depths of 4 to 8 m (13 to 24 ft) have been reported. It is believed that all precipitation penetrating the soil is removed by evaporation; however, the extent of natural recharge to the groundwater from precipitation in the 200 Areas has not been quantified.

The unconfined aquifer occurs within the sedimentary deposits of the Hanford and Ringold Formations. The aquifer receives natural recharge from the Cold Creek and Dry Creek valleys west of the Hanford Site and from runoff along the Rattlesnake Hills. Artificial recharge enters the aquifer activities in the 200 East and 200 West Areas. Groundwater flows in a general west-to-east direction from the recharge areas and discharges into the Columbia River (ERDA 1975). The groundwater location occurs from 50 to 100 m (150 to 300 ft) below the surface at the REDOX Plant Facilities and

slopes toward the river. Near the Columbia River, the water table fluctuates in response to river level changes and, in general, is within a few meters of the ground surface.

Groundwater also exists in the interflow zones of the basalt flows and in sedimentary interbeds referred to as the Rattlesnake Ridge, Selah, Cold Creek, and Mabton zones of the Saddle Mountains and the Wanapum Basalt Formations. Recharge to these upper confined flow systems results from precipitation and stream flow in the mountains west of the Hanford Site. Hydrologic data acquired from wells penetrating these aquifers indicate the same general west-to-east groundwater movement toward the Columbia River.

Wastewaters discharged from past fuel and waste processing operations on the Hanford Site have reached the unconfined aquifer. Some of the mobile radionuclides such as ^{3}H, ^{14}C, ^{99}Tc, ^{129}I, ^{238}U, as well as nonradioactive nitrates, have reached the groundwater and will be transported eventually to the Columbia River. Other radionuclides (i.e., ^{60}Co, ^{90}Sr, and ^{106}Ru) have also reached the groundwater but are not expected to be transported to the Columbia River because of sorption into the soil and radioactive decay. The groundwater is monitored routinely and extensively to trace the movement of radionuclides and nitrates, and summary reports are produced annually (Prater et al. 1984).

Additional hydrological information is available (Gephart et al. 1979; Graham et al. 1981 and 1984; Jamison 1982; and ERDA 1975). Additional information on radionuclide concentrations in the groundwater and the Columbia River is also available (Cline et al. 1985; Eddy and Wilbur 1980; Friedrichs et al. 1977; Law 1985; McCormack et al. 1984; Prater et al. 1984; ERDA 1975; and DOE 1982a).

3.3.3 Seismicity

The Hanford Site is located in a Zone 2 area (U.S. Seismic Risk Area), as defined by the U.S. Coast and Geodetic Survey (ERDA 1975), where moderate damage might occur from earthquakes. The largest historical earthquake to occur within the Columbia Basin, the 1936 Milton-Freewater earthquake, had an intensity of VII on the Modified-Mercalli Scale and is a qualitative description of damage that might occur in an earthquake. An intensity of VII would cause moderate damage to unreinforced structures. The largest potential fault near the Hanford Site is the postulated Rattlesnake-Wallula lineament, located at the southeast end of the Rattlesnake Hills, approximately 5 mi from the REDOX Plant. A design basis earthquake acceleration of 0.25 g has been established as a design criterion by the SDC-4.1 Standard Arch-Civil Design Criteria, Design Loads for Facilities, Revision 11 for seismic resistant buildings at the Hanford Site. Note that seismic criteria for buildings do not apply to railroad flatcars. Additional seismicity information is available [Berg and Baker 1963; Myers et al. 1979; Rasmussen 1967; DOE 1984; Weston Geophysical Research 1977; and Washington Public Power Supply System (WPPSS) 1981].

3.3.4 Climatology

For general climatological purposes, meteorological data from the Hanford Meteorology Station (HMS) are representative of the Hanford Site. The HMS tower is located between the 200 East and 200 West Areas (Figure 3-1) and has gathered data continuously since 1944.

The Hanford Site climate (Stone et al. 1983) is characterized by relatively cool, mild winters and long, warm summers. Average maximum and minimum temperatures for January, the coldest month, are 3 °C (37 °F) and -6 °C (22 °F), and for July, the warmest month, are 33 °C (92 °F) and 16 °C (61 °F). Tornadoes occur rarely, tend to be small, and produce little damage. Only one tornado has been observed on the site in 29 yr of observation. Existing data indicate the probability of a tornado hitting a particular structure, onsite, during any 1 yr period is an estimated six chances per million (ERDA 1975). The design criteria given in SDC 4.1, Rev 11 do not indicate any requirements relative to tornado caused structural loads for Non-Reactor Safety Class I structures. Design criteria are given relative to a design basis wind of 90 miles/hour.

3.3.5 Background Radiation

The calculated annual dose from natural background radiation received by the average person living in the Hanford Site vicinity is approximately 100 mrem (Price et al. 1985; Sula and Blumer 1981). The average annual dose to a member of the general public from Hanford Site defense operations has been between 0.01 and 0.8 mrem to the whole body (McCormack et al. 1983; Sula et al. 1982). In 1984, the calculated per capita whole-body dose from all DOE Hanford Site operations was approximately 0.01 mrem per person (Price et al. 1985). In 1984, the whole-body dose to the maximum individual was approximately 2 mrem per person for all DOE Hanford Site activities. The whole-body dose to the population was calculated to be 5 person-rem (Price et al. 1985).

3.4 ECOLOGY

The Hanford Site is comprised of relatively large, undisturbed expanses that contain numerous plant and animal species suited to the region's semiarid environment. The 200 West Area site for the REDOX Plant facilities has been developed extensively during past construction and nuclear fuel and chemical processing activities, and cannot be considered an undisturbed area or a major habitat for site plant and animal species. The Columbia River also provides habitat for aquatic species. The Hanford Site ecology, with species lists, has been reported in detail (Jamison 1982; Rogers and Rickard 1977; and ERDA 1975).

The site lies within the sagebrush vegetation zone. Some dominant plant species (cheatgrass and tumbleweed) were introduced with agriculture. More than 100 plant species have been identified in the 200 Area Plateau, and decomposer organisms (bacteria and fungi) are the primary plant consumers (ERDA 1975).

Approximately 30 mammal species, mostly small and nocturnal, have been observed on the Hanford Site. The largest mammals on the site are mule deer and an occasional elk. Cottontail rabbits and jackrabbits are distributed widely and are an important food item for coyotes and birds of prey. Other mammals on the site include muskrat, beaver, porcupine, raccoon, badger, mice, and other burrowing rodents (ERDA 1975).

More than 125 bird species have been observed on the site (Rogers and Rickard 1977). The chukar partridge, the most important upland game bird, is located primarily in the Arid Lands Ecology (ALE) Reserve along Rattlesnake Mountain. The Canada goose, the most important nesting waterfowl, nests on islands in the river. The river also provides nesting areas for ducks and other waterfowl. Birds also nest on the ponds in the 200 Area Plateau, and birds of prey have been observed onsite during the winter (Fitzner and Rickard 1975; Rogers and Rickard 1977).

More than 300 insect species have been counted on the Hanford Site, of which the most important are darkling beetles and grasshoppers. Approximately 16 species of amphibians and reptiles also have been identified on site. Their occurrence is relatively infrequent compared to Southwest desert areas. The side-blotched lizard is the most abundant reptile, and the gopher snake, yellow-bellied racer, and Pacific rattlesnake are also common. Some toads and frogs have been observed near 200 Area ponds and ditches (ERDA 1975). The aquatic life in the Columbia River is described in ERDA (1975).

No species of plant or animal registered as threatened or endangered are known to exist nor depend on the habitats in the immediate vicinity of the REDOX Plant Facilities. However, several species within the 200 Area Plateau are listed as candidates for endangered or threatened status by the U.S. Fish and Wildlife Service. The Swainson's hawk and the long-billed curlew both nest on the 200 Area Plateau. The ferruginous hawk has nested on Gable Butte in the past, but the only nesting to occur on the Hanford Site in recent years was observed on Rattlesnake Mountain. The State of Washington also lists more than 20 animal species common to the 200 Area Plateau on the Special Species list (Washington State 1984). This list identifies the peregrine falcon and the white pelican as endangered and the pygmy rabbit, ferruginous hawk, and bald eagle as threatened.

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4.0 FACILITY AND PROCESS DESCRIPTION

4.1 FACILITY DESCRIPTION

The hexone distillation equipment is installed as a self-contained package on a railroad flatcar. An overall layout of the hexone distillation arrangement is shown in Figure 4-1. During the distillation operation the flatcar will be spotted on the REDOX chemical spur adjacent to the hexone underground storage tanks. The distillation system will be connected with aboveground piping to the hexone tanks and to four railroad tank cars that will store the distilled, radioactively-decontaminated hexone. Utility connections include electrical power from the 276-S Building Motor Control Center, nitrogen gas from two ground-mounted nitrogen dewars, and water from the adjacent fire hydrant (water used during operational testing only). Ventilation is provided via a new offgas system on the underground storage tanks. An overall layout of the flatcar-mounted distillation and oil heating system is shown in Figure 4-2 and a schematic diagram of the process piping system is shown in Figure 4-3. The individual components are described in more detail below.

4.1.1 Distillation Module

The distillation module is the main component of the distillation system. It consists of the following equipment items:

a. Steel base pan--An 8 ft by 10 ft steel pan designed to contain 110% of the entire inventory of the largest vessel in the distillation vessel section as required by the RCRA regulations. The pan is equipped with a valved drain that allows any accumulated liquid to be routed either to the tank car drain pan sump if free of hexone, or to the underground hexone tanks via temporary hose connections, in the event hexone is detected. The drain valve is normally closed to allow sampling of any accumulated liquid before disposition to the appropriate system. A liquid-level sensor (weight factor) in the pan is interlocked with the electrical power supply to shut off the two hexone transfer pumps in the event of a significant liquid accumulation.

b. Hexone transfer pumps--The pump section of the base pans contains two 0.75-horsepower gear pumps. The pumps are identical. Pump No. 1 draws liquid from the underground tanks into the No. 1 distillation vessel feed weir. Pump No. 2 transfers distilled product from the distillate catch tank into the railroad tank cars. Each pump is equipped with a class 1, division 1, group D explosion-proof motor and a seal-less magnetic drive. The magnetic drive eliminates the possibility of seal leakage since no seals are present. The pump housing is totally sealed. The feed pump is equipped with a valved bypass that is set to reduce the nominal discharge flow rate from 6 gal/min to 3 gal/min. The pumps are also fitted with 50 lb/in^2 (gage) internal relief valves to eliminate the possibility of discharge pipe overpressurization.

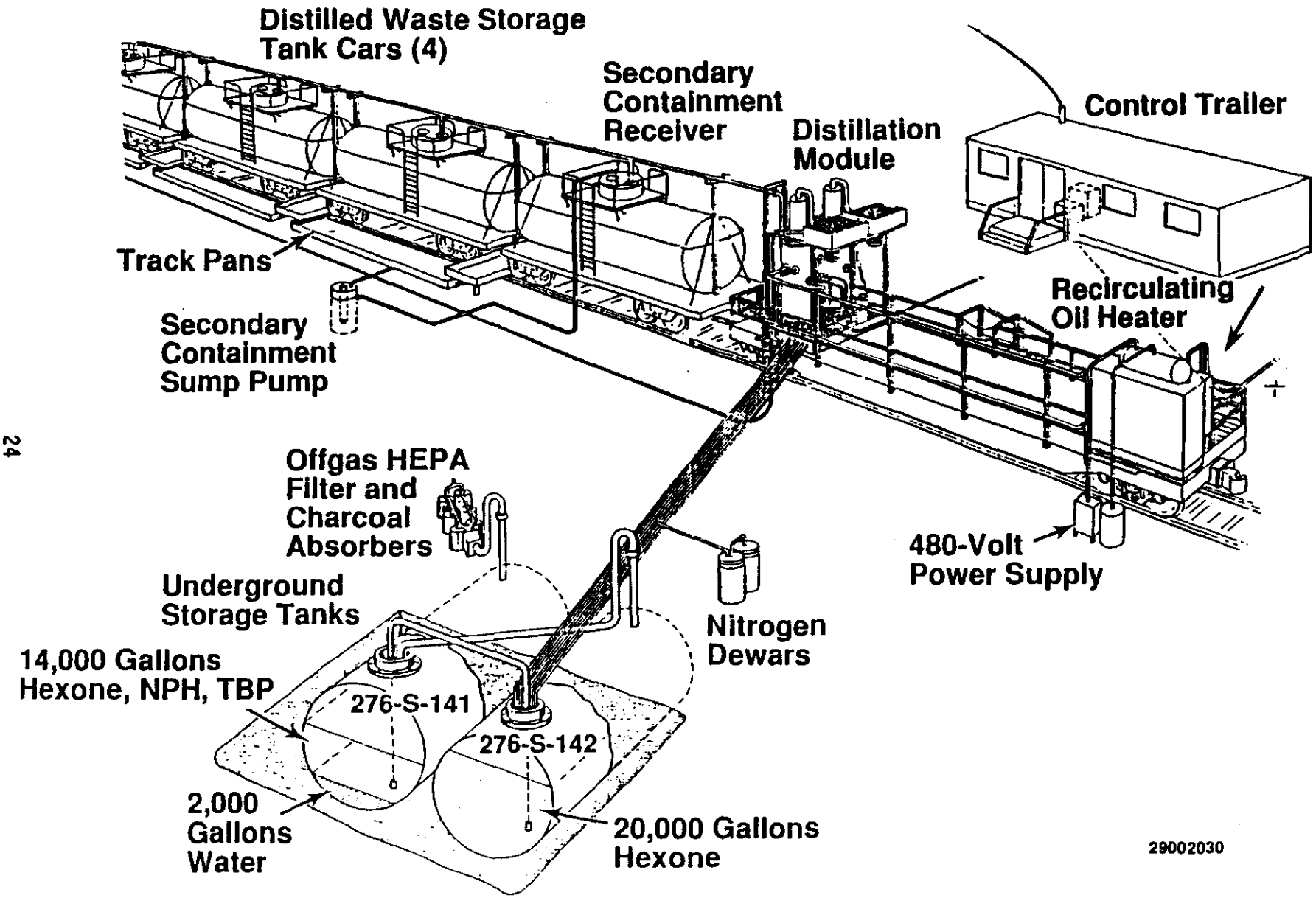


Figure 4-1. Hexone Distillation Arrangement.

