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Abstract

This document is a Safety Analysis Report (SAR) for the T Plant facility. This facility is used to decontaminate and repair or decommission radioactive equipment used in various Department of Energy facilities, primarily PUREX and B Plant at Hanford.

The impacts of natural phenomena and those of normal and accident conditions during the operation of T Plant have been reviewed and analyzed in this SAR. It is concluded that the operation can be conducted without undue risk to the environment or to the health and safety of employees in adjacent facilities and to the general public. It is further concluded that, the nature or extent of T Plant operations is increased, the acceptability of the risk to the occupants and workers at T Plant must be reevaluated.

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T PLANT SAFETY ANALYSIS REPORT

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1.0 INTRODUCTION

This Safety Analysis Report (SAR) for the T Plant Complex has been prepared by Rockwell Hanford Operations (Rockwell) in compliance with U.S. Department of Energy (DOE) Order 5481.1A, Safety Analysis and Review System.(1) The specific content and format of this SAR are in accordance with RHO-HS-MA-1, Safety Analysis and Report Preparation Guide.(2)

1.1 PLANT DESIGN AND FUNCTION

The T Plant Complex was constructed in the mid 1940's to extract plutonium and uranium from spent reactor fuel using the Bismuth Phosphate ($BiPO_4$) Process. The T Plant continued to perform this function until it was deactivated in 1956. Most of the original process equipment has subsequently been removed. In 1957, T Plant was placed in service as a beta-gamma decontamination facility and as a support complex for experiments or other operations requiring containment or isolation. It has continued to perform these functions until now, although at present it functions primarily as a decontamination facility. The T Plant Complex is composed of the buildings listed in Table 1-1.

TABLE 1-1. T Plant Complex Facilities.

Facility	Function
211-T	T Plant chemical storage area
221-T	Equipment decontamination facility
221-TA	Fan house
222-T	Offices
224-T	Plutonium storage (no longer used)
2706-T	Equipment decontamination
271-T	Shop and offices
2715-T	Paint storage
2716-T	Storage
277-T	Shop and storage building
291-T	Sand filter and stack
292-T	FP[a] release laboratory
M104-371	Women's SWP[b] change trailer

[a]Fission product.
[b]Special work permit.

1.2 ANALYSIS SCOPE

Two facilities within the complex are the subjects of earlier safety analyses and will not be discussed further: the plutonium storage facility, building 224-T, and the containment systems test facility (CSTF), located in the headend of building 221-T and in building 277-T.[3,4] The FP release laboratory, building 292-T, was operated by Pacific Northwest Laboratory (PNL) and is now inactive. This laboratory and office building 222-T have been excluded from the T Plant SAR. Thus, the scope of this SAR includes buildings 211-T, 221-T, 221-TA, 2706-T, 271-T, 2715-T, 2716-T, and 291-T and trailer 104-371.

Two operations conducted in building 221-T have already received extensive safety analyses: storage of pressurized water reactor (PWR) spent fuel and transloading of ion-exchange resin cask liners from the Three Mile Island (TMI) shipping casks into burial containers.[5-8] Further discussion of these operations is outside the scope of the T Plant SAR.

1.3 PROCESS DESCRIPTION

The T Plant Complex fulfills its mission as a decontamination and repair facility primarily through the use of chemical decontamination performed by either immersion or spray application. In addition to chemical decontamination, abrasive methods such as sandblasting are occasionally used. Operating personnel perform the work in direct contact with the contaminated item, but wear appropriate protective clothing at all times. This clothing usually includes two pairs of SWP protective clothing and a full-face respirator.

1.4 APPLICABILITY

This document reports the safety analysis of the T Plant Complex, which primarily consists of decontamination and repair operations in buildings 2706-T and 221-T. This report addresses the T Plant Complex as it now exists and does not take into account any planned facility upgrades or modifications. Any significant future changes to the T Plant Complex configuration or process will require additional analysis. Such changes will be documented in revisions or appendixes to this SAR.

1.5 REFERENCES

1. DOE, Safety Analysis and Review System, DOE Order 5481.1A, U.S. Department of Energy, Washington, D.C. (August 13, 1981).

2. G. M. Christensen and R. Jacobs, Safety Analysis and Report Preparation Guide, RHO-HS-MA-1 REV 1, Rockwell Hanford Operations, Richland, Washington (January 1984).

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4. R. A. Yoder, J. R. LaRiviere, and G. L. Jones, 224-T Building Safety Analysis Report, SD-HS-SAR-003 REV 2, Rockwell Hanford Operations, Richland, Washington (August 5, 1983).

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7. G. M. Christensen, Three Mile Island Submerged Demineralizer System Liners Transloading and Burial Safety Analysis Report, RHO-CD-1554, Addendum 1, REV 1, Rockwell Hanford Operations, Richland, Washington (March 1983).

8. R. A. Van Meter, Safety Analysis Report for Packaging TMI SDS Liner/Overpack (HCS-068-001-00), SD-RE-SAP-12, Rockwell Hanford Operations, Richland, Washington (October 1982).

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2.0 SUMMARY SAFETY ANALYSIS

The risk of continued operation of the T Plant Complex has been analyzed and evaluated. A baseline risk has been established that will serve as a reference point for analysis of future T Plant Complex activities. The safety analysis did not discover any hazard at the T Plant Complex that could produce significant radiological or nonradiological consequences to offsite individuals or onsite personnel as defined in RHO-HS-MA-1.(1) The analysis did, however, show significant operational and accident risk to onsite personnel, specifically the occupants and operating cadre at the T Plant.

2.1 RISK OF POTENTIAL ACCIDENTS OR ABNORMAL EVENTS

The T Plant preliminary hazards analysis (Chapter 9.0) identified several hazards that may produce significant onsite consequences in the event of an accident. These hazards were examined in detail to estimate the risk each one represents.

2.1.1 Potential Accident Scenarios

2.1.1.1 Chemical Distribution System Rupture. The possibility of a rupture in the caustic permanganate ($NaOH/KMnO_4$) piping system outside of the building 221-T canyon was analyzed. The analysis showed a maximum accident risk of 0.09 per year for an accident that would cause permanent blindness to one worker.

2.1.1.2 Toxic Fumes in the Building 221-T Canyon. The accidental transfer inside the canyon of nitric acid (HNO_3) into a tank containing $NaOH/KMnO_4$ was considered. Analysis showed that the risk from this accident was not significant enough to warrant additional precautions at the facility.

2.1.1.3 Release of Contaminated Liquid to the Environment. An accident was analyzed that involved a major spill outside of the T Plant Complex while liquid radioactive waste was being transferred to the tank farm. Based on previous analyses, it was concluded that the accident risk from this scenario was insignificant.(2)

2.1.1.4 Nuclear Excursion in the Building 221-T Canyon. The effect of a design basis criticality in the T Plant Complex liquid waste system was analyzed. This accident would give personnel inside the canyon a dose of approximately 54 rem over several hours, assuming the ventilation system operated properly. The dose to other onsite personnel and to offsite individuals was also calculated and is shown in Table 2-1.

TABLE 2-1. Nuclear Excursion at the T Plant Complex (rem Dose Commitment).

Location	Time	Body	Bone	Lung	Thyroid
Maximum offsite	1 yr/50 yr*	8.4 E-04	1.2 E-03	1.2 E-03	9.8 E-03
Maximum onsite (730 m)	1 yr/50 yr	1.6 E-01	1.6 E-01	2.0 E-01	5.3 E-01

*Annual dose equivalent is essentially equal to a 50-yr dose equivalent.

2.1.1.5 Industrial Accident in the Building 221-T Canyon. The probability and possible consequences of an accident involving the overhead crane dropping an object into a tank of $NaOH/KMnO_4$ was examined. The recurrence interval for a dropped crane load somewhere in the canyon was calculated to be approximately 10 yr, but the recurrence interval for dropping an object into a tank was only once in every 50 yr. The consequences of the postulated accident would be temporary partial disability and some lost work days for the affected operators. The low probability of occurrence and the moderate consequences resulted in a low risk from this accident.

2.1.1.6 Fires. The consequences of maximum credible fires in various T Plant Complex buildings were examined. The results are shown in Table 2-2. The radiological consequences of fires at T Plant are insignificant because of the small amount and nondispersible (in solution stored in tanks or surface contamination on noncombustible objects) form of the radioactive material present.

TABLE 2-2. Fires at the T Plant Complex.

Location	Maximum dollar loss	Maximum programmatic loss
Building 271-T	1,000,000	1 yr
Building 221-T		
Canyon	100,000	1 wk
Galleries	100,000	4 mo
Building 2706-T	Negligible	Minor

2.1.2 Natural Disaster Scenario

A Hanford Region Historic Earthquake (HRHE), a Safe Shutdown Earthquake (SSE), or a Design Basis Tornado (DBT) would cause substantial damage to the T Plant Complex; however, because of the nature and small amounts of hazardous or radioactive material at T Plant, the radiological consequences of natural disasters would be small.

2.2 RISK OF NORMAL OPERATIONS

Operations at the T Plant involve a certain amount of residual risks. These risks are inherent to the nature of the facility and combine to form the baseline operational risk for the T Plant.

2.2.1 Airborne Radioactivity in Building 271-T

The decontamination operations conducted in building 2706-T may affect radioactive airborne contamination levels in the building 271-T ventilation supply system. The resulting dose to workers in building 271-T is shown in Table 2-3. Because of the small dose commitment, this operational risk, on a per event basis, is insignificant.

TABLE 2-3. Operational Dose to Building 271-T Occupants (mrem per event).

Source	Time	Body	Bone	Lung
MFP*	1 yr	7.0 E-02	1.0 E+00	7.0 E-02
	50 yr	8.2 E-01	1.21 E+01	6.7 E-01

*Mixed fission products.

2.2.2 Toxic Fumes in the Building 221-T Canyon

The operational risk of mixing incompatible chemicals during the course of normal decontamination was examined and found to be small.

2.2.3 Exposure to High Radiation in the Building 221-T Canyon

An actuarial risk assessment was performed using the T Plant operators' radiation exposure data. This risk assessment showed an annual average operating risk of 300 mrem per person. The analysis also predicted that a single worker will receive a maximum monthly exposure of 500 mrem approximately once a year.

2.2.4 High Airborne Radioactivity in the Building 221-T Canyon

The possibility of operator exposure in the canyon to undetected airborne contamination in excess of levels permitted for respirator use was examined. The possible dose commitments to an individual worker were analyzed and found to be at least 100 mrem to the lungs for work on equipment contaminated with plutonium or 1,600 mrem to the bone for work on equipment contaminated with MFP.

2.3 CONCLUSIONS

In addition to the radiological hazards, there is sufficient energy at the T Plant Complex in the form of electricity, energy from falls, and very high pressure water to cause severe injury or death if not properly controlled. Such accidents have not occurred primarily because of the operating cadre's individual initiative and safety consciousness.

Other contributing factors include the following items.

1. Operators are not rotated and remain at T Plant long enough to gain experience and acquire adequate on-the-job training.

2. The same equipment, chemicals, procedures, etc., are used for nearly all jobs done at T Plant, thus generating a good deal of familiarity.

3. All special jobs (i.e., new or unusual decontamination techniques or chemicals) must be approved by the Process Engineering Department and accompanied by special procedures and training.

In view of the operational and accident risk to the occupants and operating cadre, the T Plant Complex should be classified as a "moderate" hazard facility. However, according to the requirements of RHO-HS-MA-1[1] for facility hazard classification, the T Plant is classified as a "low" hazard facility. That is, the worst credible accidents at T Plant would have only minor onsite (except inside the T Plant) and negligible offsite impacts to individuals or the environment.

It is the conclusion of this safety analysis that if the nature of the operations conducted at T Plant (as described in Chapters 5.0 and 6.0) changes, or if the extent of T Plant activity increases beyond the baseline year for this analysis (1983), the acceptability of the risk to the occupants and operating cadre at T Plant must be reevaluated.

2.4 REFERENCES

1. G. M. Christensen and R. Jacobs, Safety Analysis and Report Preparation Guide, RHO-HS-MA-1 REV 1, Rockwell Hanford Operations, Richland, Washington (January 1984).

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

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3.0 SITE CHARACTERISTICS

This chapter presents a brief description of the Hanford Site environmental characteristics that might affect or be affected by T Plant Complex. Detailed environmental information about the Hanford Site is available in ERDA-1538, DOE/EIS-0089, PNL 3509 PT 2, and the Plutonium-Uranium Reduction Extraction Final Safety Analysis Report (PUREX FSAR).[1-4]

3.1 GEOGRAPHY

3.1.1 Location

The T Plant Complex is located inside the fenced 200 West Area, near the center of the approximately 570-mi^2, federally owned Hanford Site located in the State of Washington (Fig. 3-1). The location of the T Plant Complex within the 200 West Area is shown in Figure 3-2.

3.1.2 Population Distribution

The 1970 population living outside of the controlled Hanford Site and within a 50-mi radius of the Hanford Meteorological Station (HMS) was 246,000.[1] This population expanded to 342,000 in 1980 and is projected to grow to a population of 417,000 by 1990.[5] (The HMS is used as the population reference point for the Hanford Site because of the availability of data and its central location.) Population estimates were made through the year 1990 based upon 1980 census information, current birthrate trends, and estimates of net migration into or out of the area as economic and employment opportunities change over the forecast period.[5]

Access to the Hanford Site is controlled for national security reasons and health and safety considerations. It is assumed that the Hanford Site, specifically the 200 West Area, will remain under institutional control of the DOE for a minimum of 300 yr and that no persons will reside within the Hanford Site boundary during that time.

3.1.3 Uses of Nearby Land and Waters

Major industrial facilities in the region include a meat-packing plant, food-processing facilities, fertilizer plants, a pulp and paper mill, a chemical plant, and small manufacturing firms. Agriculture also plays a major role in the regional economy. Three regional power dams are located on the Columbia River near the Hanford Site, and a fourth dam, on the site, has been proposed; however, construction is considered unlikely at this time. The site has several major operating government facilities including N Reactor, the PUREX Plant, the Fast Flux Test Facility (FFTF), waste management facilities, nuclear materials storage, and research laboratories.

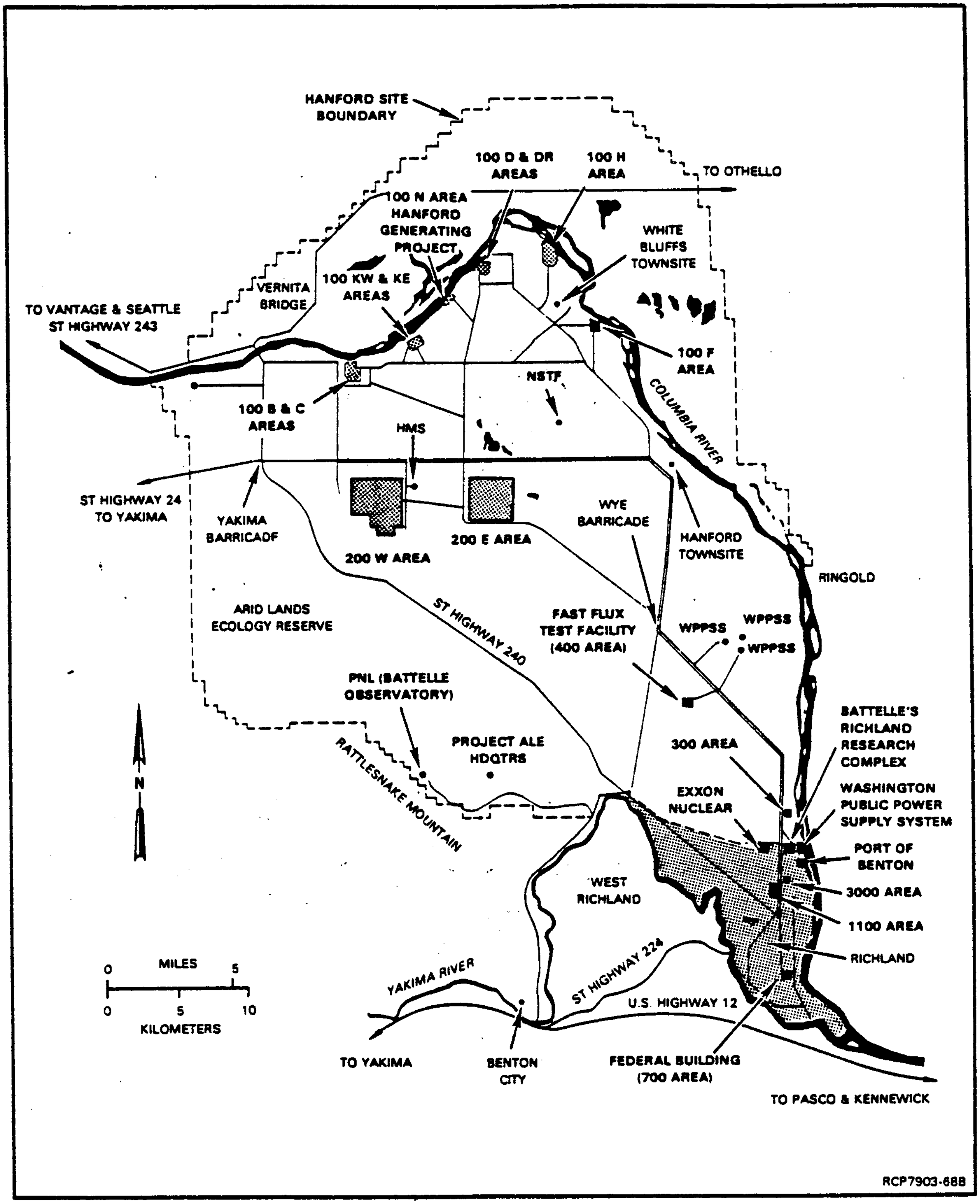

FIGURE 3-1. Hanford Site.

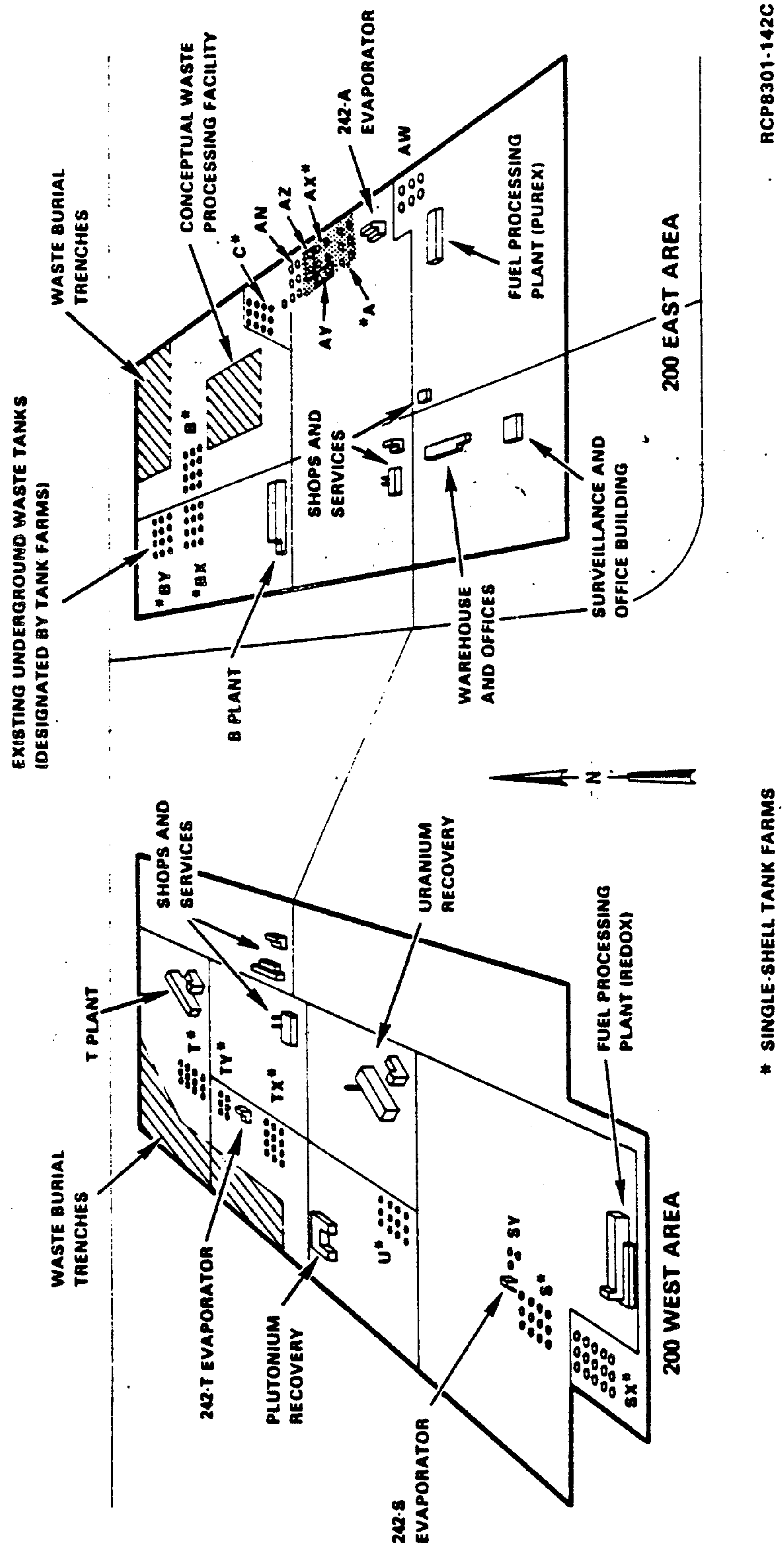

FIGURE 3-2. 200 East and West Areas.

Hanford Site commercial activities include a commercial nuclear power station (construction on two other nuclear power stations has been discontinued) and a low-level waste burial operation. The Exxon Nuclear Corporation fuel fabrication plant is located just south of and adjacent to the site boundary.

Radioactive releases as a result of the postulated maximum credible accident for each facility will not present an unacceptable risk to the T Plant operations. The distance of these facilities from the T Plant provides adequate assurance that no significant hazard to the T Plant or its personnel could result from activities outside of the 200 Areas.

The nearest military facility is the U.S. Army Yakima Firing Range, located just northwest of the Hanford Site's western boundary.

Public transportation facilities nearest to the 200 Areas are State Highways 24 and 240 (see Fig. 3-1). State Highway 240, for general public use, passes within 5 mi of the 200 East and West Areas. A four-strand, barb-wire fence separates the highway right-of-way and the site. These highways are used by many types of vehicles including commercial trucks for deliveries of gas, diesel fuel, and chemicals as well as commercial and DOE radioactive materials. However, the separation of the roads from the Hanford Site operations is such that no adverse effects from highway accidents are expected at the T Plant.

There are no private or commercial airports within a distance of 15 mi of the Hanford Site. The Richland Airport, nearest to the site, is a small, general utility airport and is located approximately 20 mi away, and the Tri-Cities Airport at Pasco, used by local carriers, is 28 mi from the Site. Due to the low volume of air traffic and distance of airports from the Site, the probability of aircraft affecting T Plant is remote.

There are no refineries, major oil storage facilities, or large munition or explosive storage facilities within 20 mi of the Site. The nearest natural gas transmission pipeline is approximately 30 mi away. The considerable distance of these facilities eliminates any potential hazard to the T Plant from fires and explosions in other facilities.

3.2 GEOLOGY

The Hanford Site lies in a portion of the geologic formation known as the Columbia Plateau Physiographic Province. It is part of a smaller subdivision called the Pasco Basin that is composed of large quantities of basalt interspersed with layers of sedimentary material. These sedimentary layers are water bearing and collectively constitute a vertically stratified series of confined aquifers beneath the Hanford Site. Above the uppermost layer of basalt lies the unconsolidated sand and gravel of the Ringold Formation, ranging up to 1,000 ft in depth. Above this, and extending to the surface, is the Hanford Formation, covered by a thin layer of windblown silts and sands.

3.3 HYDROLOGY

3.3.1 Surface Water

The Columbia River is the dominating feature of the Hanford Site hydrology, and flows through the northern part of the Site and along the eastern boundary. Additional surface waters consist of various ditches and ponds in and near the 200 Areas and three ponds located in the 300 Area. Two ephemeral streams just west of the Hanford Site, Cold and Dry Creeks, may flow for a short period after a heavy rainfall or snowmelt. The Yakima River borders part of the Hanford Site southern boundary. Under maximum flood conditions, the 200 Areas are 200 to 250 ft above the highest probable water level. The groundwater ranges from 150 to 300 ft below the surface and slopes toward the river. This groundwater aquifer occurs in the Hanford and Ringold Formations. Groundwater also exists in the interflow zones between layers of basalt flows. Additional hydrological information is available in ERDA-1538.[1]

The surface hydrology of the Hanford Site has been extensively studied.[1,6] These studies include an analysis of the Columbia and Yakima Rivers, as well as extensive investigations of man-made ditches and ponds used for the disposal of low-level radioactive liquid waste, certain industrial waste, and cooling waters from various processes.[1]

3.3.2 Floods

The climate at the Hanford Site is arid to semiarid with an average annual rainfall of 6.25 in. The projected maximum annual rainfall that might occur in the next 1,000 yr is about 18 in. (a threefold increase in the recorded average annual precipitation).[1]

A calculation of the effect of a Columbia River flood that might occur in the next 1,000 yr on operations has been performed and reported.[1] The flooding condition used in the analysis is the dam-regulated "probable maximum flood" (PMF) previously predicted by the U.S. Army Corps of Engineers.[1] This projection was derived using extensive data and computer modeling techniques and incorporating assumptions for a combination of conditions that are the most severe and are considered "reasonably possible" for the Columbia River Basin. Contributing factors of winter snow accumulation, spring melting, and runoff-season rainstorms were maximized. However, the calculation shows that, even under these circumstances, there would be no affect on the T Plant and other operations in the 200 Areas from a PMF.

3.3.3 Hydrogeology

The sediments beneath the site consist of a thin mantle of windblown silts and sands covering layers of sand and gravels that are up to 200 ft thick. Older sands, silts, and gravels lie beneath the glacial Lake Missoula flood deposits. These sedimentary deposits have the capacity to sorb and retain most radioactive contaminants from the liquid waste streams and from accidental spills or leaks from waste tanks.

Because of the mild, dry climate, the influence of precipitation and evapotranspiration on the sediment moisture content is most pronounced in the first 6 to 7 ft from the surface, but with measurable changes occurring as deep as 40 ft.(7) Although the sorption capacity of the sediments is low, the total sorption capacity of the sediment column between waste release point and the water table is high because of the long length of the column (up to about 320 ft). The high column sorption capacity and low precipitation provide excellent conditions for maximum sorption of radionuclides released to the sediments. This prevents most of the radionuclides (except neutral and negatively charged species) released to the sediments from reaching the water table.(1)

On the Hanford Site, the thickness of the unsaturated zone varies from 0 to 350 ft.(8) The movement of water in the unsaturated zone is influenced by the physical properties of the sediments in two ways: the size and structural arrangement of the sediment particles determine the space configuration through which the water moves, and the interaction between the sediments and the water gives rise to water-moving force. In sediments where pores are completely filled with water, the fluid is a single phase. Where water does not completely fill the pores, the hydraulic potential depends on the gravitational field and on the absorptive forces associated with interfacial boundaries in the sediments. Where air partially fills the soil pores, with water occupying the remaining void space, a two-phase flow can take place. As the percentage of liquid water decreases, it occupies the smallest capillaries that exist between soil particles.

During the year August 1, 1973 through July 31, 1974, Hanford experienced 170% of normal rainfall. At a field test site located south of the 200 East Area, where rainfall moisture penetration is measured routinely, this rainfall penetrated about 8 ft into the sediments. All of the moisture from rainfall during this period evaporated to the atmosphere. Data indicates that the loss of moisture by evaporation is greater than that gained through precipitation, forming a desiccated zone at the near-surface during the summer months.(9) The Hanford sediments from a depth of about 30 ft to the top of the water table are essentially dry.

3.4 SEISMICITY

Hanford Site facilities are exposed to the possibility of moderate earthquake damage (Zone 2) both from active seismic zones of western Washington and closer shocks originating in the seismic zone that includes Walla Walla.

3.4.1 Safe Shutdown Earthquake

The SSE now in use for designing nuclear facilities on the Hanford Site would produce a peak horizontal free-field acceleration of 0.25 g. The SSE was originally established for the FFTF in 1970 and is in compliance with DOE criteria.(10,11) The probability of an SSE occurring at the Hanford Site is 1.2×10^{-4} a year.(12)

The SSE earthquake of 0.25 g of horizontal ground acceleration for the Hanford Site allows for an earthquake of an intensity MM VIII on the Modified Mercalli scale epicentered at the same site. This is considered conservative, since no earthquake of this magnitude has been recorded in eastern Washington or Oregon.(1) The largest recorded earthquakes were one of Richter magnitude 5.7 at Milton-Freewater, Oregon, July 15, 1936, and one of Richter magnitude 4.0, located south of College Place, Washington, April 7, 1979.(1)

A December 14, 1872 earthquake in the North Cascades is estimated to have resulted in an intensity of MM VI. The resulting ground acceleration at the Hanford Site was approximately 0.05 g. All other events attenuated to intensities of MM IV or less. In 1976, a panel of experts concluded that this earthquake was of Richter magnitude 7.0. Because this earthquake occurred in a distinct tectonic province separate from the Columbia Plateau, it is considered unlikely that an event of the magnitude of the 1872 earthquake could take place in the Columbia Plateau.

The largest local earthquake of historical record occurred at Corfu, a few miles north of the Hanford Site, in 1918. Various damage estimates have been reported resulting in a classification of MM IV or V. Estimates of the peak ground acceleration made for the Corfu event range from 0.01 to 0.03 g.

3.4.2 Hanford Regional Historical Earthquake

The largest historical earthquake known to have occurred within the Columbia Plateau and the resulting free-field motion expected at the Hanford Site should an earthquake of the same size occur again has been identified. This earthquake is based on a postulated extension of the Rattlesnake-Wallula structure, whose surface trace passes within 10 mi of the 200 Areas.(11) This event has been designated as the HRHE. The expected HRHE peak horizontal ground acceleration at T Plant is 0.1 g. This is estimated to occur with a probability of 0.7×10^{-3}/yr.(12)

3.5 METEOROLOGY

A peak gust wind (straight) of 80 mi/h was measured on January 11, 1972, at the 50-ft level of the HMS tower. Tornadoes, however, are rare in this region and tend to be small, causing only minor damage.[1] On June 16, 1948, a tornado was observed near the east end of Rattlesnake Mountain, approximately 10 mi south of Hanford's waste management facilities; no damage resulted. The formation of a severe tornado of the Midwest type is highly unlikely under the climatologic and orographic conditions of the Pacific Northwest. There have been only two tornado funnel clouds and one small tornado (June 16, 1948) observed on the Hanford Site in the 34-yr period 1945 through 1978. Although one of these touched ground, it caused no damage. The nearest reported tornado damage was in Yakima (April 30, 1957), about 45 mi to the west, and at Wallula Junction (June 26, 1958), about 50 mi to the southeast.[1] Only minor damage was noted.

The climate in the vicinity of the Hanford Site has been recorded since 1912 and is characterized as mild and dry with occasional periods of high wind.[1] Water erosion associated with facilities located on the 200 Areas plateau is minor because of the minimal precipitation, high soil porosity, and lack of sufficient relief to initiate runoff.

The maximum 24-h precipitation that can be expected at least once in one thousand years is 11 in. (The maximum amount of precipitation ever recorded in a 12-h period was 1.9 in.)[1] Even this amount of rainfall would not cause appreciable flood damage to facilities on the Hanford Site.[1] Neither the maximum expected rainfall over the next 1,000 yr or the effect of the 100-yr probable flood of the Columbia River would pose any additional hazard to the 200 Area operations.[1]

The Cascade Range serves as a source of cool air, especially during the summer months, and has a considerable effect on the Hanford Site wind regime. The drainage (gravity) wind, plus topographic channeling, causes a considerable diurnal range of speeds during the summer. In July, average speeds range from a low of 5.2 mi/h, from 0900 to 1000 h, to a high of 13.0 mi/h from, 2100 to 2200 h. In contrast, the corresponding speeds for January are 5.5 and 6.3 mi/h.

While gravity winds occur with regularity in the summer, these are seldom strong unless reinforced by frontal activity. In June, the month of highest average speed, there are fewer instances of hourly averages exceeding 31 mi/h than in December, the month of lowest average speed. It is also notable that, although channeling results in a prevailing west-northwest or northwest wind the year around, the greatest wind speeds are from the southwesterly direction.

Light winds at Hanford in winter cause considerable atmospheric stagnation. December, for example, has an average of 10 d with a peak gust under 13 mi/h. By contrast, only once in 7 yr does June have even one such day.

The average maximum temperatures in January and July are 37°F and 92°F, respectively. The average minimum temperatures for the same months are 22°F and 61°F, respectively. The average monthly relative humidity varies from a low of 31.8% in July to a high of 80.4% in December. The minimum diurnal temperature in winter seasons ranges from -27°F to 22°F; the maximum diurnal temperatures in summer seasons vary from 100°F to 115°F.

Meteorological data for the Hanford Site is summarized in Figure 3-3.

The principal source of climatologic data for the Hanford Site is the HMS. Elevation of the station is 733 ft above mean sea level. This meteorological station has been collecting data since 1944. Meteorological and climatological services available from the HMS include the following list.

- Emergency response capability to provide information in the event of an accidental release of radioactive material and production of computer printouts of trajectories and concentrations over the Hanford Site. This service is available 24 h/d, 365 d/yr.
- Severe weather advisories to provide safe and efficient operation of the Hanford plants. These advisories consist primarily of winds in excess of 35 mi/h and thunderstorms; however, occasional warnings are required for drifting snow and freezing rain.
- General weather forecasts are prepared and recorded at 0700 and 1500 h each day. The forecasts are tailored to the requirements of DOE and Hanford contractors for general work scheduling.
- Climatologic data and analyses for the Hanford Site are provided to assess energy demands for preliminary site assessments and for the design and construction of facilities in which environmental control is essential.