Figure 4-2. Overall Layout of Distillation and Oil Heating Modules on Railroad FlatCar.

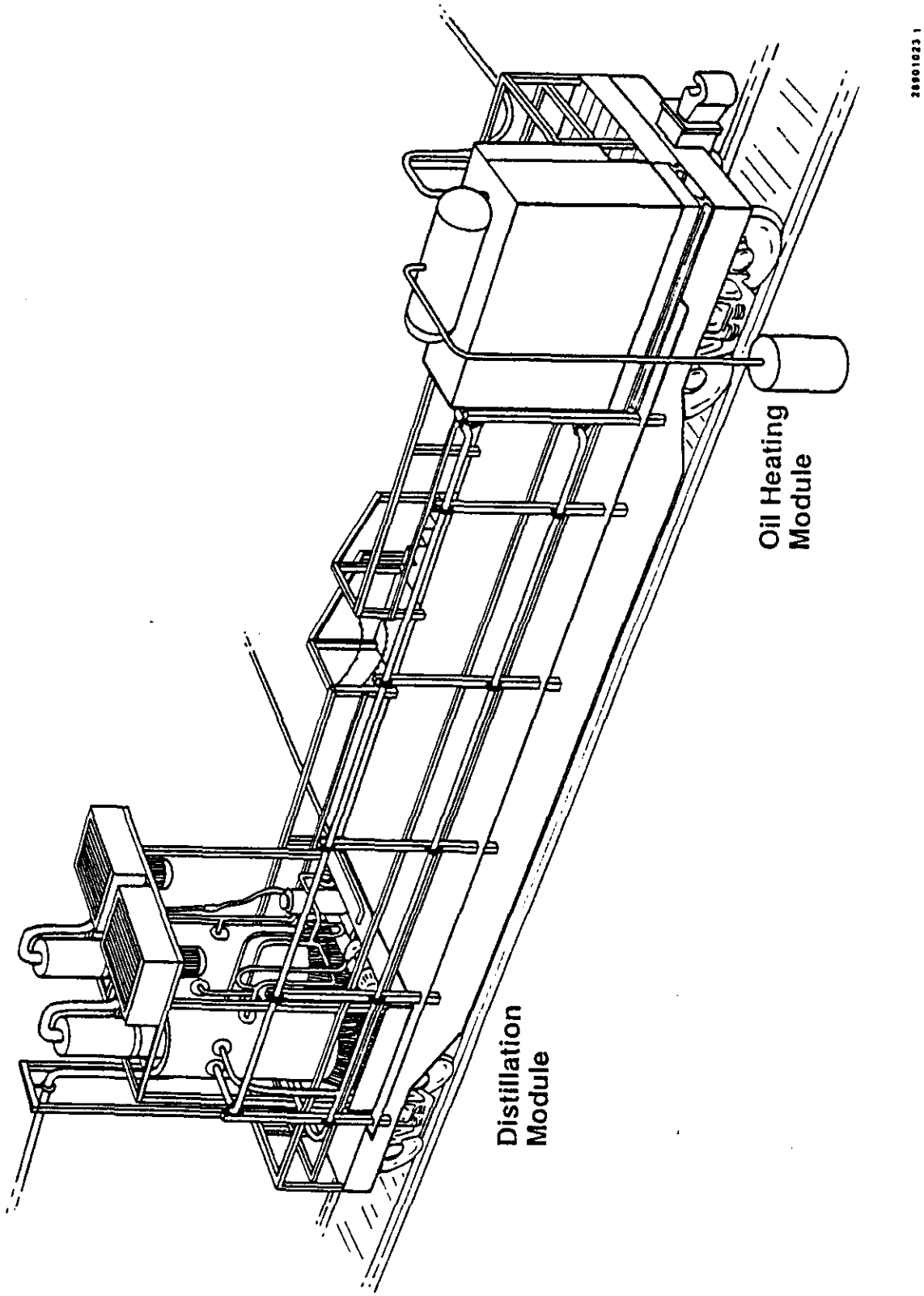
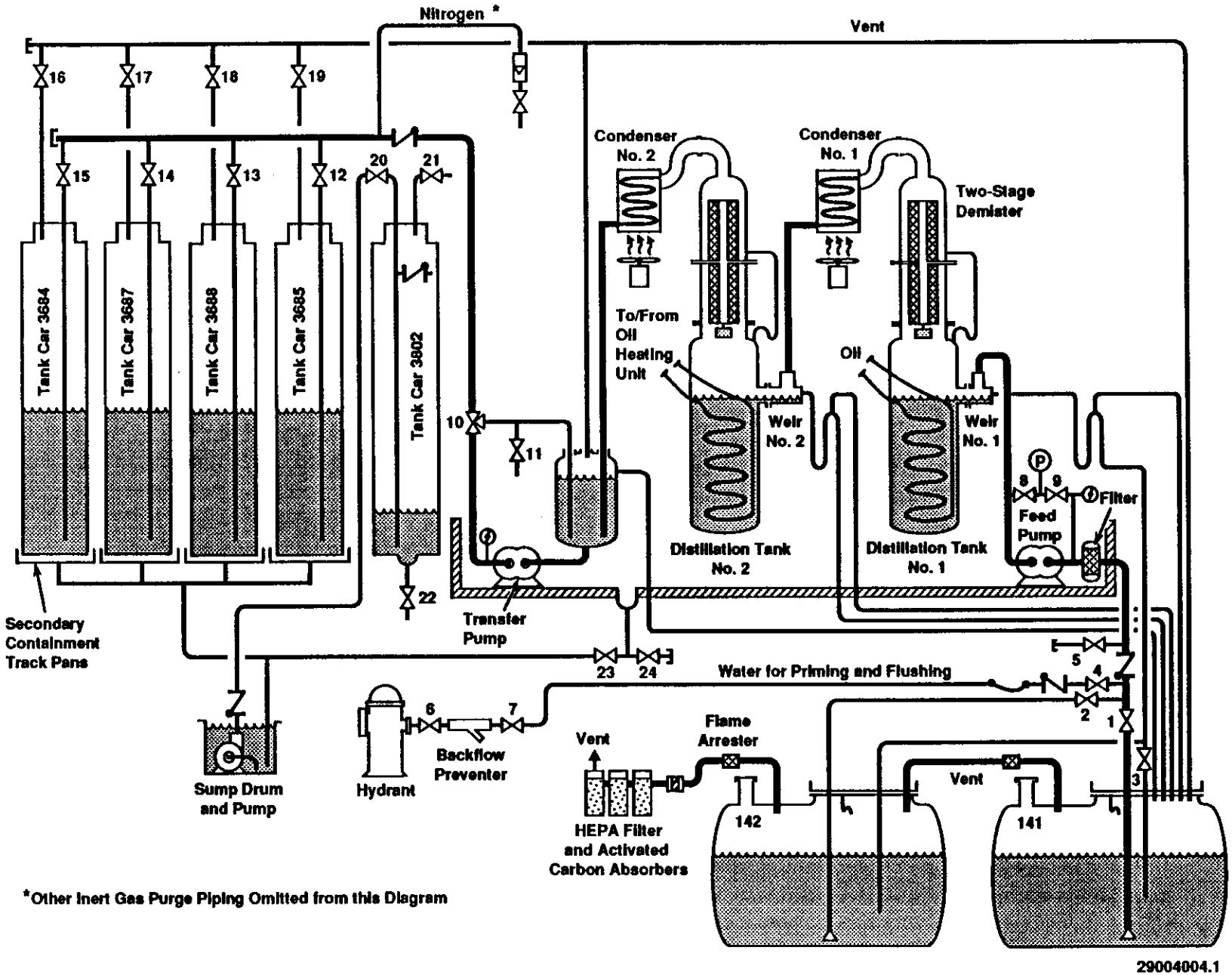


Figure 4-3. Schematic Diagram of the Hexone Process Piping System.



c. Distillation Vessels--Two distillation vessels, installed in series via a condenser, provide the actual distillation of the waste. Each vessel is fabricated from 3/8-in. carbon steel to the ASME Section 8 Boiler and Pressure Vessel Code for 100 lb/in^2 pressure. The vessels, shown in Figure 4-4, are equipped with double-helical heating coils fabricated from 1.5-in. schedule 40 carbon steel pipe. The coils are connected via steel flex hoses and piping to the oil heating unit. Each vessel is equipped with a 3-in. flanged feed inlet, an 18-in. flanged vapor outlet, as well as three piping/instrumentation/sampling ports. The 7-ft-high, 3-ft-dia. vessels have a volume of approximately 300 gal. An overflow weir is connected to each distillation vessel to maintain a constant liquid level in the No. 1 vessel and to limit the maximum level in the No. 2 vessel. Excess liquid is returned to the underground tanks by gravity.

d. Demisters--A two-stage demister system is connected to the top of each distillation vessel. Each demister stage is housed in a flanged 18-in.-diameter steel pipe.

   The first stage demister element is a coarse demisting unit designed to remove large droplets entrained in the vapor stream. The element hangs from the upper flange and is equipped with a condensate seal trap.

   The second stage demister element is an ultra-fine demisting unit designed to remove very small droplets. Condensate is drained back into the distillation vessel via a seal loop.

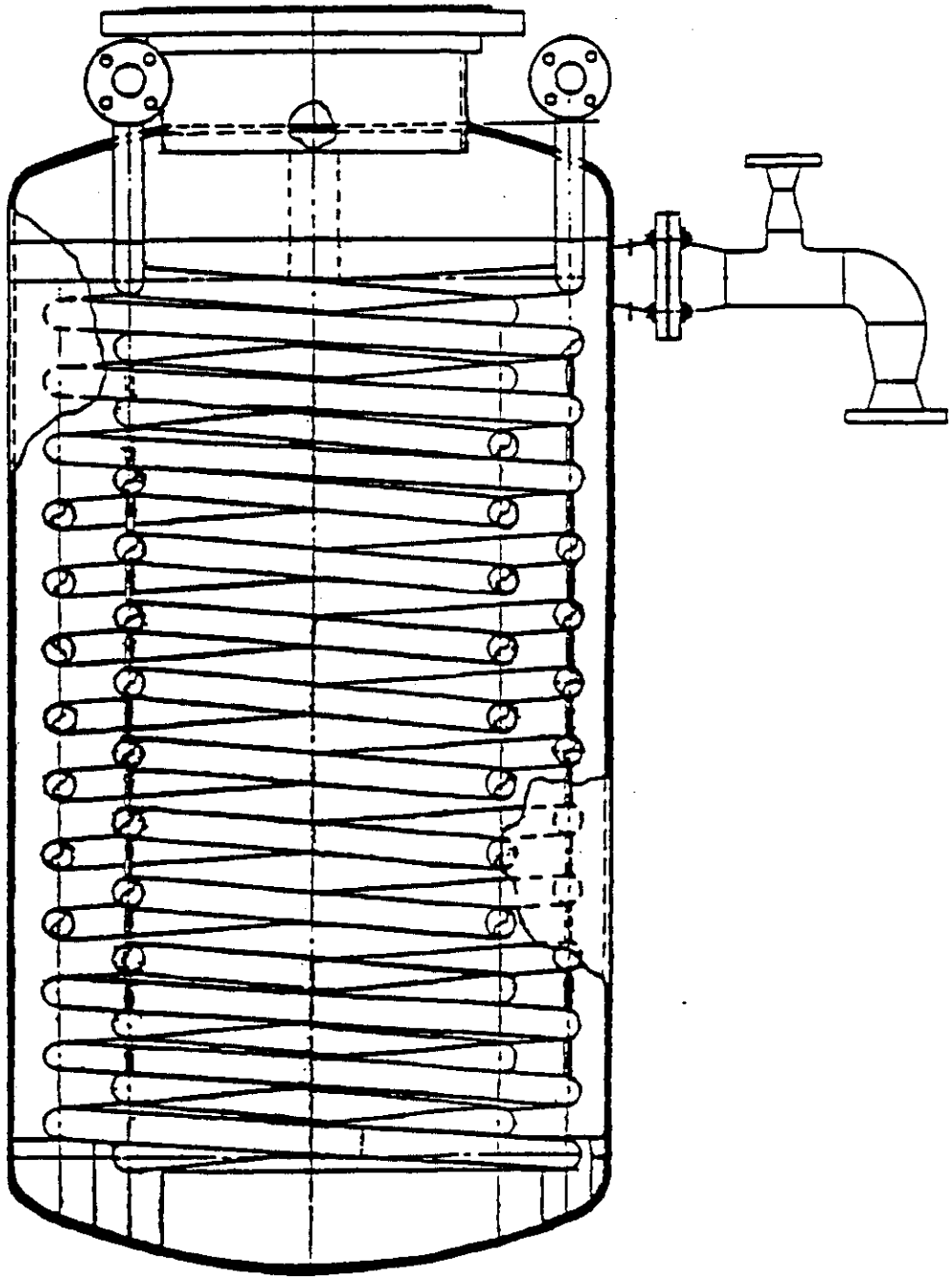
e. Condensers--Each demister system vents into a finned-tube air-cooled condenser. A motor-driven fan provides the necessary airflow for effective cooling. The fan motors are 0.75-horsepower explosion-proof class 1, division 1, group D, 480-volt motors.

f. Condensate Catch Tank--A 40-gal-capacity stainless steel catch tank receives the distillate from the No. 2 condenser and serves to feed the condensate transfer pump (pump No. 2). The catch tank is equipped with a weight factor liquid-level sensing system that is connected to an automatic on-off switch for the transfer pump.

g. Concrete Shields and Steel Framework--The distillation vessels and the condensers are mounted on a framework of steel supporting members and two concrete pipes. The concrete pipes serve to provide radiation shielding in the event significant radiation dose levels build up in the distillation tanks. The concrete shields are equipped with penetrations for the hot-oil piping and the feed weir connection. The concrete pipes also serve to support one end of the steel frame work.

h. Electrical Conduit--Electrical power and instrument signals are transmitted in explosion-proof electrical conduit within 25 ft of the hexone distillation system, piping, and tank cars.

Figure 4-4. Hexone Distillation Vessel.



4.1.2 Recirculating Oil Heating System

The Recirculating Oil Heating System provides controlled heating to the distillation tanks. The system, manufactured as a packaged unit by American Hydrotherm Inc., is a standard industrial heating unit. A centrifugal recirculation pump moves oil at the rate of 100 gal/min through two electrical immersion heaters to the distillation vessels via a 3-in.-dia. insulated pipeline. The oil flow is split into two streams in the distillation module, simultaneously heating the two distillation tanks. The oil is returned to the oil heating system via another 3-in.-pipeline and a strainer to the recirculation pump intake. The oil heating system is equipped with thermostatic controls and interlocks to protect the heating element. The interlocks include a high temperature cutout switch activated at 475 °F and a low oil pressure cutout switch. An oil expansion tank is located on top of the unit. The tank is connected via piping to an overflow drum located on the ground. The oil used in the system is a non-hazardous grade of mineral oil.

4.1.3 Electrical Power Supply

The 480-volt power is supplied from the 276-S Building main power panel. The main power supply can be shut down at the heating system panel, at a new disconnect switch outside the 276-S Building, and at the 276-S power panel. Both power panels are equipped with overload protection. Rigid conduit connects the 276-S panel to the main control cabinet on the oil heating unit. The oil heating unit control cabinet supplies power to a separate motor control panel mounted adjacent to the oil heating unit. The motor control panel provides power to five motors: two condenser fan motors, the two transfer pumps, and to the sump pump motor for the tank car drain pan system (see below). While all electrical systems on the hexone distillation module are of the explosion-proof class 1, division 1, group D design, the electrical systems in the heating unit are not explosion proof. However, the PG-1 white mineral heat transfer oil manufactured by Mobiltherm Corp. has an autoignition temperature of 690 °F. The flash point is 340°F using the COC method (ASTM D92). If a leak does occur the hot liquid on the cooler exposed surfaces should rapidly cool to below its flash point. The necessary protection from potential spark effects on hexone vapor is provided by distance. All non-explosion-proof electrical equipment is separated by at least 25 ft of distance from the distillation module in an outdoor environment.

4.1.4 Tank Car System

The distillation system utilizes five railroad tank cars. The tank cars were re-certified for the Hexone Remediation Demonstration by triple rinsing (by North West Enviro Services) as required by the Washington Administrative Code (WAC)/RCRA regulations, pressure testing, installation of new pressure relief valves, internal inspection, and a Class "A" inspection of the running gear. Four 10,000-gal tank cars, Department of Transportation (DOT) type 103-W, will receive distilled hexone waste for interim storage between the distillation and the incineration phases of the remediation

action. Each of the tank cars is connected via piping to the distillation module. Pipe fittings on the dome of each tank car include a valve and a 2-in. fill line that ends approximately 1 in. above the bottom of the vessel. A 1-in. pipe and valve connect the tank car dome to the vent piping. The cars are equipped with valved bottom outlets. These outlets are sealed with pipe caps and will not be used during the distillation operations.

The four hexone storage tank cars are spotted over drain pans that provide secondary containment in the unlikely event that one of the tank cars should leak. The pans are connected via piping to a sump vessel. Any liquid that accumulates in the sump vessel is automatically transferred to the fifth railroad tank car by a float-switch-actuated electrical sump pump. The sump pump is equipped with an explosion-proof class 1, division 1, group D electrical motor. The sump receiver tank car is an insulated DOT type W40 tank car with a nominal capacity of 11,360 gal. This tank car is large enough to hold the volume of any one 103-W tank car plus the 10% extra volume required by RCRA regulations. The inlet piping extends from the dome to within 1 in. of the vessel bottom and is equipped with a vacuum relief valve to prevent back-siphoning when the pump stops. The sump liquid receiver car is vented to the atmosphere, unlike the hexone receiver cars that are vented back to the underground storage tanks when actively receiving waste. The tank car system will remain in place until the incineration phase is initiated or other hexone disposition is started.

4.1.5 Inert Gas System

Two 4,000 ft^3 gas capacity liquid nitrogen dewars provide gas for inerting the four distillate receiver tank cars, the distillation module vessels, the underground hexone tanks, and the oil heating system expansion tank. The nitrogen gas also serves as the medium for operating the weight factor dip tube bubblers that are used for liquid level measurements in the condensate catch tank, the tank cars, and the underground storage tanks. The gas pressure from the nitrogen dewars is regulated with automatic pressure regulators and is distributed via small-diameter tubing. In addition to the continuous purges through the weight factor dip tubes, a demand regulator on the nitrogen supply system will add nitrogen as required to maintain the hexone system pressure above ambient pressure to prevent air infiltration. Once the tank cars are inerted the demand for gaseous nitrogen is less than 50 $stdft^3/h$.

4.1.6 Offgas System

Purge nitrogen from the distillation system, noncondensable gases, as well as gas flow due to barometric pressure changes is vented via the underground tanks to a filtration system on tank 276-S-142. Gases vented from the distillation system will vent first to tank 276-S-141 and will then flow via a flame arrester to tank 276-S-142 before entering the offgas filtration system. This arrangement allows the two underground tanks to be .

used as vapor condensing pots in the event a power failure or other event shuts down one or both condenser fans. While the No. 1 feed weir pressure sensor will shut down the oil heater, vapors will continue to be produced until residual heat in the system dissipates.

Gases vented from tank 276-S-142 will flow through a flame arrester, a high-efficiency particulate air (HEPA) filter, and then pass through two parallel banks (each bank containing three stages) of activated carbon for adsorption to remove organics and ^{129}I. Excess purge gas supplied by the demand regulator to overcome barometric pressure rises will enter between the underground tanks and HEPA filter to minimize the amount of hexone entrained in the vent exhaust. Intermittent ambient air sampling for organic vapor and radionuclides will be carried out as close to the vapor vent as possible.

4.2 PROCESS DESCRIPTION

The distillation process consists of two single-stage distillation operations in series that are expected to remove at least 99.9% of the radioactive material in the waste inventory. The less contaminated of the two tanks, 276-S-141, will be processed first, followed by tank 276-S-142. The process steps are outlined below.

4.2.1 Vessel Inerting

Before process operations get underway, the vessels in the system will be purged with inert gas to reduce the oxygen level from 21% to less than the 11% (Alter 1949; Jones 1949) required to sustain hexone combustion. The four receiver tank cars will be prepurged and sealed. Cars will normally be valved to the vent system only when they are actively receiving distillate or when weight factor liquid levels are to be taken as part of scheduled surveillance. The underground tanks also will be prepurged. The distillation tanks, condensers, and condensate catch tank will be purged with nitrogen before initial operations. The underground tanks and the receiver tank car(s) will be monitored periodically with oxygen sensing equipment to assure that inert conditions are obtained and maintained throughout the distillation operation and during hexone storage in the tank cars.

4.2.2 Feed Start and Distillation Operations

The feed piping will be filled with about 0.5 gal water to assist in priming the No. 1 pump, and hexone recirculation will then be initiated into the No. 1 tank feed weir. The weir will fill the No. 1 distillation tank at a nominal rate of 3 gal/min until the tank liquid level reaches the level of the weir. Excess liquid will then overflow the weir back to the underground tank. The tank fill will require approximately 2 h.

When the No. 1 distillation tank is full, heating will be initiated. The oil recirculation pump will start oil flow through the heating coils of both distillation vessels. When oil flow is fully established, the thermostatically controlled oil heaters will be turned on. The oil temperature will be increased gradually until the liquid in the distillation tanks starts to boil. The first condensate is expected to come over at 189 °F, when a small amount of water-hexone azeotrope boils off. The remainder of the 276-S-141 inventory is expected to boil at a temperature of 243 °F. The vapors from the distillation tank will pass through the two demister elements to remove entrained droplets. The condenser fan motors will be turned on to provide efficient cooling of the condenser coils. The vapors will condense in the finned-tube condenser and enter the weir of the No. 2 distillation tank. Condensate will drain into the No. 2 distillation tank and will again be evaporated. Any excess condensate entering the weir will overflow back to the underground storage tank via a seal-loop. The vapors from the No. 2 distillation tank will pass through two demisting stages, condense in the No. 2 condenser, and will enter the condensate catch tank.

4.2.3 Distillate Transfer to Tank Cars

The distillate from the No. 2 condenser accumulates in the distillate catch tank until the automatic weight factor level-sensing system actuates the transfer pump start switch. The pump will transfer hexone to the hexone receiver tank car until the low-level set point is reached and the pump shuts off automatically. In the event the catch tank liquid level rises above the pump start level, the catch tank will overflow back to the underground storage tank.

The tank cars will be filled to a maximum level of 9,500 gal one at a time, leaving more than 500 gal as expansion space in each car. The inert gas mixture in the tank car will be displaced via the vent line into the underground storage tank system. The vent line also serves as an overflow line in the unlikely event that the tank car is overfilled. Full tank cars will be valved out from the condensate transfer pipe, but may continue to be vented to the vent line when necessary. Liquid levels will be measured in each full car daily via weight factor instrumentation.

4.2.4 Steady State Distillation Operations

The distillation system is intended to operate weekdays on an around-the-clock basis (XYZ shift). The initial condensate production rate is expected to be approximately 2 gal/min. This production rate will gradually slow as the heating coils become fouled with a tar-like distillation residue. The coil fouling can be overcome to some extent by raising the temperature of the heating oil.

The thermostatically-controlled oil temperature will be limited to a maximum of 475 °F (246 °C) by procedural controls and to 500 °F (260 °C) by an automatic cutoff switch in the oil heating unit. A temperature of 475 °F was found to be fully adequate to reduce the distillation residue to a dry

tar. When the tar inventory in the No. 1 distillation tank increases to the point that continued processing is not practical, the tank must be replaced with one of the three spare distillation tanks constructed for this purpose (see Section 4.2.6).

The demister element differential pressure will be routinely monitored to assure that the elements do not become plugged. If a demister differential pressure becomes excessive, the demister element will have to be replaced. The demisting system is designed for a two-stage operation with a coarse element followed by a high-efficiency element to minimize the chance of a high demister pressure drop. The distillation system is designed to operate at a slight positive pressure. This positive pressure is imposed by pressure drop across the demisters, condensers, and piping. The liquid seal loops on the feed weir overflow systems allow this pressure to be maintained. If the pressure in the system exceeds the height of the seal loops, approximately 40 in. of water or organic mixture, the liquid will be pushed out of the seal loops and the system will vent back to the cold underground storage tanks, where the vapors will condense. Operating procedures will require oil temperature adjustments and/or demister replacement well before the demister differential pressure increases to the point where a direct venting to the underground storage tanks will occur. An automatic pressure interlock will shut off power to the electric heaters and to the hexone transfer pumps when the differential pressure exceeds 30 in. of water.