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	TEMPERATURE (°F)														
	1912-1975 AVERAGES							1912-1975 EXTREMES							
								DAILY MAXIMUM				DAILY MINIMUM			
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR
JAN	37.0	22.2	29.6	42.5	1953	12.1	1950	72	1971	-2	1950	53	1971	-23	1934
FEB	45.4	27.6	36.4	44.5	1958	21.4	1929	71	1924	-3	1950	55	1932	-23	1950
MAR	56.5	33.7	45.1	49.9	1926	39.4	1955	83	1960	24	1960	54	1942	6	1955
APR	66.1	39.9	53.1	59.6	1934	47.5	1955	95	1934	41	1945	60	1956	12	1935
MAY	75.6	48.0	61.9	68.8	1947	56.6	1933	103	1936 -	49	1918	70	1956	28	1954
JUNE	83.2	55.4	69.4	75.4	1922	63.0	1953	110	1912	55	1966	81	1924	33	1933
JULY	91.9	61.1	76.5	81.8	1960	72.4	1963	115	1939	59	1966	82	1925	41	1935
AUG	89.4	59.3	74.3	81.5	1967	69.8	1964	113	1961	63	1920	81	1961	40	1918
SEPT	79.6	50.7	65.2	71.7	1967	58.8	1926	102	1950	52	1934 -	72	1955	25	1926
OCT	65.3	40.7	53.0	59.0	1952	48.8	1930	90	1933	31	1935	60	1945 -	6	1935
NOV	48.6	31.5	40.0	46.0	1954 -	31.3	1955	75	1975	14	1955	52	1959 -	-1	1955
DEC	39.3	26.0	32.7	42.0	1933	18.5	1919	68	1933	-3	1919	56	1975	-27	1919
					JULY		JAN		JULY		FEB		JULY		DEC
YEAR	64.9	41.3	53.1	81.9	1960	12.1	1950	115	1939	-3	1950 -	82	1925	-27	1919

	DEGREE DAYS (BASE 65°F)										PRECIPITATION (INCHES)															
	HEATING 1974-1975 TOTALS					COOLING 1960-1975 TOTALS					1912-1975 TOTALS															
																		SNOW, ICE PELLETS (SLEET)								
	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MAXIMUM IN 24 hr	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MAXIMUM IN 24 hr	YEAR	MAXIMUM DEPTH	YEAR		
JAN	1085	1640	1950	694	1953	0	0	---	0	---	0.92	2.47	1970	0.13	1962 +	1.08	1948	5.1	23.4	1950	7.1	1954	12.0	1969		
FEB	778	1147	1956	576	1958	0	0	---	0	---	0.60	3.08	1940	T	1967 -	1.24	1916	2.4	26.0	1916	5.6	1975	10.0	1969		
MAR	641	794	1955	476	1947	0	0	---	0	---	0.37	1.86	1957	0	1942 +	0.59	1949	0.3	4.2	1951	2.2	1957 -	2.3	1957		
APR	396	522	1955	266	1947	1	5	1968 +	0	1975 -	0.38	1.22	1969	0	1933 +	0.53	1951	T	T	1975 +	T	1975 +	0	---		
MAY	154	255	1962	36	1947	49	99	1971	3	1962	0.47	2.03	1972	0	1931	1.39	1972	T	T	1960	T	1960	0	---		
JUNE	34	90	1953	3	1958	192	310	1969	53	1971	0.56	2.92	1950	0	1919	1.50	1934	0	0	---	0	---	0	---		
JULY	3	22	1955	0	1975 +	404	518	1960	232	1963	0.15	0.31	1966	0	1939 -	0.73	1914	0	0	---	0	---	0	---		
AUG	5	32	1960	0	1974 +	338	508	1967	171	1964	0.20	1.18	1920	0	1955 +	0.69	1975	0	0	---	0	---	0	---		
SEPT	71	179	1972	13	1967	107	216	1967	27	1970	0.30	1.34	1947	T	1961 -	0.32	1947	0	0	---	0	---	0	---		
OCT	377	479	1946	200	1952	2	10	1971	0	1975 -	0.58	2.72	1957	0	1917 -	1.91	1957	#	1.5	1973	1.5	1973	1.5	1973		
NOV	747	1008	1955	567	1954	0	0	---	0	---	0.86	3.05	1926	T	1939 -	0.78	1966	1.3	12.7	1955	4.8	1955	5.1	1946		
DEC	990	1224	1964	822	1957	0	0	---	0	---	0.89	2.53	1931	0.11	1946	1.00	1958	3.9	19.1	964	5.4	1965	12.1	1964		
			JAN		JULY			JULY		OCT			FEB		AUG		OCT			FEB		JAN		DEC		
YEAR	5271	1640	1950	0	1975 -	1093	518	1960	0	1975 -	6.28	3.08	1940	0	1955 +	1.91	1957	13.0	26.0	1916	7.1	1954	12.1	1964		

	WIND (mi/hr)									RELATIVE HUMIDITY (%)									
	1946-1975 AVERAGES						PEAK GUSTS			1946-1975 AVERAGES					1946-1975 EXTREMES				
	PREVAILING DIRECTION	MEAN MONTHLY SPEED	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	SPEED	DIRECTION	YEAR	MEAN	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST	YEAR	LOWEST	YEAR	
JAN	NW	6.6	10.3	1972	3.1	1955	80	SW	1972	75.2	88.8	1960	60.0	1963	100	1975 +	13	1963	
FEB	NW	7.1	9.4	1961	4.6	1963	65	SW +	1971	70.0	86.9	1963	54.0	1967	100	1975 +	14	1962	
MAR	WNW	8.4	10.7	1964	5.9	1958	70	SW	1956	55.8	65.9	1950	44.0	1965	100	1974 +	12	1965 -	
APR	WNW	9.1	11.1	1972 -	7.4	1958	73	SSW	1972	46.5	64.5	1963	36.9	1966	100	1973 +	9	1954	
MAY	WNW	8.9	10.5	1965 -	5.8	1957	71	SSW	1948	42.3	61.9	1948	31.2	1966	100	1975 +	7	1953	
JUNE	WNW	9.2	10.7	1949	7.7	1950 -	72	SW	1957	39.5	53.5	1950	30.0	1949	100	1972 -	10	1964 -	
JULY	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1968	31.8	40.5	1955	21.9	1959	99	1972	6	1961	
AUG	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961	34.8	43.8	1968	24.5	1967	100	1972 -	7	1951	
SEPT	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953	40.6	55.1	1959	33.2	1974	100	1962 -	10	1962 -	
OCT	WNW	6.7	9.1	1946	4.4	1952	63	SSW	1950	57.0	74.2	1962	42.5	1952	100	1975 -	10	1962 +	
NOV	NW	6.1	7.9	1945	2.9	1956	54	SSW	1949	73.5	88.1	1972	64.2	1963 -	100	1975 -	16	1959	
DEC	NW	6.1	8.3	1968	3.9	1963 -	71	SW	1955	80.1	90.5	1950	69.0	1968	100	1975 -	26	1972	
				APR		NOV			JAN			DEC		JULY		DEC		JULY	
YEAR	WNW	7.7	11.1	1972 -	2.9	1956	80	SW	1972	53.9	90.5	1950	21.9	1959	100	1975 -	6	1951	

	SKY COVER SCALE (0-10)					SOLAR RADIATION (LANGLEYS)*								
	1946-1975 AVERAGES (SUNRISE TO SUNSET)					1953-1975 AVERAGE DAILY TOTALS					1953-1975 EXTREME DAILY TOTALS			
	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR
JAN	7.8	9.0	1969	4.3	1949	1[illegible]0	136	1973	88	1955	277	1969	16	1971 +
FEB	7.4	8.9	1961	5.9	1964	202	238	1960	164	1954	422	1958	37	1970 +
MAR	6.8	7.9	1950	4.9	1965	3[illegible]0	388	1965	305	1961	542	1968	47	1972
APR	6.4	8.1	1963	3.7	1951	4[illegible]5	535	1973	374	1963	704	1972	75	1974
MAY	5.8	7.7	1960	4.5	1949	5[illegible]6	634	1970	511	1962	782	1959	67	1962
JUNE	5.3	7.0	1950	2.8	1961	6[illegible]8	698	1960	563	1953	821	1971	112	1965
JULY	2.8	4.5	1974 +	0.9	1953	6[illegible]9	714	1973	588	1955	808	1974	118	1972
AUG	3.2	5.9	1968	0.6	1955	5[illegible]8	613	1955	475	1968	721	1957	107	1959
SEPT	4.0	6.1	1959	1.4	1975	4[illegible]3	463	1975	354	1959	591	1970	61	1957
OCT	5.9	8.0	1975	3.9	1952	2[illegible]2	299	1958	216	1975	434	1973	33	1974
NOV	7.6	9.1	1972	6.2	1957	1[illegible]2	180	1957	97	1964	295	1971	14	1969
DEC	8.1	9.2	1962	6.8	1954	[illegible]2	116	1970	57	1969	196	1972	9	1973
			DEC		AUG			JULY		DEC		JUNE		DEC
YEAR	5.9	9.2	1962	0.6	1955	372	714	1973	57	1969	821	1971	9	1973

EXTREME AVERAGES OR TOTALS AND YEAR OR SEASON OF OCCURRENCE

1912-1975 TEMPERATURE AVERAGES (°F)		
HIGHEST ANNUAL	56.2	1958 +
LOWEST ANNUAL	50.2	1929
HIGHEST WINTER (D-J-F)	41.1	1933-34
LOWEST WINTER	24.2	1948-49
HIGHEST SPRING (M-A-M)	58.2	1947
LOWEST SPRING	48.0	1955
HIGHEST SUMMER (J-J-A)	78.2	1958
LOWEST SUMMER	70.3	1954
HIGHEST FALL (S-O-N)	56.6	1963
LOWEST FALL	49.6	1946
1912-1975 PRECIPITATION TOTALS (IN.)		
GREATEST ANNUAL	11.45	1950
LEAST ANNUAL	3.26	1967
SNOW, ICE PELLETS (SLEET) GREATEST SEASONAL	43.6	1915-16
LEAST SEASONAL	0.3	1957-58
1945-1975 WIND SPEED AVERAGE (mi/hr)		
HIGHEST ANNUAL	8.3	1968 -
LOWEST ANNUAL	6.3	1957
1946-1975 RELATIVE HUMIDITY AVERAGE (%)		
HIGHEST ANNUAL	57.9	1950 -
LOWEST ANNUAL	49.4	1967
1946-1975 SKY COVER AVERAGES (SUNRISE TO SUNSET SCALE 0 - 10)		
HIGHEST ANNUAL	6.4	1956
LOWEST ANNUAL	5.1	1949
1953-1975 SOLAR RADIATION AVERAGE DAILY TOTAL (LANGLEYS)		
HIGHEST ANNUAL	390	1973
LOWEST ANNUAL	357	1967

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FIGURE 3-3. Averages and Extremes of Climatic Elements at Hanford. (Sheet 1 of 2)

NUMBER OF DAYS (1945-1975)**

	CLEAR					PARTLY CLOUDY	CLOUDY				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	3	7	1963	0	1955 -	6	22	27	1969	17	1963
FEB	5	9	1968 -	1	1972 -	5	18	26	1958	12	1964
MAR	6	12	1966 -	2	1961	8	17	22	1968	9	1965
APR	6	12	1962	1	1963	10	14	21	1963	6	1956
MAY	9	14	1973	2	1960	10	12	19	1960	6	1958
JUNE	10	21	1961	5	1972 -	10	10	15	1973 +	5	1960 +
JUL	20	26	1960	13	1974	7	4	9	1974	1	1961
AUG	19	30	1955	11	1968	7	5	13	1968	0	1969 +
SEPT	15	27	1975	8	1969	7	8	13	1969	1	1975
OCT	9	14	1970	1	1975	7	15	22	1973	9	1970
NOV	4	10	1957	1	1973 -	5	21	25	1973 +	15	1961
DEC	3	7	1972 -	1	1962 -	5	23	28	1962	18	1967 +
YEAR	109	30	AUG 1955	0	JAN 1955 -	87	169	28	DEC 1962	0	AUG 1969 +

	THUNDERSTORMS					HEAVY FOG (VISIBILITY 1/4 mi OR LESS)				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	0	0	—	0	—	5	14	1965	0	1949
FEB	#	1	1972 +	0	1975 +	3	11	1963	0	1971 +
MAR	#	1	1969 +	0	1975 +	1	5	1951	0	1975 +
APR	1	3	1948	0	1975 +	#	1	1975 +	0	1974 +
MAY	2	7	1956	0	1974 +	#	1	1958	0	1975 +
JUNE	3	8	1972 +	0	1963 +	#	1	1971	0	1975 +
JUL	2	7	1975	0	1973 +	0	0	—	0	—
AUG	2	8	1953	0	1974 +	#	1	1959	0	1975 +
SEPT	1	4	1959	0	1975 +	#	1	1957	0	1975 +
OCT	#	1	1975 +	0	1974 +	1	6	1962	0	1974 +
NOV	0	0	—	0	—	6	13	1965	0	1960
DEC	#	1	1971	0	1975 -	8	17	1950	2	1968 -
YEAR	11	8	JUNE 1972 -	0	—	24	17	DEC 1950	0	—

	PRECIPITATION 0.10 in. OR MORE					SNOW 1.0 in. or MORE				
	MEAN	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	3	8	1970	0	1972 +	2	10	1950	0	1967 +
FEB	2	5	1961 +	0	1972 +	2	4	1975 +	0	1974 +
MAR	2	8	1967	0	1973 +	#	2	1957 +	0	1975 -
APR	1	5	1948	0	1973 +	0	0	—	0	—
MAY	2	4	1967 +	0	1968 +	0	0	—	0	—
JUNE	2	8	1950	0	1973 +	0	0	—	0	—
JUL	1	3	1974 +	0	1973 +	0	0	—	0	—
AUG	1	4	1975	0	1974 +	0	0	—	0	—
SEPT	1	5	1959	0	1975 +	0	0	—	0	—
OCT	2	8	1950	0	1972 +	#	1	1973	0	1975 +
NOV	3	10	1973	0	1967	#	6	1955	0	1974 +
DEC	3	10	1964	0	1949 +	2	6	1964	0	1974 +
YEAR	23	10	NOV 1973	0	SEPT 1975 +	6	10	JAN 1950	0	—

REFERENCE NOTES

*	CALORIES/cm^2
**	SKY COVER AND PRECIPITATION OBSERVATIONS NOT BEGUN UNTIL 1946
#	LESS THAN 1/2
-	ALSO ON EARLIER YEARS

NUMBER OF DAYS (1946-1975)

	3 in. OR MORE SNOW ON GROUND					PEAK GUST 40 mi/hr OR GREATER				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	5	23	1969	0	1975 -	3	11	1972	0	1973 -
FEB	3	16	1950	0	1974 -	3	6	1961 -	0	1973 +
MAR	0	0	—	0	—	3	9	1956	1	1973 +
APR	0	0	—	0	—	3	7	1972	0	1967
MAY	0	0	—	0	—	2	6	1971 -	0	1963 +
JUNE	0	0	—	0	—	2	6	1973	0	1971 +
JULY	0	0	—	0	—	1	4	1962 +	0	1975 -
AUG	0	0	—	0	—	1	5	1951	0	1974 -
SEPT	0	0	—	0	—	2	4	1946	0	1975 -
OCT	0	0	—	0	—	2	8	1967	0	1974 +
NOV	#	10	1955	0	1975 -	2	5	1973 -	0	1974 -
DEC	2	14	1955	0	1975 -	3	8	1957 +	0	1969 -
YEAR	10	23	JAN 1969	0	—	27	11	JAN 1972	0	—

NUMBER OF DAYS (1912-1975)

	MAXIMUM TEMPERATURE 90°F OR ABOVE					MAXIMUM TEMPERATURE 100°F OR ABOVE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	0	0	—	0	—	0	0	—	0	—
FEB	0	0	—	0	—	0	0	—	0	—
MAR	0	0	—	0	—	0	0	—	0	—
APR	#	4	1926	0	1975 +	0	0	—	0	—
MAY	3	11	1924	0	1974 +	#	1	1966 +	0	1975 -
JUNE	9	20	1940 +	0	1953	1	9	1970	0	1975 +
JULY	21	29	1941	8	1963	7	16	1971 -	0	1963 -
AUG	18	29	1915	7	1948	4	16	1942	0	1975 +
SEPT	5	16	1938	0	1970 +	#	2	1956 +	0	1975 +
OCT	#	1	1933	0	1975 +	0	0	—	0	—
NOV	0	0	—	0	—	0	0	—	0	—
DEC	0	0	—	0	—	0	0	—	0	—
YEAR	56	29	JULY 1941 -	0	—	12	16	JULY 1971 -	0	—

	MAXIMUM TEMPERATURE 32°F OR BELOW					MINIMUM TEMPERATURE 32°F OR BELOW					MINIMUM TEMPERATURE 0°F OR BELOW				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
JAN	11	29	1937	0	1967 +	28	31	1960 +	9	1953	2	14	1950	0	1975 +
FEB	3	15	1956	0	1974 +	22	28	1944 +	5	1958	1	9	1929	0	1975 +
MAR	#	2	1960	0	1975 +	16	25	1944 +	6	1968 +	0	0	—	0	—
APR	0	0	—	0	—	5	15	1935	0	1974 +	0	0	—	0	—
MAY	0	0	—	0	—	#	3	1938	0	1975 +	0	0	—	0	—
JUNE	0	0	—	0	—	0	0	—	0	—	0	0	—	0	—
JULY	0	0	—	0	—	0	0	—	0	—	0	0	—	0	—
AUG	0	0	—	0	—	0	0	—	0	—	0	0	—	0	—
SEPT	0	0	—	0	—	#	4	1933 +	0	1975 +	0	0	—	0	—
OCT	#	2	1935	0	1975 +	5	12	1916	0	1962 +	0	0	—	0	—
NOV	2	15	1956	0	1974 -	17	30	1938	4	1949	#	1	1956 +	0	1975 +
DEC	8	19	1914	0	1974	26	31	1963 +	14	1933	1	14	1919	0	1975 +
YEAR	24	29	JAN 1937	0	—	119	31	DEC 1963 +	0	—	4	14	JAN 1950 +	0	—

NUMBER OF DAYS

CLEAR (0-3 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1946-75)	141	1951
LEAST ANNUAL (1946-75)	85	1966
CLOUDY (8-10 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1946-75)	181	1969 +
LEAST ANNUAL (1946-75)	84	1949
THUNDERSTORMS		
GREATEST ANNUAL (1974-75)	23	1948
LEAST ANNUAL (1974-75)	3	1949
HEAVY FOG VISABILITY 1/4 mi OR LESS)		
GREATEST SEASONAL (1945-1975)	42	1950-51
LEAST SEASONAL (1946-75)	9	1948-49
PRECIPITATION 0.10 in. OR MORE		
GREATEST ANNUAL (1946-75)	39	1950
LEAST ANNUAL (1946-75)	10	1965
SNOW 1.0 in. OR MORE		
GREATEST SEASONAL (1946-75)	15	1955-56
LEAST SEASONAL (1946-75)	0	1957-58
3 in. OR MORE SNOW ON GROUND		
GREATEST SEASONAL (1946-75)	40	1964-65
LEAST SEASONAL (1946-75)	0	1966-67 +
PEAK GUST 40 mi/hr OR GREATER		
GREATEST ANNUAL (1945-75)	41	1961
LEAST ANNUAL (1946-75)	13	1958
MAXIMUM TEMPERATURE 90°F OR ABOVE		
GREATEST ANNUAL (1912-75)	85	1940 +
LEAST ANNUAL (1912-75)	31	1964
MAXIMUM TEMPERATURE 100°F OR ABOVE		
GREATEST ANNUAL (1912-75)	32	1942
LEAST ANNUAL (1912-75)	1	1964
MAXIMUM TEMPERATURE 32°F OR BELOW		
GREATEST SEASONAL (1912-75)	53	1955-56
LEAST SEASONAL (1912-75)	1	1937-38
MINIMUM TEMPERATURE 32°F OR BELOW		
GREATEST SEASONAL (1912-75)	141	1916-17
LEAST SEASONAL (1912-75)	75	1957-58
MINIMUM TEMPERATURE 0°F OR BELOW		
GREATEST SEASONAL (1912-75)	18	1949-50
LEAST SEASONAL (1912-75)	0	1974-75 +

LOCATION AND HISTORY

PRESENT LOCATION 25 mi NW OF RICHLAND, WASHINGTON
LATTITUDE 46°34'N; LONGITUDE 119°36'W, ELEVATION 733 ft
OBSERVATIONS FROM 1913 TO 1944 WERE BY UNITED STATES WEATHER BUREAU COOPERATIVE OBSERVERS AT A SITE ABOUT 10 mi ENE OF PRESENT LOCATION. BETWEEN 1944 AND 1975, OBSERVATIONS HAVE BEEN MAINTAINED ON A 24 hr-A-DAY BASIS BY THREE DIFFERENT GOVERNMENT CONTRACTORS.

RCP8204-191

FIGURE 3-3. Averages and Extremes of Climatic Elements at Hanford. (Sheet 2 of 2)

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4.0 DESIGN CRITERIA

4.1 PLANT PURPOSE

The T Plant Complex provides decontamination and reclamation of equipment contaminated with FPs or other radioactive material. The T Plant Complex operates to support the Chemical Processing and Waste Management Programs of Rockwell and also functions as a central decontamination center for all Hanford Site Contractors and DOE.

4.2 STRUCTURAL AND MECHANICAL SAFETY BARRIERS AGAINST NATURAL PHENOMENA

The T Plant Complex consists of two primary decontamination facilities (221-T and 2706-T) and four support facilities (291-T, 221-TA, 2715-T, and 271-T). Buildings 221-T, 271-T, and 291-T were constructed during 1943 to 1944, and 2706-T was constructed during 1959 to 1960. Other small buildings were added as needed. Facility design, safety protection systems, and engineered safety features are described in the facilities' technical and training manuals.[1,2]

4.2.1 Buildings 221-T and 271-T

Buildings 221-T and 271-T were designed and built to codes and standards applicable in 1944. These standards included static, vertical, live and dead loads and lateral wind forces based on the projected building area. These codes had no seismic provisions and no requirements for tornado resistance.

4.2.1.1 Wind and Tornado Loading. The structures of buildings 221-T and 271-T can withstand a tornado having a maximum tangential wind speed of 150 mi/h with a 25 mi/h translational wind speed (or a resultant speed of 175 mi/h).[3] The buildings can also withstand a negative pressure loading that results from a 0.75 lb/in^2 ambient pressure decrease in 3 s to a constant held for 1 s and returned to ambient pressure at the same rate. Thus, the structures of buildings 221-T and 271-T are able to survive a DBT.

4.2.1.2 Water Level (Flood Design). Neither the maximum expected rainfall over the next 1,000 yr or the effect of the 100-yr probable flood of the Columbia River poses any added hazards to the 200 West Area operations.[4] Therefore, flooding of the T Plant is not credible for design purposes.

4.2.1.3 Seismic Design. An assessment of the capability of buildings 221-T and 271-T to withstand an SSE has been made.[5] Results of a first-phase elastic analysis indicate that the canyon walls would be substantially overstressed near the roof (above the canyon crane rails) and at the canyon wall-gallery slab intersections. The primary load-bearing reinforced concrete of the canyon would also be damaged. Technical judgment projects that these walls will not collapse and that the integrity of the decontamination cells will be maintained, although extensive damage will occur to the structure.[5]

4.2.2 Building 2706-T

Building 2706-T was designed and built to then-applicable Uniform Building Code requirements for Type IV Buildings.[6] Wind design loads for a vertical projection of the building are not less than 15 lb/ft^2 and for horizontal projections are not less than 20 lb/ft^2. The building's rigid frame is capable of supporting a minimum of 5,500 lb at each load point, which enables it to support the overhead monorail system for the crane. The building foundation design is based on an allowable soil-bearing load of 4,000 lb/ft^2.

4.2.3 Chemical Storage Area 211-T and Building 2715-T

Chemical storage area 211-T was constructed at the same time as buildings 221-T and 271-T and was built in conformance to the same design criteria. Services in building 2715-T, a prefabricated metal shed, do not require stringent construction standards.

4.2.4 Buildings 221-TA, 291-T, 2716-T, and M104-371

Buildings 221-TA, 291-T, 2716-T, and M104-371 were built in conformance to the design criteria applicable at the time they were constructed. The use of these buildings does not require stringent criteria or standards.

4.3 MISSILE PROTECTION

Missiles generated from a DBT could cause the most damage at the T Plant Complex.[3] The objects listed in Table 4-1, traveling end-on at any height, could result from a 175 mi/h DBT.[7] Buildings 221-T and 271-T are capable of withstanding these missiles; however, buildings 2706-T, 2715-T, 2716-T, 221-TA, 291-T, and area 211-T tanks are probably not.

4.4 SAFETY PROTECTION SYSTEMS

4.4.1 Protection by Multiple Confinement Barriers and Systems

The T Plant Complex confinement system was designed to restrict releases of radioactivity or other hazardous materials to the environment or into areas normally occupied by plant personnel. This confinement system was designed to be in compliance with DOE guidelines and Rockwell criteria.[8,9]

TABLE 4-1. Missiles Resulting from a 175 mi/h Design Basis Tornado.

Missile	Weight (lb)	Velocity (ft/s) Horizontal	Vertical
Wood plank[a] (4-in. by 12-in. by 12-ft)	115	110	105
Schedule 40 pipe[b] (6-in.-dia. by 15-ft-long)	287	55	30
Steel rod[a] (1-in.-dia. by 3-ft-long)	9	24	24
Utility pole[b] (13.5-in.-dia. by 35-ft-long)	1,125	55	30
Schedule 40 pipe[b] (12-in.-dia. by 15-ft-long)	750	35	30
Vehicle[b] (20-ft^2 front)	4,000	50	20

NOTE: These requirements are applicable in all cases except where adjacent structures or high ground create a potential for more damaging missiles or missile impacts at higher elevations.

[a]Velocity of missiles apply at any height.

[b]Velocity of missiles apply at heights not greater than 20 ft above grade. Velocity above these heights is zero.

Various methods of confinement are used at the T Plant Complex to control the spread of contamination. Primary confinement barriers consist of process cells, building walls, liquid waste vessels, and piping.

Selective or secondary barriers are designed to minimize radioactive hazards to onsite personnel or offsite individuals and to the environment due to breach of a primary confinement. Selective barriers in the T Plant Complex are the ventilation system and administrative controls.

4.4.2 Protection by Equipment and Instrument Selection

Equipment and instrumentation control provide protection against the uncontrolled release of airborne radioactive particulates and from inadvertent exposure of plant personnel to high radiation.

The following criteria were used to determine the capabilities required of equipment and instrumentation.

- Protective instrumentation shall sense the presence of hazardous conditions and provide visual and audible alarms to ensure the safety of public, personnel, and equipment.
- The status of protective systems shall be determined by inspection, periodic checking, and testing of functions or calibration. The system shall be designed and configured to allow maintenance.
- The system shall initiate safety-related action when necessary.
- The system shall monitor and maintain critical facility parameters outlined in the Operational Safety Requirements (OSR) limits.

The ventilation system at the T Plant Complex has an audible alarm to indicate loss of ventilation in the building 221-T canyon. In addition, visual indications of canyon pressure and exhaust filter differential pressure (DP) are provided for the canyon ventilation system.

4.4.2.1 Nuclear Criticality Safety. Nuclear criticality safety at T Plant is achieved through administrative measures to ensure that operations involving use of significant quantities of fissile materials are not conducted in the complex. The T Plant Complex is classified as a limited-control facility with regard to nuclear criticality safety.(10) The possibility of achieving criticality is considered to be extremely small. There is, however, a possibility that traces of fissile material may be found in the large volume of radioactive waste produced during decontamination operations and that this plutonium could accumulate in the T Plant Complex.

In the event of a violation of these administrative controls, as discussed in Chapter 11.0, the manager of the T Plant Complex is immediately notified of the situation and will take the necessary actions. Written plans for recovery are prepared by knowledgeable technical personnel for approval by the managers of Process Engineering, Operations, and Criticality Engineering and Analysis.(10)

The storage of the PWR Core II blanket fuel assemblies requires no special handling for criticality control.(11)

4.4.2.2 Radiation Protection and Monitoring System. The radiation protection system, administrative procedures, facility layout and design, training, and proper protective hardware are used at the T Plant Complex to ensure that personnel exposure in controlled areas and offsite radiation exposures in unrestricted areas due to routine releases of radioactive material are maintained within the scope of as low as reasonably achievable (ALARA) guidelines and in accordance with DOE Order 5480.1A, Chapter XI.[12,13]

The Radiological Standards and Operational Controls manual establishes criteria and standards to assure that plant operations are conducted in a manner that is in compliance with DOE requirements.[13,14]

Record air samplers and continuous air monitors (CAM), for detection and measurement of airborne radioactive materials, and area radiation monitors, for radiation background measurements, are placed at locations within the T Plant Complex as determined by Radiological Engineering (Chapter 8.0).

4.4.2.3 Fire and Explosion Protection. The fire protection system is designed to prevent or detect the occurrence of fires and explosions and to minimize their effect. The structure, systems, and components of the T Plant Complex are protected to ensure that emergency response activities are not hindered during a credible fire or explosion. In all cases, noncombustible or fire-resistant materials are used throughout the T Plant Complex wherever practicable.

Fire detection, alarm, and suppression systems (e.g., extinguishers) are compatible with the radiation, chemical, and temperature environments in which they are used. Fire alarm systems supplemented by manually activated sirens are audible in buildings 2706-T, 221-T, 271-T, and other support facilities. Fire protection systems and equipment are maintained and operated in accordance with national fire codes.[15]

The T Plant Complex facilities have been surveyed for conformance to the National Fire Protection Association (NFPA) life safety code.[16,17] Several areas do not meet the "improved risk" criteria established by DOE because of life safety code deficiencies.[13] Areas have been identified that require modification to add egress fire doors, fire dampers, wall upgrades, and sealant to wall and floor penetrations.[17] The impact of these deficiencies is discussed further in Chapter 9.0.

4.4.2.4 Fuel Handling and Storage Safety. The handling and storage of spent reactor fuel is in compliance with DOE Order 5480.1A to assure that approved safety specifications are imposed during the unloading and storage of the fuel.[13] Storage of PWR spent fuel assemblies in the building 221-T canyon is kept in compliance with DOE Order 5480.1A, through building OSRs and Safety Assessment Documentation.[18,19]

4.4.2.5 Radioactive Solid Waste and Effluent Monitoring System. Detection apparatus capable of detecting alpha- and beta-gamma-emitting radionuclides must be used on any contaminated or potentially contaminated gaseous effluent discharge to ensure that radioactivity concentrations are maintained below the Table I guidelines of DOE Order 5480.1A, Chapter XI.(13) All T Plant's potentially contaminated release points, except the single exhaust stack in building 2706-T, are equipped with sampling and continuous monitoring devices for measurement of radionuclide concentration to ensure accurate measurement of routine and nonroutine releases.(14) The beta-gamma emitters are detected by effluent CAMs. Alpha emitters are detected with record air samplers.

Solid radioactive waste in the form of miscellaneous solid waste and failed process equipment is handled within the general criteria requirements for the management of radioactive waste set forth in DOE-RL Order 5820.2.(20)

4.4.2.6 Industrial and Chemical Safety. Operations at the T Plant Complex are performed in a manner to protect the general public, operating personnel, and public and private property against potential health and safety hazards. Application of recognized standards and codes in design, construction, and operations are upheld to maintain a safe working environment. T Plant Operations conducts its activities within the criteria outlined in the Rockwell Accident Prevention Standards and DOE Orders 5480.1A, Chapter I, and 5483.1.(13,21,22)

The T Plant Complex uses the following methods to avoid exposure to chemical hazards.

- Proper barriers and confinement systems (storage vessels) are provided to isolate oxidizing, flammable, and corrosive chemicals
- Personnel protective equipment is used to protect personnel during use of toxic or hazardous material.

4.5 DECOMMISSIONING

The original design of the T Plant Complex contained no criteria for future decommissioning of the facility. Some decontamination and decommissioning work, however, was done after the initial shutdown of the original $BiPO_4$ Separation Process and before the T Plant Complex was used as a decontamination facility. Based on this experience and the nature of the work done in the T Plant Complex, decontamination and decommissioning of T Plant is not expected to be inordinately expensive or difficult.

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5.0 FACILITY DESCRIPTION

5.1 SUMMARY DESCRIPTION

5.1.1 Location and Facility Layout

The T Plant Complex is composed of several buildings and support facilities within the 200 West Area. These facilities are discussed in the following sections and are shown in Figures 5-1 and 5-2.

5.1.2 Principal Features

5.1.2.1 Site Boundary. The general location of the T Plant Complex is shown in Chapter 3.0. The complex is within the 200 West Area, which itself has limited access as a DOE security area. Security is maintained by guards staffing both the entrances to the Hanford Site and to the 200 West Area. Therefore, the 200 West Area is considered the exclusion area for the T Plant Complex.

5.1.2.2 Utilities. Steam, water, and electrical utilities are supplied to T Plant from sources outside T Plant. Compressed air is supplied from building 271-T. A detailed description of these services is provided in 5.3.

5.1.2.3 Storage Facilities. Four tanks within the chemical storage (or tank farm) area 211-T receive and store bulk chemicals for T Plant. These tanks are located on a concrete pad adjacent to the northeast side of building 271-T. The contents of these tanks are listed below.

- Tanks SQ-141 and SQ-142 (each a 17,000-gal horizontal tank) contain sodium hydroxide (NaOH)
- Tanks SA-102 and SA-103 (each an 8,000-gal vertical tank) contain HNO_3.

Two other tanks are also located in area 211-T.

- Tank SQ-143 (a 17,000-gal tank) was used to store low-level radioactive liquid waste. This tank is no longer in service.
- Tank SQ-144 (a 15,000-gal tank) remains unused.

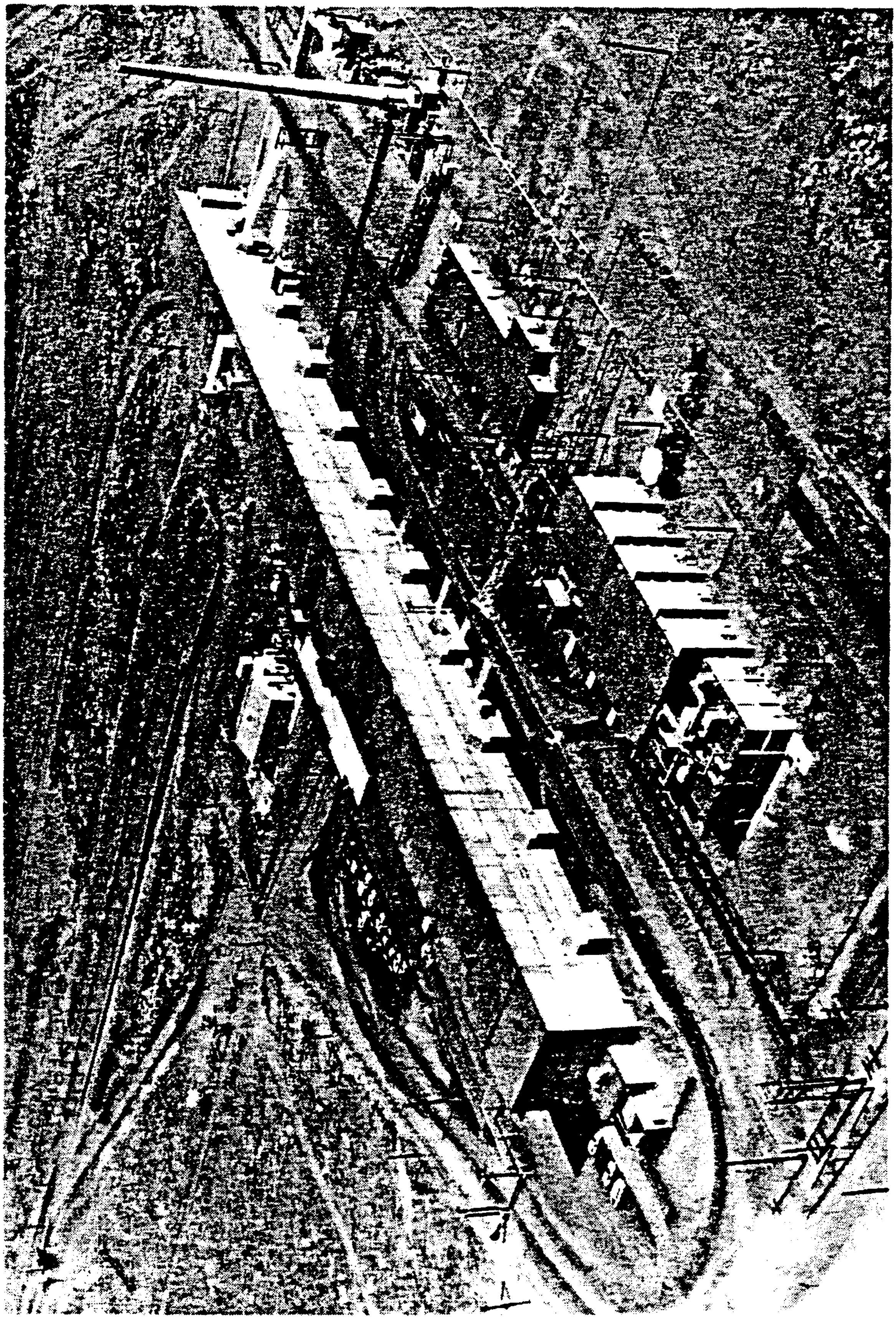

FIGURE 5-1. T Plant Complex

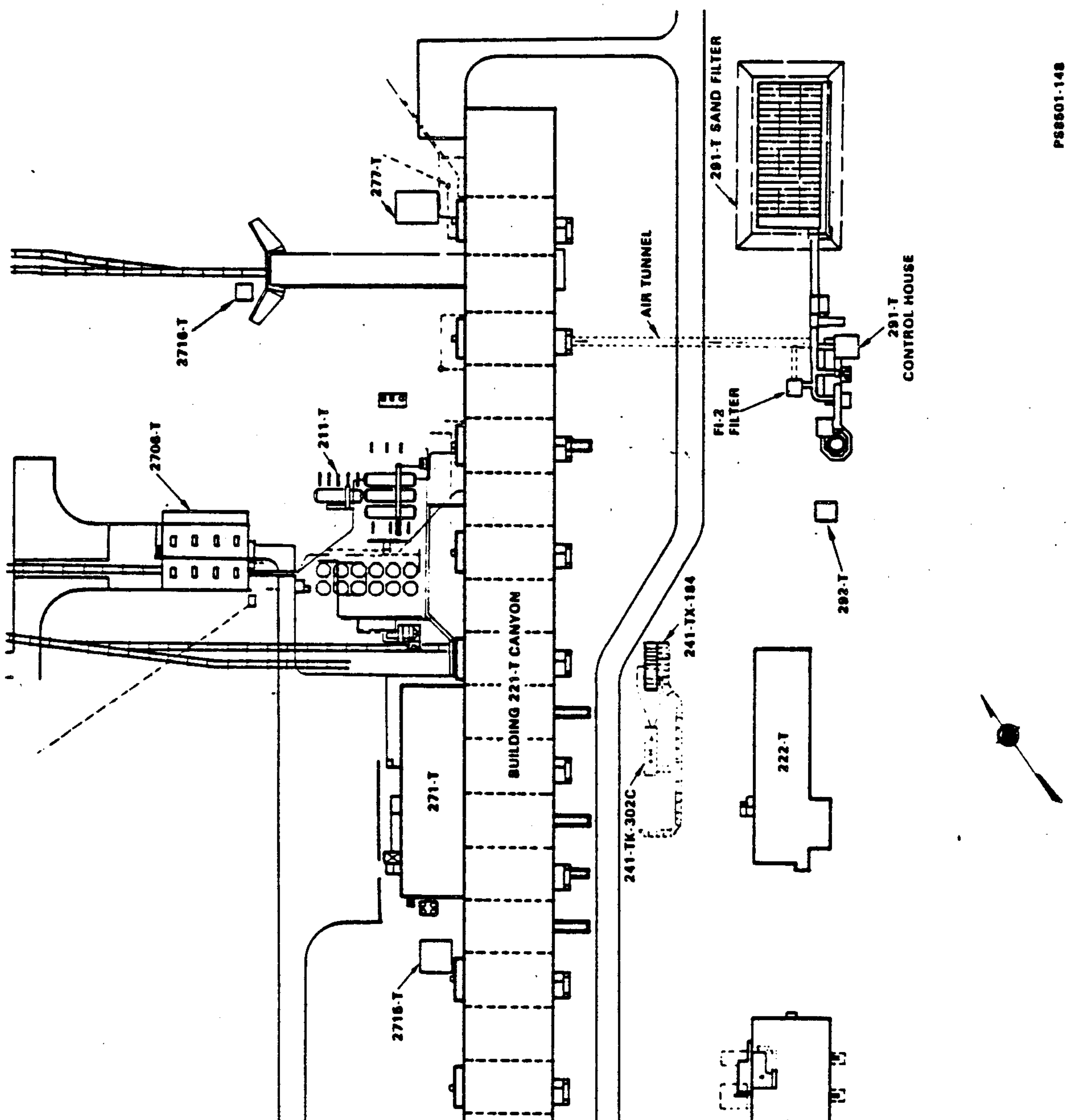

FIGURE 5-2. T Plant Complex Layout.