When the 20,000-gal inventory in tank 276-S-141 has been removed, a small pump heel will remain in the bottom of the tank. This pump heel will be diluted with water several times as required to remove the last of the floating hexone layer. The water will be processed through the distillation system. The piping system will then be re-directed to tank 276-S-142. While processing operations are in progress for 276-S-142 liquids, preparations will be made to assess the condition of tank 276-S-141 and to determine the extent of further flushing required to remove residual hexone to the level required by WAC/RCRA regulations for disposal of the tanks.

The first processing operation from tank 276-S-142 will involve the distillation of the 2,000-gal water heel in this tank. The distillation will then proceed to the hexone-TBP-NPH mixture in this vessel. The formation of tar from tank 276-S-142 waste is expected to be much more rapid than from 276-S-141. The temperature of the boiling liquid will also gradually increase. The final boiling temperature required to drive off the heaviest volatiles is expected to be approximately 450 °F. The system has been analyzed and designed to accommodate thermal expansion under these temperature conditions.

4.2.5 Sampling

The tops of the distillation tanks are equipped with plugged access ports that allow samples of the liquid or tars to be withdrawn when the system is in a cold shutdown status.

No routine distillation vessel samples are planned; however, special samples may be required for process control purposes and for verifying the absence of peroxides before concentrating the first-stage distillation vessels to dryness. The distillate transfer tank is equipped with a sampling valve to obtain routine distillate samples. The main purpose of the distillate samples is to verify that distillate with a very low radionuclide content continues to be produced. Each tank car will be sampled after filling to assess distillate quality and to establish requirements for the hexone incineration phase. The tar in the distillation vessels will be sampled, after residue dry-out, for waste characterization as required by WAC/RCRA regulations for storage and disposal.

4.2.6 Distillation Tank and Demister Changeout

Three spare tanks have been constructed to replace distillation tanks that fill with residual tar. It is expected that all of the tank 276-S-141 inventory can be distilled in the original No. 1 distillation tank, but that the 276-S-142 tank organic will produce tar at a faster rate. It is also expected that the No. 2 distillation tank will last for the duration of the distillation process, but a replacement cannot be ruled out. When a distillation tank is judged to require replacement, as evidenced by low distillation rates, the following steps will be carried out.

4.2.6.1 Dryout. Laboratory tests have shown that the distillation residues can be taken to dryness and that no exothermic reaction occurs when residue is heated (Weiss 1989). The feed to the distillation system will be shut off and the vessel content will be allowed to evaporate down to a dry residue. The recirculating oil temperature will be gradually raised to 475 °F to assure that all volatiles are removed and only solids without free liquid remain. The final dryout is expected to require one or two operating shifts.

4.2.6.2 Cooldown. The heat supply will be shut down and the system allowed to cool off. The cooling phase is expected to require 1-2 days dependent largely on ambient temperature conditions. The distillation tanks will then be purged with nitrogen to assist in cooling and removing any remaining vapor.

4.2.6.3 Oil Drainage. Part of the recirculating oil will be drained from the heating coils into the oil overflow drum. The intent is to drain enough oil from the coils to allow disconnecting the oil inlet and outlet flanges without spilling oil. Nitrogen gas will be purged into the high point of the oil piping to allow oil drainage and siphoning.

4.2.6.4 Disconnecting. The flanged oil lines will be disconnected from the distillation tank that is to be removed. The oil hose flanges will be blanked. The feed inlet flange will be disconnected and blanked on both sides. Sparkproof tools will be used for operations involving hexone-bearing piping and flanges. The demister assembly will be disconnected from the distillation tank and from the condenser piping, and then will be blanked on both ends and placed on the ground with a crane. The distillation tank will be sealed with a blank flange and placed on a truck for transport to a permitted radioactive waste storage area. Long-range disposal of the

distillation tanks will require sampling, characterization of the tar, fill of void spaces, and weighing of the vessel to determine the total amount of tar and radionuclides in the tank. Residual oil in the coils will be drained by inverting the tank and allowing the oil to flow by gravity into the oil overflow tank.

4.2.6.5 Installation of New Distillation Tank. A spare distillation tank will be installed on the framework, and the demister system, feed connection and oil hoses will be reinstalled.

4.2.6.6 Demister Replacement. The first stage (roughing) demisters are expected to be usable throughout the life of the process. A spare demister element and housing are available for the event that one of the secondary (high efficiency) demisters becomes plugged and unusable, although it is expected that a changeout will not become necessary. If a changeout is carried out, the demister element can be removed by separating the secondary demister housing flange from the primary demister housing. The element can then be removed and replaced with a new element.

4.2.7 Tanks 276-S-141 and 276-S-142 Flush and Dry-Out

The underground hexone tanks will be flushed with water to remove residual organics to the level required for storage and disposal by the applicable WAC/RCRA regulations. The final flushes may be made with hot water to increase the organic removal efficiency. A special suction intake will be employed to leave a minimal water heel in the tanks. All flush water will be processed through the distillation system. The tank vapor space will be monitored to assure that no significant quantities of volatile organics remain. The tanks will then be dried out by venting the vessels with a portable HEPA-filtered exhauster. The dry tanks will be sealed with blank flanges and pipe caps to prevent future moisture intrusion or condensation in preparation for closure of the tank site. Closure of the tank site will be covered in a separate closure plan.

4.2.8 Close-Out of the Distillation Operations

During the final stages of distillation operation, all organic piping will be flushed with water and the water processed in the distillation system. The distillation tanks will be removed and sealed per Section 4.2.6.4. All oil will be collected in the oil heating system. The disposition of the equipment will be determined at the time of distillation completion. Disposition options include dismantling or preparation for other organic remediation projects.

4.3 WASTE MANAGEMENT

The distillation system will generate several waste types during operation:

a. Tar-filled distillation tanks

b. A long-term average of approximately 20-30 ft^3/h of HEPA-filtered nitrogen purge gas vented to the atmosphere. Nitrogen that has passed through the hexone tank system will be passed through HEPA filtration followed by activated charcoal adsorption.

c. Distillate (water and organic) stored in railroad tank cars. This waste material will be disposed of in the second stage of this remediation demonstration.

d. Activated charcoal (approximately 600 lb) loaded with hexone in 35 gal containers which can be easily overpacked in 55 gal drums.

Other wastes include radioactively contaminated piping and equipment, as well as normal materials used in radiation zones such as contaminated tools, plastic, rags, tape, etc. These wastes as well as the distillation tanks and charcoal drums will be buried or treated as required by the applicable solid waste disposal regulations.

Final disposal of the distillation vessels is dependent upon two parameters: the residual hexone content of the bottoms residues, and the TRU content of the bottoms residues. If the TRU content of the vessel and residues exceed 100 ηCi/g then the spent vessel will be stored at the Central Waste Complex as TRU waste for eventual shipment to WIPP. The residues will also be sampled for residual hexone and a Toxicity Characteristic Leaching Procedure (TCLP) analysis performed in accordance with 40 CFR 268, Subpart D. If the results of this analysis are below the standards set in 40 CFR 268, then the vessels can be buried as nonhazardous. Since the standards are set based on distillation as the recommended treatment of hexone contaminated wastes, it is expected that this limit can be achieved. If both the TRU and TCLP limits are both met then the vessels can be disposed of as low specific activity (LSA), nonhazardous waste.

4.4 SAFETY FEATURES

The hexone distillation system is designed for safe operation. The design includes the following safety features.

4.4.1 Fire Protection

The following features are provided for fire protection:

a. Inert gas purge of vessels and piping--All tanks and piping in the system are designed to operate in an inert atmosphere through the purge of vessels with inert gas. Periodic oxygen concentration checks will be made in the tank cars and underground tank vapor spaces to assure that inert conditions are maintained at all times.

b. Class 1, division 1, group D explosion-proof motors on the two pumps and two fans in the distillation module, and on the tank car drain pan sump pump.

c. Separating hexone-containing systems at least 25 ft from non-explosion-proof electrical equipment.

d. Heating with controlled-temperature recirculating oil rather than direct heating by flame or electric heaters.

e. Installation of the distillation equipment outdoors in an unconfined setting for dispersal and dilution of flammable vapors in the event of a leak.

f. Availability of fire extinguishers.

g. Barricading to keep potential spark-producing vehicles at least 25 ft from hexone equipment.

h. Venting noncondensable gases through flame arrester-equipped vents via the existing underground storage tanks.

i. Grounding all tanks, vessels, and equipment used in the distillation operations to prevent buildup of static electrical charges.

j. Utilizing both of the two large, cold, underground vessels as backup vapor condensers in the event electrical power is lost and heat energy stored in the distillation vessel mass continues to evaporate liquid feed inventory.

k. Prior testing of the hexone waste that verifies the absence of materials that could increase the fire hazards such as liquid peroxides and exothermic materials in the tar residue.

l. Distillation system is protected against over pressurization by a system of vent and overflow piping that discharges to the underground storage tanks and eventually to the outside environment. In, addition, the integrity of the vessel and piping system was verified by pressure testing the piping and the distillation vessels to 100 lb/in^2, and the tank cars to 65 lb/in^2 at ambient temperature. The system is designed to maintain integrity at full operating temperatures.

4.4.2 Radionuclide and Hazardous Chemical Containment

Containment of radionuclides and hazardous chemicals is maintained through the following features:

a. Pressure tested steel piping and flexible steel transfer hoses.

b. Catch pans under the distillation module and the hexone-storage railroad tank cars capable of holding the contents of the largest storage vessel in its system. The tank car catch pan system includes an automatic sump pump for transferring liquids from the pans to a rail tank car for storage.

c. Tank cars of the type 103-W approved by the DOT for hexone storage and shipment. The tank cars also meet RCRA requirements for hexone storage.

d. Activated carbon and high-efficiency filtration for venting purge gas.

e. Magnetically coupled, seal-less transfer pumps in the distillation module to prevent the possibility of seal failure and leakage.

f. A complete overflow header system for tanks, tank cars, and seal loops to return any hexone overflow liquids to the underground storage tanks.

g. Interlock on the hexone pumps with the liquid-level detector in the distillation module pan.

h. Concrete shielding around the distillation vessels to reduce potential radiation exposure to personnel.

4.4.3 Industrial Hazards

Industrial hazards are controlled by the following features:

a. Insulation as required to prevent accidental contact and burns.

b. Handrails on the stairs and deck of the flatcar holding the distillation module as fall protection.

c. Inert gas blanketing of the hexone system vessels and tank cars to prevent fires.

d. Class 1, division 1, group D electrical equipment on the distillation module to avoid the presence of electrical ignition sources.

e. Removal of organic vapors from the offgas with activated charcoal.

f. Personal Protective Equipment including protective clothing, hard hats, face shields and goggles, and chemical cartridge respirators where appropriate to the task being performed.

g. Personnel training in handling hazardous materials and in response to emergencies at the remediation demonstration site.

5.0 DESIGN CRITERIA

5.1 PURPOSE

This phase of the Hexone Remediation Demonstration will remove the hazardous organic solvent waste from existing single-wall underground storage tanks and separate it by distillation. The products of this distillation will be a solvent suitable for destruction in a commercial incinerator and a solid radioactive mixed waste suitable for storage.

The hexone distillation module will process all the liquids, both organic and water, in tanks 276-S-241 and 276-S-242. The distillation module will provide pumps and piping to remove all but the last 1 to 3 in. of water from both tanks with only a thin layer of organic left floating on this water. The distillation process will separate nonvolatile radioactive elements, salts, and sludge from the liquids. The products will include up to four tank cars of very low activity, clear organic liquid suitable for incineration with minimum offgas treatment. Also, up to five 300-gal-capacity distillation tanks containing 99.9% of the nonvolatile radioactivity with the salts and tars from the distillation of 36,000 gal of waste organic, water, and sludge are expected to be produced.

5.1.1 Product and Waste Criteria

Liquid product from the distillation will contain less than 0.1% of the nonvolatile salts, solids, and radioactive contamination now present in the waste liquid. The product liquid will be stored in four railcars with inert gas covers to reduce the fire potential.

The residue from distillation will be retained in the distillation heating vessels as a solid for storage and eventual disposal as radioactive mixed waste. The distillation heating vessels will provide primary containment for the solid waste residue for subsequent storage and/or disposal.

5.2 FACILITY CRITERIA

The Hexone Remediation Demonstration is not a project and does not have a Functional Design Criteria (FDC) but must still meet the general design criteria in DOE Order 6430.1A.

The major accidents that require prevention and mitigation by design requirements include fire, explosion, and spill to the soil column. The following paragraphs provide a discussion on the requirements, which are particularly relevant to these accident scenarios, from by DOE Order 6430.1A.

The waste hexone presently stored in tanks 276-S-141 and 276-S-142 is characterized as mixed radioactive/hazardous waste. DOE Order 5820.2A establishes requirements for handling mixed waste.