5.2 STRUCTURAL SPECIFICATIONS

5.2.1 Building 221-T

Building 221-T (see Fig. 5-2) provides services in radioactive decontamination, reclamation, and decommissioning of process equipment contaminated with FP. Building 221-T is the original $BiPO_4$ Separation Plant built in 1944 as one of the early Hanford Works Construction Projects.(1) The building was shut down in 1956 and converted to a decontamination facility in 1957.(2) The building is made of reinforced concrete and is 850 ft long by 68 ft wide by 74 ft high and covers an area of 57,800 ft^2. The building consists of the canyon, three galleries (operating, pipe, and electrical), one craneway, and a "headend" facility. A cutaway view of building 221-T is shown in Figure 5-3; the layouts of each building level are shown in Figure 5-4.

5.2.1.1 Canyon Service Area (Canyon Deck). The canyon area consists of 37 cells and one railroad tunnel entrance/exit. The cells are grouped into 40-ft sections arranged in a single row running the length of the building. The canyon deck (Fig. 5-5) is about 40 ft below a 3- to 4-ft-thick concrete roof. The headend is isolated from the building 221-T canyon by a thin metal wall located at the beginning of section 2.

Shielding walls made of 9-ft-thick reinforced concrete separate the cells from the electrical and pipe galleries. The operating gallery is separated from the canyon deck by a 7-ft-thick reinforced-concrete wall and the crane cab is protected by a 5-ft-thick concrete wall that extends part way (9 ft) to the ceiling. Most of the cells are covered by four 6-ft-thick reinforced-concrete blocks. Each block is stepped to eliminate a direct path for radiation streaming. Cover blocks for cells 11R, 13R, and 15R are 2 ft thick and are covered with a 3/8-in.-thick stainless steel decontamination pad. Each cover block has a carbon steel lifting bail to allow access into the cells. Cells 2R, 2L, and 3L are not covered and are used for the railroad tunnel and storage of PWR core II fuel.

The railroad tunnel used for transporting equipment into and out of the canyon enters the plant at cell 2L (section 2). A 16-ft-wide by 22-ft-high opening, covered by a motor-driven rolling steel door, provides railroad canyon access.

The canyon deck is used for special decontamination services, repair, and storage. An example of a typical layout of stored equipment that requires decontamination for repair, storage, or burial is shown in Table 5-1. The amount and type of equipment stored on the canyon deck and in the cells vary with decontamination support requirements.

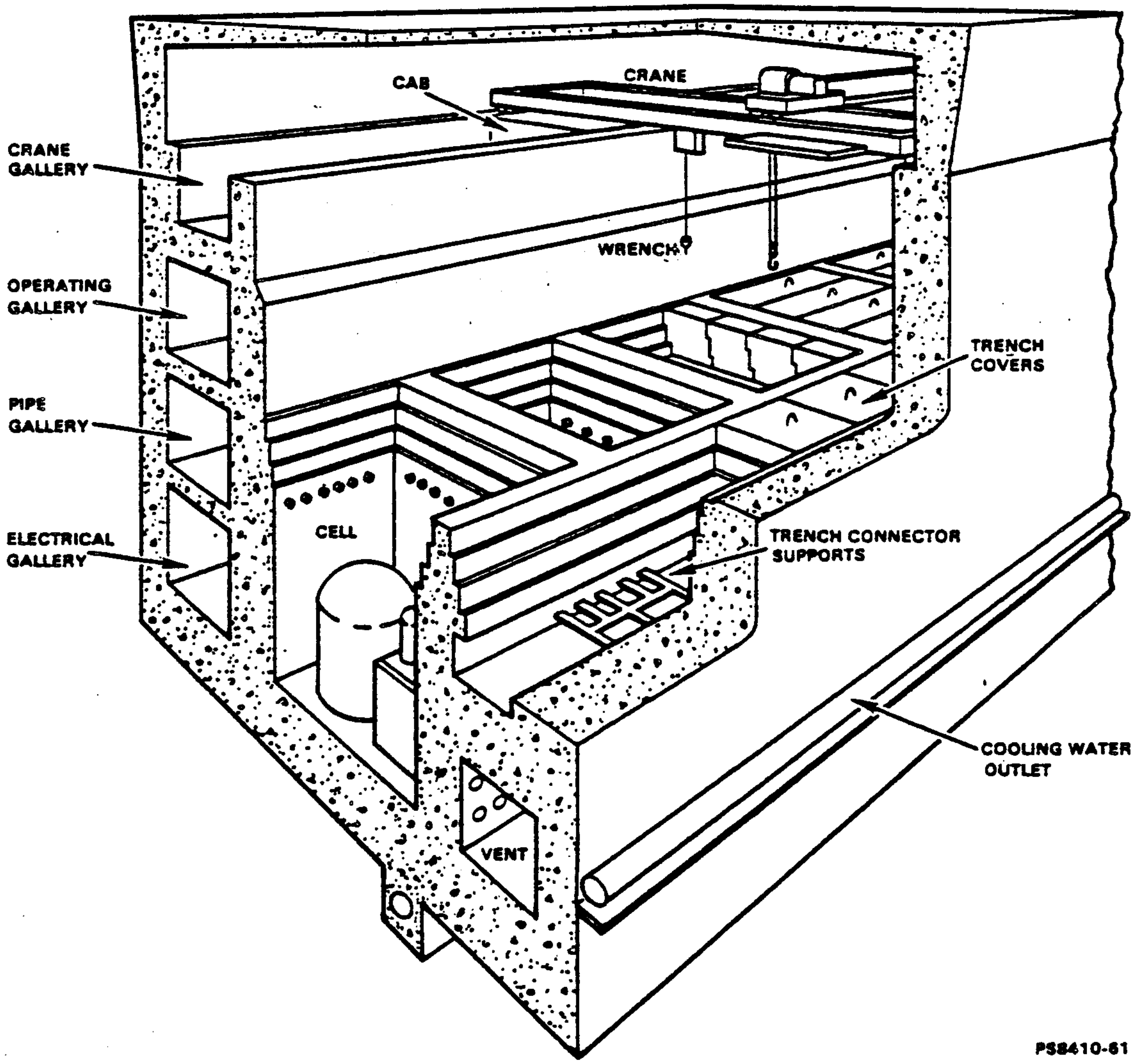

FIGURE 5-3. Building 221-T, Cutaway View.

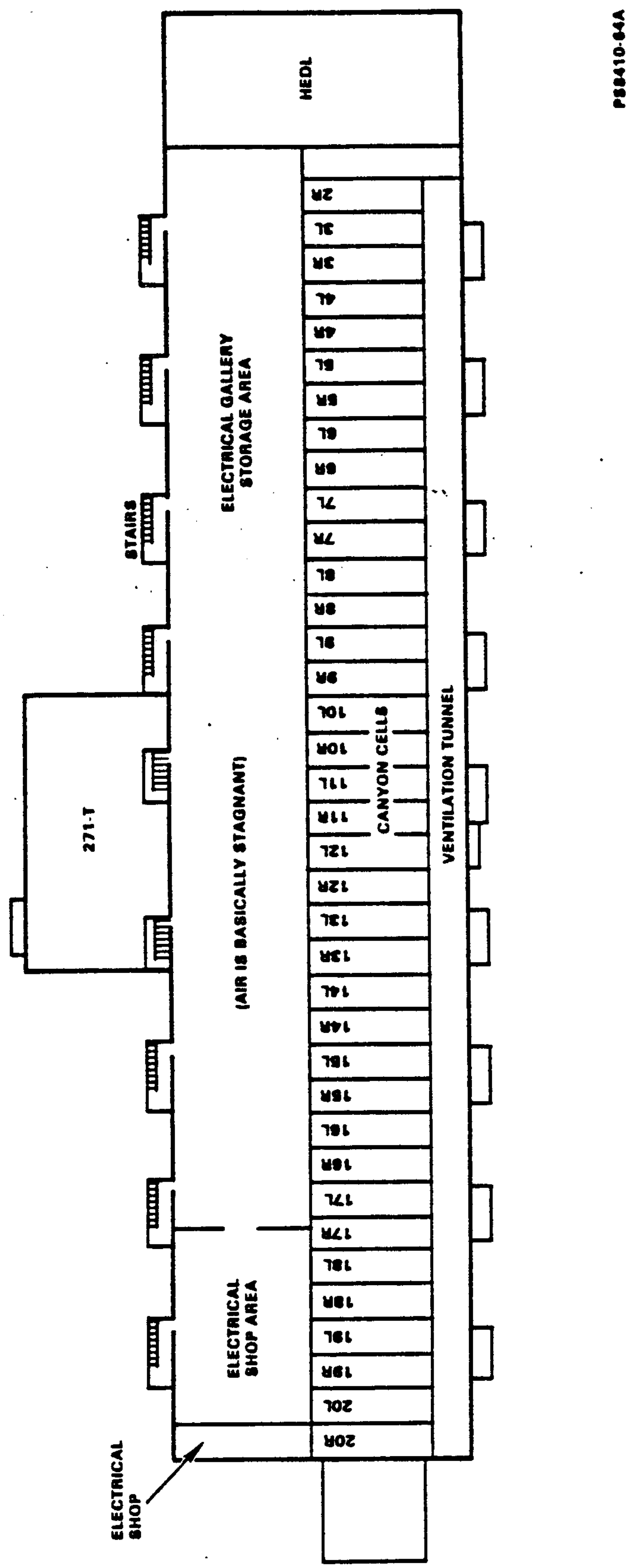

FIGURE 5-4a. Building 221-T, Basement Layout.

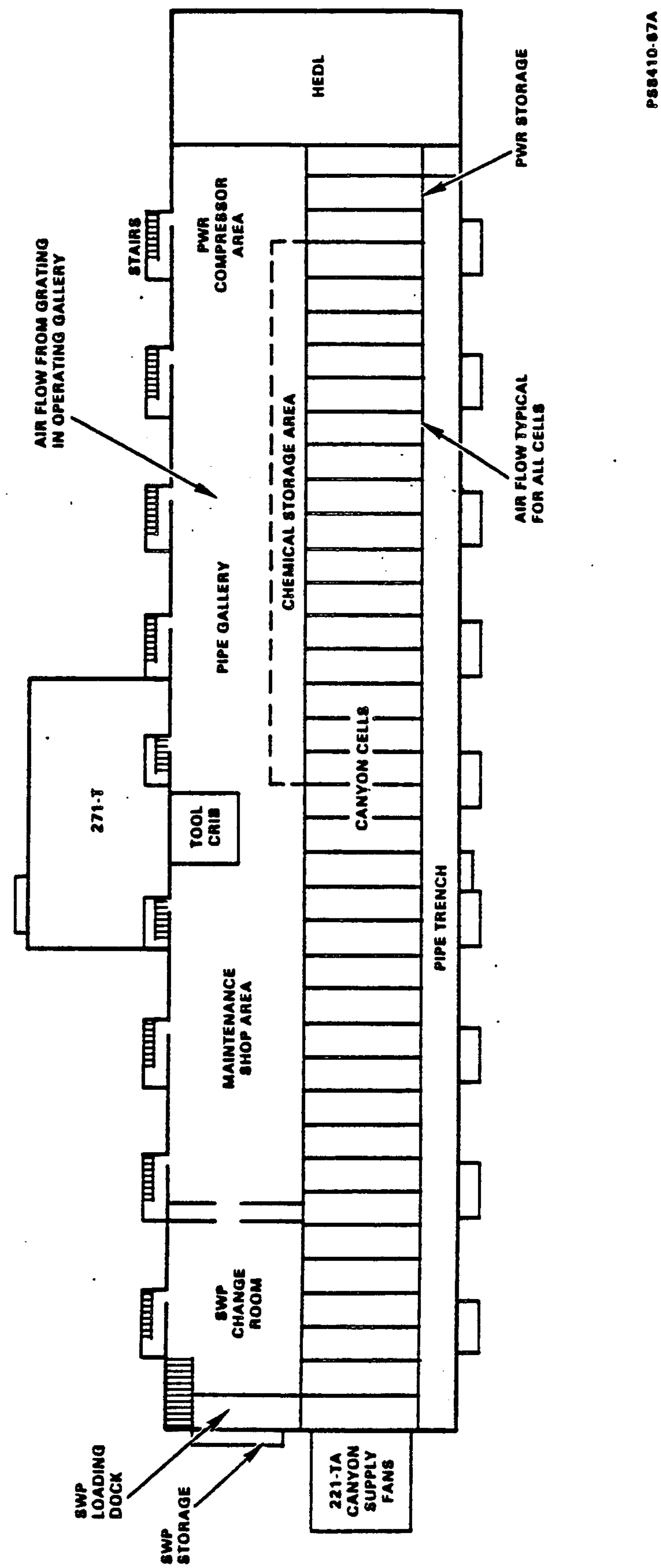

FIGURE 5-4b. Building 221-T, First Floor Layout.

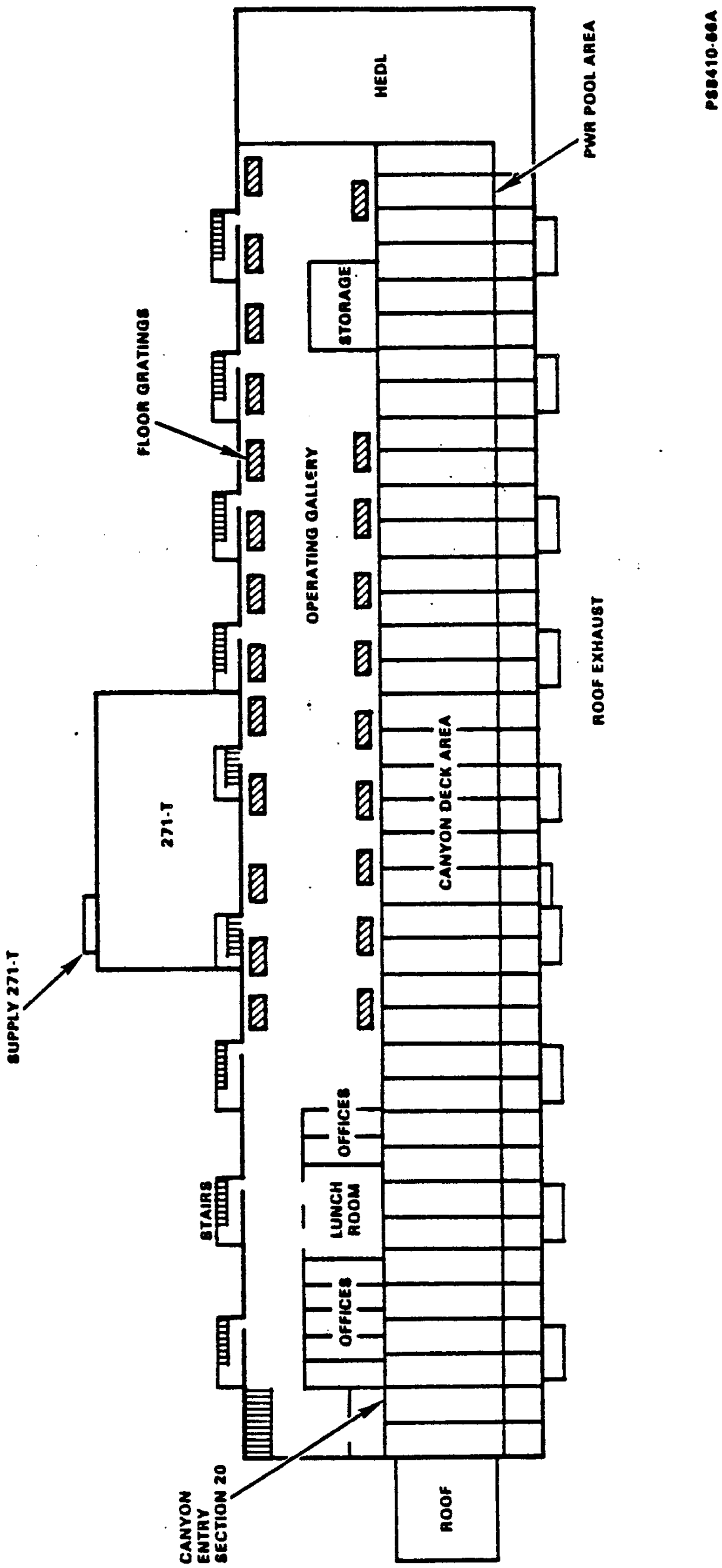

FIGURE 5-4c. Building 221-T, Second Floor Layout.

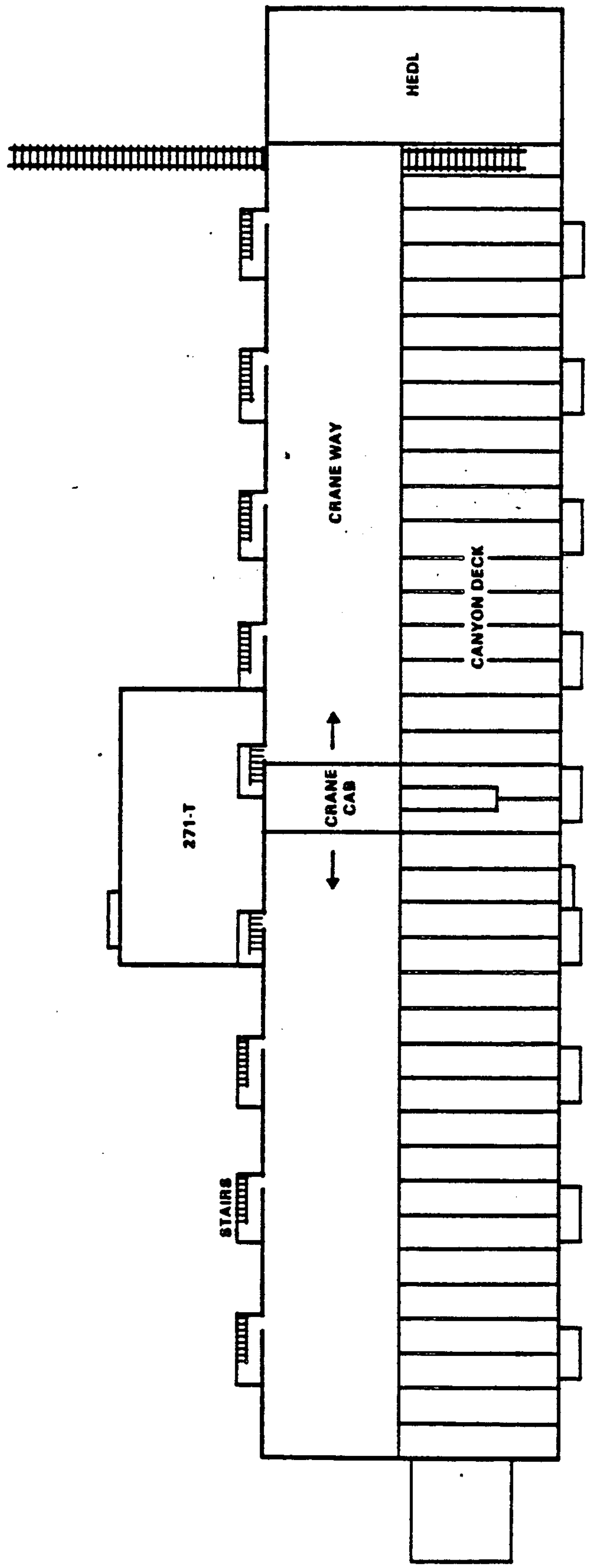

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FIGURE 5-4d. Building 221-T, Third Floor Layout.

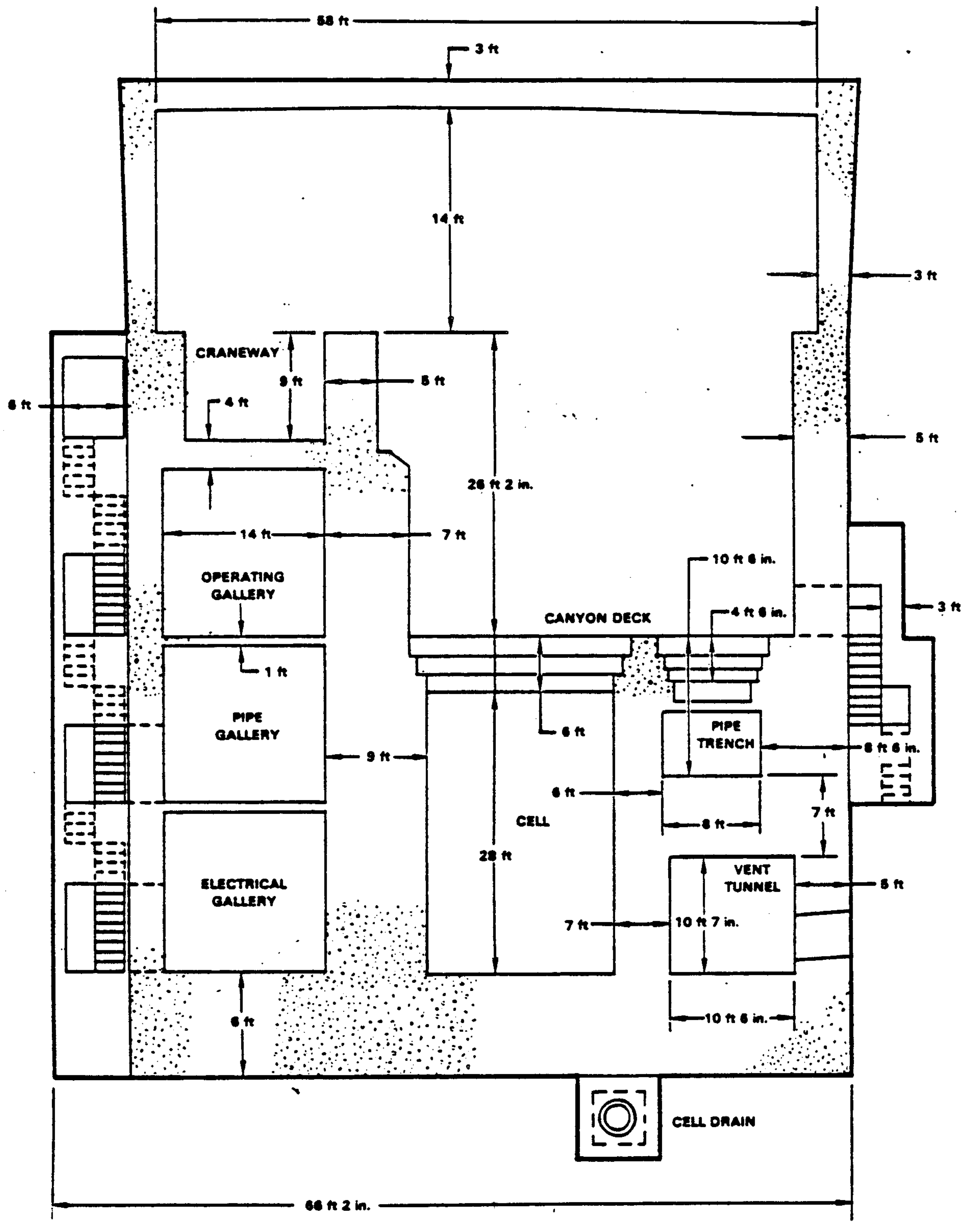

FIGURE 5-5. Building 221-T, Dimensional Cross Section of Canyon Deck and Cell.

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 1 of 6)

Section	Cell	On deck	In cell
1		Headend HEDL[a] occupancy	-- --
2	2L	Railroad tunnel	--
	2R	--	PWR spent fuel storage pool, 72 elements
3	3L	PWR equipment Miscellaneous equipment	Miscellaneous equipment
	3R	--	Pumps from PUREX and B Plants
4	4L	--	Rack 1 PUREX XC-1 pump 1 B Plant 22-1 pump 1 PUREX J-21 pump 1 PUREX 6P-J5 pump 1 PUREX (no ID[b]) pump 1 PUREX (no ID) pump 1 PUREX (no ID) pump 1 PUREX XD-2 pump 2 PUREX F-13 pumps without motors 1 PUREX JG4173 pump 1 PC52 pump 2 tank farm sluicer assemblies
	4R	1 wooden box (14- by 8- by 6-ft) 1 canyon deck pan for miscellaneous 4-to-1 pump and Partek hoses (burial) 1 portable chemical pump air hose 1 waste tanker unloading flex assembly and quick-disconnect in cell 1 waste tanker decontamination siphon tank	1 miscellaneous jumper assembly 1 pulser 2 contaminated filter assemblies

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 2 of 6)

Section	Cell	On deck	In cell
5	5L	2 sections of erected scaffold 1 working scaffold (9- by 9-ft) 1 pump and agitator miscellaneous fuel handling tools 1 jumper assembly (46400) 1 drum of pool filters 1 section of single-shell pipe from pool (12-ft)	2 tanks in use: •5-6 (4,800-gal) •5-9 (4,600-gal)
	5R	1 fuel storage rack (burial)	Original equipment tank 5-7 (10,000-gal)
6	6L	17 non-TRU drums for burial (55-gal)	--
	6R	--	1 agitator 18-1 1 pump 25-1 1 agitator 2A-31-1 1 pump P2P-F13 1 pump P-22-1 1 agitator A20-1 1 agitator (philly gears agitator) 1 pump PA-22-1 1 pump 45P-F13 1 pump P26-3 1 agitator A11-1-1 1 pump P17-2 1 pump P-13-1 3 high-speed B Plant agitators 1 (no ID) PUREX pump
7	7L	2 B Plant jumper 2 B Plant pulser 1 power transformer on stand 1 skid (jumper, motor, hoses)	2 PUREX Ti-Tube bundles 1 PUREX tower vent line pulser stand
	7R	1 001 AR agitator	2 pulser 001 AR agitator 2 jumpers

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 3 of 6)

Section	Cell	On deck	In cell
8	8L	Pieces of PUREX dissolver sheathing 14-2 tank coil 1 PUREX process pump 1 tank farm jumper	Original equipment tanks and jumpers
	8R	1 B Plant pulser in pulser run-in rack 1 L-shaped centrifuge (shielded) 1 10-ton power crane hook	Original equipment jumpers and centrifuges
9	9L	1 PWR unlocking tool (move to PWR area) 1 PWR swimming pool monorail and hoist assembly 5 slug buckets (lead bricks in buckets) 3 portable working shields 1 pallet (lead shielding 2,000+ lb) 1 scaffolding storage rack	Original equipment tank, jumpers, etc.
	9R	1 storage rack (H-2-60978) 1 miscellaneous sheet (4-ft by 4-ft by 3-in.-thick lead) 1 NFS storage box 8 miscellaneous yolk (equipment-handling yolks)	Original equipment tanks, jumpers, centrifuges
10	10L	1 modified 100-N cask lid top for centrifuge shielding rack 1 SS^{c} work hood 1 002 CR pump 2 miscellaneous motors 1 obsolete lamp from crane	Miscellaneous T Plant jumpers, drums of connector heads

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 4 of 6)

Section	Cell	On deck	In cell
10 (cont)	10R	1 miscellaneous storage stand (3- by 3-ft) 1 pallet miscellaneous connector heads (12-14) 1 miscellaneous piece of water hose (waste)	Open top decontamination tank (14- by 16- by 10-ft)
11	11L	1 extension ladder 1 I beam (18- by 30-in.) 1 NFS fuel storage stand 1 NRS fuel-handling stand 1 L-shaped pipe 2 B Plant agitators 1 SS decontamination pad thimble 1 lid for thimble 1 2 portable decontamination tanks 3 drum pallets PWR dummy fuel 1 drum-handling skip 1 tanker-sluicing pump 1 designated salt well 1 jumper station	Open top decontamination tank (14- by 16- by 10-ft; 14,000-gal) Open-top waste tank (14- by 16- by 10-ft; 14,000-gal)
12	12L	Decontamination cell (empty)	Decontamination cell (empty)
	12R	Decontamination cell (empty)	Decontamination cell (empty)
13	13L	U Plant pulser yolk 1 miscellaneous 15-ton lift yolk (possible bent leg)	PUREX offgas silver reactor
	13R	1 U Plant pulser 1 decontamination cell 1 SS flat cover block	Jumpers and connector heads
14	14L	1 portable chemical mixing tank (3- by 4-ft) 1 power panel for electropolisher 3 pipes (6-in.-dia.)	12 centrifuges Centrifuge block

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 5 of 6)

Section	Cell	On deck	In cell
14 (cont)	14L	1 bucket and drum lid (5-gal) 1 4-to-1 pump stand 1 4-to-1 pump portable cart	
	14R	1 heat coil 1 drum (5589) 1 electropolisher	Original equipment
15	15L	2 small impact wrench motors 1 tanker tube assembly (8-ft-long) 1 drum (55-gal; solidified 4518)	Waste tanks 15-6 and 15-9 (not in use)
	15R	1 pad area Valves from waste tanker (tube assembly)	Waste tank 15-1 (14,000-gal)
16	16L	1 waste tanker piping assembly 1 SS plate (4-ft by 10-ft 5/8-in.) 1 work platform PWR 2 wooden pallets 7 1/2-hp-motor 1 used crane cab filter 2 empty cans (5-gal) 1 hog through 4 SS pipes (10-ft-long; tank farms) 3 tank farm sludge sampler stands	Original equipment, tanks, and jumpers
	16R	1 B Plant tank 14-2 maintenance repair stand 1 B Plant jumper PB-2 pump run-in piping 1 tank farm jumper 46401 1 tank farm jumper	Original equipment, tank centrifuges, and jumpers
17	17L	1 centrifuge run-in stand 2 jumpers 1 hydraulic press	Original equipment, tanks, and jumpers

TABLE 5-1. Typical Layout of Building 221-T Canyon Cell and Storage Equipment. (Sheet 6 of 6)

Section	Cell	On deck	In cell
17 (cont)	17R	1 metal waste skip 1 mockup jig 1 242-S resin column (6574-2412-E) 1 motor stand (miscellaneous wood) 1 PB-2 pump and flowmeter stand	Original equipment tank, centrifuges, and jumpers
18	18L	1 mockup jib 1 well from car 39	Original equipment and tank jumpers
	18R	1 portable welder 3 mockup jigs 1 colpis blower 1 unidentified cylinder	Original equipment, centrifuge, tanks, and jumpers
19	19L	1 power hood-damaged (10-ton) 1 sheating lathe 1 elevated block for sheating lathe 1 portable pipe cutter 3 welding bottle rigs 1 contaminated paint pot	Original equipment tanks
	19R	1 centrifuge motor 1 base plate for (no ID) pump 2 empty drums (55-gal) 1 pump run-in station and repair 1 repaired pump (36P-F13)	Pump run in recirculation tank
20	20L	2 centrifuge motors 2 drums (unidentified PUREX pump parts)	Original equipment 20-1 tank
	20R	2 10-ft wooden skips 5 miscellaneous motors 3 end bell centrifuge motors	Not for storage Contains miscellaneous centrifuge parts

[a]Hanford Engineering Development Laboratory
[b]Identification
[c]Stainless steel

Section 2 is used as the PWR core II storage facility area. Cell 2R contains seventy-two 12-ft-long irradiated fuel elements stored underwater in a 13-ft-wide by 27-ft 6-in.-long by 28-ft-deep pool with a capacity of about 50,000 gal. A catwalk is placed 5 ft above the pool to allow access to the pool for sampling and maintenance. An ion-exchange column recirculating system is used to limit the concentration of radioisotopes in the pool water. The resin column is made of 3/8-in.-thick carbon steel and is enclosed behind 1-ft-thick concrete barriers to limit personnel exposure to 5 mrem/h above canyon background. Specifics of the system are described in References 3 and 4.

The canyon service areas, sections 4 through 10, are used as staging and storage areas for contaminated and decontaminated equipment. The major staging and storage areas for pumps and agitators are located in sections 4 and 6.

All decontamination work is performed in sections 11 through 15. A description of decontamination and service equipment used within this area is given in Table 5-2.

Contact maintenance work is performed in sections 16 through 20. The centrifuge run-in station is located on the deck in section 17 where a 16-ft-long run-in stand allows access for servicing 40- and 48-in.-long B Plant and PUREX Plant centrifuges. Power supplies of 480 V and 115 V for the run-in station and required instrumentation are available from the motor control station located in section 18 of the electrical gallery. The control center for the station is located in the operating gallery, room 218.

The pump run-in station is located in section 19. The PUREX Plant, B Plant, and other facility pumps are tested using a 440-V supply from the motor control station in section 18 of the electrical gallery. A 4,000-gal recirculating tank located in cell 19R is also used for run-in purposes. Controls for the pump run-in station are located on the panel board in building 221-T, room 220.

Several entry and exit doors are located throughout the canyon area. The main canyon entry door is located in section 20. The rear canyon "R" doors are normally used for emergency exit only, except for R-19, which is used for access to the laundry storage area and a canyon viewing room or "bubble" at section 13. Access to the bubble is made through the canyon or the outside R-13 shack located adjacent to building 221-T. Entries are also made through R-13 and R-17 for work that requires supplied-air respiratory protection.

The original building design provided for two electrical overhead bridge cranes with capacities of 75 tons and 10 tons, respectively. The cranes move parallel to the canyon, allowing easy access to the canyon deck area. This allows for remote decontamination and maintenance activities. The crane repair catwalk located in section 20 allows hands-on crane maintenance work.

TABLE 5-2. Equipment Available for Decontamination and Run-In Support.

Equipment	Section	Description	Function
Decontamination thimbles			
1	11R	68-in.-deep by 50-in.-dia., SS, 2,128-gal-capacity.	Immersion tank for chemical decontamination purposes. Piping includes air, steam, caustic, acid, and water.
2	15R	48-in.-deep by 30-in.-dia., SS, 350-gal-capacity.	
3	15R	48-in.-deep by 36-in.-dia., SS, 332-gal-capacity.	
Electrochemical decontamination equipment	14R	4- by 4- by 6-ft, SS, 700-gal-capacity. Rectified-input power requirement of 25 A for three-phase 440 V ac; produces 1,000 A at 0 to 12 V.	Alpha and beta-gamma decontamination using reverse electroplating processes in phosphoric chromic acid bath.
Partek liquid blaster headers from Partek pumps	12 through 15 (headers) 13 (pump located in operating gallery)	Main header--160-gauge; SS; welded pipe construction.	Beta-gamma decontamination using water or sand and water mixture with a 10,000 lb/in^2 output pressure.
4-to-1 and 5-to-1 portable chemical spray pumps	Where needed (i.e., 11R, 13R, 15R)	SS pump section. Outlet discharge pressure is four or five times greater than inlet supply pressure.	Beta-gamma decontamination using chemicals or water. Pressure at nozzle four times greater than air pressure applied.

The standard canyon cells are 17 ft 8 in. long by 13 ft wide by 28 ft deep and are normally covered by four 6-ft-thick concrete cover blocks. The cells are separated from each other by 7-ft-thick reinforced-concrete walls. All lines that service the cells are encased in concrete and terminate in a row of connector flanges on the cell wall 9 ft below canyon deck level. In some instances, process lines go directly through the wall to the adjacent cell in the same section. Since there are expansion joints between sections of the building, there are no direct through-the-wall connections from section to section; however, all intracell liquid transfers are made through jumpers within the cells. Intersection liquid transfers are made through an 8-ft-long by 10-ft 6-in.-wide pipe trench that runs parallel to the canyon. The trench is covered by a series of 4-ft 6-in.-thick reinforced-concrete blocks that are stepped on the side to eliminate a path for radiation streaming. All pipes in the trench are sloped to permit proper drainage.

Each cell slopes to a corner drain that drops into a 24-in. tile sewer running the length of the building. The sewer is an integral part of the building structure and empties into tank 5-7.

Cells are used for storage and for handling of radioactive waste resulting from decontamination efforts. The cells that are now in use are listed in Table 5-3.

A 10-ft 6-in.-square concrete exhaust air tunnel runs parallel to the canyon and provides exhaust for the canyon cells. The tunnel exits building 221-T at section 3, 22 ft below the deck level where it narrows to a 4-ft by 7-ft duct. The duct then runs 214 ft underground to the 291-T exhaust system located just southeast of building 221-T. The part of the exhaust system outside of the canyon is shown in Figure 5-2.

5.2.1.2 Building 221-T Galleries. The electrical gallery is 760 ft long and 14 ft wide. A corridor extends along the full length of the gallery and can be entered through nine stairwells. The electrical gallery contains the main electrical lines, motor control centers, and the electrical distribution centers for the building. The main steam lines and water lines also enter the building through this gallery. Electrical and instrument shops are located in sections 17 through 20.

The pipe gallery is 760 ft long and 14 ft wide. It also can be entered through nine stairwells. The pipe gallery contains most of the nonradioactive chemical, process, and utility piping. The pipe gallery is divided into four areas to meet requirements for present operations. Section 2 is the location of two compressor/condenser units for the PWR core II storage pool, and also the main power supply for the compressor/condenser units and the ion-exchange column. Sections 2 through 15 are used for chemical storage. The maintenance shop area is located in sections 11 through 18, and the SWP change room, shower room, and locker rooms are located in sections 19 and 20. The laundry dock is located west of the building, off section 20. A maintenance dock is located adjacent to the section 17 stairwell.

TABLE 5-3. Cells Used for Decontamination and Storage Purposes.

Cell	Equipment	Function
2L	Railroad tunnel	
2R	PWR core II pool	Maximum 20-yr storage of spent reactor fuel elements
5L	Enclosed tank 5-6 (SS, 4,600-gal-capacity)	Radioactive liquid waste storage
	Enclosed tank 5-9 (SS, 4,808-gal-capacity)	
5R	Open tank 5-7 (SS, 14,000-gal-capacity) and sump 5-8 (14- by 16- by 10-ft)	Radioactive liquid waste storage
6R	Empty cell (~18- by 13- by 22-ft)	Radioactive liquid waste from building 2706-T
11R	Open tank 11-L (SS, 14,000-gal-capacity)	Radioactive liquid waste storage
12L	Open cell (no cover block, ~18- by 13- by 22-ft)	Decontamination cell
12R	Open cell (no cover block, ~18- by 13- by 22-ft)	Decontamination cell
13R	Empty cell (~18- by 13- by 22-ft)	Radioactive liquid waste drainage for SS decontamination pad
15R	Open tank 15-1 (SS, 14,000-gal-capacity)	Radioactive liquid waste storage
19R	Pump run-in station with tank (SS, 4,000-gal-capacity)	Testing of various pumps

The operating gallery is approximately 760 ft long and 14 ft wide. Nine stairwells provide access into the operating gallery. This gallery is the control center for remote operation of the canyon equipment. Section 2 is the PWR core II operating station. Various panel control boards are located in sections 5 through 15; however, only the control panels in sections 5, 11, and 15 are in use. The other control panels have been out of service since the shutdown of the $BiPO_4$ process. The location and types of panel boards and equipment used for operations are shown in Table 5-4. Sections 16 through 19 contain the lunchroom and offices of the decontamination and decommissioning (D&D) operations personnel. The office adjacent to section 19 contains panel controls for canyon air, water, steam, and lights along with power controls for the centrifuge run-in station. The office adjacent to section 18 contains controls for the pump run-in station. The canyon entry area and decontamination shower are located in section 20.

TABLE 5-4. Control Panels Used in the Building 221-T Operating Gallery.

Section	Equipment	Function
5	Panel board for PWR core II and panel board with WF[a] manometers. Steam jet valves (padlocked until used)	Liquid waste transfers for tanks 5-6, 5-7, and 5-9 and sump 5-8
11	Panel board with WF manometers. Steam jet valves (padlocked until used)	Liquid waste transfers from tanks 11-L and 11-R
	Chemical makeup control panel for thimble 1	Provides chemicals for decontamination in the building 221-T canyon
13	75-hp Partek pump rated at 10,000 lb/in^2 (has safety pop-off valve set at 11,500 lb/in^2 and a PRV[b])	Provides high-pressure water blasting decontamination in the building 221-T canyon
15	Chemical makeup control panel for thimbles 2 and 3	Provides chemicals for decontamination in the building 221-T canyon
	Panel board with WF manometer and steam jet valve (padlocked except when used)	Liquid waste transfers for tank 15-1

[a]Weight factor.
[b]Pressure relief valve, vents locally.

Building 221-T stairwells also allow access to a 760-ft-long, 11-ft-wide craneway. The craneway is a radiation area. Only the stairwells in sections 11 and 13 are used for access into the craneway from building 221-T. The other stairwell entrances are barricaded at the third floor to prevent unauthorized entry.

The 75-ton-capacity canyon crane is operated by use of periscopes from a crane cab that is shielded by a parapet and 4-in.-thick lead walls. Other remote equipment includes a left and right 1-ton-capacity auxiliary hoist, an impact wrench, a clam bucket, and an auxiliary impact wrench. A 10-ton-capacity crane and rotary hook provide adaptability for handling, positioning, and maneuvering functions. The 10-ton-capacity crane is normally operated from the canyon deck by use of a suspended control box that hangs from the crane assembly. This crane can also be operated from the crane cab on the crane bridge.

5.2.2 Building 271-T

Building 271-T is the original $BiPO_4$ office and support facility and is situated adjacent to building 221-T. The building is 160 ft long, 48 ft wide, and 54 ft high. The building is constructed of 1-ft-thick concrete blocks with reinforcing steel beams. The building consists of three floors and a basement. Every floor can be accessed by two stairwells or by two entry doors in sections 11 and 13 from each of the galleries. Two outside doors are located on the north side of the first floor. The building 271-T layout is shown in Figure 5-6.

5.2.2.1 Basement. The basement of building 271-T contains the compressor room, the fan room for ventilation, machine shops, riggers loft, service elevator, and various offices and store rooms. The bottom halves of two chemical makeup tanks, M-101 and M-102, extend down from the first floor chemical makeup room. The pumps and power switches, P-332 for tank M-101 and P-322 for tank M-102, are also located in the basement.

5.2.2.2 First Floor. The first floor of building 271-T contains a chemical makeup room where chemical storage tanks M-101 and M-102 (with agitators) are located. Piping originates from these tanks and is routed through building 271-T and the pipe gallery and into the building 221-T canyon. Also within the chemical makeup area are two storage areas and a service elevator. An instrument electronics laboratory and several offices and shops are also located on this floor. A service dock adjacent to the chemical makeup room allows equipment and chemical deliveries.

5.2.2.3 Second Floor. The second floor of building 271-T consists mainly of offices, a lunchroom, restrooms, and the service elevator.

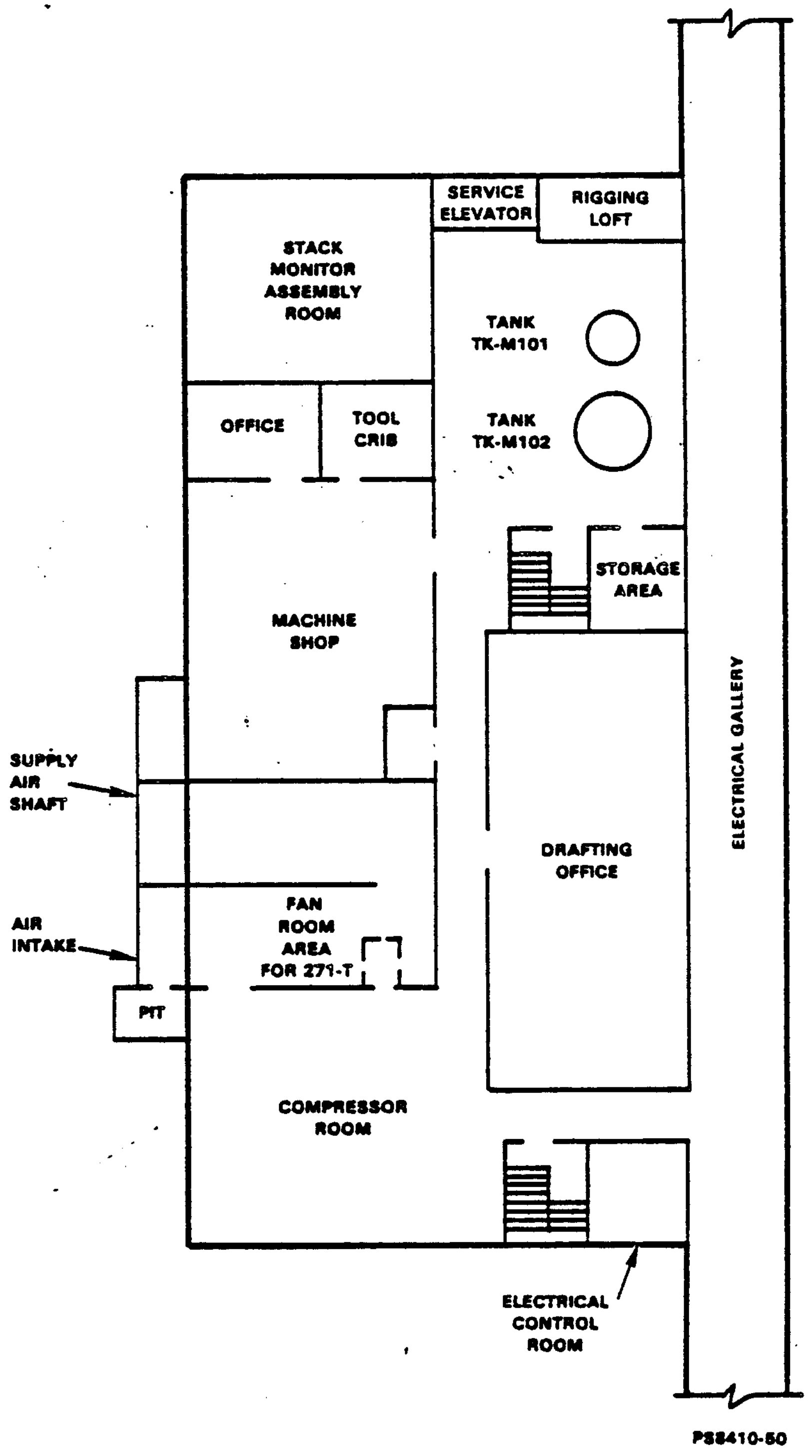

FIGURE 5-6a. Building 221-T, Basement Layout.

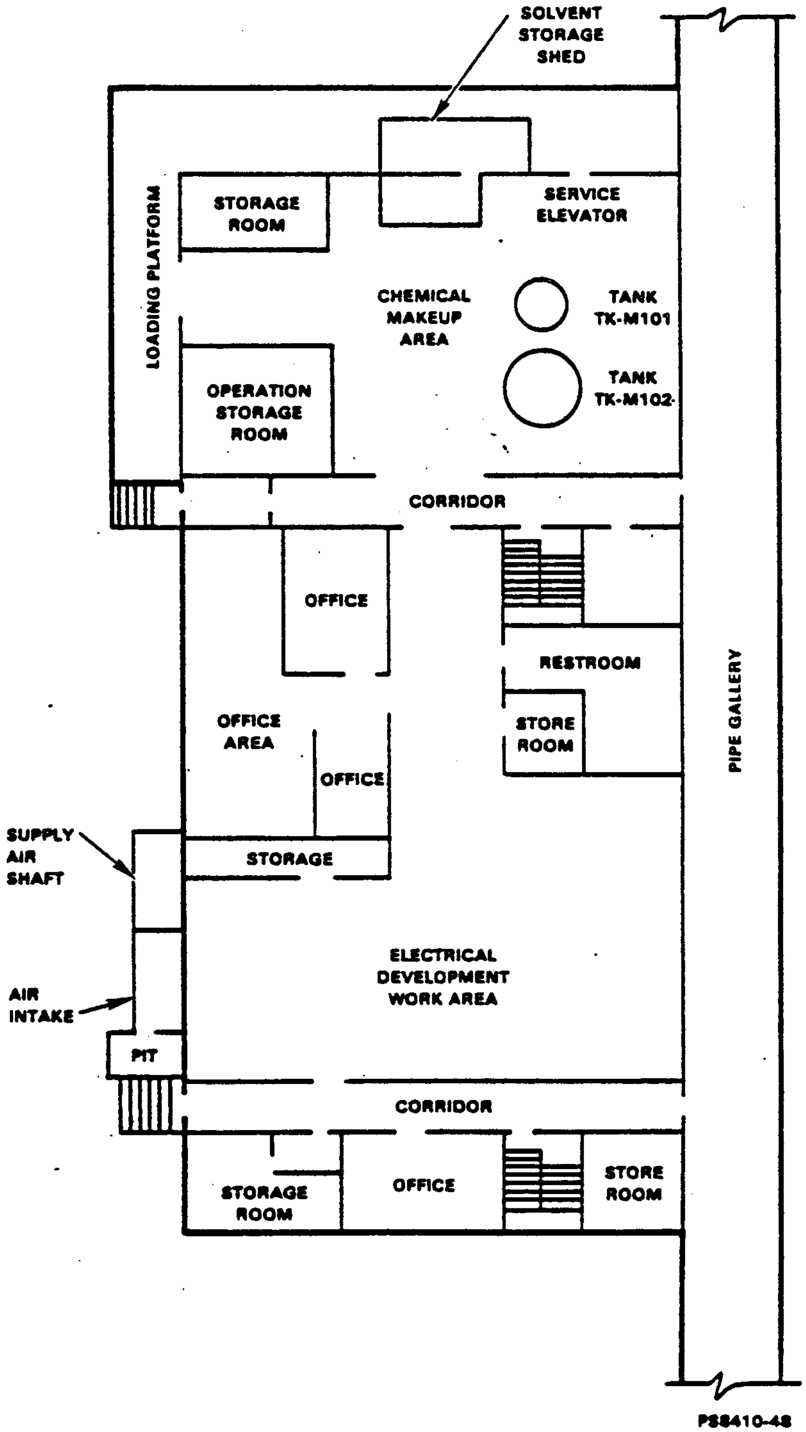

FIGURE 5-6b. Building 271-T, First Floor Layout.

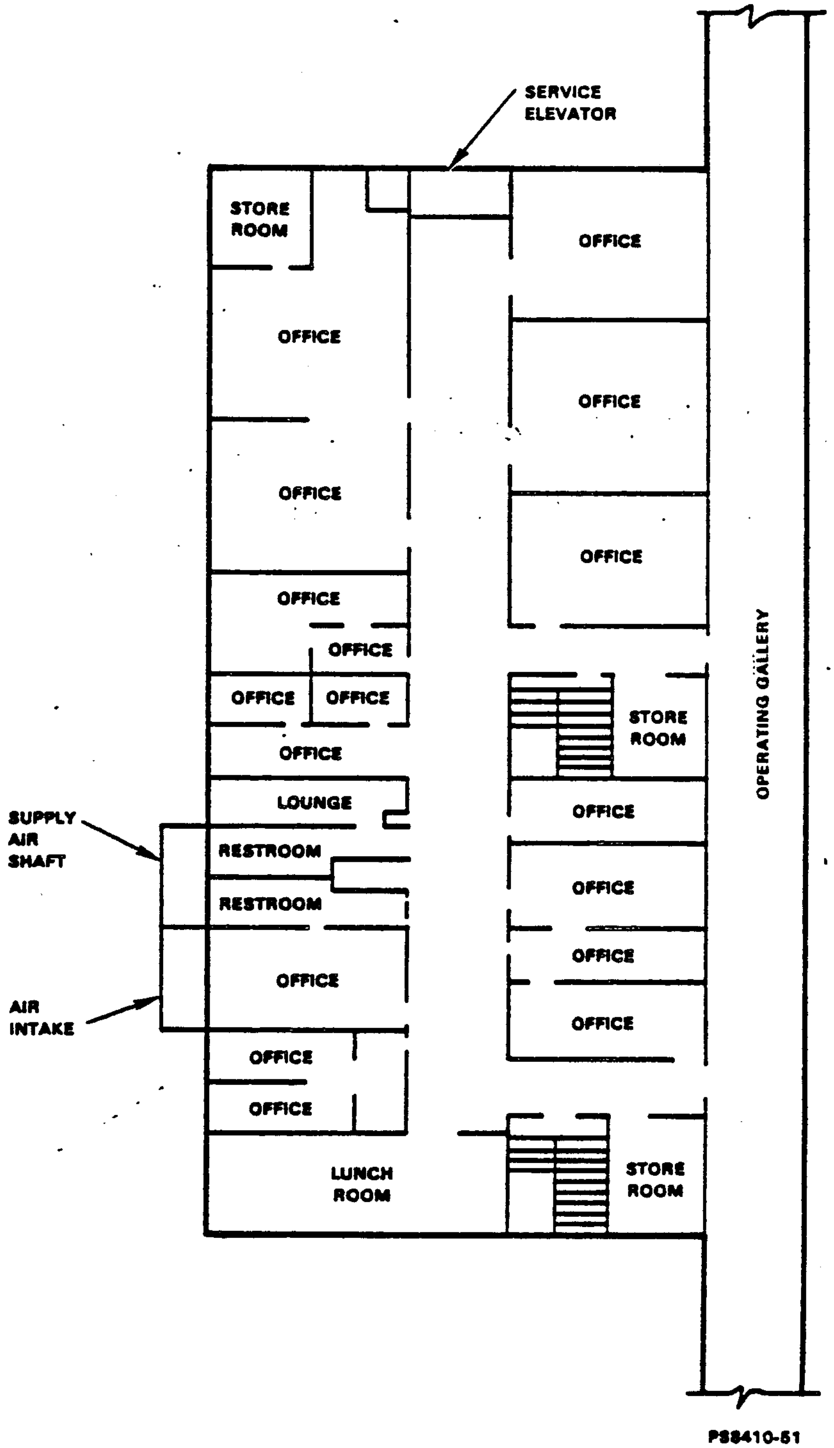

FIGURE 5-6c. Building 271-T, Second Floor Layout.

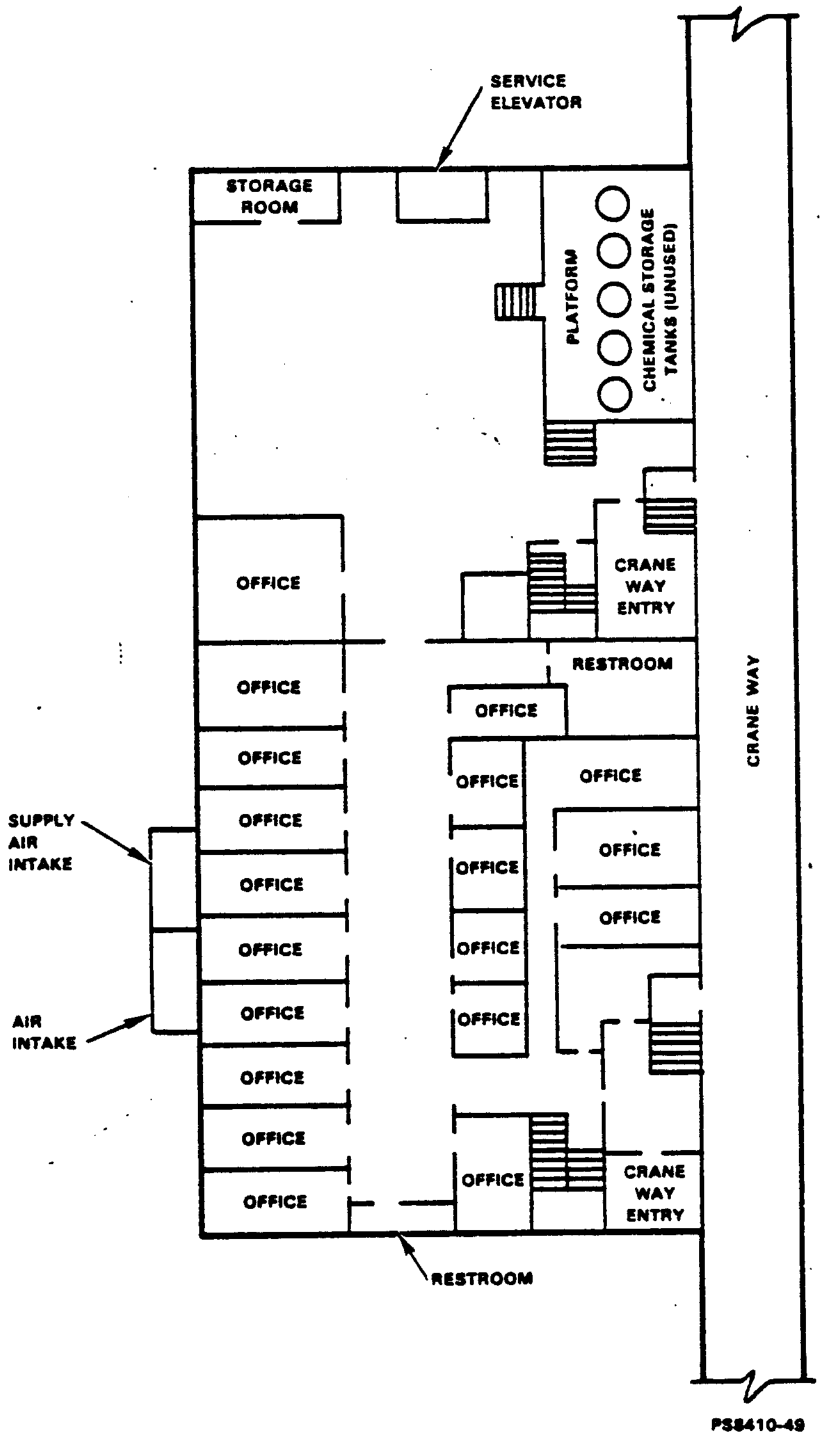

FIGURE 5-6d. Building 271-T, Third Floor Layout.

5.2.2.4 Third Floor. The third floor of building 271-T consists of offices, restrooms, an elevator, and chemical storage tanks for HNO_3, which are now unused. This floor also provides access into the craneway and crane cab via the section 11 and section 13 entry doors.

5.2.3 Building 2706-T

Building 2706-T was constructed in 1959 as a low-level radioactive decontamination facility (Fig. 5-7).[5] The facility is used to decontaminate railroad equipment, buses, trucks, automobiles, road building equipment, and plant process equipment. Low-level radioactive equipment is defined as equipment or material that is contaminated to less than 100 mrad/h at the surface and has no alpha contamination present.[6]

5.2.3.1 Building Layout. Building 2706-T is a 50-ft-wide by 66-ft-long by 25-ft-high ground-level building constructed of prefabricated steel with 20-ft-high side walls. Building 2706-T has two openings on the west end that are fitted with rollup metal doors. The larger door, 16 ft high by 12 ft wide, is the entrance to the railroad pit area; the other door, 9 ft wide by 14 ft high, is the entrance to the automotive pit area. An overhead 10-ton-capacity crane is available for maintenance use. The crane travels the length of the building. An electric motor moves the crane across the bridge. The bridge, however, can only be moved by a hand operated pulley. An office is located in the southeast corner of the building.

5.2.3.2 Cleaning Pits. The railroad pit is 55 ft long by 17 ft wide by 6 ft 3 1/2 in. deep. The floor has a slope of 2 ft to 1/2 in. to allow drainage. Four recessed lights in the pit provide lighting when cleaning the undercarriages of railroad cars. Two stairways at opposite ends of the pit provide access to the pit floor. One emergency ladder is located at the southwest end of the pit. Except for the center, the openings are completely covered with steel grating.

The automotive pit is 30 ft long by 4 ft 2 in. wide by 6 ft deep. The pit is covered by a steel grating. There is a stairway at one end and an escape ladder at the other next to the rollup door. Two recessed lights provide lighting in the pit.

A 3-in.-diameter drain line runs from both pits to two collection sumps. All liquid waste generated in building 2706-T is pumped from these sumps to a larger sump located approximately 40 ft southeast of the building. The larger sump is constructed of 8-in.-thick reinforced concrete, measures 6 ft long by 10 ft wide by 15 ft deep, and is covered by 1/4-in.-thick diamond-plate steel. Liquid waste from this sump is moved into the building 221-T canyon by steam jet or with an installed sump pump.

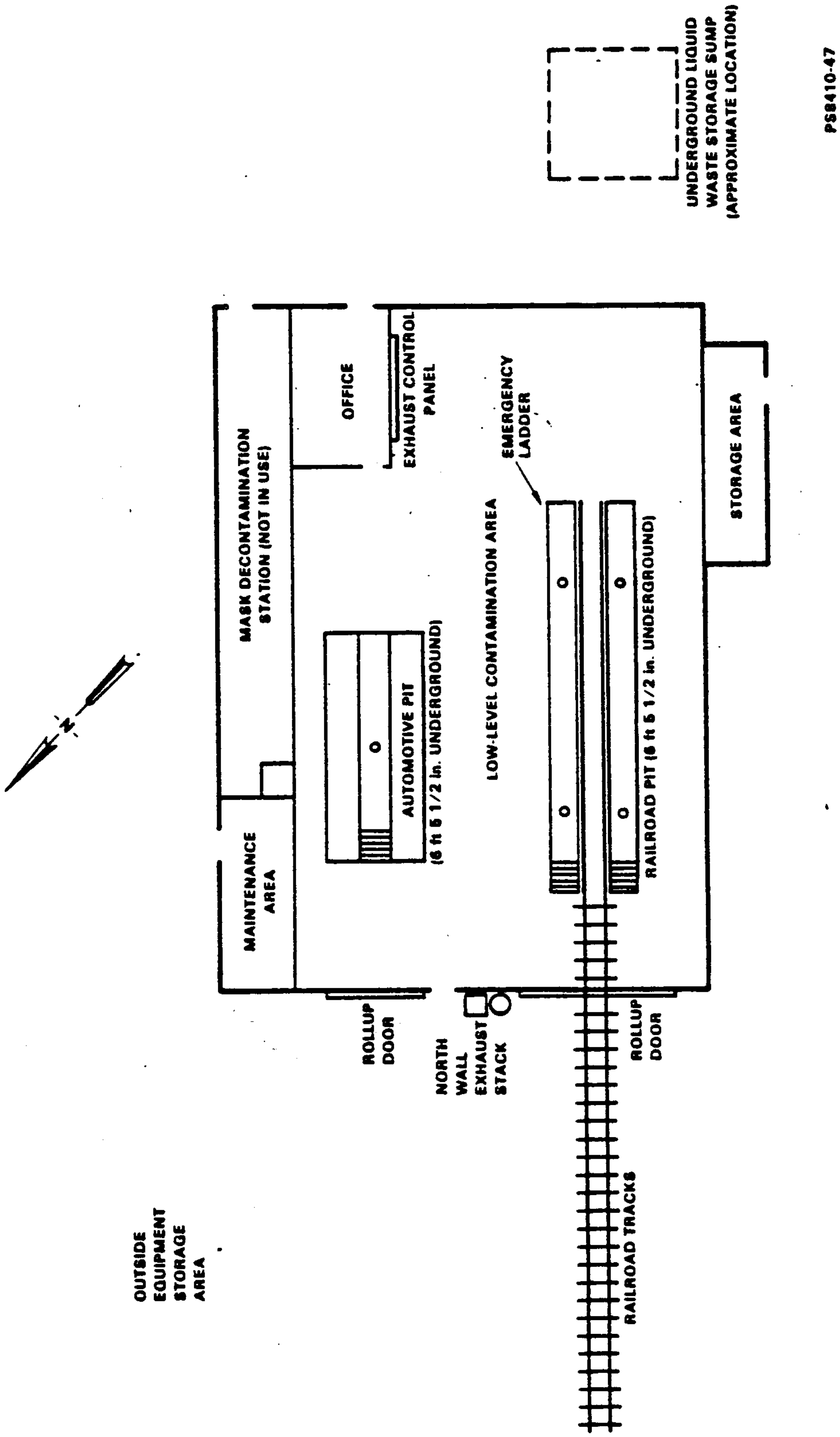

FIGURE 5-7. Building 2706-T, Low-Level Decontamination Facility.

5.2.3.3 Equipment. Various decontamination and cleaning equipment is used within building 2706-T. This equipment is described in Table 5-5. A portable sump pump is available, if needed, to remove liquid waste from the two pits and into the main building sump.

5.2.4 Support Facilities

5.2.4.1 Building 221-TA. The two ventilation supply fans to the building 221-T canyon are located inside of building 221-TA. A preheater, air filter, evaporative cooler, and reheat coil are also located in building 221-TA to condition supply air flowing into the canyon.

5.2.4.2 Building 2715-T. Building 2715-T is a metal shed used by maintenance as a shop in support of T Plant activities. It is located just outside of building 221-T on the west side.

5.2.4.3 Building 2716-T. Building 2716-T is a metal storage building located just outside of the railroad tunnel door. It is used for storage purposes and has a telephone for tunnel operation and emergency situations.

5.2.4.4 Building 291-T. The control room that serves the 291-T exhaust ventilation system for the building 221-T canyon is located inside building 291-T. The concrete building is 19 ft long by 17 ft wide by 11 ft high and was built as one of the original Hanford Works Projects.[1]

5.2.4.5 Women's Change Room M104-371. Trailer M104-371, located northwest of building 221-T, is the women's SWP change room.

5.3 SERVICES AND UTILITY SYSTEMS

The T Plant Complex provides for in-house services and utility distribution systems within the major process buildings. Piping services (i.e., water, air, electrical power) are available throughout the T Plant facilities via the operating, pipe, and electrical galleries. All of building 2706-T services and utilities are also distributed from these galleries.

5.3.1 Ventilation

5.3.1.1 Building 221-T. There are two separate ventilation systems for building 221-T: (1) the canyon supply and exhaust system and (2) the supply and exhaust system for the galleries. The building 221-T galleries are maintained at atmospheric pressure while the building 221-T canyon area is maintained at a negative pressure with respect to atmosphere. The building 221-T ventilation system is shown in Figure 5-8.

TABLE 5-5. Building 2706-T Equipment. (Sheet 1 of 2)

Equipment	Type/Model/Rating	Function
Liquid blaster	Partek high-pressure pump unit is rated at 30 gal/min maximum volume and at 4,500 lb/in^2 maximum pressure. It contains a nozzle rated at 10,000 lb/in^2 working pressure and 32,000 lb/in^2 burst pressure.	Uses a water or water/sand mixture on equipment for abrasive
Portable chemical spray pumps	Grover and Gracos pumps, rated as 4-to-1 pumps with supply air pressure requirements to operate pump at 20 to 180 lb/in^2 while discharging four times the supply air pressure. The pump is used to supply chemicals from 55-gal drums.	Spray application of chemical solutions onto equipment
Hydraulic jet cleaner	Sellers Hydraulic Jet Cleaner, a series of venturi jets, delivers 15 gal/min water at 180°F. Carbon steel construction. Permanently mounted.	Uses a mixture of steam, water, and detergent to produce high-pressure cleaning
Hydro steam cleaner	Clayton Hydro Steam Cleaner, uses steam supply maintained between 80 and 100 lb/in^2. A 5.5-gal tank is used for chemical makeup.	Used to decontaminate and degrease heavy-duty equipment
Vacuum blaster	Air ejector type vacuum pump, compressed air required is 70 to 100 lb/in^2 to produce a jet of abrasive.	Uses dry abrasive blasting for decontamination of material or equipment

TABLE 5-5. Building 2706-T Equipment. (Sheet 2 of 2)

Equipment	Type/Model/Rating	Function
Air tugger	Uses 100 lb/in^2 air, capable of pulling up to 4,000 lb, operated only to pull 3,000 lb.	Used for pulling railroad cars in and out of building 2706-T
Thimbles	Three round SS tanks (32-in.-dia. by 42-in.-high)	Chemical immersion decontamination of equipment. Air, water, and steam piping is available.
Decontamination pad	SS, 3/8-in.-thick by 10-ft-wide by 12-ft-long	Equipment decontamination

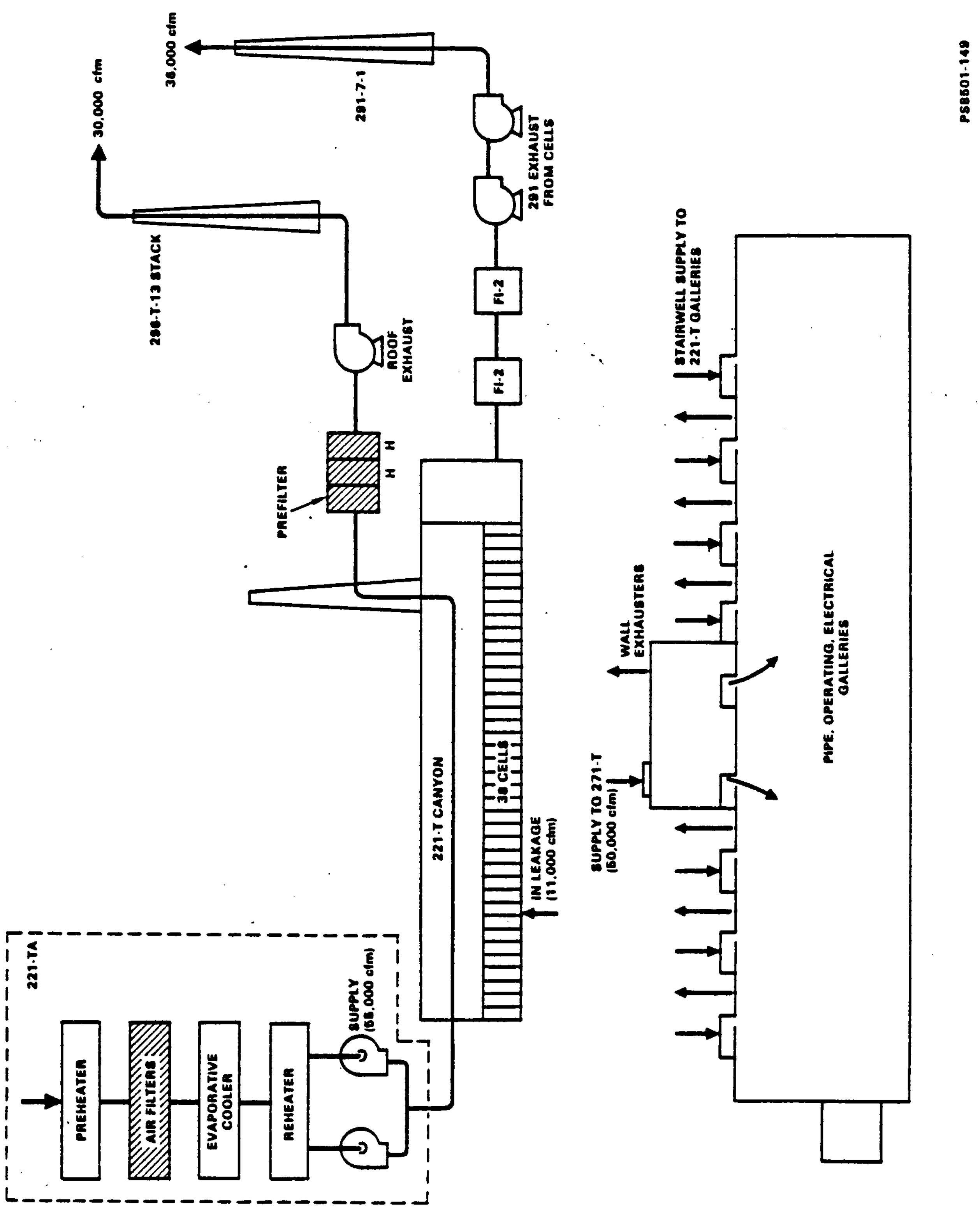

FIGURE 5-8. Building 221-T Ventilation System.

5.3.1.1.1 Building 221-T Canyon. Supply air is provided by two units that discharge air into a common supply plenum. The supply fans, rated at 40,000 ft^3/min each, draw outside air in through louvered roof openings in building 221-TA. The air passes through a preheater, air filters, an evaporative cooler, and a reheater before being delivered to the supply plenum. The evaporative cooler, preheater, and reheater are used to maintain a year-round canyon temperature between 70°F to 80°F.

Each of the two building 221-TA supply fans have manual dampers that can be adjusted to regulate flow. In addition, there are also eight supply units distributed along the craneway that are capable of supplying 25,500 ft^3/min of additional air. The eight units are currently not in service and are blanked off.