Paragraph 1530-2 of DOE Order 6430.1A discusses improved risk concepts for fire protection systems and gives criteria for selection of automatic fire suppression systems. Paragraph 0275-4 of DOE Order 6430.1A defines the requirements for each facility to develop a spills prevention control plan (SPCP) for petrochemical/hazardous waste systems or tanks as required by 40 CFR parts 122, 260-265, 270-271, and 280-281.

5.2.1 Spill Control

Secondary containment will be used for all process vessels and non-welded liquid transfer pipe installed as part of the Hexone Remediation Demonstration as required by the WAC/RCRA regulations. The system, consisting of drain pans, a sump vessel, pump, and receiver tank car, will meet the requirements for secondary containment as defined in the Washington Administrative Code (WAC). These containment systems will hold 110 percent of the contents of any one vessel. Straight welded pipe runs such as the transfer lines, do not require double containment. The underground storage tanks are not doubly contained, which is one of the reasons for emptying them.

5.2.2 Fire and Explosion Prevention

Hexone vapors are highly flammable and at ambient temperature the concentration of hexone vapor over the liquid may be in the explosive range. To prevent possible ignition in the storage tanks and other vessels, an inert gas purge will be provided to reduce the oxygen content in all vessels below the concentration required to support combustion. The distillation module is located outside which will allow vapors to quickly dissipate in the unlikely event of a spill. Ignition sources near the distillation module will be eliminated. All electrical and instrument equipment in the distillation module will be explosion proof. The tanks, piping, pumps, and condensers in the distillation module have been designed and tested for operation at up to 100 lb/in^2 from -20 to 650 °F. The Design Analysis found the maximum credible pressurization from fire, hot oil coil break, or heating vessel stratification and mixing is less than 100 lb/in^2.

5.2.3 Radiological Design

The Radiological Design Manual, WHC-CM-4-9 (WHC 1989), provides the basis for radiological design of the hexone distillation facility. The very low concentration of radionuclides results in a minimum of shielding. The specific activity of the liquid in the underground storage tanks is about 2 x 10^{-9} Ci/g, the de minimus value for confinement. Transfer lines, pumps, and instruments may be disassembled without radiological confinement such as a greenhouse. The residue in the distillation heating vessels will be up to 200 x 10^{-9} Ci/g and may require some confinement during sampling (controlled ventilation, plastic cover, etc.). The distilled product is expected to be suitable for release as non-radioactive waste.

5.2.4 Hazardous Chemical Emissions

The only hazardous chemical of concern for the offgas system emissions is hexone. There are two considerations which are the basis for controlling the hazardous chemical emission. These are the limits on the vent as a point source and the impact of emissions on ground-level occupational limits. The RQ (reportable quantity) for release of hexone vapor is 5,000 lb/d (40 CFR 302.4, July 1988). Release of this quantity from the vent system is considered unachievable. There are also no maximum permissible levels established for hexone in the Environmental Compliance Manual WHC-CM-7-5 (WHC 1989). Therefore, the release limit is not based on point source constraints, but instead is based on the occupational threshold values at ground level (per WHC-CM-7-5, Part C4.0, a.1). The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for hexone is 50 ppm for an 8 h average concentration; the short term (15 min) exposure limit (STEL) is 75 ppm. The IDLH (immediately dangerous to life and health) level is 3,000 ppm. The ventilation system is designed to assure that ground-level concentrations in the immediate area are below the TLV.

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6.0 SAFETY ANALYSIS

Westinghouse Hanford's requirements and procedures for conducting a risk analysis are given in Section 4 of the Nonreactor Facility Safety Analysis Manual (WHC-CM-4-46). Risk acceptance criteria are defined relative to both radiological doses and toxicological doses. It is shown in paragraph 6.2.5 of this SAD that the radioactive material inventory present in the waste hexone is sufficiently low to ensure that radiological doses from credible release scenarios would be sufficiently low that the Hexone Remediation Demonstration should be considered to be a low hazard facility. Radiological risk acceptance criteria given in WHC-CM-4-46 are not expected to be exceeded. The manual also defines risk acceptance criteria based on toxicological considerations. Hexone is only moderately toxic and has an immediately dangerous to life or health (IDLH) value of 3,000 ppm, an 8 h TLV of 50 ppm and a 15 min STEL of 75 ppm. The equilibrium concentration of hexone in air at 20 °C is 6,580 ppm. This is equivalent to a vapor pressure of 5 mm of mercury. Since the entire remediation will be conducted outdoors, ventilation is very good, and any hexone volatilized from a spill would be expected to be quickly dissipated. Concentrations to the nearest non-facility worker would not be expected to approach the IDLH value of 3,000 ppm. The only other potentially volatile component of the waste is NPH, and this material is both less volatile and less toxic than hexone. It is concluded that radiological and toxicological dose considerations are not factors with respect to risk acceptance criteria.

The major safety considerations which do have potential for loss of life and property have to do with fire and explosion. The Nonreactor Facility Safety Analysis Manual does not provide any risk acceptance criteria for fires and explosions, but it is generally recognized that any major accidents which have potential for loss of life and property are unacceptable at any U.S. Department of Energy site. The Nonreactor Facility Safety Analysis Manual, paragraph 3.4, states that "It is intended that SARs and SADs be used to document analysis of facilities which present hazards not normally accepted by the vast majority of the public." The fire/explosion risk associated with the hexone distillation operation is not very different from the risks associated with the use of gasoline. These risks are accepted by the public. The only significant difference in risk between the use of gasoline and the hexone operation is the potential for low level radioactive contamination which exists in the case of hexone.

6.1 SAFETY ANALYSIS METHODOLOGY

This SAD employs the safety analysis technique of development of a Preliminary Hazards Analysis (PHA) which is shown in Table 6.1. This is used as a first step in identifying significant plausible abnormal operations and accidents which could be expected to result in radiological or toxic chemical releases. Fault tree analysis is done in order to establish relationships and sequences of events which must occur in order for the overall accident scenario's consequences to take place. Fault trees provide a convenient means for mathematically combining the probabilities of contributing events in order to systematically quantify the probability for

the overall accident scenario. Radiological doses and toxicological doses are calculated to establish that risk acceptance criteria will probably not be exceeded. A detailed analysis and discussion of factors which are important in the prevention of fires and explosion is also given.

6.2 HAZARDS ANALYSIS

6.2.1 Preliminary Hazards Analysis

The Preliminary Hazards Analysis is provided in tabular form in Table 6-1. This table is intended to provide an overview of all system or administrative failures that have safety significance. The PHA does not include consideration of damage from natural phenomena such as earthquakes because the expected duration of the distillation is sufficiently short that an earthquake during distillation is incredible. The PHA does not include distillation vessel rupture because of the thickness of vessel walls and the relatively low peak pressures (i.e., 90 psi) possible from a hexone explosion. Further information on the relationship between events that lead to uncontrolled radiological releases and releases of hazardous chemicals is provided in Figure 6-1 which provides two fault trees for the hexone distillation operation.

6.2.2 Fires

The one chemical property that makes hexone particularly susceptible to fires and explosions is its high volatility. This property also provides the driving force for concern about toxicity resulting from spills in enclosed areas where ventilation is poor. The vapor pressure of hexone as a function of temperature is given in Table 6-2.

Paragraph 5.2.4 defined the release limit criterion for hexone release from the distillation process which is based on the TLV of hexone. The Threshold Limiting Value or TLV given for hexone is 50 ppm. Threshold Limiting Value is defined as the concentration in air of a substance to which a worker can be exposed for an eight hour day with no ill effects. The IDLH value is much more meaningful and is set at 3000 ppm. The IDLH is defined as a concentration which may be endured for no longer than 30 minutes without risk of permanent damage or loss of life. Table 6-1 shows that even at freezing temperatures the vapor pressure of hexone is sufficiently high that a spill of hexone would result in equilibrium air concentrations of 1,000 ppm in the vicinity of the spill. This concentration would be quickly diluted to less than 50 ppm because of air circulation resulting from conducting the operation out doors. Vapors from any spill on the flatcar would tend to disperse to the ground level due to hexone having a greater density than air. Calculations of concentration as a function of distance are provided in Figures 6-2 and 6-3 for a spill scenario in order to demonstrate the effectiveness of dilution.

Table 6-1. Preliminary Hazards Analysis.

Event/system failure	Accident scenario	Consequences predicted	Barriers/mitigating measures	Probability/yr
Transfer line pipe break	Continuous hexone spill at 3 gal/min (pump capacity)	Release of hexone vapor to atmosphere and formation of toxic plume	Distillation unit is mounted on flatcar. Connection to transfer lines is by flexible jumper. All lines pressure tested.	7.27 E – 04
Feedline pipe break coupled with ignition of vapor	Hexone fire	Potential injury to workers. Minor radiological release, equipment damage.	In addition to above, electrical grounding, use of explosion proof electrical equipment, and insulation of oil piping make ignition unlikely.	7.27 E – 06
Loss of inert gas blanket in feed tank plus ignition source	Vapor phase hexone explosion in underground tank	Same as above	System electrically grounded. Ignition source unlikely.	1 E – 06
Nitric acid concentration in distillation vessel exceeds 3M	Hexone/nitric acid explosion	Same as above	pH is maintained above 10 to minimize corrosion. Nitric acid cannot exist at pH = 10	<1 E – 06
Concentration of hexone peroxides in distillation vessel exceeds 5%	Hexone peroxide explosion	Same as above	Tests of feed for peroxides show <.15 ppm. 5% concentration is not achievable by distillation	1 E – 06

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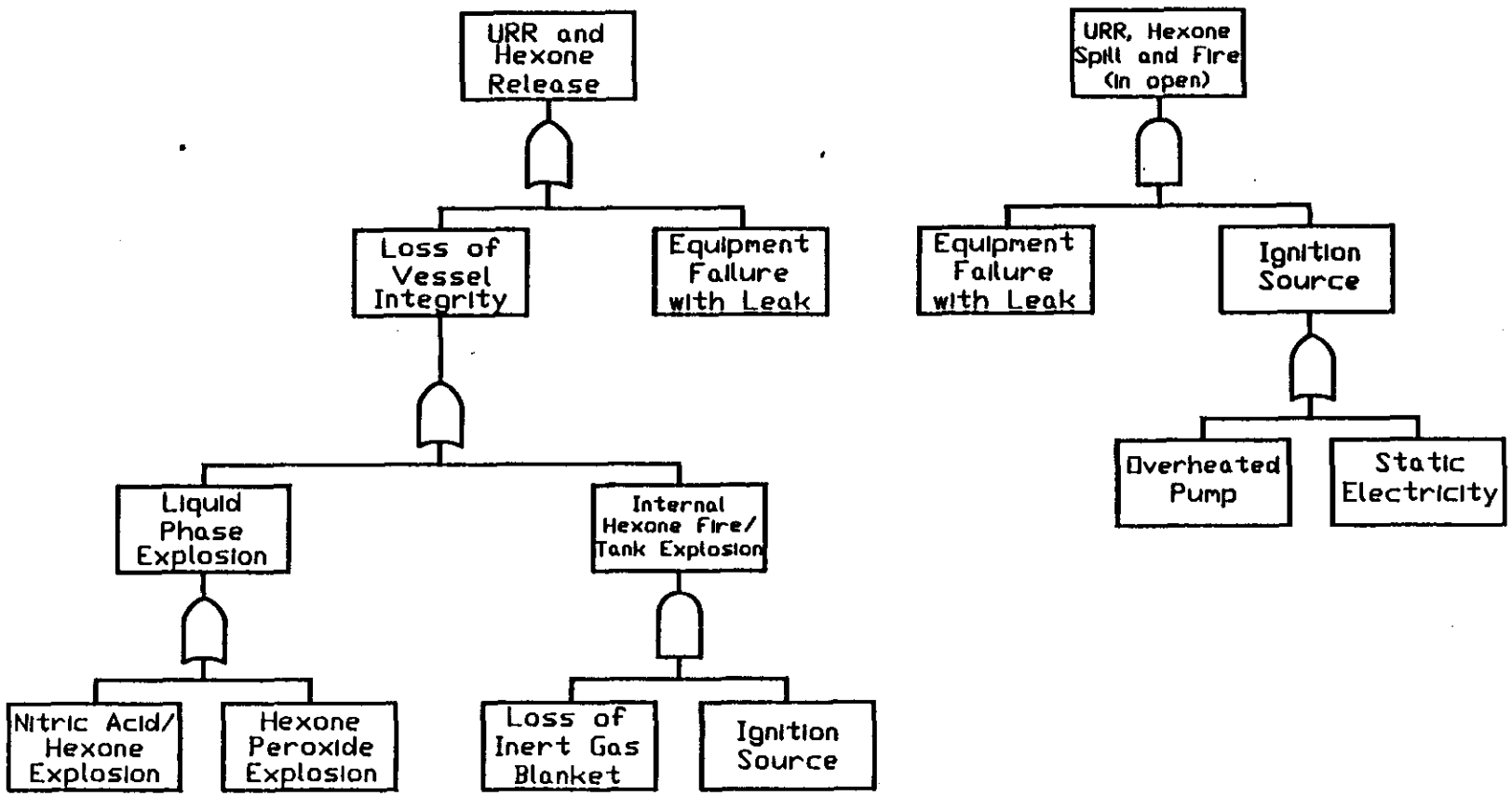

Figure 6-1. Fault Tree Analysis of Hexone Distillation.