The supply air can be exhausted through either of two systems: (1) the roof exhaust system to the 15-ft-high stack 296-T-13 or (2) the 291-T exhaust system through the 200-ft-high stack 291-T-1.

The roof exhaust system consists of an exhaust fan rated at 70,000 ft^3/min that pulls canyon air through a roof opening at section 2. The air is pulled through one bank of prefilters and two banks of high efficiency particulate air (HEPA) filters before being exhausted out of stack 296-T-13. The HEPA or dustop filters are replaced when the pressure drop across the filter is in excess of 4 in. water gauge (WG).

The building 291-T exhaust system consists of 2 fans (20,000 ft^3/min each) that pull canyon air past the cell cover blocks down into the cells and pipe trench. The air then travels through 10-in-diameter ceramic ducts from each cell or section of the pipe trench into a 10-ft 6-in.-square exhaust tunnel. The air is pulled through the exhaust tunnel into a 4-ft-wide by 7-ft-high concrete duct where it flows to the building 291-T exhaust system. The air is then pulled through two type FI-2 HEPA filter banks.

An air balance for building 221-T is shown in Figure 5-9. Normal canyon pressure ranges from -0.25 to -0.5 in. WG. Usually, the building 221-TA supply fan 1, roof exhaust fan, and both building 291-T exhaust fans are operating to ensure that negative pressure is maintained in the canyon. An interlock system is provided between the 221-TA supply fans and the roof exhaust to prevent operation of a supply fan unless the roof exhaust is running. Pressure switches located in room 218 of the operating gallery are set at -0.09 in. WG for supply fan 1 and -0.15 in. WG for supply fan 2. The switches energize or de-energize the fan in use as needed. If canyon pressure becomes negative while supply air is off, the supply fans will start at -0.09 or -0.15 in. WG depending on which fan is in service. If canyon pressure becomes more positive when the supply is on, the supply fans will stop at -0.09 or -0.15 in. WG to prevent buildup of pressure. The roof exhaust pressure switch will open at -0.5 in. WG to prevent excess negative pressure (the fan will restart automatically when pressure increases). A control panel in the operating gallery allows operation of either supply fan. The control diagram for these pressure switches is given in Figure 5-10.

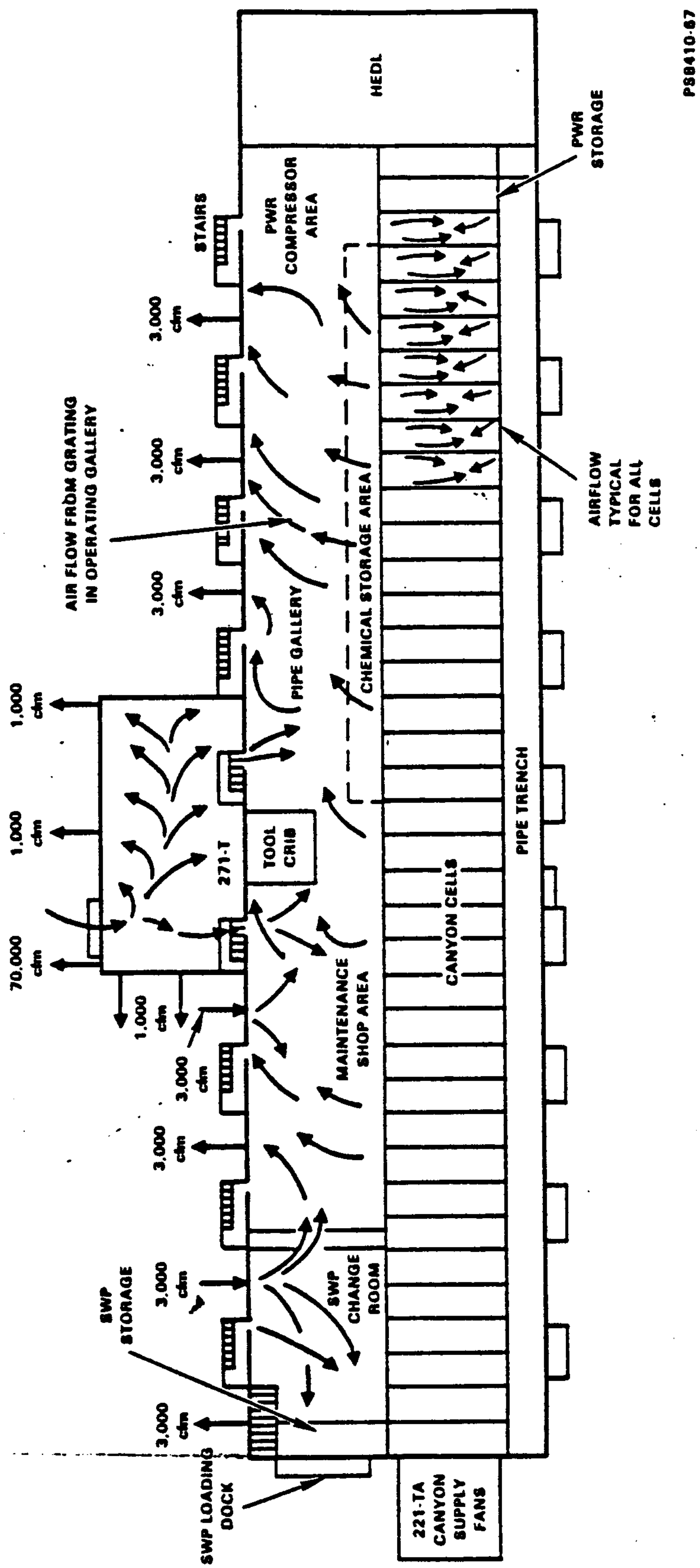

FIGURE 5-9 a. Building 221-T, Basement Airflow Diagram.

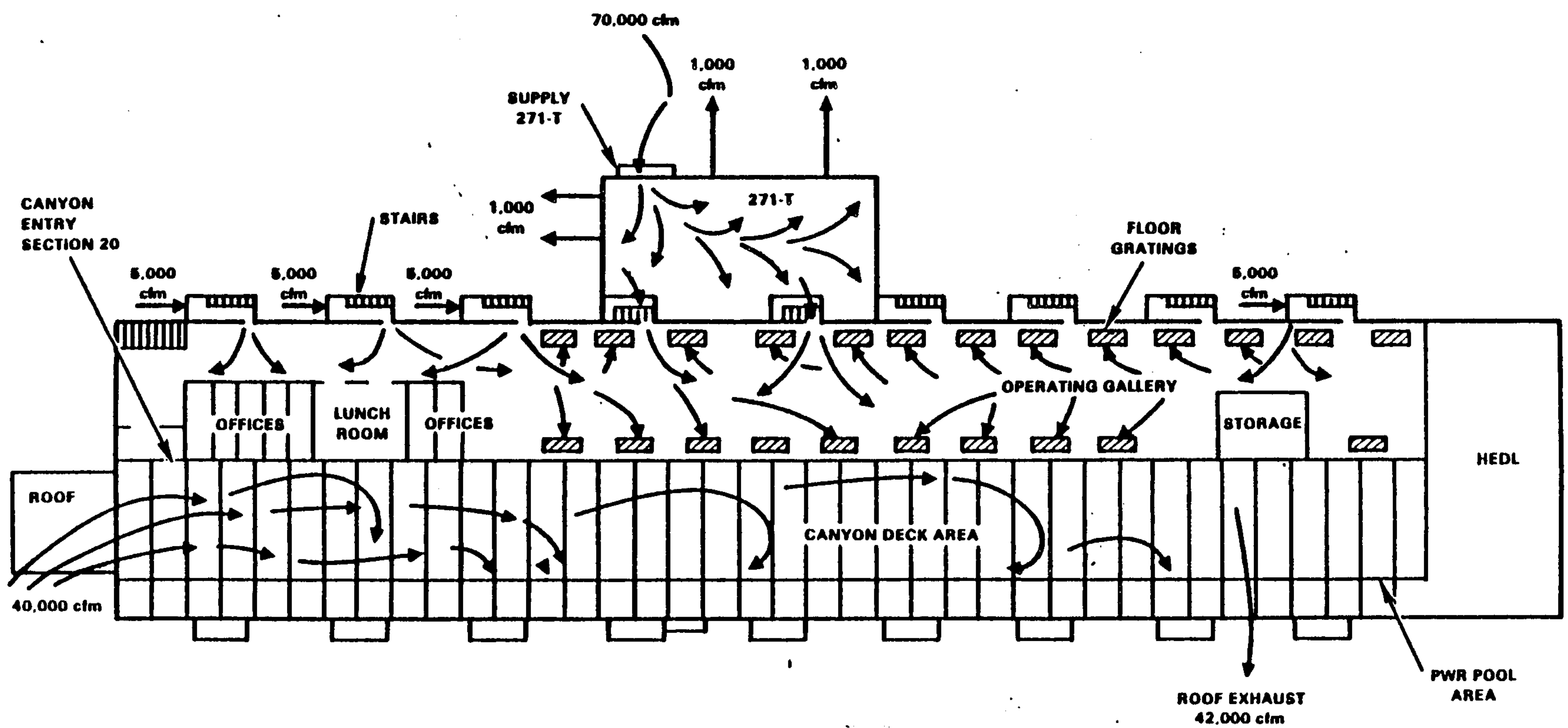

FIGURE 5-9b. Building 221-T, First Floor Airflow Diagram.

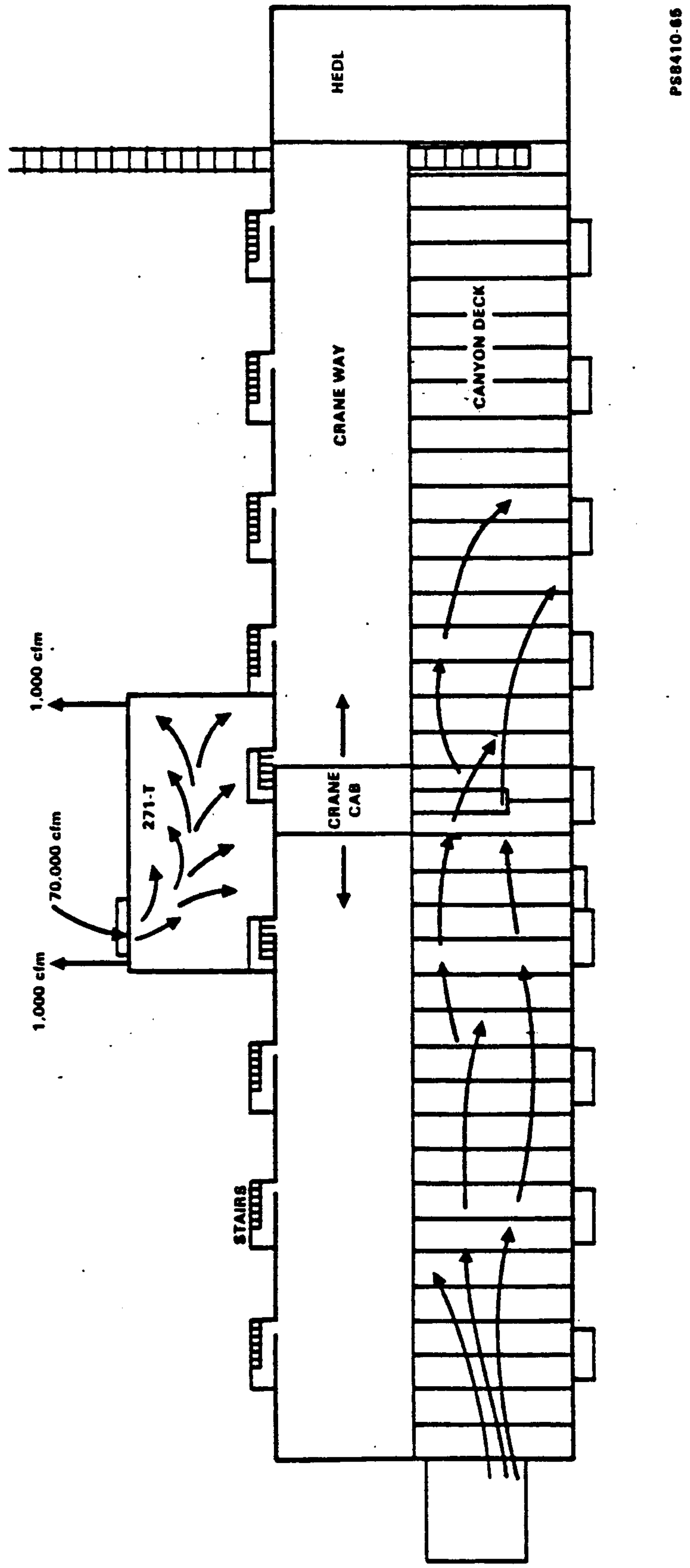

FIGURE 5-9c. Building 221-T, Second Floor Airflow Diagram.

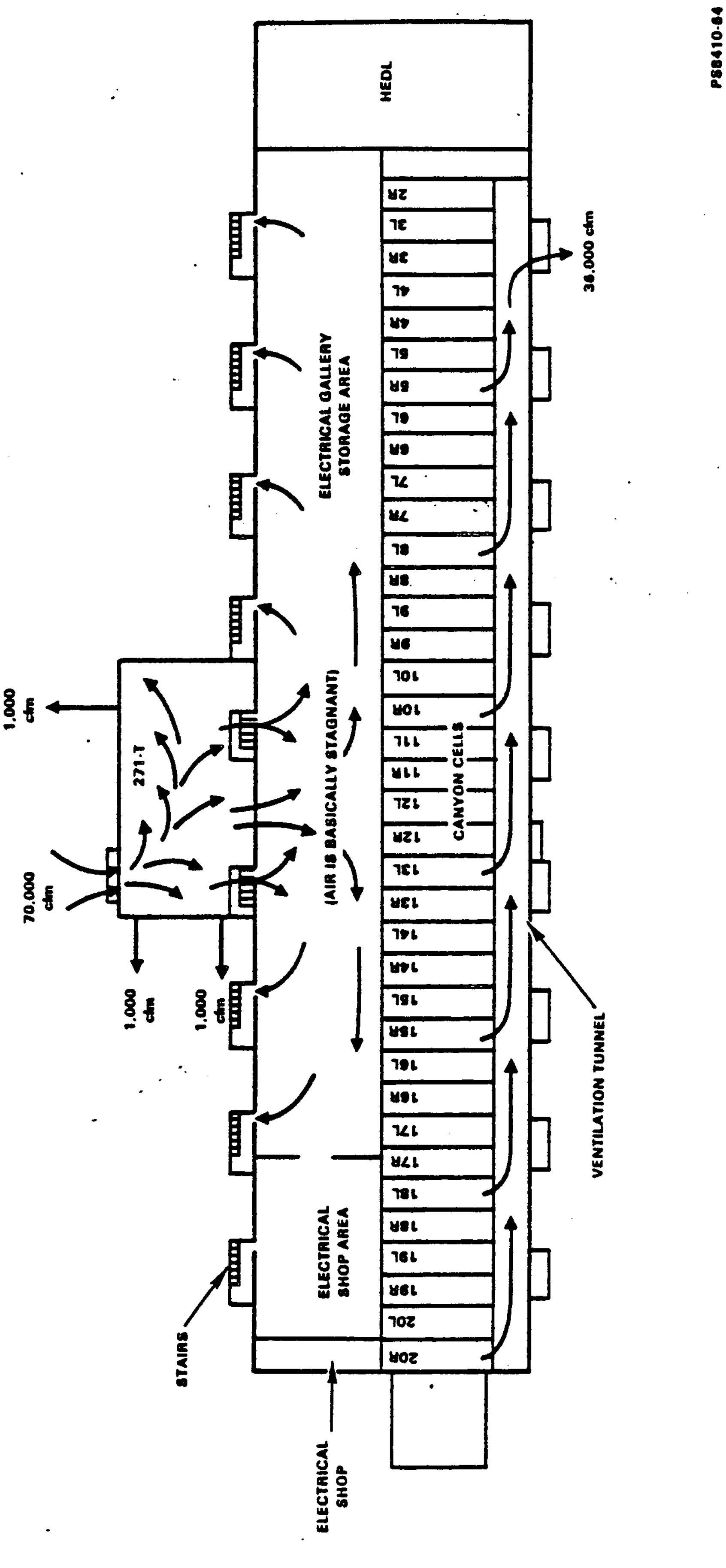

FIGURE 5-9.d. Building 221-T, Third Floor Airflow Diagram.

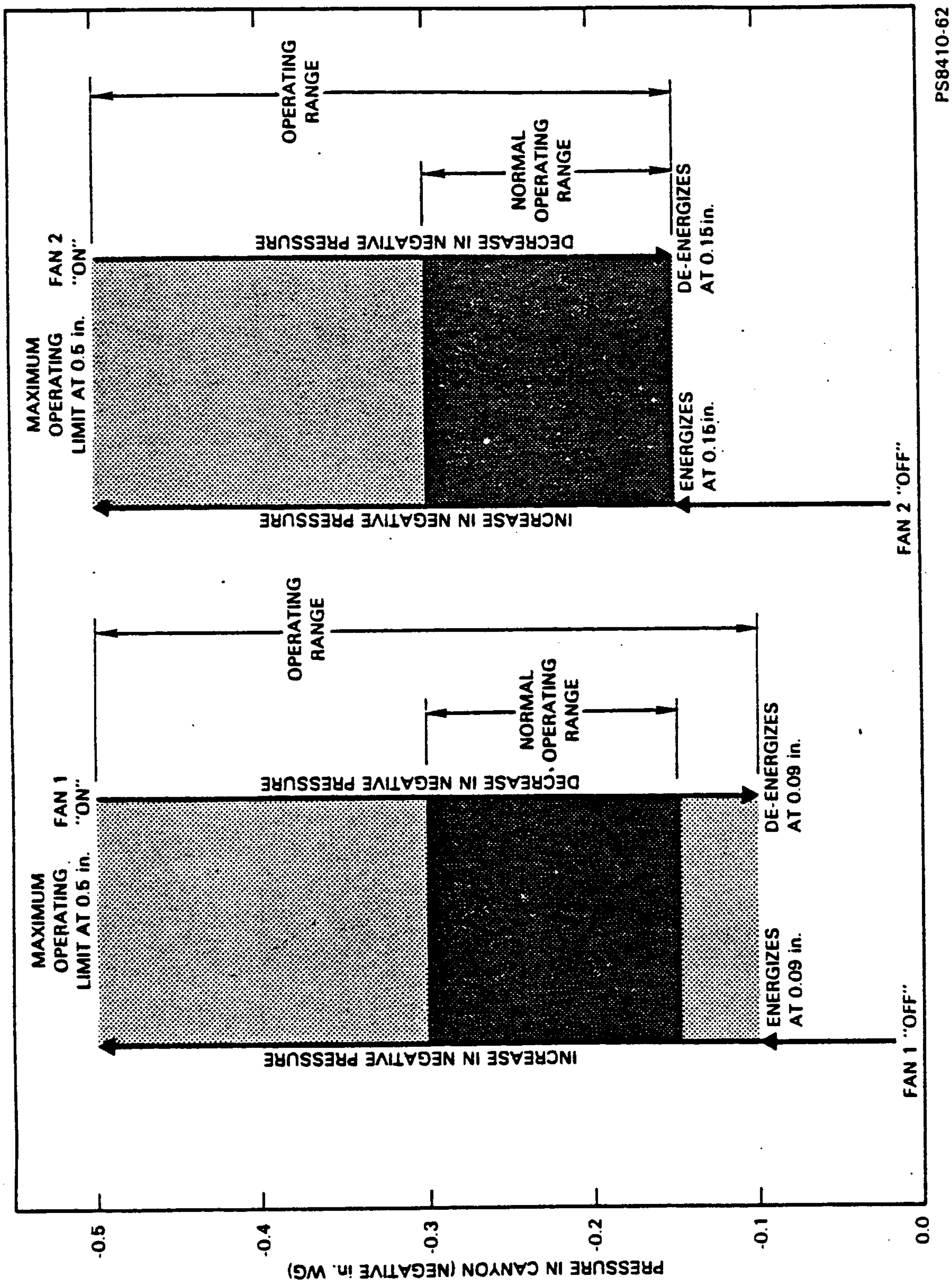

FIGURE 5-10. Building 221-T Ventilation Supply Pressure Control Diagram.

5.3.1.1.2 Building 221-T Galleries. The gallery air supply ventilation consists of seven air handling units each rated at 4,500 ft^3/min. Each unit is located in stairwell fan rooms at the operating gallery level. Normally, only fans located in stairwells 3, 15, 17 and 19 are in use. Each fan is manually controlled from the fan rooms. Outside air is pulled through separate louvered openings for each unit; the air then goes through washing and air filter units before being distributed into the operating gallery. Air is also supplied from the adjoining building 271-T through entry doors at sections 11 and 13. From the operating gallery, the air flows through gratings in the floor and down into the pipe gallery. The air is then exhausted out of the pipe gallery directly into the atmosphere by five fans rated at approximately 3,000 ft^3/min each. Supply air is also provided for the maintenance shops (section 12 through 17) by two cooler/heater units located in sections 14 and 16.

The electrical gallery receives about 5,000 ft^3/min of air from building 271-T through a duct located in section 11. No exhaust system is in use in the electrical gallery; out-leakages through existing stairwells provide exhaust. Supply and exhaust air flows for the three galleries are shown in Figure 5-9.

5.3.1.2 Building 271-T. The inlet supply air for the building 271-T ventilation system comes through a vertical concrete duct 32 ft long by 8 ft wide by 58 ft high. Air is pulled into the fresh air intake duct and then through dustop filters, a preheater (for winter months), an air washer, and a reheater (for winter months) before being discharged by a fan rated at 70,000 ft^3/min. The supply air is then routed throughout the basement and the first, second, and third floors. Fourteen small (1,000 ft^3/min each) air exhaust units are located in building 271-T. There are three in the basement, five on the first floor, four on the second floor, and two on the third floor. These fans exhaust air out of the building directly into the atmosphere.

Some typical readings of DP throughout the buildings 221-T and 271-T during normal operations (291-T exhaust fans, roof exhaust, supply fan 1, all stairwell fans and the 271-T ventilation systems operating) are listed in Table 5-6.

5.3.1.3 Building 2706-T. The ventilation system for the building 2706-T consists of one exhaust system for the railroad and automotive pits and three evaporative coolers located on the south wall of the building. The exhaust does not have a filtration system.[7] The system pulls air from the pits into four 15-in.-diameter vitrified clay ducts that flow into a common 2-ft-diameter clay duct. The air is then exhausted up a 26-in.-diameter by 28-ft-high stack by a fan rated at 5,000 ft^3/min. A small roof exhauster is used to remove hot air near the ceiling of the building.

TABLE 5-6. Typical Differential Pressures.

Airflow	Differential Pressure (in. WG)
Canyon to atmosphere	-0.29
Canyon to operating gallery	-0.26
Operating gallery to office 218, building 221-T	-0.02
Pipe gallery to operating gallery	-0.01
Electrical gallery to operating gallery	-0.02
Operating gallery to atmosphere	-0.03

5.3.2 Electrical System

5.3.2.1 Normal Power. Electrical power is supplied to the Hanford Site from the Bonneville Power Administration substation at Midway through a 240-kV loop (Fig. 5-11). The loop furnishes the primary power to transformers at substation 251-W. There the electrical power is reduced to 13.8 kV and runs through four circuits to the 200 West Area (Fig. 5-12). Two of these lines to 200 West Area, C8-L1 and C8-L2, run into substation C8-S1 (building 252-W) to two transformers rated at 2,500 kVA, and 13.8 to 2.4 kV. Electrical power is then furnished to the T Plant Complex by two normal power incoming lines, E8-L2 and E8-L7. These lines feed 2,400 V to the switch gear equipment in the building 221-T electrical gallery. From the 2,400-V switch gears, E8-L2 and E8-L7 power is fed to 2,400-V/440-V transformers and to 2,400-V/120-240-V transformers for power and lighting, respectively (Fig. 5-13). The 440-V power from the transformers is distributed to cubicles in the electrical gallery where switch gear and distribution circuits for individual pieces of equipment are located to support T Plant activities. The lower voltage transformers feed lighting circuits and various small loads. The electrical feed to building 2706-T is a 440-V line coming from the section 5 panel in the building 221-T electrical gallery. The line comes into the load center located in the northwest corner of building 2706-T. The load center contains all the switch gear for the equipment and lights in building 2706-T.

5.3.2.2 Auxiliary Power. If a power failure occurs on either of the normal lines, E-L2 or E-L7, the loads can be switched at the 440-V level to the other normal line. An auxiliary power line to T Plant is provided in the event that both normal electrical power supply lines fail. Auxiliary power is furnished by a 2,400-V, three-phase line, E8-L16, from powerhouse 284-W, which is powered by substation 252-W.

If a complete loss of power occurs, the 2,400-V feeders, E8-L2 and E8-L7, are automatically backed up by a 750-kW steam turbine generator at the 284-W powerhouse. The generator has the capability of supplying 2400 V on the auxiliary line, E8-L16, and will supply 2,400-V/120-240-V electrical power to two 2,400-V/120-240-V transformers. The only known loads on the

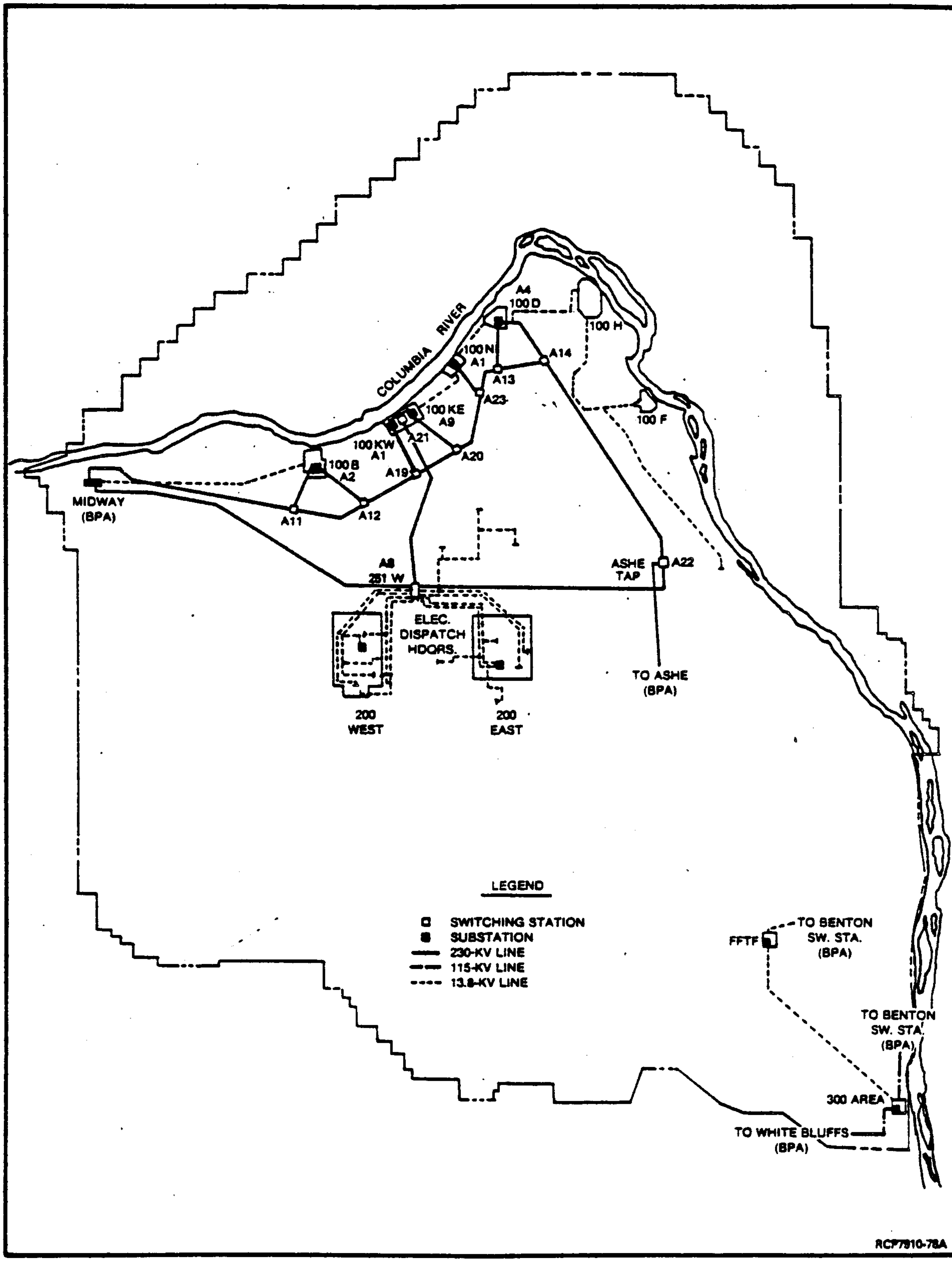

FIGURE 5-11. Hanford Transmission and Power Distribution System.

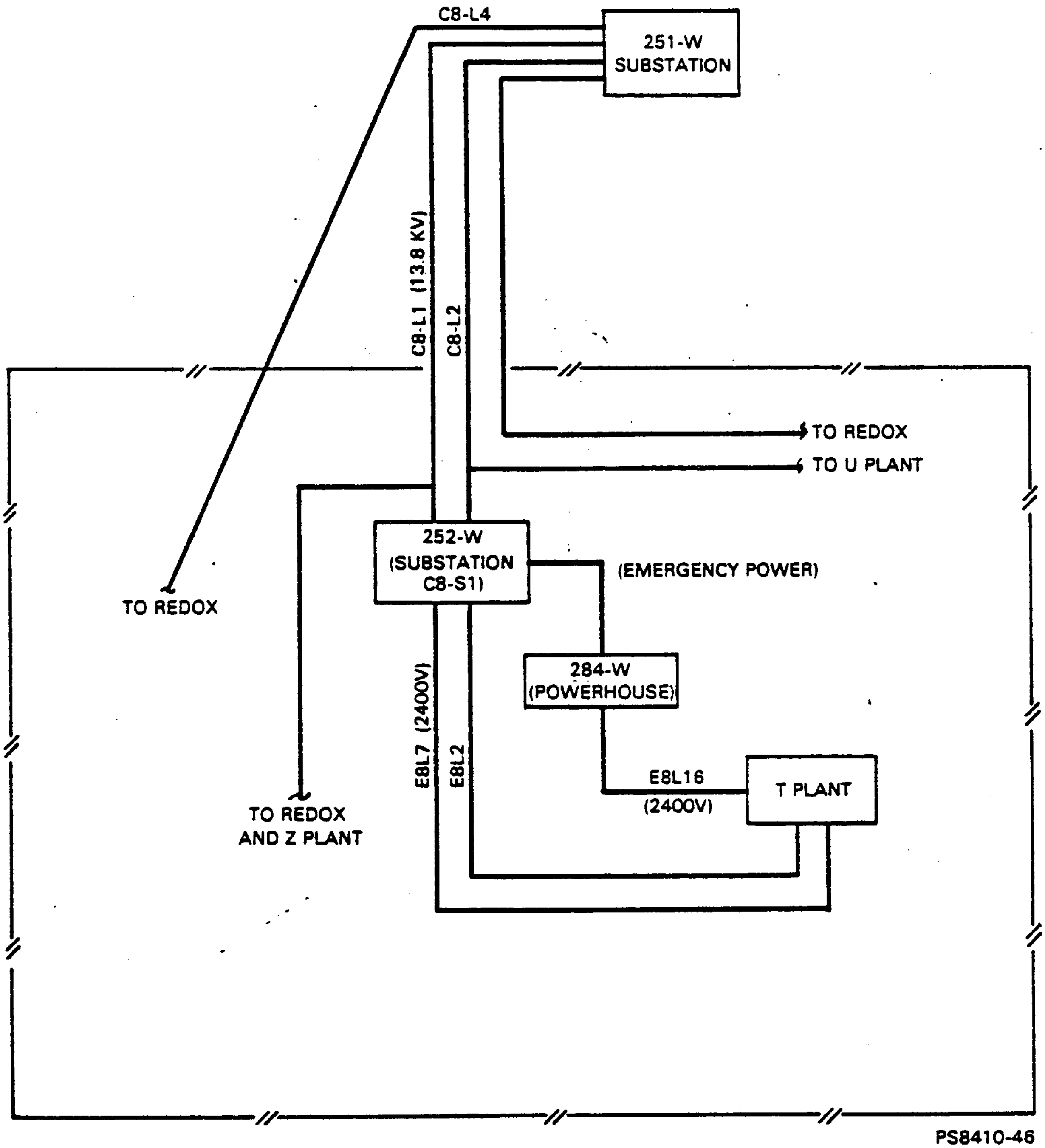

FIGURE 5-12. Distribution of 13,800 V.

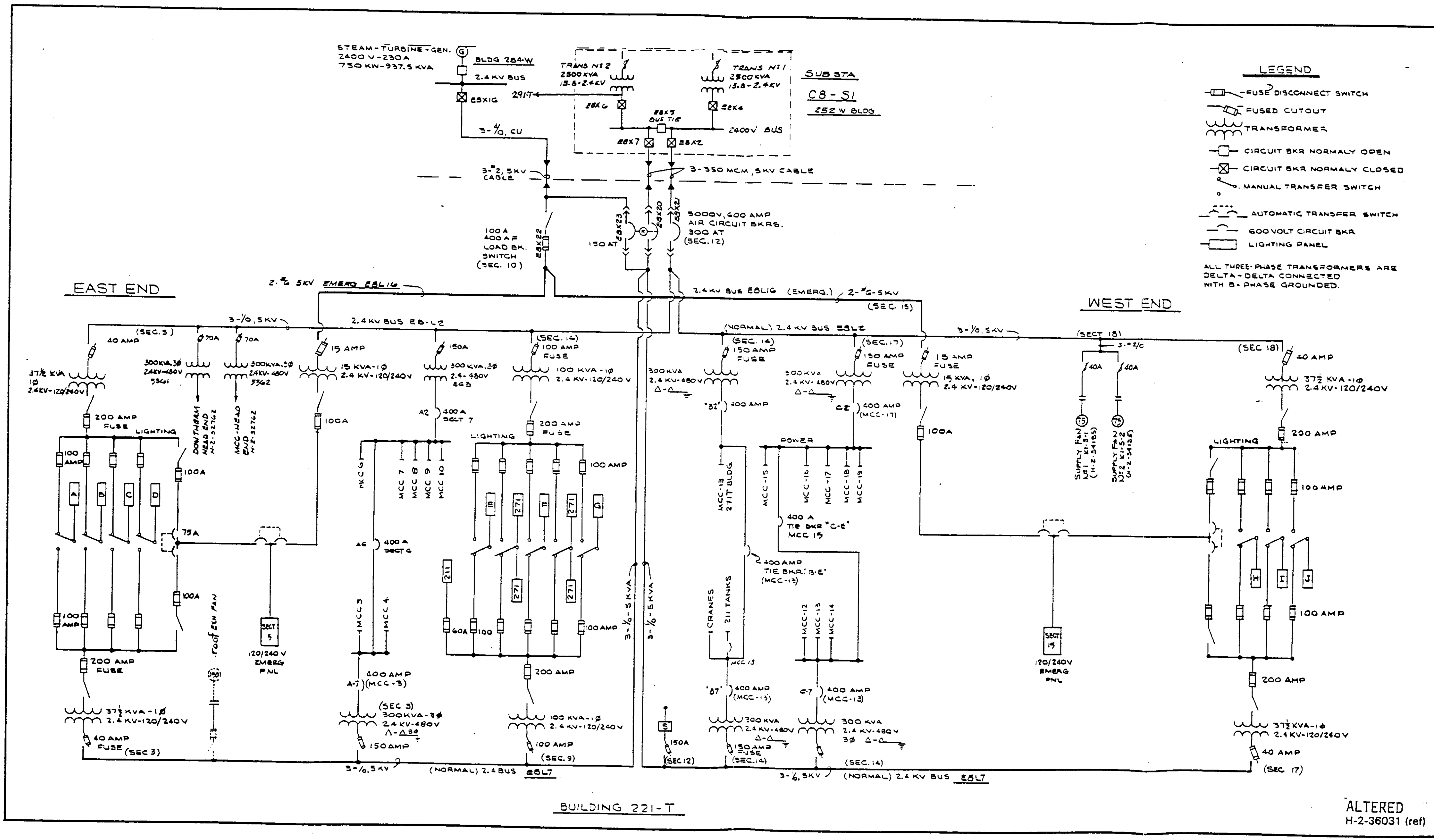

FIGURE 5-13. T Plant Complex Electrical Distribution System.

emergency power system are selected lights in buildings 221-T and 271-T and building 221-T CAMs. Loss of full power stops the operation of the ventilation system in building 221-T canyon and all major decontamination equipment.