Table 6-2. Vapor Pressure of Hexone.

Vapor pressure (mm of Hg)	Concentration (ppm)	Temperature (°C)
1	1,316	−1.4
5	6,579	19.7
10	1.32 E + 04	30.0
20	2.63 E + 04	40.8
40	5.26 E + 04	52.8
60	7.89 E + 04	60.4
100	1.32 E + 05	70.4
200	2.63 E + 05	85.6
400	5.26 E + 05	102.0
760	1.00 E + 06	119.0

NOTE: Data from Perry Chemical Engineering Handbook.

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Figure 6-2. Hexone Spill-Continuous with Pipebreak and Flowrate of 0.36 kg/s Crosswind Profile at 100 m Downwind.

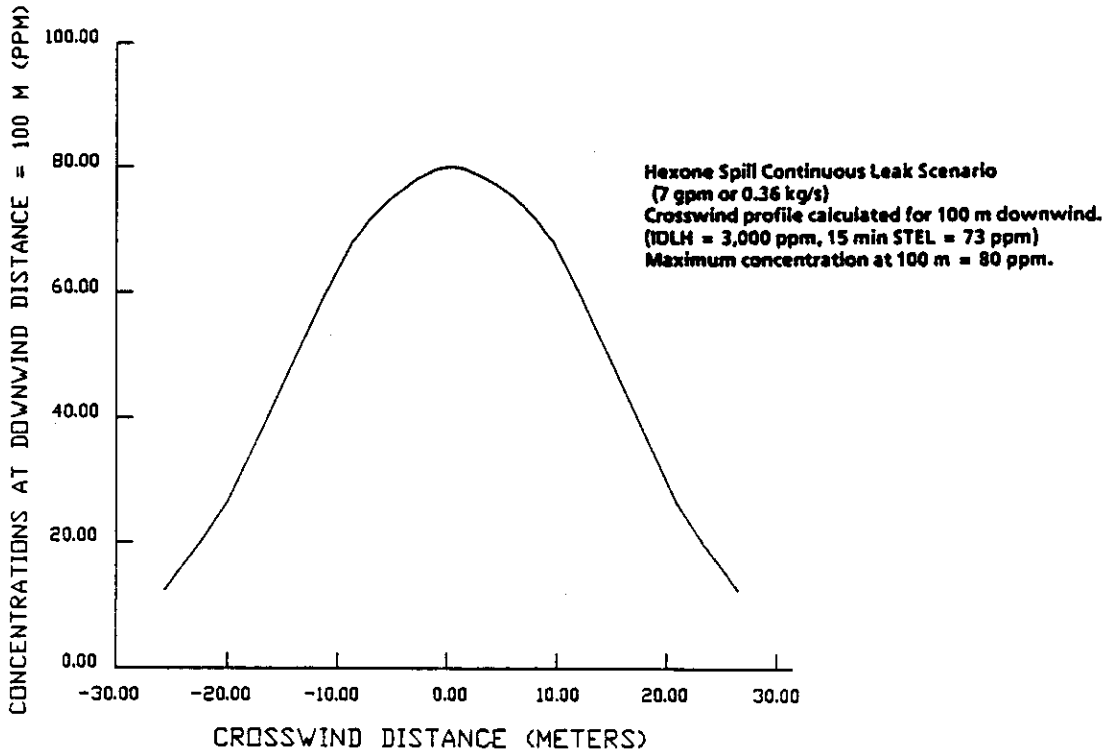
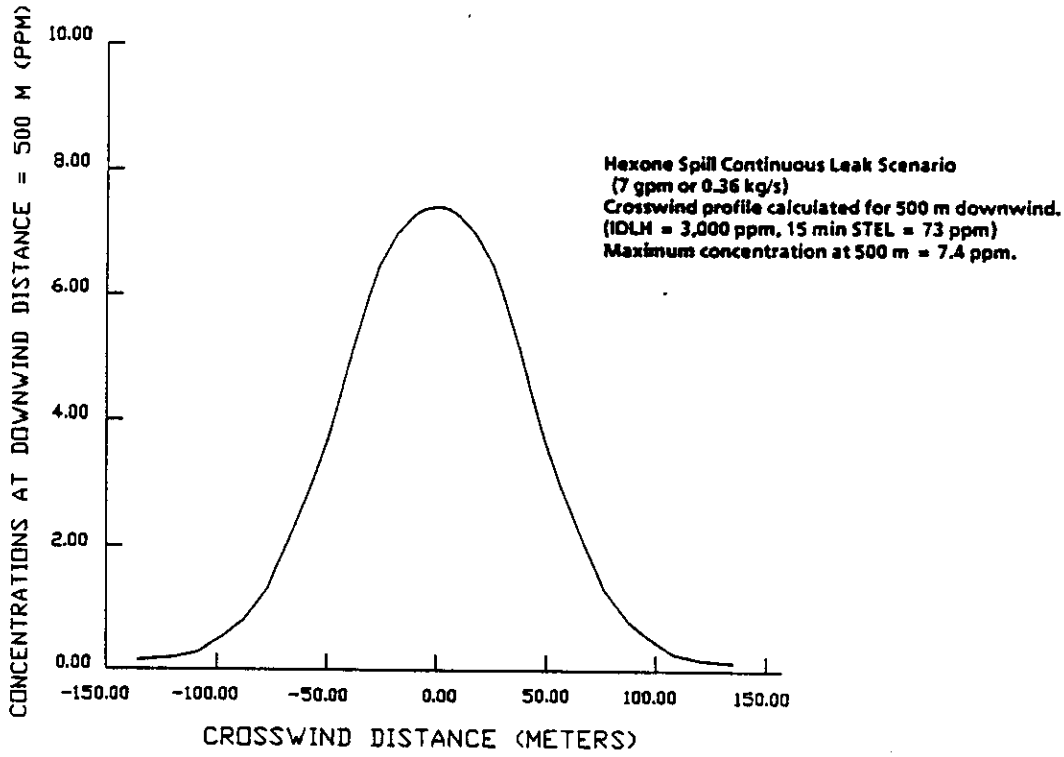


Figure 6-3. Hexone Spill-Continuous with Pipebreak and Flowrate of 0.36 kg/s Crosswind Profile at 500 m Downwind.



The flammability limits (explosive limits) for hexone in air are 1.3% to 8.0% by volume. For vapor pressure equilibrium conditions, the lower limit of 1.3% by volume or 13,000 ppm occurs at a minimum temperature of approximately 30 °C which is 86 °F. The flash point for hexone is defined as 73 °F in Sax (1975). The maximum adiabatic pressure rise is approximately 335 lb/in^2, but the detonation shock wave produces considerably more damage than the adiabatic pressure rise. The U.S. Bureau of Mines states in Bulletin 3537 that the peak pressure in a gas phase hexone explosion, with vapor at 40 °C, is no greater than 90 lb/in^2. It is pointed out to establish a perspective that explosive limits for gasoline are very similar to those given for hexone; however, the flash point for gasoline is much lower (i.e., -45 °F). It may be concluded that gasoline is nominally a much more dangerous substance with respect to fire than hexone.

Static electricity discharge is quite capable of igniting hexone vapors, and all hexone-containing equipment is grounded. The importance of grounding cannot be overemphasized. Eichel (1967) gives an excellent discussion of the hazards associated with static electricity generated by flowing fluids. He states that charges of up to 2,000 volts can build up during tank truck unloading operations. He goes on to say that the minimum sparking potential is about 350 volts. The National Fire Code (National Fire Protection Association, 1979) discusses the electrostatic charging tendency of flammable liquids relative to tank car filling operations and provides guidance on fill rate limits to minimize the charging hazard. It states that fill lines should end not further than 6 in. from the bottom of the receiving vessel and that linear velocities should be limited to no more than 3 ft/s. These conditions are met in the tank car fill lines and the weir overflow lines returning to the underground storage tanks. The railroad tank cars used as hexone receivers will be grounded.

National Electrical Codes require class I, division I explosion proofing for all electrical equipment that processes hexone. Further protection against fires and explosions is provided by the use of inert gas blanketing for the distillation equipment and tank car distillate receiver.

The flash point for NPH is 80 °C (176 °F), well above that of hexone. It is pointed out that the presence of any solute in an organic liquid reduces the vapor pressure and raises the flash point. Thus, the presence of TBP as a solute would raise the minimum flash point of NPH to a temperature higher than 176 °F. Since the flash point of NPH is so much higher than that of hexone, it is concluded that safety measures which prevent hexone fires will also prevent NPH fires.

The auto-ignition temperature of hexone is 923 °F, which is much higher than any temperature expected to be reached during distillation. The NPH fraction in tank 276-S-142, however, will pass through its auto ignition temperature of approximately 400 to 465 °F during final distillation to

dryness. While an inert atmosphere will be maintained in the distillation tanks and the associated storage vessels throughout the distillation operations, maintaining inert conditions will be especially important during final distillation to dryness.

6.2.3 Explosions

Gas phase explosions were discussed along with fires under the previous paragraph and will not be discussed here. Two different scenarios have been identified that could potentially result in a liquid phase explosion in the distillation vessel. The first scenario involves rapid oxidation of hexone by nitric acid, while the second scenario involves formation of explosive ketone peroxides in the hexone.

The REDOX Technical Manual (General Electric Hanford Company, 1951) states that at room temperature, static contact between nitric acid (up to 4M) and hexone only results in slow reaction. Prosser (1986) states that hexone is stable in the presence of high concentrations of nitrate salts. Since the aqueous phase of tank 276-S-142 was adjusted to a pH of greater than 10 to minimize corrosion, the relatively small amount of nitrate present can only exist in the salt form and presents no explosion risk relative to distillation of hexone.

Report HW-42068 RD (General Electric Hanford Company, 1949) discusses a hexone/nitric acid explosion which took place at Hanford's 321 Building on January 23, 1949. The explosion took place in a submerged turbine pump test stand in which a mixture of hexone and 3.4M nitric acid was being mixed by the pump. The estimated liquid temperature was 80 °F at the time of the accident. During the course of this test, the hexone was observed to darken in color to a dark amber color prior to the explosion. It was concluded that a simple gas phase explosion between hexone vapor and atmospheric oxygen could generate peak pressures of only 90 lb/in^2 which are not high enough to account for the actual damage observed in the 321 Building explosion. The report proposes the hypothesis that a gas phase explosion was caused by a phenomenon called "pressure heaping" in which ignition in the torque tube (turbine pump chamber) causes a compression of gases in the surrounding 55-gal drum. This is followed by ignition in the drum of the gases which are now at higher initial pressure which results in much higher final pressures in the drum. The report also mentioned a turbine pump bearing failure which could provide hot bearings to act as an ignition source. Hexone is well known for its ability to wash away lubricants, which could lead to bearing failure. The hexone distillation system eliminates this ignition source by using a pumping system essentially identical to that used in gasoline service stations: magnetically coupled, totally sealed gear pumps located outside the hexone vessels, and connected to the hexone vessels only with small diameter piping. The gear pumps utilize hexone as the lubricating medium and are subject to overheating only when running dry. Dry running could lead to bearing seizure. Extreme heat generation is avoided by the limited torque inherent in the magnetic coupling.

The above-mentioned "pressure heaping" hypothesis does have weaknesses. Experimental evidence has indicated that an initial pressure of 3 atmospheres would have to be in the drum before an explosion could develop enough energy to destroy the drum (i.e., a gas phase explosion is not plausible unless the initial pressure in the drum before ignition was 50 lb/in^2). On the other hand, it is quite possible that the explosion in the 321 Building was caused by liquid phase explosive reaction between nitric acid and hexone. The acid concentration was sufficiently high for such a reaction to take place.

A nitric acid/hexone liquid phase explosive reaction is not possible in the hexone distillation operation. This is true because the pH of the aqueous portion of the waste held in tank 276-S-142 has been adjusted to pH = 10 in order to minimize corrosion. Nitric acid no longer exists at this pH.

The second liquid phase explosion scenario considered by this SAD is based on speculation that over a period of time explosive ketone peroxides may have been formed in the hexone. The potential for existence of peroxides in tank 276-S-142 was discussed by Shaw (1976) who stated that the concentration of peroxides would have to be at least 5 or 10 vol% before any explosion hazard exists. He said that the concentration of peroxides in the waste tanks was estimated by assuming that the oxidation potential of the organic waste was entirely due to peroxides. From this it was concluded that peroxide concentration may be as high as 0.09 vol%. Shaw went on to say that substantial boil down of hexone, as would occur in a distillation vessel, could increase peroxide concentration to the explosive level.