If all power external to T Plant fails, 12-V emergency lamps are available to provide emergency lighting throughout various locations in the building 221-T galleries, stairwells, and canyon and in the building 271-T stairwells. There are also two 12-V emergency lamps in building 2706-T, but there is no emergency lighting in building 291-T.

5.3.3 Compressed Air System

Equipment is installed in the building 271-T basement to provide system compressed air and breathing air.

5.3.3.1 Compressed Air (90 lb/in^2). All of T Plant process and instrument air is supplied by two 100-hp compressor units located in the basement of building 271-T (Fig. 5-14). These water-cooled compressors are self-contained units with aftercoolers and control systems built into the system. The compressors distribute process air at a gauge pressure of 90 lb/in^2 throughout the building by use of hard piping. Some service air is routed through an electrodryer. This air is then used for instrument air needs throughout the facility. Instrument air is reduced by PRV to a gauge pressure of 50 lb/in^2 before use. Process and instrument air is routed from building 271-T through 4-in.-diameter piping into the pipe and operating galleries for use. Air enters the building 221-T canyon at various locations by pipe penetrations through the canyon wall. The process air is available for use in the canyon by quick-connect air fittings. The process air is mainly used for the operation of decontamination equipment, air sparging, and air tools.

Process air to building 2706-T is also supplied by a 4-in.-diameter pipe from building 271-T compressors and is used in a similar manner for decontamination purposes and operating equipment.

Controls for the process and instrument air are located in room 218 in the building 221-T operating gallery and in the building 271-T basement.

5.3.3.2 Breathing Air System. Breathing air is available for use where required. The T Plant Complex utilizes two supplied air systems: a compressor-driven breathing air system and a portable cascade bottle system (PCBS).

1. Breathing Air System

   This system consists of one air-cooled compressor (150 lb/in^2 at 37 ft^3/min), an air purifier, a 400-gal receiver tank, a manifold station capable of servicing 12 workers, Schrader-type disconnects, airhose, and single-flow air masks. The system is limited to the handling of 10 workers by administrative controls.

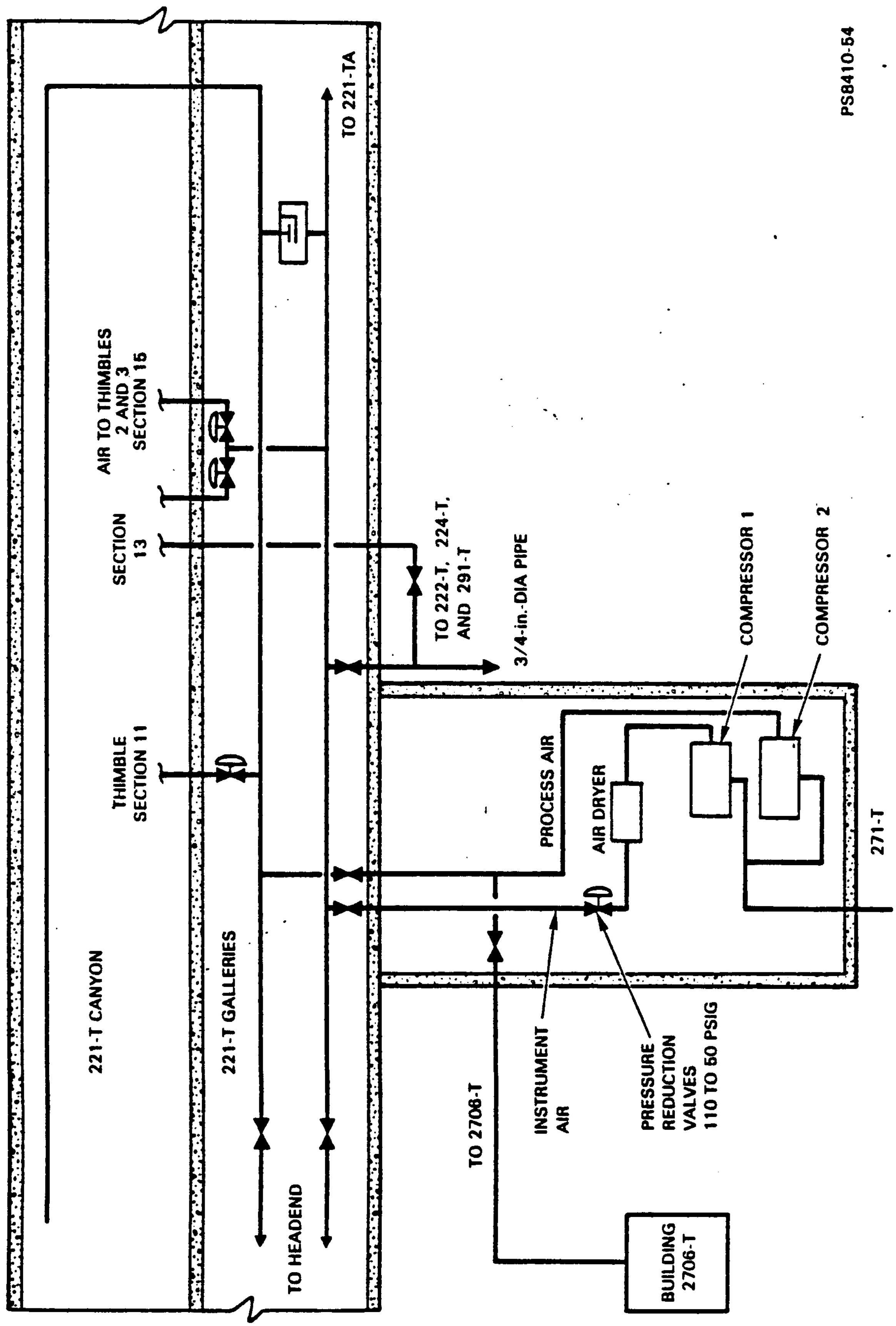

FIGURE 5-14. T Plant Complex Compressed Air System.

The system is capable of handling 10 workers for an unlimited amount of time. The system has a reserve capacity of 5 min in the event of compressor failure. Breathing air is provided by a 1 1/2-in.-diameter pipe that runs through the electrical gallery into a pipe chase, then to the two outside breathing air stations located at sections 13 and 17 on the east side of building 221-T canyon (Fig. 5-15). The breathing air station contains airlocks and six service outlets per station. A service pressure of 125 lb/in^2 is available to each manifold.

2. PCBS

This system utilizes a cart with two compressed air tanks (200 ft^3 each) and five outlets and is capable of using Mine Safety Appliances or Scott pressure demand masks. Both tanks are filled with air at 2,000 lb/in^2; however, only one tank is in service at a time. When the tank being used reaches 500 lb/in^2, an alarm is activated and the monitor [usually an radiation protection technologist (RPT)] switches to a full tank. This assures that a full tank is always available. Only four outlets are used, leaving one for emergency. The PCBS is usually located in the operating gallery, section 20 entry area, for use in any location where breathing air is required but is not available from the breathing air system.

5.3.4 Steam Supply and Distribution System

Steam service for building 221-T is provided from the powerhouse 284-W. The 10-in.-diameter line enters building 221-T through the electrical gallery at section 13. The line then branches out to different levels of buildings 221-T and 271-T to provide service steam. The 225 lb/in^2 steam is reduced to a lower pressure by individual PRV valve stations. The T Plant operations use 20, 90, and 125 lb/in^2 steam. Steam at 125 lb/in^2 is supplied by a 2-in.-diameter line that runs through the canyon walls and then along the inside wall of the canyon. The steam is used for heating solutions, liquid waste transfers, operating portable jets, and steam cleaning. The controls for this canyon supply steam are located in the operating gallery, room 218. Steam at 90 lb/in^2 is supplied to permanent operating equipment in the canyon via the pipe gallery by means of cell jumpers. The 20-lb/in^2 steam is also used for the building 221-TA ventilation supply air heaters.

The original steam distribution system is still in use in building 221-T, except for new valving. At sections 11 and 15, steam lines are run through holes in the wall into the tube bundles located at cell 11R and the decontamination thimbles at section 15R. Additional steam lines are located in wall niches inside the building 221-T canyon. Originally steam was piped to all 20 wall niches in each section. These lines have been deactivated except for three wall niches in sections 5, 14, and 15, which are now used for T Plant operations.

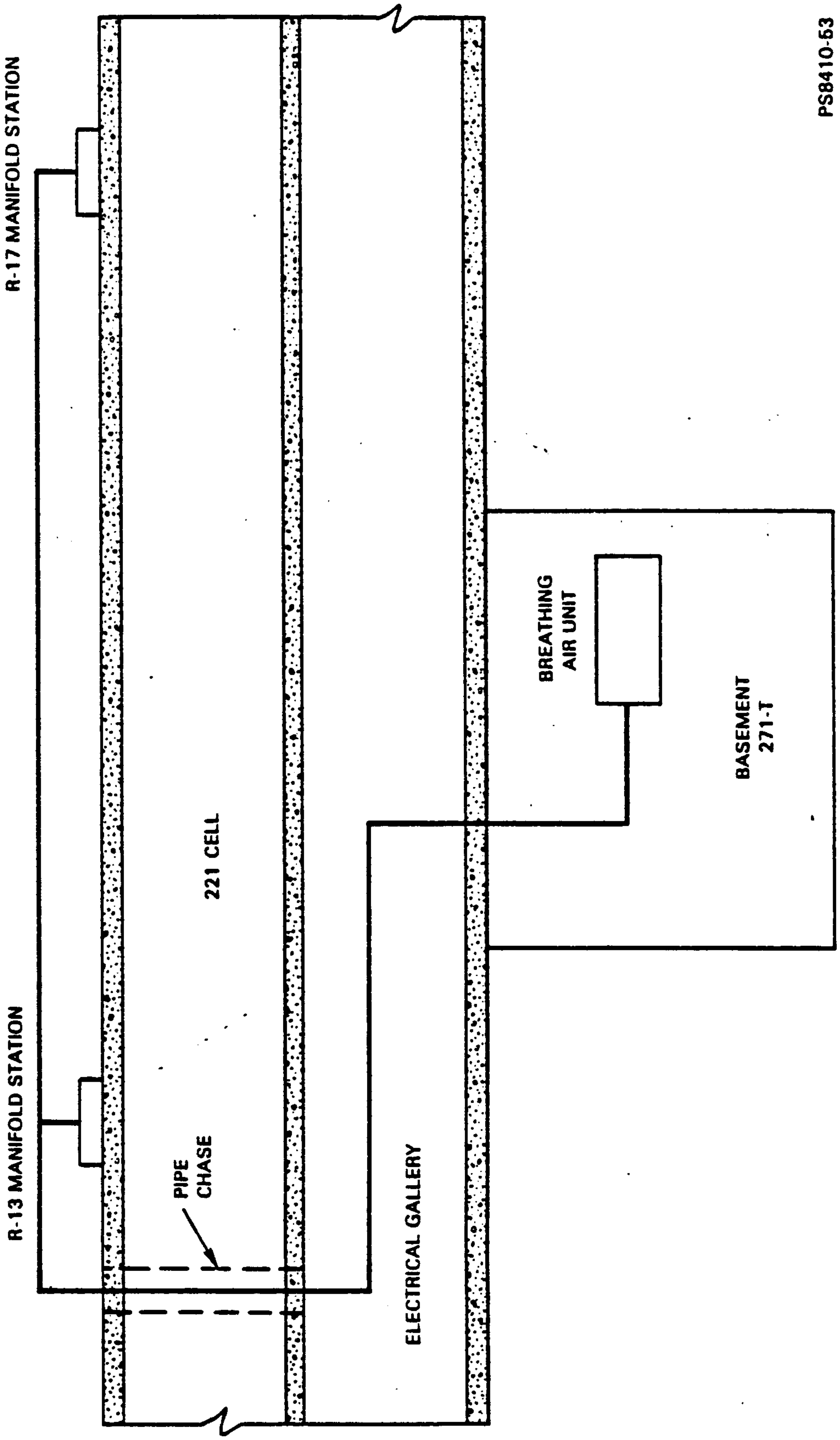

FIGURE 5-15. T Plant Complex Breathing Air System.

The steam supply to building 2706-T is fed from the main header in building 221-T. A 3-in.-diameter header leaves building 221-T at section 10 and provides 90 lb/in^2 steam to the building 271-T chemical makeup room enroute to building 2706-T. The present line supplies 90 lb/in^2 steam to meet the low-level decontamination needs.

5.3.5 Water Supply and Distribution

Water for the 200 Areas is drawn from the Columbia River at the 100-B Area and from two clean water wells. This water is pumped through a piping system known as the "export water system." Pumps at the 100-D Area are tied into this system for use as a backup.

Within the 200 West Area, the "export water" is pumped to the reservoir 282-W which furnishes three million gallons of storage capacity. As needed, the water is then pumped directly to the plants within the 200 West Area as "raw" water for processes, or indirectly through building 282-W for conversion to "sanitary" water by chlorination and filtration. Only raw water and sanitary water are used at the T Plant Complex. The water distribution system within T Plant is shown in Figure 5-16.

- Raw water

  Raw water is treated to remove mud and debris before it is pumped from 283-W. Its primary use at the T Plant Complex is for decontamination purposes and as a cooling medium. An 8-in.-diameter water line enters building 221-T at 100 psig at section 20 in the electrical gallery. The line then reduces to two 3-in.-diameter lines. One line runs into the pipe and operating galleries to supply water to buildings 221-T and 271-T. The other line enters the building 221-T canyon at section 20 in the operating gallery. The control of this water line is maintained by diaphragm-operated valves (DOV) operated by air switches on a panel in room 218, building 221-T operating gallery. Raw water lines are properly trapped to prevent backflow, in accordance with APS-35 of RHO-MA-221.[8]

- Sanitary water

  Sanitary water at 100 psig enters the T Plant electrical gallery at section 20 where it is then routed throughout the operating gallery for use in buildings 221-T, 271-T, and 2706-T. This water is safe for human consumption and is used in lunchrooms, toilets, all showers, and fire hydrants. Sanitary water lines that run through radiation areas are properly trapped to prevent any backflow from the radiation area into the sanitary water system.

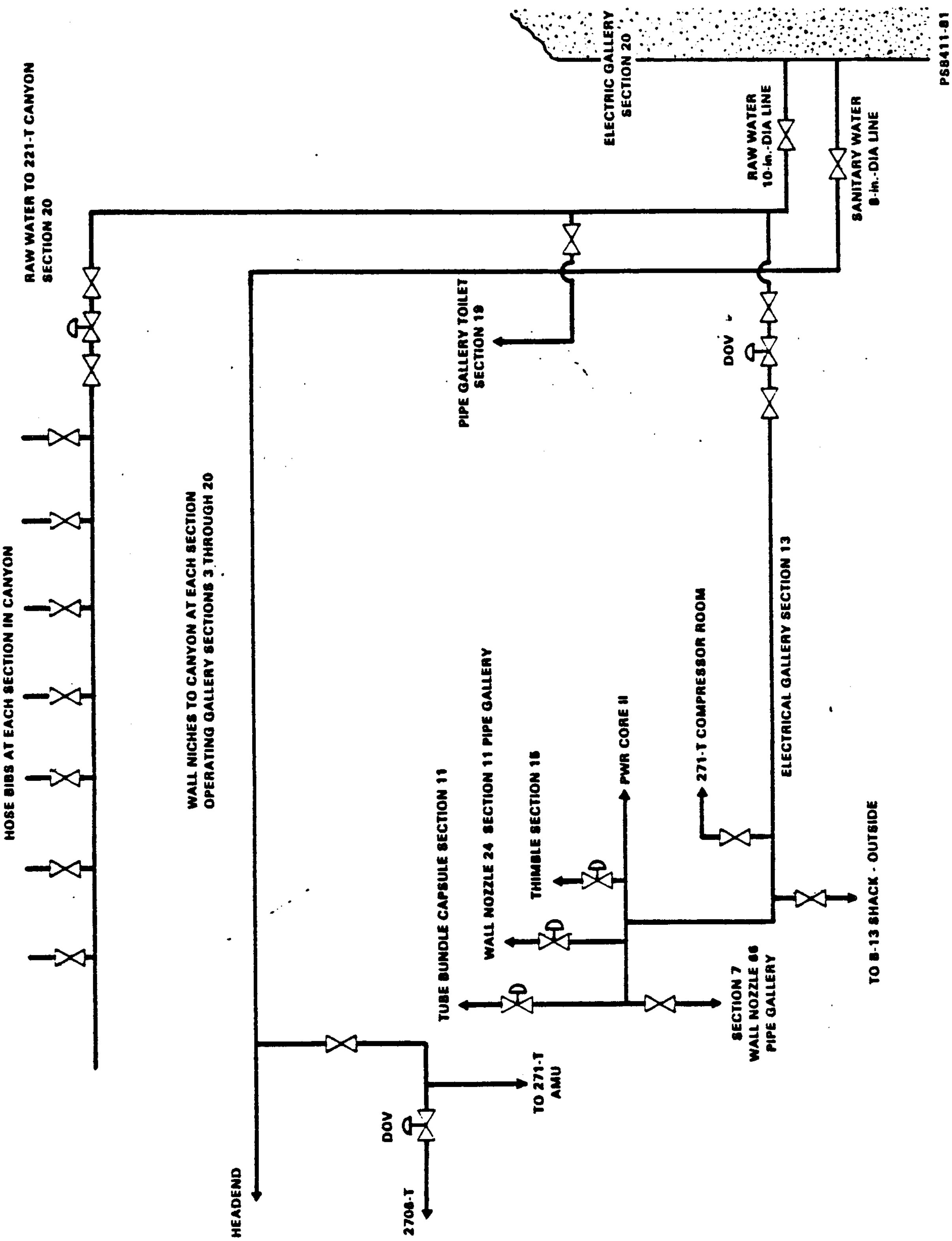

FIGURE 5-16. T Plant Complex Water Supply System.

The valve controls for sanitary water to building 2706-T are located in room 218, building 221-T operating gallery. The control panel operates a DOV located in the building 271-T basement. The water supply to building 2706-T is diverted to different locations by feeder lines of various sizes once inside the facility.

5.3.6 Sewage and Waste Treatment

The T Plant Complex is serviced by the following three liquid nonradioactive waste systems.

- A sanitary sewer system used for drainage of sinks and toilets flows into a tile field located at the north side of the building 221-T.
- The chemical sewer handles the chemical tank drainage, gallery floor drains, and the building 271-T floor drains. The various acid-proof, stainless steel branch lines discharge into a 12-in.-diameter tile line on the northwest side of the building. This tile line runs southeast along the building to join the line from buildings 222-T and 224-T for eventual disposal, as described in Chapter 7.0.
- The 200 West Area tank farms handle all building 221-T canyon liquid waste.

5.4 FIRE PROTECTION SYSTEM

Fire protection for the T Plant Complex is outlined in the following sections.

5.4.1 Buildings 221-T and 271-T

The concrete construction of buildings 221-T and 271-T minimizes the chance of major damage caused by a fire. General fire control planning and response is covered in RHO-MA-111, Rockwell Hanford Operations Emergency Plan.[9] A klaxon alarm system is installed for the building 221-T canyon and the galleries for use in the event of a fire or explosion. The alarm is manually activated from room 218, building 221-T operating gallery. Contact with plant personnel in building 221-T can also be made through the voice-powered phone system (PAX).

Chemical and water fire extinguishers are located throughout building 221-T in the pipe gallery, the operating gallery, the craneway, and the canyon. The extinguishers are mounted on the walls for easy access. Extinguishers are also located in building 221-TA.

There is no ventilation fire protection for the building 221-T canyon ventilation system. However, all the HEPA filters for the building 291-T FI-2 exhaust system and the 296-T-13 exhaust system are constructed of fire-retardant substances. The effect of a fire on the building 221-T canyon exhaust system is addressed in Chapter 9.0.

Building 271-T has a fire detection/alarm system located in the Instrument Electronics Laboratory and manual pull boxes on all three floors and in the basement areas. The laboratory alarm can be activated automatically (by detection of smoke) or manually. The manual pull boxes on each floor are located near each of the stairwells. In addition to the alarm system, a PAX phone is located in building 271-T chemical makeup area and fire extinguishers are strategically located on each floor of the building. Fire extinguishers are also provided for the flammable material storage lean-to, located on the building 271-T receiving dock.

5.4.2 Building 2706-T, Building 2715-T, and Chemical Storage Area 211-T

Building 2706-T is constructed of prefabricated steel, thus reducing potential fire hazard.(5) A minimal amount of combustible materials is stored in the building. Building 2706-T has a fire detection and alarm system located within the decontamination area. The fire detectors are set to alarm at temperatures above 165°F. The alarm can also be activated manually at the control panel on the north wall. A PAX phone and fire extinguishers are located within the building, and a PAX phone is located next to chemical storage area 211-T. The fire protection system for building 2715-T consists of temperature-actuated fire alarms and manual fire extinguishers.

5.5 CHEMICAL SYSTEMS

The decontamination chemicals in use at the T Plant Complex are stored in chemical storage area 211-T, the building 271-T loading dock, the building 221-T pipe gallery sections 4 through 11, or in the building 221-T canyon. Almost all of the chemicals are stored in either chemical storage area 211-T or the building 221-T pipe gallery.

Bulk liquid chemicals, consisting of NaOH (50%) and HNO_3 (57%), are stored in tanks in chemical storage area 211-T. Figure 5-17 shows the equipment layout for chemical storage area 211-T. Tanks SA-102 and SA-103 are 8,000-gal-capacity steel tanks used for HNO_3 bulk storage. The HNO_3 is no longer used in large quantities at T Plant, and the acid distribution system is out of service. Tanks SA-102 and SA-103 contain only a few hundred gallons of acid. They can be filled from a tank truck but not from a railroad tanker, since the piping connecting them to the railroad filling station has been removed.

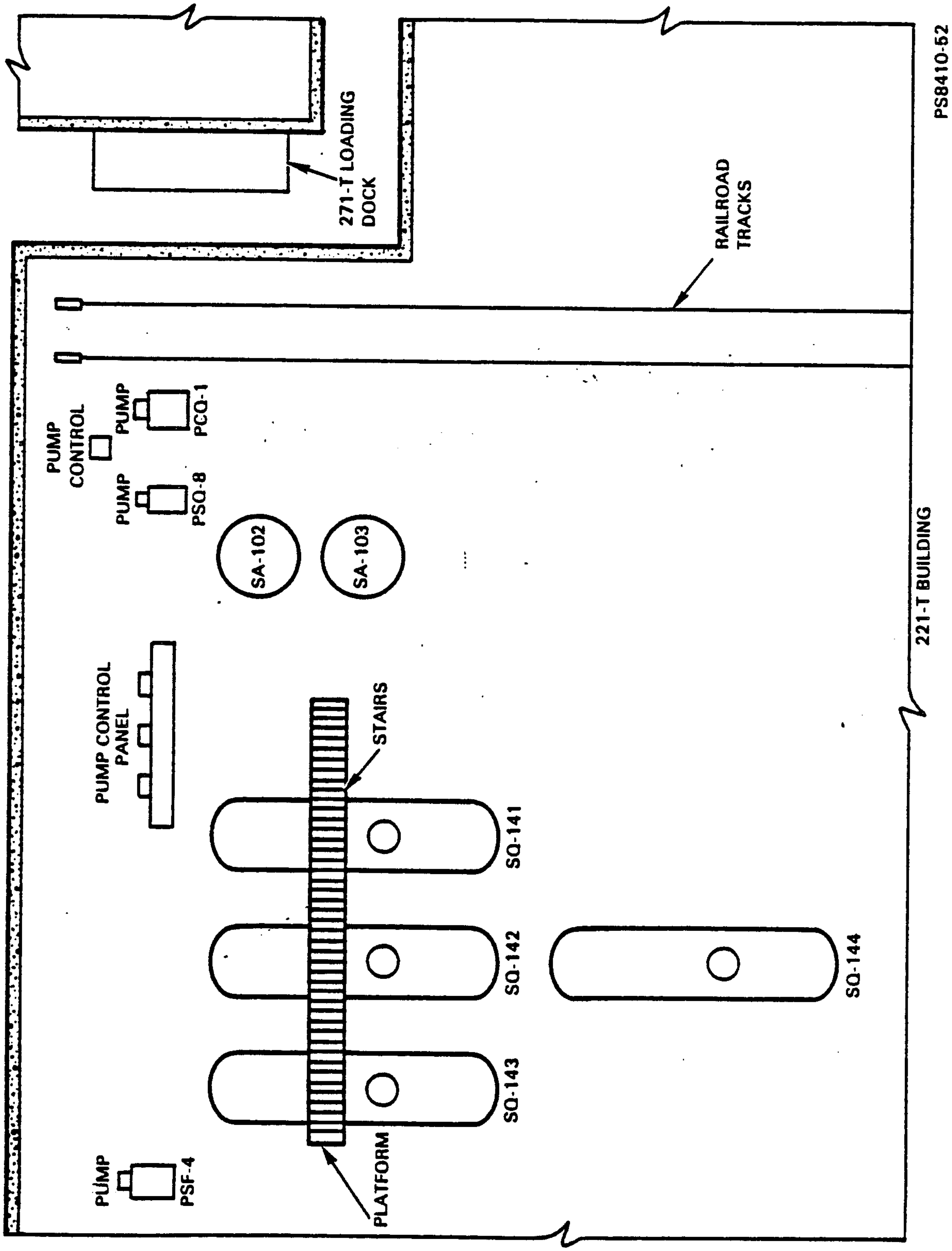

FIGURE 5-17. Chemical Storage Area 211-T.

The HNO_3 can be pumped by pump PSQ-8 from chemical storage area 211-T into tanks H-303 or H-304, located on the third floor of building 271-T. Acid in these tanks can then be diluted as required and drained into the canyon for use in various decontamination activities. As mentioned, HNO_3 is not used in bulk quantities at T Plant. Tanks H-303 and H-304 are, therefore, not in service. When HNO_3 is required for use in decontamination activities, it is drained from SA-102 or SA-103 and carried into the canyon in drums.

Tanks SQ-141 and SQ-142 are 17,000-gal-capacity tanks used for bulk storage of NaOH. Tanks SQ-143 and SQ-144 are not in service and are empty. The active NaOH tanks on tank farm area 211-T are filled from a railroad tanker using pump PCQ-1.

The NaOH is pumped into tanks M-101 or M-102 on the second floor of building 271-T by pump PSF-4. The caustic solution is then further diluted as required and stored for use in the canyon. Other decontamination solutions are also mixed in these tanks,[10] although normally tank M-101 is used only for mixing and interim storage of NaOH solution. The T Plant chemical distribution system is shown in detail in Figure 6-2.

Dry chemicals are stored in various containers (i.e., 55-gal drums) of different sizes and quantities. Liquids in drums are stored in appropriate areas according to their characteristics. Flammable materials are placed in the lean-to at the building 271-T dock and their containers are grounded. The other chemicals are placed on pallets and stored in the building 221-T pipe gallery.

5.6 REFERENCES

1. General Electric, "Separations," Section C in Hanford Engineering Works Technical Manual, HW-10475, General Electric Hanford Company, Richland, Washington (May 1, 1944).

2. R. A. Kenerly, Use of T Plant Canyon as a Decontamination Facility, HW-48467, Hanford Atomic Products Operations, General Electric Hanford Company, Richland, Washington (February 14, 1957).

3. G. L. Hanson and R. R. Jackson, Safety Assessment Document PWR Core II Project, RHO-CD-356, Rockwell Hanford Operations, Richland, Washington (April 1978).

4. B. C. McClelland, PWR Core II Operations Safety Requirements, RHO-CD-423, Rockwell Hanford Operations, Richland, Washington (June 1978).

5. General Electric, Project Proposal, Equipment Decontamination Building - 2706-W Project CAC-812, HW-56106, General Electric Hanford Company, Richland, Washington (May 26, 1958).

6. Rockwell, Radiation Work Permits - T Plant and Associated Facilities, RHO-MA-172, Rockwell Hanford Operations, Richland, Washington.

7. E. N. Dodd to M. T. Bayless, "T Plant Ventilation System," Internal Letter 72320-79-275, Rockwell Hanford Operations, Richland, Washington (November 12, 1979).

8. Rockwell, Accident Prevention Standards, RHO-MA-221, Rockwell Hanford Operations, Richland, Washington.

9. Rockwell, "Emergency Plan Z Plant," Section 11.4, in Rockwell Hanford Operations Emergency Plan, RHO-MA-111, Rockwell Hanford Operations, Richland, Washington.

10. Rockwell, T Plant Special Services Operation Training Manual, RHO-MA-232, Rockwell Hanford Operations, Richland, Washington.

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6.0 PROCESS SYSTEMS

6.1 INTRODUCTION

Most decontamination operations at T Plant are accomplished in the building 221-T canyon. Building 2706-T is used only to decontaminate railroad equipment, buses, automobiles, road building equipment, and some plant process equipment.

Process equipment is decontaminated for the following reasons:

1. To determine reasons for failure

2. To determine extent of damage

3. To gather information for decision to refurbish, repair, or replace with new equipment

4. Repair

5. Bury.

Contaminated equipment, fuel casks, or equipment requiring transloading or repair is transported to the T Plant Complex from Hanford Site contractors via the Hanford Site highway or railroad systems. The T Plant operators perform decontamination operations on equipment that is contaminated with alpha- and beta-gamma-emitting radionuclides. The T Plant is a limited control facility and is not capable of handling large amounts of fissile material.(1) Depending on radiation levels, the equipment is either sent to the building 221-T canyon or the building 2706-T low-level decontamination facility. Items that exceed 100 mrad/h near the surface or that have alpha contamination are prohibited in building 2706-T unless approved by Decontamination Operations and the Radiation Monitoring Managers. All other high dose rate and alpha-beta-gamma-contaminated equipment is transported into the building 221-T canyon via the canyon railroad tunnel located at section 2.

Equipment is transported into the canyon as discussed in 6.2.2. A flow diagram of the decontamination process within the T Plant Facilities is shown in Figure 6-1. This figure shows the normal work process at the T Plant Complex from the time an item is received for decontamination until it leaves the plant as solid radioactive waste or as refurbished equipment ready for service. The following listing indicates the types of equipment serviced at T Plant:

- PUREX Plant dissolvers

- PUREX E-2 and E-4 centrifuges

- B Plant centrifuges

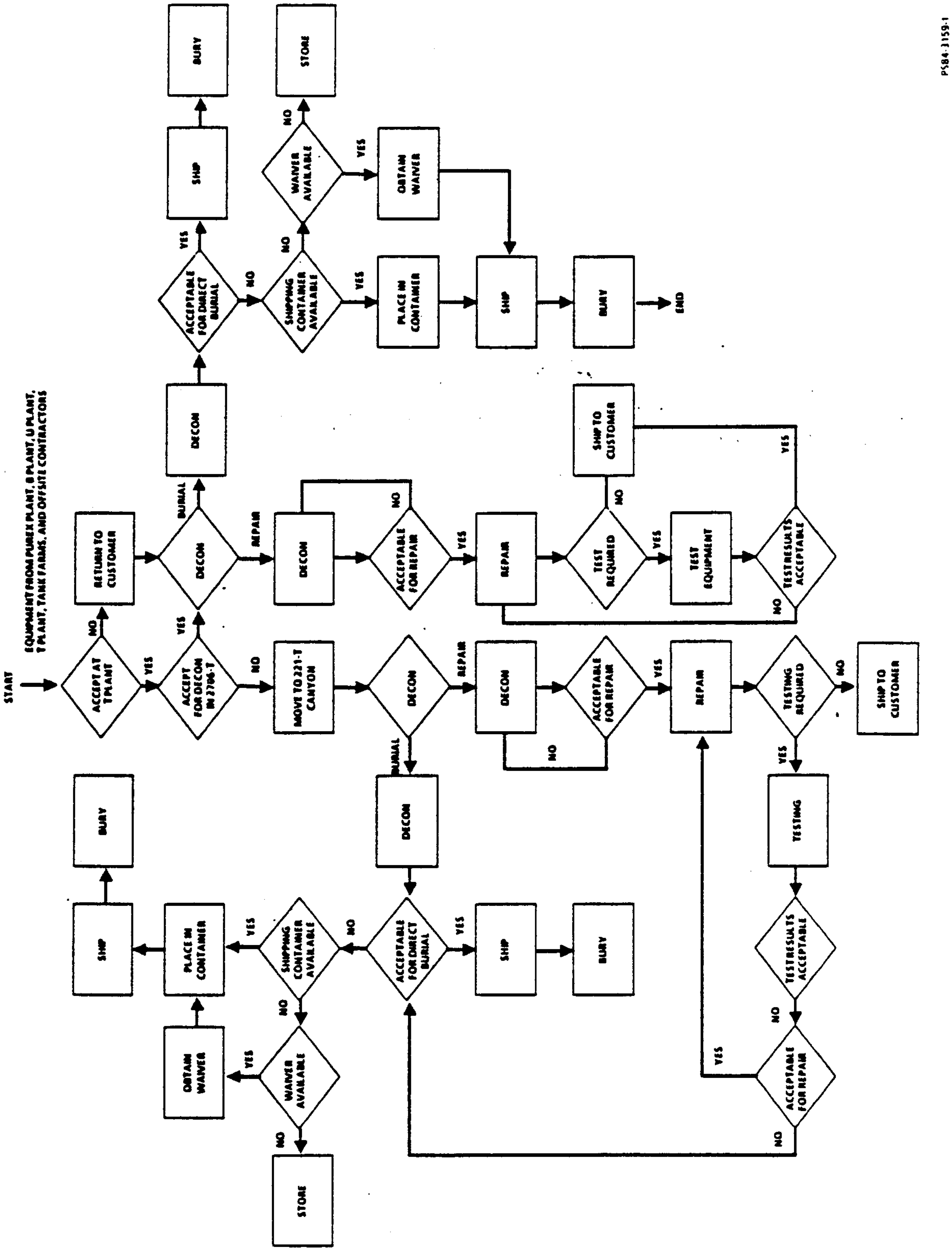

FIGURE 6-1. T Plant Complex Process Flow Diagram.

- PUREX Plant small and large pulse columns
- B Plant small and large pulse columns
- B Plant, PUREX Plant, and Tank Farm pumps
- B Plant, PUREX Plant, and Tank Farm agitators
- B Plant, PUREX Plant, and Tank Farm process vessels
- B Plant and PUREX Plant connector heads and jumper assemblies
- PUREX Plant and B Plant tube bundles for condenser/reboiler heat exchanger
- Well cask cars
- PUREX Plant and B Plant impact wrenches
- Various piping and valves
- Vehicles and rolling stock (flatbed railroad cars, waste tankers, acid cars, etc.)
- Crane equipment
- Fuel transport and unloading equipment
- Instrumentation
- Speciality equipment (radiography cameras, CAM units, etc.)
- Sampling equipment.

Equipment to be decontaminated or refurbished is brought into the building 221-T tunnel and then transferred to the canyon deck storage area (sections 1 through 10) by the overhead 75-ton-capacity crane. A 10-ton-capacity crane is also available for handling, positioning, and maneuvering equipment within the building 221-T canyon.

Equipment stored in sections 4 through 10 is transferred to section 11, 12, 13, 14, or 15 if decontamination is required to reduce exposure limits in preparation for repair or burial. If possible, before decontamination operations begin, an evaluation is made to determine probable causes of failure and to request repairs.

Decontamination of equipment is performed on 3/8-in.-thick stainless steel pads resting on cell cover blocks 11-R, 13-R, and 15-R. Open cells 12L and 12R are used for in-cell flushing of highly contaminated equipment. After completion of decontamination operations, another decision is made to either refurbish, test, store, or prepare the equipment for burial.

All repair and testing is performed in sections 16 through 20. The centrifuge run-in test station is located on the deck in sections 16 and 17. The pump run-in testing is performed in section 19 where a 4,000-gal-capacity recirculating tank is located in cell 19R. The cell has been converted to a shop for pump repair. The deck area in sections 16 through 20 can be rearranged when equipment testing is required.

When repair and testing are complete, an evaluation is made to determine if the equipment meets the criteria specified by the customer. The equipment is then relocated to sections 4 through 10 where it is either prepared for shipment back to the customer or is placed in a container for burial. All equipment that leaves the building 221-T canyon is removed through the railroad tunnel in transport or burial containers.

The PWR spent fuel storage facility is located in cell 2R. There are seventy-two 12-ft-long irradiated PWR fuel elements stored underwater in a 13-ft-high by 27.5-ft-long by 28-ft-wide cell. The elements have been stored since 1978 and are being held for processing at the PUREX Plant.[2,3]

Transloading operations are also performed in the building 221-T canyon tunnel. Transloading involves the transfer of equipment from a shipping container to another shipping or burial container. Safety hazard analysis, special radiation work permits (RWP), and standard operating procedures (SOP) are used by T Plant operations personnel when performing transloading operations.[4-6]

Building 2706-T is used mainly for the low-level decontamination of vehicles and equipment (e.g., flatbeds, waste tankers, acid cars). Small equipment is occasionally also decontaminated and repaired. A variety of equipment is brought in through two rollup doors: a 16-ft-high by 12-ft-wide door that leads to the railroad pit, and a 14-ft-high by 9-ft-wide door that leads to the automobile pit. Movement of heavy equipment inside building 2706-T is accomplished by a 10-ton-capacity bridge crane. All vehicle and rolling stock decontamination operations are performed over two cleaning pits: a 55-ft-long by 17-ft-wide by 6-ft 3 1/2-in.-deep railroad pit, and a 30-ft-long by 4-ft 2-in.-wide by 6-ft-deep automotive pit. Other equipment is decontaminated on the deck area over the pits, on the decontamination pad, or in the thimbles. Building 2706-T contains equipment used for steam cleaning; high-pressure water application, dry sandblasting, and wet sandblasting; and chemical decontamination activities. After the completion of the decontamination activities, repairs are made to put the equipment back in service or, if beyond repair, the equipment is placed in a container to be buried. Equipment that is repaired is returned to the customer.

6.2 EQUIPMENT RECEIPT, HANDLING, AND STORAGE

6.2.1 Principal Sources

The T Plant Complex receives most of its equipment for decontamination, refurbishment, burial, or storage from the Hanford Site 200 East and 200 West Areas; however, equipment from other Hanford Site contractors and from the DOE may also be received.

The T Plant is not a typical processing plant; therefore, the type and quantity of equipment received varies with demand in support of Hanford Site processing plants. The T Plant supports primarily the PUREX Plant, B Plant, and Tank Farm Operations.

6.2.2 Method of Receiving and Handling

Shipping containers must comply with all requirements of RHO-MA-222 before T Plant can receive and handle them.(7) The SOP are required for the use of shipping and burial containers. The use of containers is evaluated and described in detail in various Safety Analysis Reports for Packaging (SARP).(8-11)

Equipment may be received at the T Plant Complex in any of the following containers:

- Burial and Storage Containers
  - Fiberboard box
  - General purpose burial box
  - Lined plywood burial box
  - Plastic film
  - Canyon burial box.
- Multipurpose Containers
  - 55-gal drum
  - Department of Transportation (DOT)-6M.

- Transfer Containers
  - Laundry bag
  - Multipurpose transfer (MPT) box
  - Reusable transfer box CI 447R.(4)

6.2.2.1 Multipurpose Transfer Box. Most of the equipment that enters building 221-T is contained in the MPT box. Instructions for use of the MPT box are given in the T Plant SOP.(4)

The contamination present on the equipment shipped via MPT boxes is predominantly dry salts containing FP, primarily ^{90}Sr and ^{137}Cs, in the form of nitrates, sulfates, and chlorides. Use of the box is limited to nonfissile waste shipments (less than 15 g of plutonium or ^{235}U). All shipping requirements for an MPT box are outlined in SARP HCS-039-001.(8)

Before unloading an MPT box, all personnel are cleared from the railroad tunnel and the tunnel door is closed to prevent personnel exposure to potentially high dose rates and to contain the contamination. Occupants of the headend are also notified and evacuated if necessary (in the event they were not notified, occupants would be warned of high radiation levels by installed radiation air monitors (RAM) in the headend).

6.2.2.2 Plastic Wrap. Equipment wrapped in plastic is received in the building 221-T canyon or building 2706-T on trucks or railroad cars. The items are wrapped in polyethylene plastic or polyvinyl chloride plastic of at least 4 mil (nominal) thickness. The items must have a minimum of two layers of plastic wrap. The plastic wrap is used only for non-transuranic (TRU) waste. The radiation levels and controls for use are specified in SARP HCS-057-003.(9)

6.2.2.3 Cardboard Waste Carton. Cardboard waste cartons are used to transfer small tools and equipment into building 2706-T and the building 221-T canyon. Controls and handling of this container are described in SARPS HCS-047-001 and HCS-047-002 and T Plant operating procedures.(4,10,11)

6.2.2.4 Rolling Stock and Vehicles. Railroad cars and vehicles used to transport chemicals, contaminated equipment, and decontaminated equipment are handled at buildings 221-T and 2706-T. This includes, but is not limited to, waste tankers, acid cars, flatbed railroad cars, trucks, buses, and automobiles.

Railroad cars are brought into building 2706-T through the large rollup door. An air tugger is used to move railroad rolling stock on and off of the railroad decontamination pit. Other vehicles are driven or pushed into the building.

6.2.2.5 Chemical Receiving and Handling. Bulk chemicals, NaOH (50% caustic), and 57% HNO_3 are received by truck or rail tank car in chemical storage area 211-T. The NaOH is transferred by pump PCQ-1 to two 17,000-gal-capacity, horizontal, carbon steel tanks, SQ-141 and SQ-142 (Fig. 6-2). The HNO_3 is transferred from a tank truck to two vertical 8,000-gal-capacity tanks, SA-102 and SA-103. The NaOH and HNO_3 shipments are sampled before unloading.

The NaOH and HNO_3 are transferred from the building 211-T holding tanks by pumps PSF-4 and PSQ-8 into the building 271-T chemical makeup facility (see Fig. 6-2). The NaOH is transferred by a 2-in.-diameter pipe to the building 271-T chemical makeup room where tanks M-101 (1,200-gal-capacity) and M-102 (3,000-gal-capacity) are available for use. These tanks store the NaOH for use in the building 221-T canyon. Tank TK-M-101 is used primarily to make up 25 wt% NaOH. Tank TK-M-102 is also used to make up other chemical solutions. Tanks TK-M-101 and TK-M-102 are equipped with pumps and 2-in.-diameter distribution piping for transferring chemical solutions to the building 271-T loadout dock or to the building 221-T canyon at sections 11, 13, and 15.

The HNO_3 can be transferred from building 211-T by a 2-in.-diameter pipe to the third floor of the building 271-T, where two 850-gal-capacity tanks, TK-H-303 and TK-H-304, are available for use. These tanks are not in service, but are available for use in making up dilute solutions of HNO_3 for use in the building 221-T canyon if large quantities of HNO_3 are ever needed for a special decontamination task. The HNO_3 can then be gravity fed by piping from 271-T to sections 12 and 15 inside the building 221-T canyon. Current practice is to carry what little HNO_3 is needed into the canyon in 5-gal containers.

Chemical transfers within building 221-T are made by using pump and valve controls located inside and outside of the building 221-T canyon at sections 11 and 15 and in the makeup room in building 271-T. Most of the decontamination solutions used in building 221-T canyon are made up in auxiliary tanks or 55-gal drums inside the building 221-T canyon.[1] All bulk dry chemicals used for decontamination are stored on pallets in the building 221-T pipe gallery, sections 3 through 10, or in a lean-to on the building 271-T loading dock. The chemical distribution system for the building 221-T canyon is shown in Figure 6-3.

Chemical distribution piping to the building 2706-T low-level decontamination facility is not provided. Consequently, all chemicals used in building 2706-T are transported by forklift or truck from building 271-T and are made up in auxiliary tanks or drums located inside building 2706-T.

All chemical handling, storage, and distribution is controlled by T Plant SOP and accident prevention standards (APS).[12]

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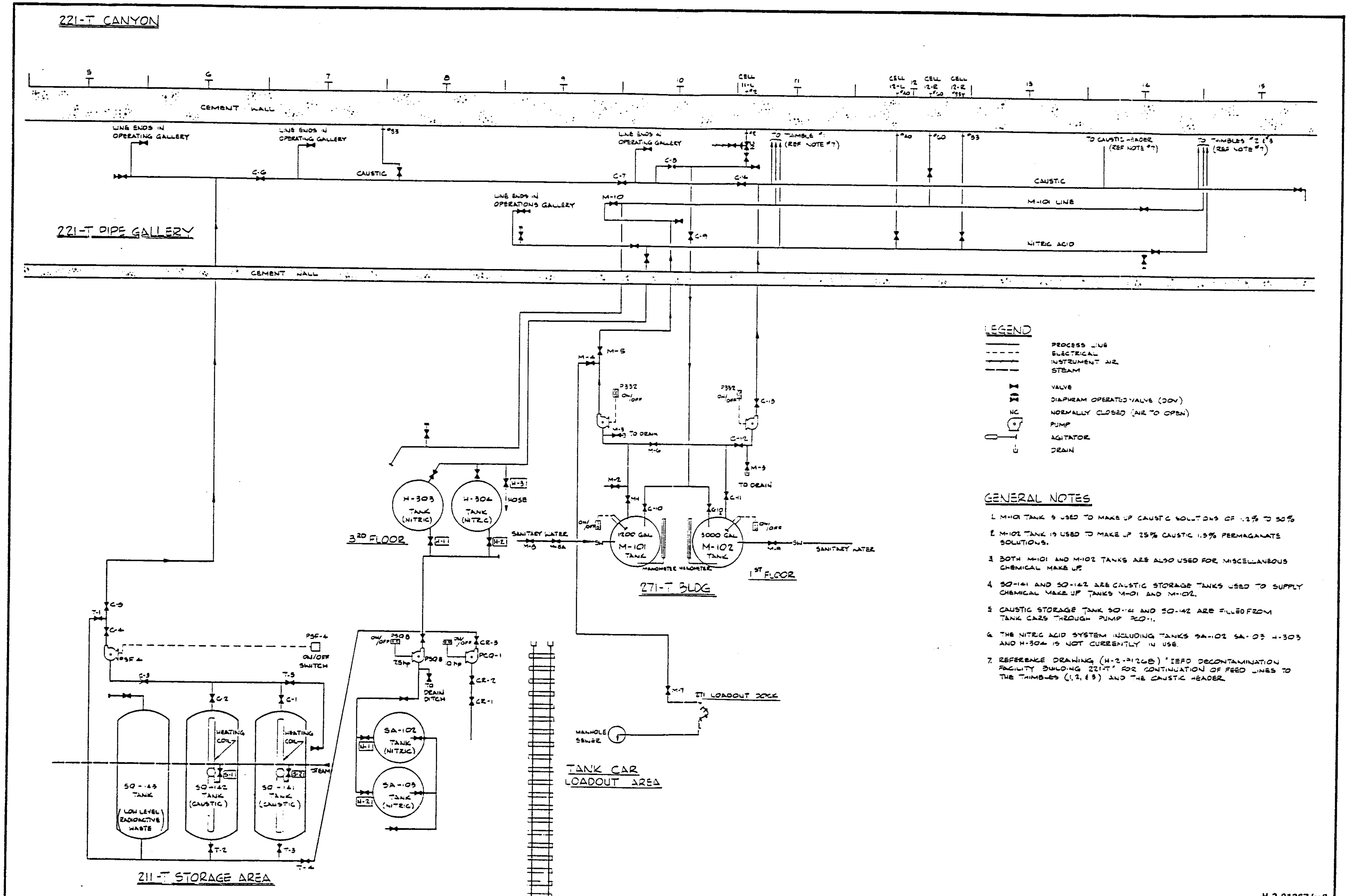

FIGURE 6-2. T Plant Complex Chemical Distribution System.

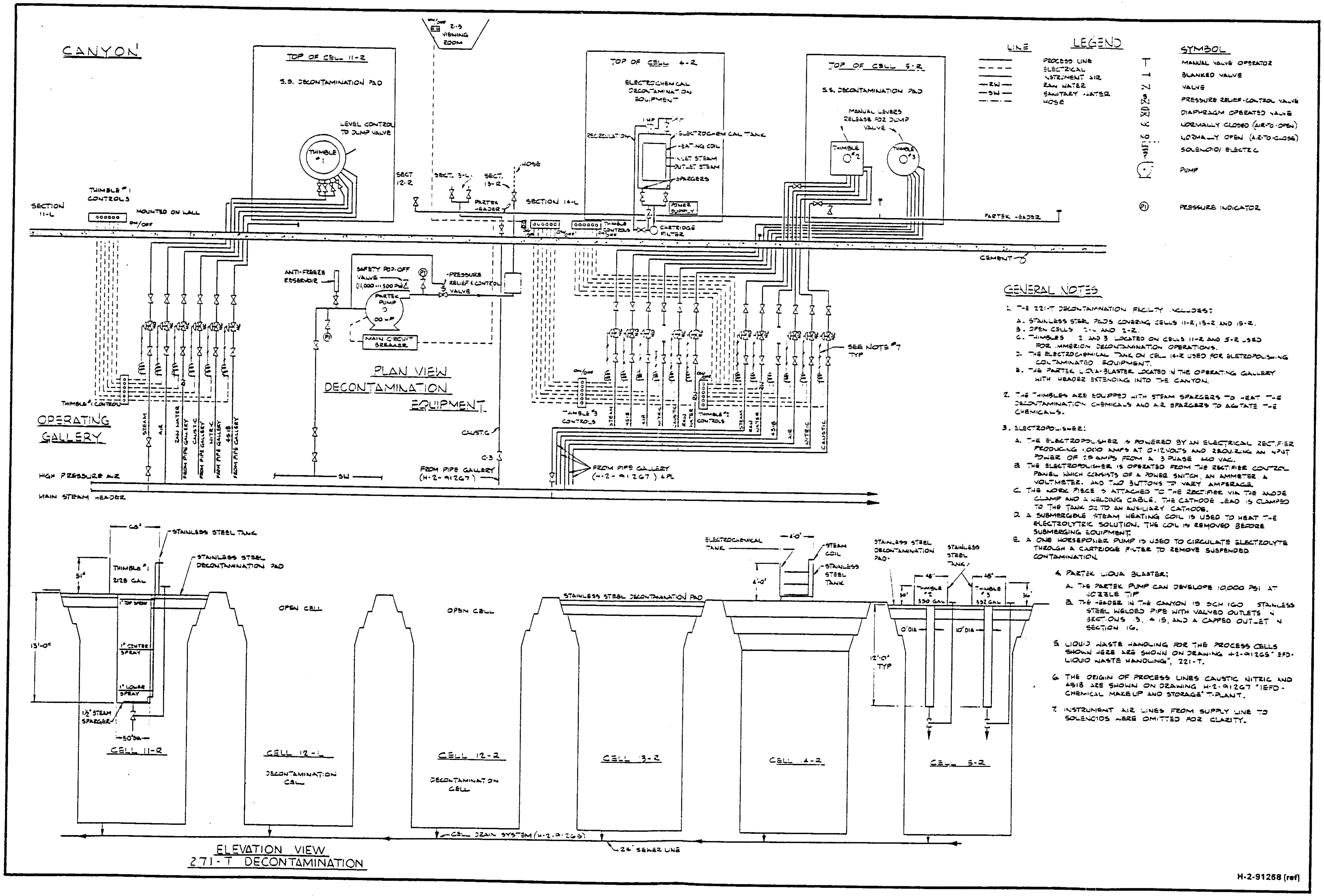

FIGURE 6-3. Building 221-T Chemical Distribution System.

6.3 DECONTAMINATION, REPAIR, AND SHIPMENT PROCESS SYSTEM

The main process system in T Plant is decontamination and refurbishment work on process equipment as needed to support Hanford Site contractors. The equipment is initially decontaminated to lower radiation levels to reduce personnel exposure during maintenance or to meet burial requirements. This allows an inspection to be performed by T Plant maintenance personnel to determine the cause of failure and to see if repairs are practical. Repairs are completed (if practical) and the equipment undergoes operability testing to ensure that it is functioning according to specified requirements. The equipment is then packaged and placed in storage for shipment to the customer. Equipment that cannot be repaired is sent to the burial grounds for disposal.

6.3.1 Building 221-T Canyon Decontamination Facility

6.3.1.1 Transfer of Equipment from Railroad to Canyon Deck and Cell Area. Equipment received in the building 221-T canyon is unloaded from the railroad tunnel by use of the overhead 75-ton-capacity crane. The following conditions must be met during unloading of equipment from the railroad tunnel.

- All personnel must be cleared from the railroad tunnel. The RPT determines if evacuation of the canyon due to high radiation levels is necessary during unloading. If necessary, personnel are also evacuated from the headend facility until unloading operations are completed.

- The railroad tunnel door must be closed while an MPT box is being unloaded to prevent a potential radioactive release to the environment. During the unloading of other containers, the decontamination manager and RPT determine if the tunnel door may remain open.

- The canyon ventilation system must be operating properly (one 291-T exhaust fan running, 0.025-in. DP from canyon to gallery).

When all requirements for unloading have been met, the crane operator removes the equipment from the shipping container and places it in one of the following locations:

- Sections 4 through 10, on the canyon deck, for temporary storage/ staging

- Decontamination pads 11R, 13R, or 15R for immediate decontamination activities

- Sections 16 through 20 for repair and run-in testing if radiation levels meet radiation monitoring specifications
- Cell 12L or 12R for in-cell decontamination.

Once in the canyon, the equipment is surveyed by the RPT for radiation levels and removable surface contamination. If alpha contamination is detected, the work area around the equipment is zoned off for control purposes and step-off pads and a survey station are established at the exit from the zoned area. Areas with radiation levels in excess of 100 mrad/h are also zoned off and posted to warn personnel of the radiological conditions. If necessary, steps are taken to reduce the radiation levels using shielding. Shielding can be in the form of leaded rubber matting or plastics, a lead-lined man-basket, or a portable 7-ft-square by 3/4-in.-thick stainless steel shield.

6.3.1.2 Decontamination Steps and Procedures. Before steps can be taken to decontaminate equipment, the following factors are considered by T Plant personnel to determine the appropriate cleaning method:

- Chemical or physical nature of contaminant
- Radiation or contamination levels
- Isotopic makeup (if possible)
- Equipment size, shape, and material of construction.

After the RPT has established radiation levels and type of radiation or contamination (alpha or beta-gamma) present, T Plant Operations Department, together with the Process Engineering, will determine the cleaning process to be used and the area where decontamination will be performed. The decontamination methods that are available are as follows:

- Chemical spray cleaning
- Abrasive cleaning
- Immersion chemical cleaning
- Hands-on chemical cleaning.

6.3.1.2.1 Chemical Spray Cleaning. Chemical sprays are used to remove contaminants from equipment. This operation is performed only on the stainless steel pads over cells 11R, 13R, and 15R, or over open cells 12R and 12L. An oxidation-reduction cycle is normally used to remove the contaminants using one of the following methods:

- Method 1

  1. Pretreatment with $NaOH/KMnO_4$
  2. Rinse with water until pH ≤ 9.0

3. Acid treatment

4. Rinse with water until pH $\geq$5.0

5. RPT survey of equipment

6. Repeat cycle if necessary.

- Method 2

1. Acid treatment

2. Rinse to pH $\geq$5.0

3. $NaOH/KMnO_4$ treatment

4. Rinse to pH $\leq$9.0

5. Acid treatment

6. Rinse to pH $\geq$5.0

7. Survey

8. Repeat from step 3, if necessary.

Decontamination operations personnel use five-to-one or four-to-one spray pumps for spray application of chemicals (see Fig. 6-4). These pumps are rated at four-to-one and five-to-one to indicate that pressure at the discharge is four or five times greater than the air pressure being supplied to the pump. For example, at a supply air pressure of 100 lb/in^2, the pumps will put out 1.5 gal/min at 400 or 500 lb/in^2. The pumps require air pressures (gauge) of 20 to 180 lb/in^2 for operation. The pumps are constructed of stainless steel, which permits the use of corrosive chemical solutions. The four-to-one and five-to-one pumps are used for spray cleaning when large equipment (e.g. centrifuges, tanks, and pumps) cannot be placed in any of the three decontamination thimbles. The spray wand is attached to the canyon crane when remote decontamination is required. The pump suction is connected to a 55-gal drum in which chemicals have been prepared in advance according to SOPs. More detailed information on the operation of the chemical spray pumps is found in T Plant Special Services Procedures.(4)

6.3.1.2.2 Abrasive Cleaning. Abrasive methods such as high-pressure water application, dry sandblasting, or wet sandblasting are also used to remove contamination from the surface of the equipment. These methods remove the contaminants by removing a fine layer of the metal surface from a piece of equipment.

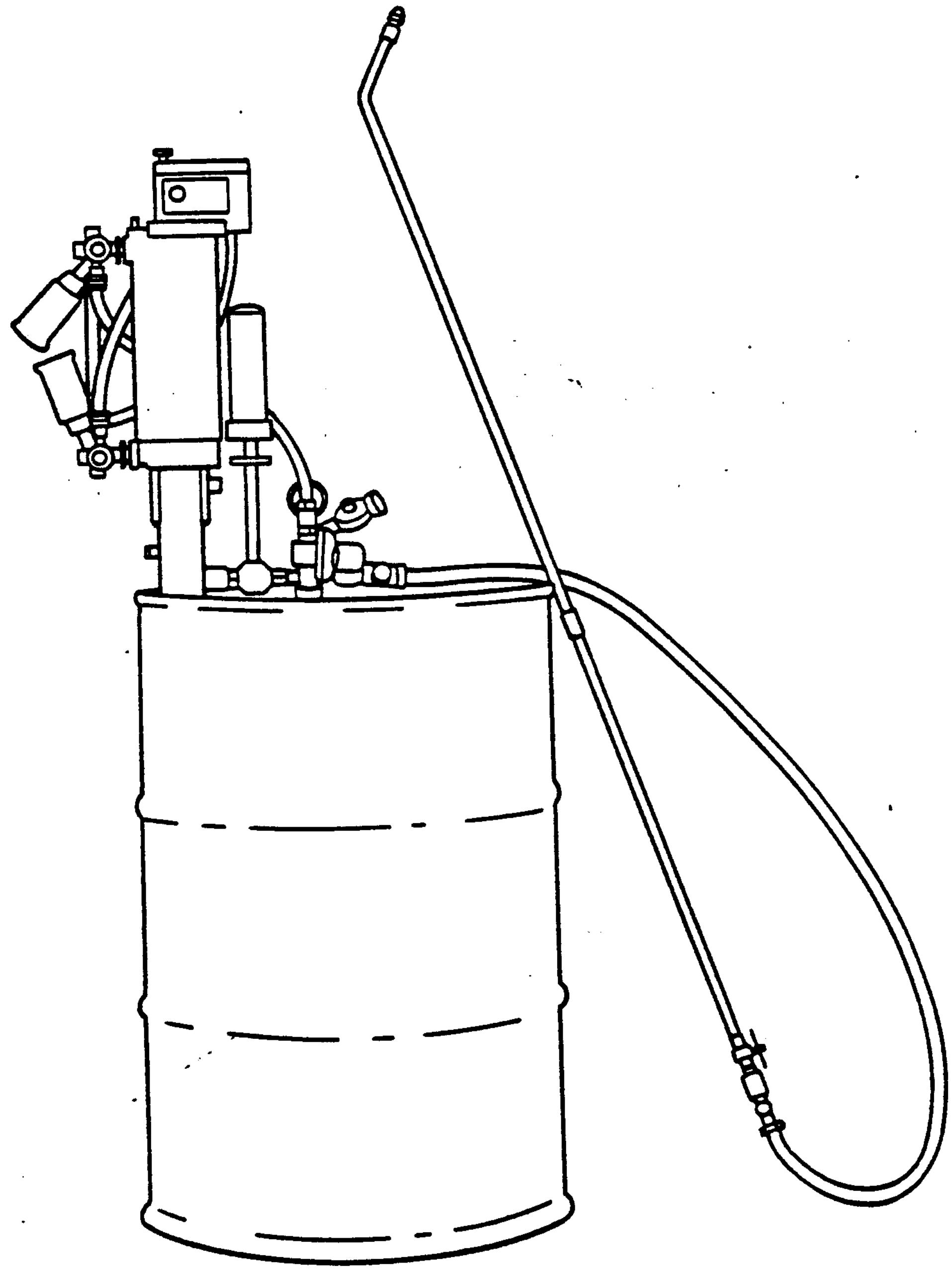

FIGURE 6-4. Spray Pump (Four-to-One or Five-to-One).

The Partek liquid blaster pump is normally used for abrasive cleaning (Fig. 6-5). This Partek pump is located in section 14 of the operating gallery. It is mounted on a movable dolly that holds the pump, motor, main circuit breaker, pressure regulator, and main supply valve. The pump can develop 10,000 lb/in^2 at the nozzle tip. A safety pop-off valve is installed and set to relieve at between 11,200 and 11,500 lb/in^2. The hose and nozzle are rated at 10,000 lb/in^2 working pressure and 32,000 lb/in^2 burst pressure. The nozzle spray valve must be held open against spring pressure to operate. The start/stop switch is located on the canyon wall in section 14 and must be energized at the main circuit breaker, section 14, in the operating gallery. A remote control start/stop switch has been installed in the viewing bubble at cell 13R. To use the switch, an extension cord must be plugged into the receptacle by the header and also into the receptacle on the bubble. For abrasive cleaning, an air-pressurized sand hopper may be attached to the nozzle by a hose. Two methods of abrasive cleaning with the Partek are used.

1. Water

   High-pressure water is used to remove caked-on contaminants from equipment. This loosens or removes contaminants to allow further chemical decontamination.

2. Water-sand

   A wet sandblasting method allows pressurized water to mix with sand that is introduced from a pressurized sand hopper. Suction is used to draw the agitated sand and water slurry into the nozzle. This method also loosens or removes contaminants to allow further chemical decontamination.

In dry sandblasting, sand is picked up by high velocity air and is blasted onto the piece of equipment being cleaned. Because of airborne dust problems, this is not a preferred method. In building 221-T, the dry sand-blasting equipment is used for small jobs only, as determined by operations management.

6.3.1.2.3 Immersion Cleaning. Chemical solutions are also used for immersion cleaning of contaminated equipment.

Initially, T Plant started decontamination and reclamation of equipment by recovering failed turbine pumps. To do this, the thimbles were designed to accommodate the geometrical configurations of these pumps. The use of the thimbles, however, is not limited to turbine pumps. The three thimbles are used for both contact and remote decontamination operations. The units are built entirely of stainless steel, including all piping and valves.

Thimbles 1, 2, and 3 are located above cells 11R and 15R, where they are used for decontamination of almost any piece of equipment that is too contaminated to be decontaminated by hands-on methods, and will fit into the thimbles. A sketch of the thimble 2 is shown in Figure 6-6.

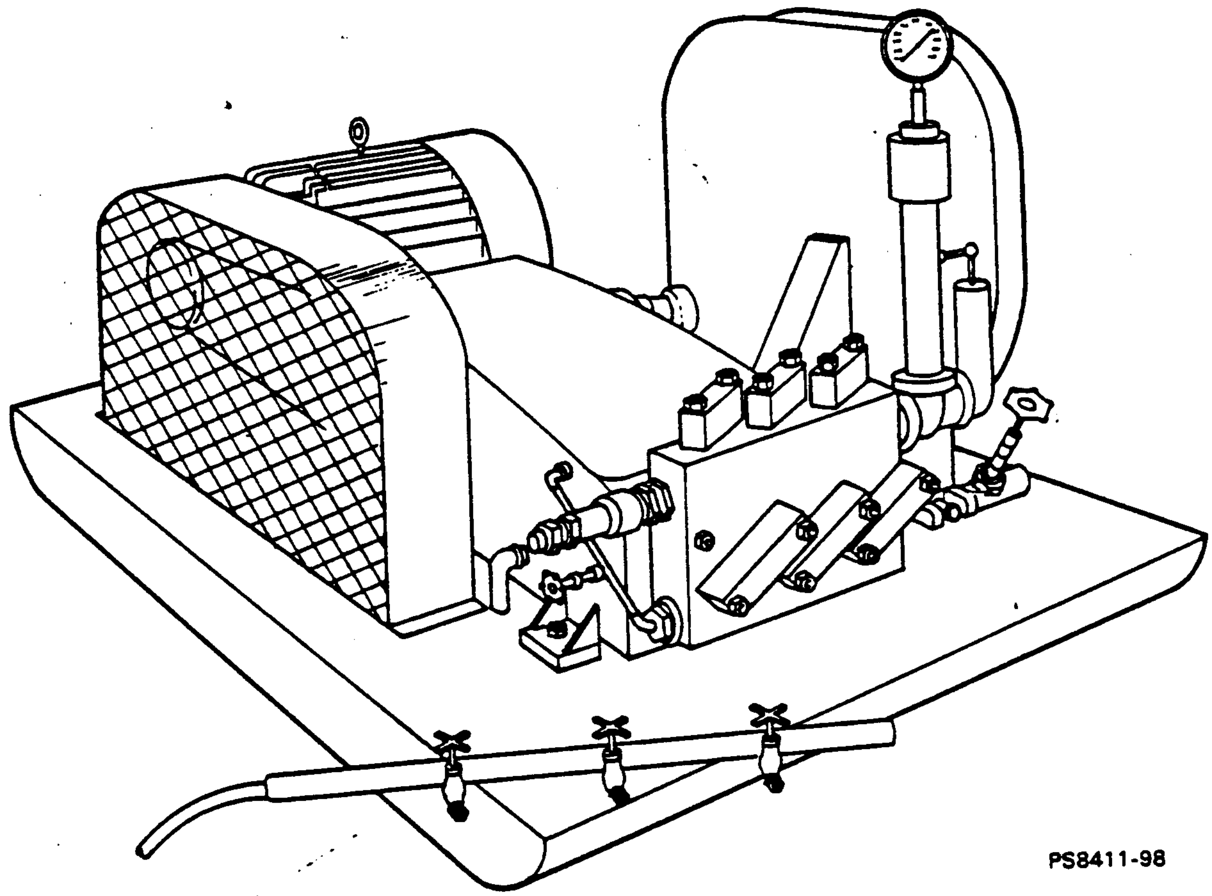

FIGURE 6-5. Partek High-Pressure Pump.

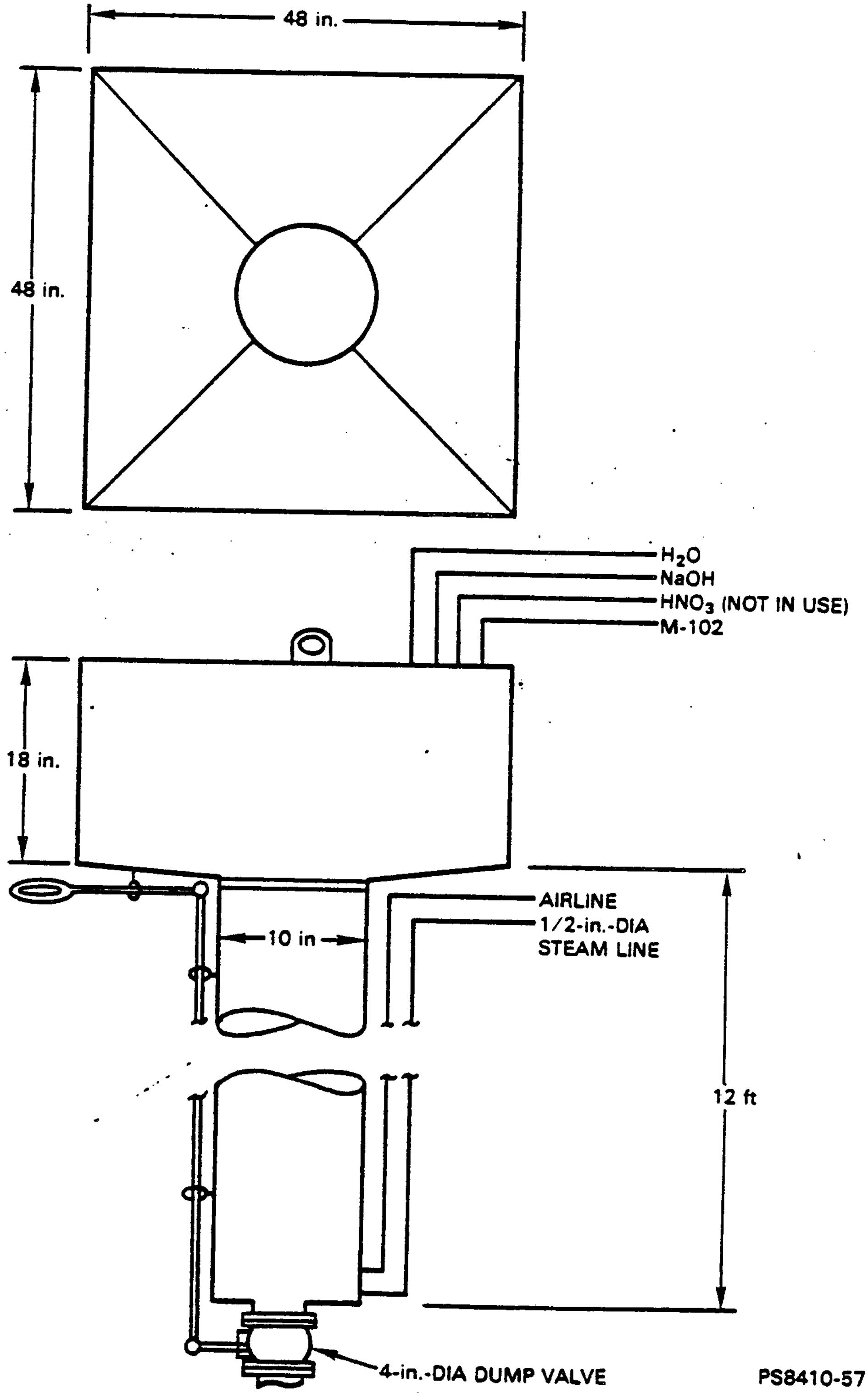

FIGURE 6-6. Typical Building 221-T Thimble Unit (Thimble 2).

The thimbles can be filled with various decontamination solutions remotely, from outside the canyon, or from control centers inside the canyon. Manual thimble dump valves are built so that they can be operated by the canyon crane if the chemicals need to be drained remotely into a cell. A description of thimbles 1, 2, and 3 follows.

- Thimble 1 is a 2,000-gal-capacity stainless steel tank with a tube section that is recessed through cover blocks on cell 11R. Controls consist of a manually operated dump valve on the side of the vessel and electrical switch controls on the canyon wall between sections 10 and 11. A DOV controls airflow through the three ring-spargers installed in the tank. Air, steam, water, NaOH, HNO_3 and other decontamination chemicals are made available by piping into the thimble. The thimble controls are located in the operating gallery at section 11 and in the canyon at section 14.

- Thimble 2 is a smaller square tank with a tube section recessed through the cover blocks on cell 15R. The tank holds 300 gal in the top section and approximately 50 gal in the lower tube section, totaling 350 gal. Air, steam, water, and decontamination chemicals are made available by piping into the thimble. Controls consist of a manual dump valve on the front upper section, and an electrical switch control panel located on the canyon wall at cell 14L. Remote valve controls are also located in the operating gallery at section 15.

- Thimble 3 is slightly smaller than 2 and is a round tank with a tube section recessed through the cover block on cell 15R. The volume is approximately 282 gal in the top section and 50 gal in the tube section, totaling 332 gal. Air, steam, water, NaOH, HNO_3 and other decontamination chemicals are piped into the thimble. Control consists of a manual dump valve on the front of the upper section and a electrical switch panel on the canyon wall at cell 14L. Remote valve controls are located at section 15 of the operating gallery.

Chemicals that are used in Thimbles 1, 2, and 3 are piped in from the pipe gallery (see Fig. 6-3). Steam at 125 lb/in^2 is used for heating the chemical solutions to the temperatures specified for decontamination purposes. Air at 80 lb/in^2 (gauge) is used for sparging the chemicals.

When the proper chemicals have been prepared in the thimbles, equipment is immersed into the thimbles by use of the overhead crane. The equipment normally undergoes an oxidation-reduction cleaning cycle during a time period specified according to the particular chemical agent being used. Each chemical application is followed by a water rinse cycle to remove contaminants. After completion of each cycle, an RPT surveys the equipment to determine if radiation levels are low enough to allow contact cleaning or maintenance. The spent chemicals are discarded into the T Plant waste system by use of the manual dump valves. More detailed information on the operation of the thimbles is found in T Plant Special Services Procedures.[4]

6.3.1.2.4 Electropolishing. Electrocleaning or electropolishing is essentially a reverse electroplating process occurring in a phosphoric chromic acid bath (Fig. 6-7). The contaminated metal piece is suspended by the overhead crane to prevent contact with the grounded cleaning tank and immersed in the electrolyte. The metal workpiece is attached via the anode clamp to a power supply that generates about 1,000 A at a 12-V dc output. The surface layer of the metal piece is continuously removed by the surrounding electrolyte layer and subsequently reacts with the phosphoric acid to form soluble phosphates. The chemicals for the electrolyte solution are mixed in 55-gal drums inside the canyon and transferred into the electropolishing tank by use of drum pumps or are poured directly into the tank from the drum.

The stainless steel tank used for electropolishing is located on cell 14R. This tank is mounted on legs and has a 1-in.-diameter drain valve at one end. A 1-hp pump is used to circulate the electrolyte in the electro-chemical tank; the pump also circulates electrolyte through a series of cartridge filters to remove suspended contaminants. An electrical rectifier is used to produce the 1,000 A at 0 to 12 V dc. The rectifier has a input power requirement of 25 A from a three-phase 440 V ac. The electrolyte is heated by an immersible steam coil, that is removed from the tank prior to electrocleaning.