Noller (1957) in Chapter 40 discusses the formation of alkyl peroxides and alkyl hydroperoxides from reaction between ketones or aldehydes and hydrogen peroxide. Hydrogen peroxide is expected to be radiolytically produced in any aqueous solution subjected to high radiation fields. In the case of hexone, which is methyl isobutyl ketone, reaction with hydrogen peroxide could lead to formation of a number of different peroxides and hydroperoxides, many of which are not explosive, but could lead to formation of hydroxymethyl peroxide which is known to be very explosive. Note that while hydroxyalkyl hydroperoxides are not directly explosive, they hydrolyze with heat to hydroxyalkyl peroxides, which are explosive. Note also that hydroxyalkyl hydroperoxides can also dimerize to cyclic alkylidene peroxides, which are extremely explosive.

The waste hexone was tested for the presence of organic peroxides using Iodine reduction and spectrophotometric analysis. Results of this analysis found the peroxides to be below the minimum detectable level of 0.15 ppm. Even a 100:1 concentration by distillation would only raise the peroxide level to 0.0015%, which is at least a factor of 3,000 below the level where any explosion hazard exists. It is concluded that a peroxide explosion hazard does not exist.

A test distillation of a small amount of hexone taken from tank S-142 was done in a laboratory hood, and no evidence of exothermic reactions was found. The dry tar residue remaining from the distillation was tested for

the presence of exothermic materials at elevated temperatures. No significant exotherms were found below 500 °F (Weiss 1989), indicating that heating the tar during final dryout does not present a chemical reaction hazard.

6.2.4 Hexone Spill Scenario (Toxic Dose Calculations)

As earlier mentioned, hexone (otherwise known as methyl isobutyl ketone) is not a highly toxic chemical with respect to inhalation of the vapors. The IDLH level is given as 3,000 ppm which is equivalent to 12,300 mg/m^3. The 15 min STEL is given as 300 mg/m^3 or 75 ppm.

An earlier discussion was given that a break in the distillation vessel is highly unlikely because of the wall thickness of the vessel. An accident scenario is proposed for consideration in which a pipe break takes place between the feed pump and the hexone distillation vessel. Note that a pipe break on the suction side of the pump between the pump and the underground tank would not result in a leak to the environment. A full-scale pipe break is not nearly so likely as a smaller leak from a fitting or valve, but a full scale break was selected for the sake of conservatism. (A smaller leak would not be expected to exceed risk acceptability criteria because of the very low concentration of radionuclides in the hexone. With a broken pipe, the maximum flow rate of the leak is limited by the capacity of the feed pump, which is 7 gal/min, which is equivalent to 0.35 kg/s of hexone leaked. At 20° C, the density of hexone is 6.7 pounds/gallon or 0.803 kg/liter.

$$\frac{(7\ gal/m)(6.7\ lb/gal)(0.454\ kg/lb)}{60\ s/m} = 0.35\ kg/s \quad \text{leak rate}$$

Note that, in reality, a pump bypass line will be used to reduce the actual hexone flow from the pump to the distillation vessel to 3 gal/min which would create a maximum leak rate of 0.15 kg/s.

A mass flow rate of 0.35 kg/s was input as the source term into the SPILLS computer dispersion model (Trinity Consultants, Inc., 1987), and crosswind concentration profiles were plotted for downwind distances of 100 and 500 m (Figures 6-2 and 6-3). The wind speed input into the model was one meter/second and atmospheric stability class was set at class F. The plots show that even as close as 100 m to the spill, the maximum airborne concentration of 80 ppm of hexone just barely exceeds the 15 min STEL which is 75 ppm. The concentration at 100 m downwind is far below the IDLH of 3,000 ppm which is the basis of the risk acceptability criteria for non-facility workers given in WHC-CM-4-46. The results also show that airborne hexone concentrations are far below toxic chemical risk acceptance criteria for offsite persons.

6.2.5 Radiological Dose Calculations

The bounding source term is based on the radiological inventory of hexone (14,000 gal) held in tank 276-S-142 which is released as described in the hexone fire scenario. The rate of release is determined by plant configuration. As discussed in the previous paragraph, the maximum mass flow rate of hexone into the environment where it is burned is 0.35 kg/s. At this flow rate, it would require 2,000 minutes to pump out the entire 14,000-gallon inventory of tank 276-S-142. If a leak and fire occur, the total mass of hexone burned may be calculated from the maximum flow rate and the duration. The leak and fire can be terminated either by shutting off the pump and the fuel supply to the fire, or by action of the fire department. The pump itself sits over a catch pan which is equipped with a liquid-level actuated shutoff switch for the pump. It can be stated with considerable confidence that a fire would be put out within 30 min of the time it is initiated. The amount of hexone burned in 30 minutes would be:

$$(30\ m)(60\ s/m)(0.35\ kg/s) = 630\ kg\ of\ hexone = 784\ liters$$

The fractional amount of the total inventory burned would be 784/52996 which is 0.0148. Only a small fraction of the radionuclides contained in the hexone actually burned would be expected to be released to the atmosphere. It can be shown from data given in Table 4-8 of Owczarski's 1978 paper that no more than 0.1% of the radionuclide inventory of the hexone would be expected to become airborne in a fire.

When these factors are multiplied together, e.g., 0.0148 and 0.001, one obtains the overall reduction factor of 1.48×10^{-5}. This overall reduction factor is multiplied by the total inventory data to calculate the radiological bounding source term for the hexone fire scenario. The results of this calculation are given in the right hand column of Table 6-3.

The maximum doses which would be expected for the hexone fire scenario have been calculated from the bounding source term using the GENII dose calculation software. These calculated Effective Dose Equivalent (EDE) values are given in Table 6-4 where they are compared to the risk acceptance guidelines taken from WHC-CM-4-46.

It should also be noted that radiological doses would actually be expected to be still smaller than shown in Table 6-4 because the GENII software does not provide for the dispersion effect which would be expected from the plume buoyancy provided by the heat generated by the fire. This effect would be expected to markedly decrease the onsite doses still further.

Comparison of the dose calculations provided in Table 6-4 to Hazard Class Criteria provided in Section 2.0 of the Nonreactor Facility Safety Analysis Manual, WHC-CM-4-46 shows that from a radiological dose consideration, the Hexone Remediation Project should be classified as a Low Hazard Facility. Any emergency situation dealing with either a spill or fire will require the use of self-contained breathing equipment.

Table 6-3. Bounding Source Term Data for Tank 276-S-142.

Nuclide	Organic concentration (µCi/L)	Organic volume (L)	Organic total (Ci)	Aqueous concentration (µCi/L)	Aqueous volume (L)	Aqueous total (Ci)	Inventory total (Ci)	Curies released by hexone fire
^{129}I	6.7 E−02	52,996	0.0035	–	7,571	–	0.0035	5.2 E−08
^{154}Eu	0.32		0.017	0.00382		2.9 E−05	0.017	2.5 E−07
^{155}Eu	0.37		0.020	0.024		1.82 E−04	0.020	3.0 E−07
^{125}Sb	1.27		0.067	0.0198		1.50 E−04	0.067	9.9 E−07
^{106}Ru	5.14		0.272	0.906		6.86 E−03	0.28	4.1 E−06
^{106}Rh	5.14		0.272	0.906		6.86 E−03	0.28	4.1 E−06
^{90}Sr	2.19		0.12	–		–	0.12	1.8 E−06
^{90}Y	2.19		0.12	–		–	0.12	1.8 E−06
^{241}Am	1.5*		0.079	0.0118		8.9 E−05	0.079	1.2 E−06
^{137}Cs	–		–	1.198		9.07 E−03	0.0091	1.3 E−07

$$\text{Organic total} = \frac{(\text{Organic concentration}) \times (\text{Organic volume})}{10^6}\ \text{Ci}$$

Total = Organic total + Aqueous total.

*All alpha was assumed to be ^{241}Am on the basis of PNL treatability work.

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Table 6-4. GENII Dose Calculations for Hexone Fire Scenario Compared to Risk Acceptance Criteria.

		Risk acceptance guidelines P =		
		E-04 to E-06	E-02 to E-04	E+00 to E-02
Maximum onsite worker, effective dose equivalent	6.1 E-04 rem	10 - 25	5 - 10	0.5 - 5.0
Maximum offsite person, effective dose equivalent	1.5 E-06 rem	4 - 25	0.5 - 4	0.1 - 0.5
Maximum onsite worker, critical organ dose	1.2 E-02 rem	100 - 250	50 - 100	5 - 50
Maximum offsite person, critical organ dose	2.4 E-05 rem	40 - 250	5 - 40	1 - 5

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7.0 OPERATIONAL SAFETY LIMITS

1. TITLE: Inerting of hexone process vessels.

1.2 APPLICABILITY: This specification applies to active process vessels, underground storage tanks, and tank cars during distillation operations. It does not apply to isolated hexone storage tanks, or the secondary containment receiver tank car.

1.3 OBJECTIVE: Inerting of the process equipment vapor spaces during distillation operations is required to prevent fires or explosions from the presence of combustible vapor mixtures in the event an ignition source is present due to equipment failure, unplanned event, or during distillation to dryness when the NPH autoignition temperature may be exceeded.

1.4 REQUIREMENT:

a. The tank cars, underground storage tanks, and process vessels shall be inerted prior to initial startup of the distillation system to an oxygen concentration of less than 10%. Tank cars storing hexone shall be maintained with an inert gas blanket.

b. A minimum total flowrate of 5 ft^3/h of nitrogen shall be purged through the active process system vessel spaces during active distillation operations.

c. A minimum nitrogen volume of 1,000 $stdft^3$ of gas equivalent shall be maintained in the operating nitrogen dewar system during active distillation operations.

d. The active process system vessel pressure, as measured at the vent pipe, shall be maintained at a positive pressure of at least 0.1 inches of water gauge with respect to ambient pressure. This will be accomplished with a demand regulator on the nitrogen supply systems.

1.5 SURVEILLANCE:

a. The oxygen concentration in the hexone storage tank cars, underground storage tanks, and process vessels shall be verified before initial startup.

b. The nitrogen purge flow rate shall be verified at least once every 4 h during active distillation operations.

c. The nitrogen level in the operating nitrogen dewar shall be verified at least once every 4 h during active distillation operations.

d. The vent pipe pressure shall be verified at least once every 4 h during active distillation operations.

1.6 RECOVERY: Immediate:

1. In the event the requirement is not met, the required condition shall be restored within 1 h, or distillation shall be suspended.

1.7 AUDIT POINT: The following records shall be kept for a minimum of 3 yr:

1. Initial pre-start purge verification.

2. Surveillance data sheets.

3. Event Fact Sheets, Critiques Reports, and Unusual Occurrence Reports.

1.8 BASES: Inert gas blanketing of the distillation system and tank car distillate receiver were identified in the Safety Assessment Document (SAD) as a means for preventing fires and explosion. The lower flammability limit (explosive limit) for hexone and/or NPH in air is 11% oxygen (Alter 1949; Jones 1949). A hexone-air mixture will not support combustion with a lower oxygen concentration. The 10 percent oxygen limit is below the explosive limit. The normal concentration of oxygen in air is 21%.

Rapid rises in ambient barometric pressure will result in air flow into a stagnant vessel system. Maintaining the pressure in the vent pipe above atmospheric pressure with a demand regulator on the nitrogen supply system will prevent air inflow into the vessel system.

8.0 REFERENCES

ACE, 1969, *Lower Columbia River Standard Project Flood and Probable Maximum Flood*, U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Alter, W. G., 1949, *Limits of Inflammability and Ignition Temperatures of Hexone in Air and in other Gaseous Atmospheres*, KAPL-250, General Electric Company Knolls Atomic Power Laboratory, Schenectady, New York.

ARHCO, 1976, *Preliminary Feasibility Study of Storage of Radioactive Wastes in Columbia River Basalts*, Vol. 1 and 2, ARH-SR-137, Atlantic Richfield Hanford Company, Richland, Washington.

Baker, V. R., 1973, *Paleohydrology and Sedimentology of Lake Missoula Flooding in Eastern Washington*, Special Paper 144, Geological Society of America, Boulder, Colorado.

Bendixsen, R. B., 1978, *Hexone Disposal*, RHO-CD-603, Rockwell Hanford Operations, Richland, Washington.

Berg, J. W. and C. D. Baker, 1963, "*Oregon Earthquakes, 1941 Through 1984*," Bulletin of the Seismological Society of America, 53.

Brown, D. J., 1959, *Subsurface Geology of the Hanford Separation Areas*, HW-61780, General Electric Hanford Company, Richland, Washington.

Brown, D. J., 1960, *An Eolian Deposit Beneath 200 West Area*, HW-67549, General Electric Hanford Company, Richland, Washington.

Census, 1981, *Washington State Advance Counts, Table I, Persons by Race and Spanish Origin and Housing Unit Counts*, U.S. Bureau of the Census, Washington, D.C.

Cline, C. S., et al., 1985, *Ground Water Monitoring of the Hanford Site for CY 1984*, PNL 5408, Battelle Pacific Northwest Laboratory, Richland, Washington.

Deere, D. C., 1989, "*Onsite and Offsite Doses for a Hexone Fire*," Memo to D. K. Oestreich, Westinghouse Hanford Operations, Richland, Washington.

DOE 1982a, *Draft Environmental Impact Statement-Operation of PUREX and Uranium Oxide Plant Facilities with 1983 Addendum*, DOE/EIS-0089D, U.S. Department of Energy, Washington, D.C.

DOE, 1982b, *Site Characterization Report for the Basalt Waste Isolation Project*, DOE/RL-82-3, U.S. Department of Energy, Washington, D.C.

DOE, 1984, *Draft Environmental Assessment, Reference Repository Location*, Hanford Site, Washington, DOE/RW-0017, U.S. Department of Energy, Washington, D.C.

DOE, 1987, "*General Design Criteria for Department of Energy Facilities*," DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1985, *Hanford Plant Standard-Standard Architectural/Civil Design Criteria 4.1, "Design Loads for Facilities," Rev 9*, U.S. Department of Energy, Richland, Washington.

Dukelow, G. T., 1980, *Status of Contingency Pump Out Plan for TK-141-S and TK-142-S*, Memo to J. H. Garbrick, Rockwell Hanford Operations, Richland, Washington.

Eddy, P. A., and J. S. Wilbur, 1980, *Radiological Status of Groundwater Beneath the Hanford Site*, PNL-3768, Battelle Pacific Northwest Laboratory, Richland, Washington.

Eichel, F. G., 1967, *Electrostatics*, Chemical Engineering, March 13, 1967, McGraw-Hill, New York, New York.

ERDA, 1975, *Final Environmental Statement Waste Management Operations, Hanford Reservation*, Richland, Washington, Vol. 1 and 2, ERDA-1538, U.S. Energy Research and Development Administration, Washington, D.C.

ERDA, 1976, *Evaluation of Impact of Potential Flooding Criteria on the Hanford Project*, ERDA-RLO-76-4, U.S. Energy Research and Development Administration, Richland, Washington.

Fecht, K. R., 1978, *Geology of Gable Mountain-Gable Butte Area*, RHO-BWI-LD-5, Rockwell Hanford Operations, Richland, Washington.

Fitzner, R. E. and W. A. Rickard, 1975, *Avifauna of Waste Ponds, ERDA Hanford Reservation*, Benton County, Washington, BNWL-1885, Battelle Pacific Northwest Laboratories, Richland, Washington.

Friedrichs, D. R., et al., 1977, *Hanford Pathline Calculational Program - Theory, Error Analysis, and Application*, ARH-ST-140, Atlantic Richfield Hanford Company, Richland, Washington.

Geoscience Research Consultants, 1978, *Geology of the Southwest Pasco Basin*, RHO-BWI-C-25, Geoscience Research Consultants, Moscow, Idaho.

Gephart, R. E., et al., 1979, *Hydrologic Studies Within the Columbia Plateau, Washington, An Integration of Current Knowledge*, RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington.

General Electric Hanford Company, 1949, *321 Explosion* #1, HW-42068 RD, General Electric Hanford Company, Richland, Washington.

General Electric Hanford Company, 1951, "*REDOX Technical Manual, HW-18700*" General Electric Hanford Company, Richland, Washington.

Goff, F. E., 1977, "*Stratigraphy and Tectonics of East Umtanum Ridge, South Central Washington*," EOS, Transactions of the American Geophysical Union, Vol. 58.

Graham, et al., 1981, *Hydrology of the Separations Area*, RHO-ST-42, Rockwell Hanford Operations, Richland, Washington.

Graham, et al., 1984, *Assessment of Aquifer Intercommunication in the B-Pond/Gable Mountain Pond Area, Hanford Site*, RHO-RE-ST-12-P, Rockwell Hanford Operations, Richland, Washington.

Hajek, B. F., 1966, *Soil Survey, Hanford Project in Benton County, Washington*, BNWL-243, Battelle Pacific Northwest Laboratories, Richland, Washington.

Harty, H., 1979, *The Effects of the Ben Franklin Dam of the Hanford Site*, PNL-2821, Battelle Pacific Northwest Laboratory, Richland, Washington.

Isaacson, R. E., 1982, *Plasma Arc Torch Incinerator*, Memo to G. A. Beitel, Rockwell Hanford Operations, Richland, Washington.

Jamison, J. D., 1982, *Standardized Input for Hanford Environmental Impact Statements, Part II: Site Description*, PNL 3509 Part 2, Battelle Pacific Northwest Laboratory, Richland, Washington.

Jones, G. W., R. E. Kennedy, and I. Spolan, 1949, *Effect of High-Pressures on the Flammability of Natural Gas-Air-Nitrogen Mixtures*, Bureau of Mines, Pittsburgh, Pennsylvania.

Jones, M. G. and R. D. Landon, 1978, *Geology of the Nine Canyon Map Area*, RHO-BWI-LD-6, Rockwell Hanford Operations, Richland, Washington.

Lang, 1949, *"Lang's Handbook of Chemistry,"* 7th edition, Sandusky, Ohio.

Law, A. G., et al., 1985, *Results of the Separations Area Ground-Water Monitoring Network for 1984*, RHO-RE-SR-85-24P, Rockwell Hanford Operations, Richland, Washington.

McCormack, W. D., et al., 1983, *A Comparison of Environmental Radiation Doses Estimated for Hanford Operations*, 1977 through 1982, PNL-4713, Battelle Pacific Northwest Laboratory, Richland, Washington.

McCormack, W. D., et al., 1984, *Hanford Dose Overview Program: Standardized Methods and Data for Hanford Environmental Dose Calculations*, PNL-3777, Rev 1, Battelle Pacific Northwest Laboratory, Richland, Washington.

McKee, E. H., et al., 1977, *"Duration and Volume of Columbia River Basalt Volcanism; Washington, Oregon, and Idaho,"* Geological Society of America, Abstracts with Programs, Vol. 9, No. 4, pp. 463-464.

McKee, E. H., et al., 1981, *"Age of Imnaha Basalt--Oldest Basalt Flows of the Columbia River Basalt Group, Northwestern United States,"* Isochron/West, Vol. 31, pp. 31-33, Richland, Washington.

Myers, C. W., et al., 1979, *Geological Studies of the Columbia Plateau--A Status Report*, RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Washington.

Myers, C. W., et al., 1981, *Subsurface Geology of the Cold Creek Syncline*, RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington.

Napier, B. A., 1981, *Standardized Input for Hanford Environmental Impact Statements, Part I*, PNL-3509, part I, Battelle Pacific Northwest Laboratory, Richland, Washington.

National Fire Protection Association, 1979, *National Fire Code*, (Volumes 2 and 3, Sections 30j and 385), NFPA, Boston, Massachusetts.

Noller, C. R., 1957, *"Chemistry of Organic Compounds,"* Chapter 40, W. B. Saunders Company, Philadelphia, Pennsylvania.

NRC, 1982, *Draft Environmental Statement Related to the Construction of Skagit/Hanford Nuclear Project Units 1 and 2*, Docket Numbers STN 50-522 and 50-523, Puget Sound Power and Light Company, Pacific Power and Light Company, The Washington Power Company, Portland General Electric; NUREG-0894, Nuclear Regulatory Commission, Washington, D.C.; and Washington State Energy Site Evaluation Council, Olympia, Washington.

Owczarski, P. C., 1978, *A Summary of Parameters Affecting the Release and Transportation of Radioactive Material from an Unplanned Incident*, Bechtel Corporation Report.

Prater, L. S., et al., 1984, *Ground Water Surveillance at the Hanford Site for CY 1983*, PNL-5041, Battelle Pacific Northwest Laboratory, Richland, Washington.

Price, K. R., et al., 1984, *Environmental Surveillance at Hanford for CY-1983*, PNL-5041, Battelle Pacific Northwest Laboratory, Richland, Washington.

Price, K. R., et al., 1985, *Environmental Monitoring at Hanford for 1984*, PNL-5407, Battelle Pacific Northwest Laboratory, Richland, Washington.

Prosser, R. D., 1986, *"Potential Hazards Associated with the Storage and Disposal of Hexone,"* Letter to J. D. White, U.S. Department of Energy, Richland, Washington.

Rasmussen, N. H., 1967, *"Washington State Earthquakes 1840 Through 1965,"* Bulletin of the Seismological Society of America, 57(3).

Rasmussen, O. R., 1988, *Hexone Remediation Demonstration Plan for Tanks 276-S-141 and 276-S-142*, WHC-SP-0350, Westinghouse Hanford Company, Richland, Washington.

Reidel, S. P., 1978, *Geology of the Saddle Mountains Between Sentinel Gap and 119° 30' Longitude*, RHO-BWI-LD-4, Rockwell Hanford Operations, Richland, Washington.

Rogers, L. E. and W. H. Rickard, 1977, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*, PNL-2253, Battelle Pacific Northwest Laboratory, Richland, Washington.

Rooney, M. L., 1989, *"Onsite and Offsite Doses for Acute Ground Level Release from 222-S,"* memo to D. K. Oestreich, Westinghouse Hanford Company, Richland, Washington.

Routson, R. C. and K. R. Fecht, 1979, *Soil (Sediment) Properties of Twelve Hanford Wells with Geologic Interpretation*, RHO-LD-82, Rockwell Hanford Operations, Richland, Washington.

Sax, N. I., 1975, *Dangerous Properties of Industrial Materials*, 4th Edition, Van Nostrand Reinhold Company, New York, New York.

Shaw, H. P., 1976, *"Status: Disposal of REDOX Organic Waste 9/9/76,"* Letter to O. J. Elgert, Atlantic Richfield Hanford Company, Richland, Washington.

Shaw, H. P., 1976, *"Status: Disposal of REDOX Organic Waste, 5/17/76,"* Letter to O. J. Elgert, Atlantic Richfield Hanford Company, Richland, Washington.

Sommer, D. J., et al., 1981, *Population Estimates for the Areas Within a 50-Mile Radius for Four Reference Points on the Hanford Site*, PNL-4010, Battelle Pacific Northwest Laboratory, Richland, Washington.

Stone, W. A., et al., 1983, *Climatological Summary for the Hanford Area*, PNL-4622, Battelle Pacific Northwest Laboratory, Richland, Washington.

Strachan, D. M., 1976, *Characterization of the Contents of Organic Waste Storage Tanks 276-S-141 and 276-S-142*, ARH-CD-685, Atlantic Richfield Hanford Company, Richland, Washington.

Sula, M. J. and P. J. Blumer, 1981, *Environmental Surveillance of Hanford for CY-1980*, PNL-3728, Battelle Pacific Northwest Laboratory, Richland, Washington.

Sula, M. J., et al., 1982, *Environmental Surveillance of Hanford for CY-1981*, PNL-4211, Battelle Pacific Northwest Laboratory, Richland, Washington.

Tallman, A. M., 1979, *Geology of the Separation Areas, Hanford Site*, South-Central Washington, RHO-ST-23, Rockwell Hanford Operations, Richland, Washington.

Trinity Consultants, Inc., 1987, *"Users Manual for SPILLS,"* Dallas, Texas.

U.S. Bureau of Mines, *Bulletin 3537*, U.S. Bureau of Mines, Pittsburgh, Pennsylvania.

U.S. Nuclear Regulatory Commission, 1975, *"Regulatory Guide 3.26-Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants."*

Washington State, 1984, *Washington Natural Heritage Data System, Washington Natural Heritage Program and Department of Game-Nongame Program*, Olympia, Washington.

Washington State Department of Ecology, 1988, *"Washington Administrative Code," Chapters 173-303, Olympia, Washington.*

Watkins, N. D. and A. K. Baksi, 1974, *Magnetostratiography and Oroclinal Folding of the Columbia River, Steens, and Owyhee Basalts in Oregon, Washington, and Idaho*, American Journal of Science, 274:148.

Weiss, R. L., 1989, *"Differential Thermal Analysis of REDOX Hexone Solvent Distillation Tars,"* memo to O. R. Rasmussen, Westinghouse Hanford Company, Richland, Washington.

Westinghouse Hanford Company, 1989, *Environmental Compliance Manual*, Westinghouse Hanford Company, Richland, Washington.

Westinghouse Hanford Company, 1989, *Radiological Design Manual*, WHC-CM-4-9, Westinghouse Hanford Company, Richland, Washington.

Westinghouse Hanford Company, 1988, *Nonreactor Facility Safety Analysis Manual*, WHC-CM-4-46, Westinghouse Hanford Company, Richland, Washington.

Weston Geophysical Research, 1977, *"Evaluation of Microearthquake Activity in Eastern Washington," Preliminary Safety Analysis Report, Amendment 23, Appendix 2RJF*, Weston Geophysical Research for Washington Public Power Supply System, Richland, Washington.

WPPSS, 1981, *WPPSS Nuclear Project No. 2 Final Safety Analysis Report, Vol. 1, Amendment 18*, Washington Public Power Supply System, Richland, Washington.

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