The main limitations on use of the electropolisher are equipment size, construction, and configuration. After each cleaning cycle, the RPT surveys the equipment to determine if radiation levels are reduced to acceptable limits.

A stainless steel cover is placed on the tank when it is not in use. The chemicals can be reused, or the tank can be drained to the stainless steel pad via a 1-in.-diameter drain line. The chemicals drain from the pad into cell 14R. More detailed information on the electropolishing process is available in Operating Specifications T Plant and T Plant Special Services Procedures.[2,4]

6.3.1.2.5 Cleaning by Hand. When dose rates permit (typically less than 50 mrem/h to the hands), hand cleaning (wiping) is used to remove loose surface contaminants from small equipment. This method usually employs small (less than 1 gal) amounts of acetone, industrial solvents, paint remover, or detergents. Specific methods for cleaning by hand are outlined in T Plant Special Services Procedures.[4]

6.3.1.2.6 Decontamination in Building 221-T Tunnel. Chemical decontamination activities are also performed in the tunnel area. Railroad cars and MPT boxes are decontaminated by the chemical spray, liquid blasting, or water-flushing techniques described previously. Specific procedures are located in T Plant Special Services and Nuclear Material Shipping Containers.[2,13] Chemical waste flows to the tunnel drain and to waste tank 5-7 located in cell 5R.

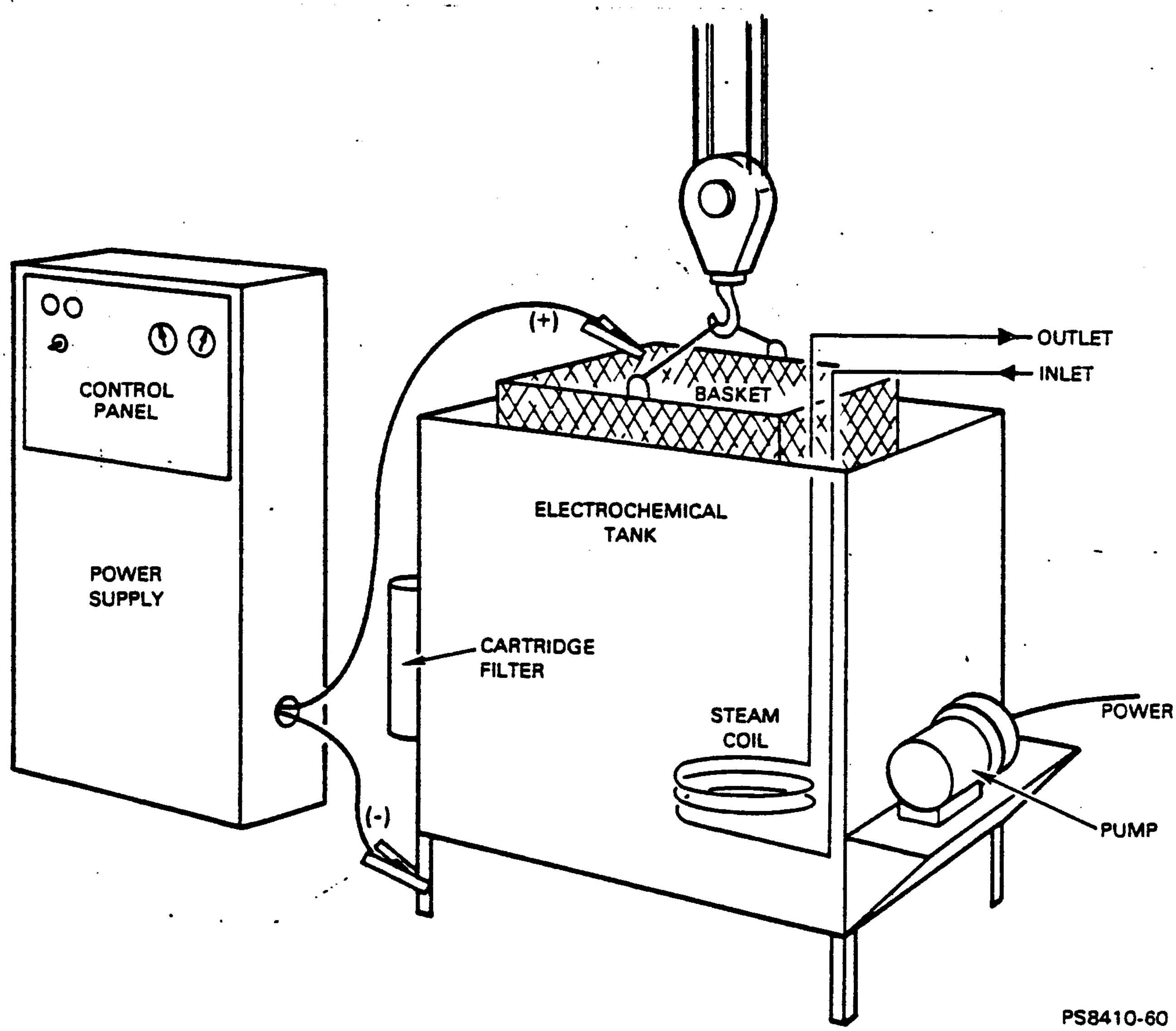

FIGURE 6-7. Electrochemical Decontamination Unit.

6.3.2 Building 2706-T Low-Level Decontamination Facility

Equipment received in building 2706-T must comply with the radiation/contamination levels outlined in 6.1. Heavy equipment is moved by the overhead 10-ton-capacity crane or the air tugger. Most decontamination activities performed on rolling stock, vehicles, and equipment are done over the railroad and automotive pits, or on the 10- by 12-ft stainless steel pad located between the two pits.

During decontamination operations, the doors to the office area are closed. No decontamination operations are performed outside the building area unless specified by the D&D Operations Manager with concurrence from Process Engineering and Radiation Monitoring.

6.3.2.1 Chemical Decontamination. Chemical decontamination is performed in the same manner as outlined in 6.3.1, by using chemical spray cleaning or immersion cleaning in the three 32-in.-diameter by 42-in.-high stainless steel thimbles. Air, water, and steam are available via piping into the thimbles. Each thimble has a 1-in.-diameter drain line that allows liquid waste to flow into the railroad pit liquid waste system. References 2 and 4 provide more detailed information on chemical decontamination in building 2706-T.

6.3.2.2 Abrasive Cleaning. Abrasive cleaning methods are performed in the same manner as discussed in 6.3.1, by using various types of "blasting" equipment. Water, sand, a water and sand mixture, or other abrasive materials such as aluminum oxides, are used in the following two pieces of equipment.

1. Liquid Blaster High-Pressure Pump Unit

   This unit provides cleaning at a 30 gal/min maximum volume at 4,500 lb/in^2 maximum pressure. The electric motor provided with this pump unit is rated at 100 hp. Only water, sand, or water and sand mixtures are used in this blaster unit. The hose and nozzle are rated at 10,000-lb/in^2 working pressure and 32,000-lb/in^2 burst pressure. The nozzle control valve must be held open against spring pressure to operate.

2. Vacuum Blasting or Dry Honing

   The vacuum blaster has a vacuum system that permits recycling of abrasives, preventing their spread to the surrounding area (Fig. 6-8). A vacuum system, together with a nylon brush surrounding the nozzle, serves to reduce contamination spread by recycling the abrasives through the system. It is capable of delivering a stream of dry abrasives whose impact intensity is limited only by the strength of the particles and the air pressure supplied. The blast gun acts as a tiny blast enclosure, completely containing the abrasive blast and vacuuming away all abrasive and debris. Vacuum blasting of equipment with detectable alpha surface contamination or with beta-gamma surface

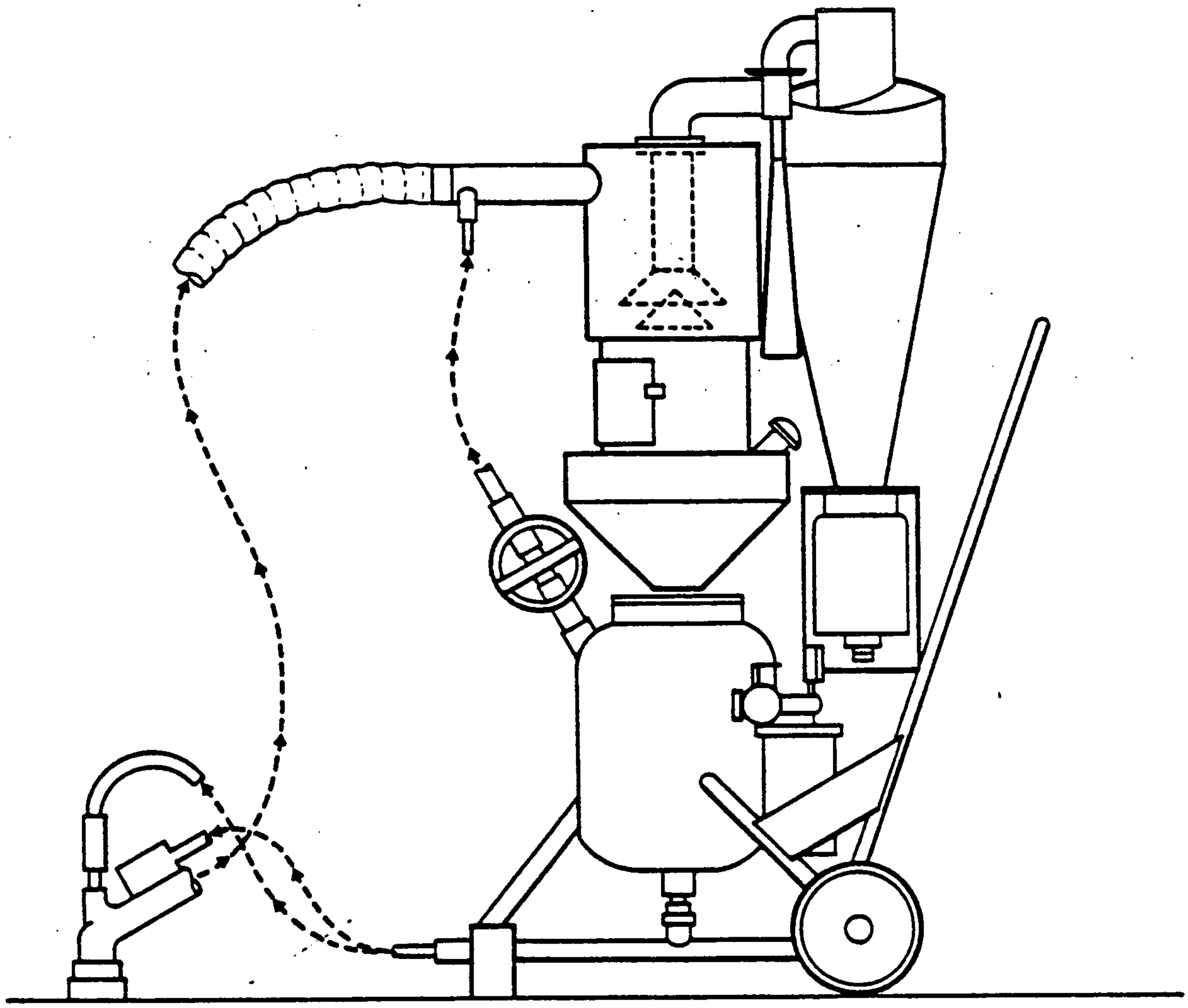

FIGURE 6-8. Vacuum Blaster.

contamination greater than 50,000 dpm/100 cm^2 is prohibited unless approved by D&D management and Radiation Monitoring. References 2 and 4 provide more specific operational details.

6.3.2.4 Steam Cleaning. Steam cleaning is also used to decontaminate equipment. Steam and chemical solutions are blended in a mixing chamber and expelled out of a nozzle onto the equipment that is to be decontaminated. A 140-gal-capacity stainless steel tank with an agitator is used for making up solutions. Steam cleaning in building 2706-T is not used on highly contaminated equipment. Equipment contaminated to greater than 2,000 cpm/100 cm^2 beta-gamma, or equipment contaminated with alpha is not steam cleaned unless specified by Process Engineering and Radiation Monitoring. The T Plant uses the following two types of steam cleaning equipment.

- Hydro-Steam Cleaner

  The hydro-steam cleaner produces an atomized spray of pressurized steam and steam-cleaning solution. A variety of industrial detergents and cleaning chemicals are used in this device. Cleaning solutions are premixed in a separate tank or container and drawn by vacuum into the cleaner through a pipe connected to an intake elbow. The steam provides both heating and driving forces.

  The hydro-steam cleaner is used for cleaning contaminated equipment and for degreasing road or construction equipment. There is also a portable steam unit mounted on a cart for outside use.

- Hydraulic Jet Cleaner

  The hydraulic jet cleaner is basically a mechanical device for mixing steam, water, and detergent. The jet cleaner is capable of delivering 15 gal/min of water at 180°F at a nozzle pressure of 400 lb/in^2 (gauge). The unit is permanently mounted and connected to steam and water. It consists of a solution makeup tank, a mechanical unit, a hose, and a wand. References 1 and 2 provide more specific operational detail.

6.3.2.5 Cleaning by Hand. Hand cleaning methods are also used in building 2706-T as outlined in 6.3.1.

6.3.3 Disposal, Refurbishment, and Operability Testing in Buildings 221-T and 2706-T

The T Plant Maintenance and Process Engineering Departments determine whether equipment is to be disposed of for burial or will undergo refurbishment and operability testing so that it may be returned to the customer for reuse.

6.3.3.1 Disposal for Burial. In some cases, equipment is decontaminated in preparation for burial. This might require partial dismantlement of large equipment to allow placement into a burial container.

A piece of equipment is decontaminated to radiation levels allowable for burial in a particular container. The burial container is determined by the size and type of equipment to be disposed of. All smearable surface contamination on the burial container must be below 2,200 dpm/100 cm^2 beta-gamma and 220 dpm/100 cm^2 alpha contamination before it is acceptable for burial.(7) All burial boxes must comply with the pertinent SARP. Equipment must be packaged, shipped, and buried according to the requirements of RHO-MA-222, Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements(7) and the T Plant SOPs.(4)

When equipment is dismantled, frequent radiation monitoring is required to locate possible contamination on interior surfaces of the equipment. Decontamination is often required during dismantling of equipment to reduce personnel exposure. In some cases, parts are salvaged for future use; in addition, the equipment is inspected to determine causes of failure.

The overhead cranes in the building 221-T canyon and building 2706-T are used to move heavy equipment into burial containers so that they may be removed from the building on railroad cars or flatbed trucks.

6.3.3.2 Refurbishment. Before refurbishment of equipment can begin, radiation levels must comply with radiation monitoring requirements. These requirements may necessitate the use of some temporary shielding.

Radiation monitoring is also required during dismantling of equipment during refurbishment to locate contaminants on newly exposed surfaces. If unacceptable contamination is found on a part, further decontamination is required.

During the dismantling process, the equipment is inspected by Maintenance and Process Engineering personnel to determine possible causes of failure. A remote camera can be attached to the overhead crane, if necessary, when high dose rates prohibit visual inspection. Each part that is removed and decontaminated is relocated to a cleaner area within the building 221-T canyon or building 2706-T. Inside the building 221-T canyon, the equipment parts are moved from the decontamination pads at sections 10 through 15 to the repair stations in sections 16 through 20. In building 2706-T, the equipment is moved to available space within the building.

During dismantling, Maintenance and Process Engineering personnel evaluate whether or not the equipment can be refurbished to meet the design criteria of the customer. If refurbishment is not feasible, the salvageable pieces are refurbished and stored as spares while unsalvageable parts are packaged for burial.

Typical refurbishment and repairs made on equipment are listed below:

- Bearing replacement
- Impeller and head repair
- Pump and motor alignment
- Electrical repairs
- Equipment modification
- Power and instrument repairs
- Instrument calibrations
- Rust removal
- Painting.

Modification and repairs on railroad tank cars are performed in the building 221-T tunnel or in building 2706-T.

All maintenance repairs are made in compliance with RHO-PS-MA-3, Plant and Facility Maintenance Manual, and RHO-PS-MA-4, Production Support Calibrations Procedures.[14,15]

6.3.3.3 Operability Test. Operability test procedures are prepared by Process Engineering for the refurbishment of equipment that requires testing (i.e., centrifuges, pumps, agitators, pulsers). These tests are performed to determine if the equipment is functioning according to the operating specifications of the customer. Run-in can be performed at centrifuge and pump run-in stations located in building 221-T, sections 16 and 19, respectively. An example of typical tests performed on centrifuges, pumps, and pulsers is outlined in the following listing:

- Centrifuge run-in
  - Slow-speed run-in test
  - High-speed run-in test
  - Motor test
  - Bowl calibration test
  - Bowl overflow/holdup test
  - Skimmer setting test
  - Bowl spray test
- Pump run-in
  - Discharge pressure test
  - Vibration test
  - Pump performance test
  - Motor performance test

- Pulser run-in
  - Overflow test
  - Pulse rate (cycle/min) test
  - Motor performance test.

Similar tests are developed for other types of equipment as required. Plant Engineering Support and Quality Engineering are required to approve all test results before the equipment is returned to the customer for reuse. If the equipment fails operability testing, maintenance is initiated again to correct equipment malfunctions. If repairs are not feasible, the equipment is either dismantled in preparation for burial, shipped for burial as is, or stored for future disposition.

6.3.3.4 Shipment to Customer. Refurbished equipment is returned to the customer in a container that is in compliance with the pertinent SARP requirements. The T Plant SOPs are followed during load-out operations.

Equipment is removed from the building 221-T tunnel using flatbed railroad cars. In most instances, the MPT box is used as the transport container for returning equipment to B Plant, PUREX Plant, or building 221-U (for storage). Before loading equipment into the tunnel by crane, all personnel are cleared from the tunnel and the tunnel door is closed. Once the container is sealed, it is surveyed and released for shipping by the RPT.

Equipment in building 2706-T is removed through the railroad and automotive rollup doors. The customer is notified of shipment and the material is shipped on a flatbed truck or railroad car after release by the RPT.

An onsite radioactive shipment record accompanies all radioactive shipments from T Plant Facilities.

6.4 CHEMICAL STORAGE

The T Plant Complex stores chemicals for use in decontamination methods described in 6.3. An estimate of these chemicals, grouped by quantity of chemicals normally on hand at T Plant, is shown in the following listing methods of chemical storage are given in 5.5):

- Chemicals in individual quantities >1,000 gal (bulk)
  - NaOH, 50%
- Chemicals in individual quantities <220 gal*
  - Turco FAB 5589
  - Turco Desealzit (methylene chloride)
  - Turco 4512A (phosphoric acid)
  - Turco 4501A (potassium hydroxide)
  - Turco 4306D (sodium bisulfite)

*All other chemicals are stored in quantities ≤100 gal or 100 lb.

- Dry chemicals in individual quantities <2,000 lb

  - Potassium permanganate
  - Rust remover
  - Sodium nitrate
  - Turco 4502 (potassium hydroxide)
  - Turco 4520 (ammonium oxalate)
  - Turco 4518 (oxalic acid)
  - Turco 4521 (oxalic acid)

- Chemical in individual quantities <1,000 lb*

  - Citric acid
  - Crystal caustic soda
  - Sodium carbonate
  - Acetone†

6.5 VENTILATION (BUILDINGS 221-T AND 2706-T)

The building 221-T canyon ventilation system consists of the 296-T-13 roof exhauster, the 291-T exhaust system, and 221-TA supply fans. Combined, these systems provide ventilation for the canyon and maintain a negative canyon pressure with respect to the environment.

The canyon ventilation system operates within the following parameters:

1.	Maximum DP, canyon to operating gallery	0.5 in. WG
2.	Minimum DP, canyon to operating gallery	0.025 in. WG
3.	Normal DP, canyon to operating gallery	0.15-0.25 in. WG

These parameters are monitored by air pressure manometers located in the operating gallery.

The following operating restrictions apply to the canyon ventilation system.

1. Decontamination operations are not conducted within the canyon area when entry doors are open except for the normal canyon entry door at section 20.

*All other chemicals are stored in quantities ≤100 gal or 100 lb.
†Acetone is maintained in very small quantities (≤1 gal).

The following operating restrictions apply to the canyon ventilation system.

1. Decontamination operations are not conducted within the canyon area when entry doors are open except for the normal canyon entry door at section 20.

2. At least one 291-T exhaust fan must be running during canyon operations.

3. The DP between the canyon and the operating gallery must be at least 0.025 in. WG.

The two FI-2 HEPA filters on the 291-T exhaust system must each pass DOP testing requirements of 99.95% efficiency. The maximum allowable pressure drop across the primary HEPA filter bank is 4 in. WG. These same operating requirements exist for the 296-T-13 roof exhaust system.

Operations within building 2706-T may be conducted only when the pit exhaust system is running.

6.6 THREE-MILE ISLAND TRANSLOADING

The T Plant Complex occasionally receives and transloads submerged demineralizer system resin columns from a lead-lined shipping cask to a 65,000-lb concrete burial overpack container. The transloading operation is performed inside the building 221-T tunnel. The operational requirements, limitations, and safety assessment for transloading are detailed in References 4, 5, and 6.

6.7 REFERENCES

1. Rockwell, T Plant Training Manual, RHO-MA-232, Rockwell Hanford Operations, Richland, Washington.

2. Rockwell, Operating Specifications T Plant, RHO-ODC, controlled books 2A and B, Rockwell Hanford Operations, Richland, Washington (June 1984).

3. G. L. Hanson and R. R. Jackson, Safety Assessment Document-PWR Core 2 Project, RHO-CD-356, Rockwell Hanford Operations, Richland, Washington (April 1978).

4. Rockwell, T Plant Special Services Procedures, Manual Number 26A, B, C, and D, Rockwell Hanford Operations, Richland, Washington (March 1984).

5. G. M. Christensen, Three Mile Island Submerged Demineralizer System Liners Transloading and Burial Safety Analysis Report, RHO-CD-1554, Addendum 1, Rev 1, Rockwell Hanford Operations, Richland, Washington (March 1983).

6. R. A. Van Meter, Safety Analysis Report for Packaging TMI SDS Liner/Overpack (HCS-06-001-00), SD-RE-SAR-12, Rockwell Hanford Operations, Richland, Washington.

7. D. L. McCall, Hanford Radioactive Solid Waste Packaging, Storage and Disposal Requirements, RHO-MA-222, Rockwell Hanford Operations, Richland, Washington.

8. Rockwell, Safety Analysis Report for Packaging, HCS-039-001, Rockwell Hanford Operations, Richland, Washington.

9. Rockwell, Safety Analysis Report for Packaging, HCS-057-003, Rockwell Hanford Operations, Richland, Washington.

10. Rockwell, Safety Analysis Report for Packaging, HCS-047-001, Rockwell Hanford Operations, Richland, Washington.

11. Rockwell, Safety Analysis Report for Packaging, HCS-047-002, Rockwell Hanford Operations, Richland, Washington.

12. Rockwell, Accident Prevention Standards, Industrial Hygiene and Safety, RHO-MA-221, Rockwell Hanford Operations, Richland, Washington.

13. Rockwell, Nuclear Material Shipping Containers, RHO-MA-327, Rockwell Hanford Operations, Richland, Washington (December 1980).

14. Rockwell, Plant and Facility Maintenance Manual, RHO-PS-MA-3, Rockwell Hanford Operations, Richland, Washington.

15. Rockwell, Production Support Calibrations Procedures, RHO-PS-MA-4, Rockwell Hanford Operations, Richland, Washington.

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7.0 WASTE CONFINEMENT AND MANAGEMENT

7.1 WASTE MANAGEMENT CRITERIA

The T Plant Complex will be managed in accordance with the environmental guidelines presented in RHO-MA-139; under normal operation, all liquid and airborne effluents shall be less than the concentrations listed in Appendix I of that document.[1] All contaminated solid waste must be managed in accordance with RHO-MA-201, Hazardous Material Packaging, Shipping, and Transportation Manual, and RHO-MA-222, Hanford Radioactive Solid Waste Packaging, Storage and Disposal Requirements.[2,3]

7.2 RADIOLOGICAL WASTE

7.2.1 Airborne Radioactive Wastes

The only sources of potential airborne radioactive waste are the monitored 221-T building canyon and the unmonitored building 2706-T. Building 2706-T had a record of uniformly low stack emissions; in addition, restrictions on the amount and type of radioactive materials allowed into the building minimize the potential for airborne contamination. Stack emissions from building 2706-T have not been monitored since the mid 1970's.

Emissions from building 221-T result from decontamination operations inside the canyon. Because operations are not allowed in the canyon unless the air activity is below 5×10^{-8} µCi/mL for beta-gamma emitters and 1×10^{-10} µCi/mL for alpha emitters, the recorded stack emissions have been generally low. The emissions from the roof exhaust stack (296-T-13) and the 291-T exhaust stack (291-T-1) are shown in Figures 7-1 through 7-4. This data is plotted as annual average emissions for the years 1974 through 1983 in Figures 7-1 and 7-2 and as monthly average emissions for 1983 in Figures 7-3 and 7-4.

The T Plant stack emissions are required to be below the values listed in Table 1 of RHO-MA-139.[1] All alpha activity is assumed conservatively to be ^{239}Pu and all beta-gamma activity to be ^{90}Sr. The limiting airborne radioactivity concentrations of the T Plant stacks are then 2×10^{-12} and 1×10^{-9} µCi/mL for alpha- and beta-gamma-emitting radionuclides, respectively. As can be seen from Figures 7-1 through 7-4, the actual recorded airborne radioactivity released from T Plant has been well below these limits.

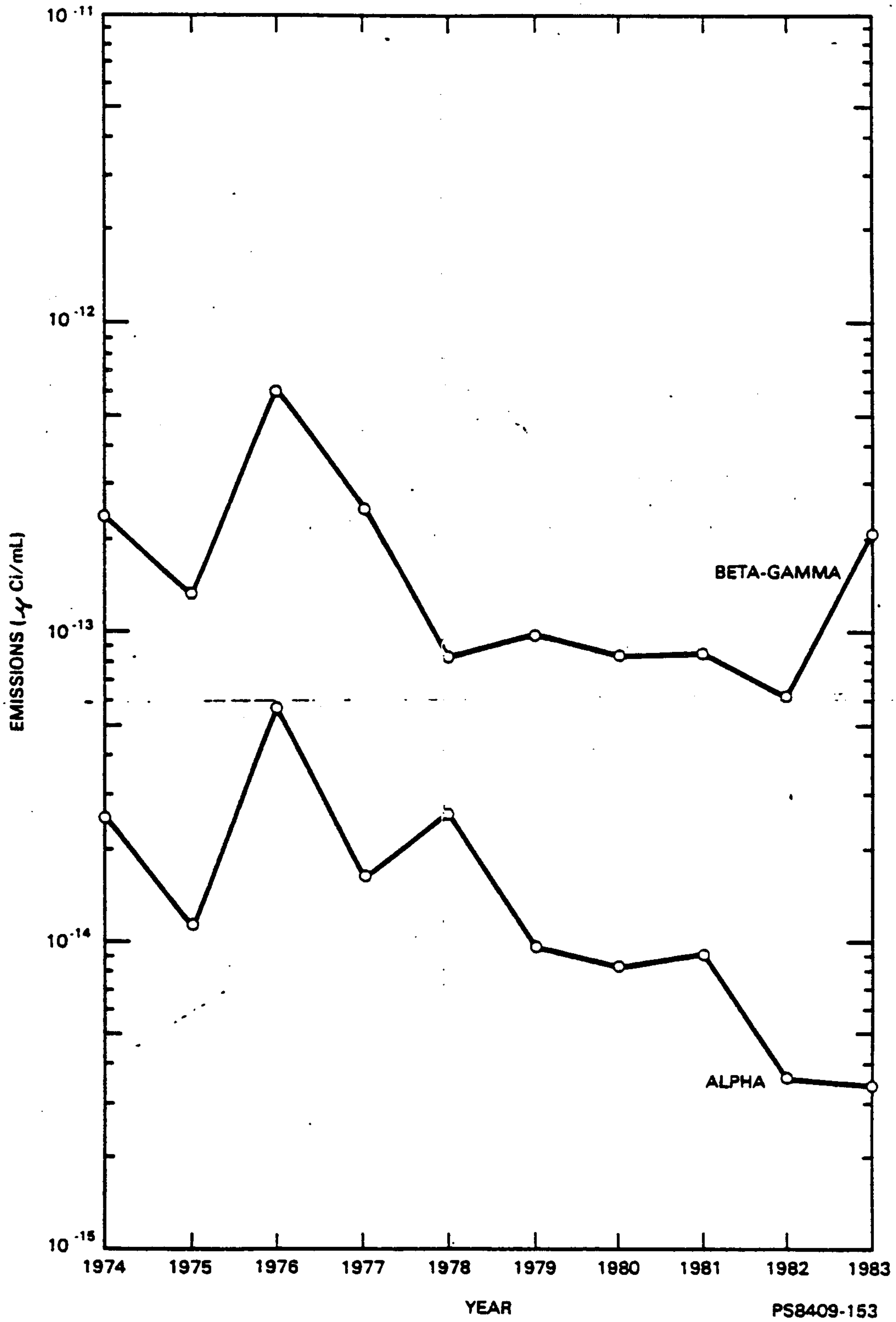

FIGURE 7-1. Stack 296-T-13 Annual Emissions.

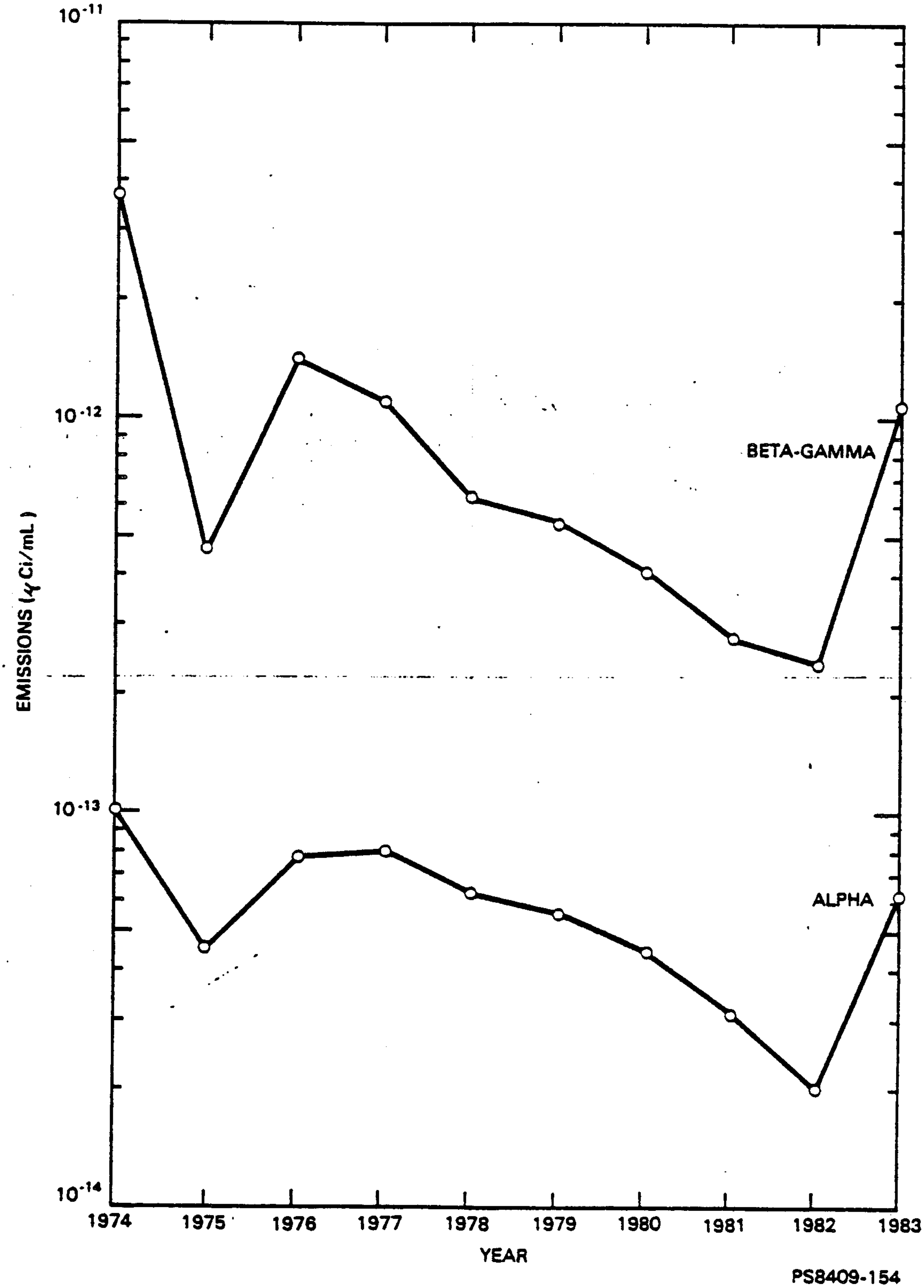

FIGURE 7-2. Stack 291-T-1 Annual Emissions.

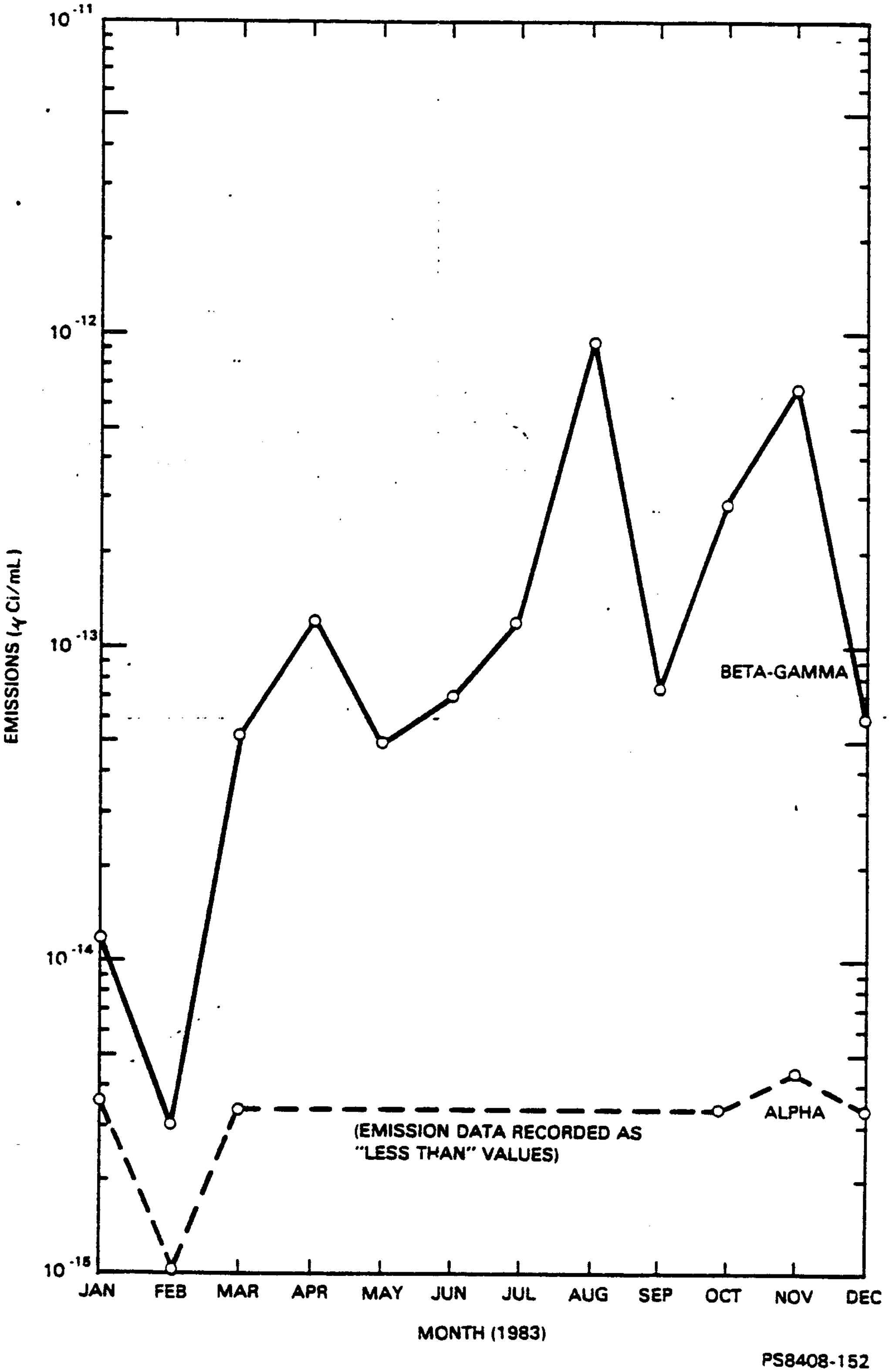

FIGURE 7-3. Stack 296-T-13 Monthly Emissions (1983).

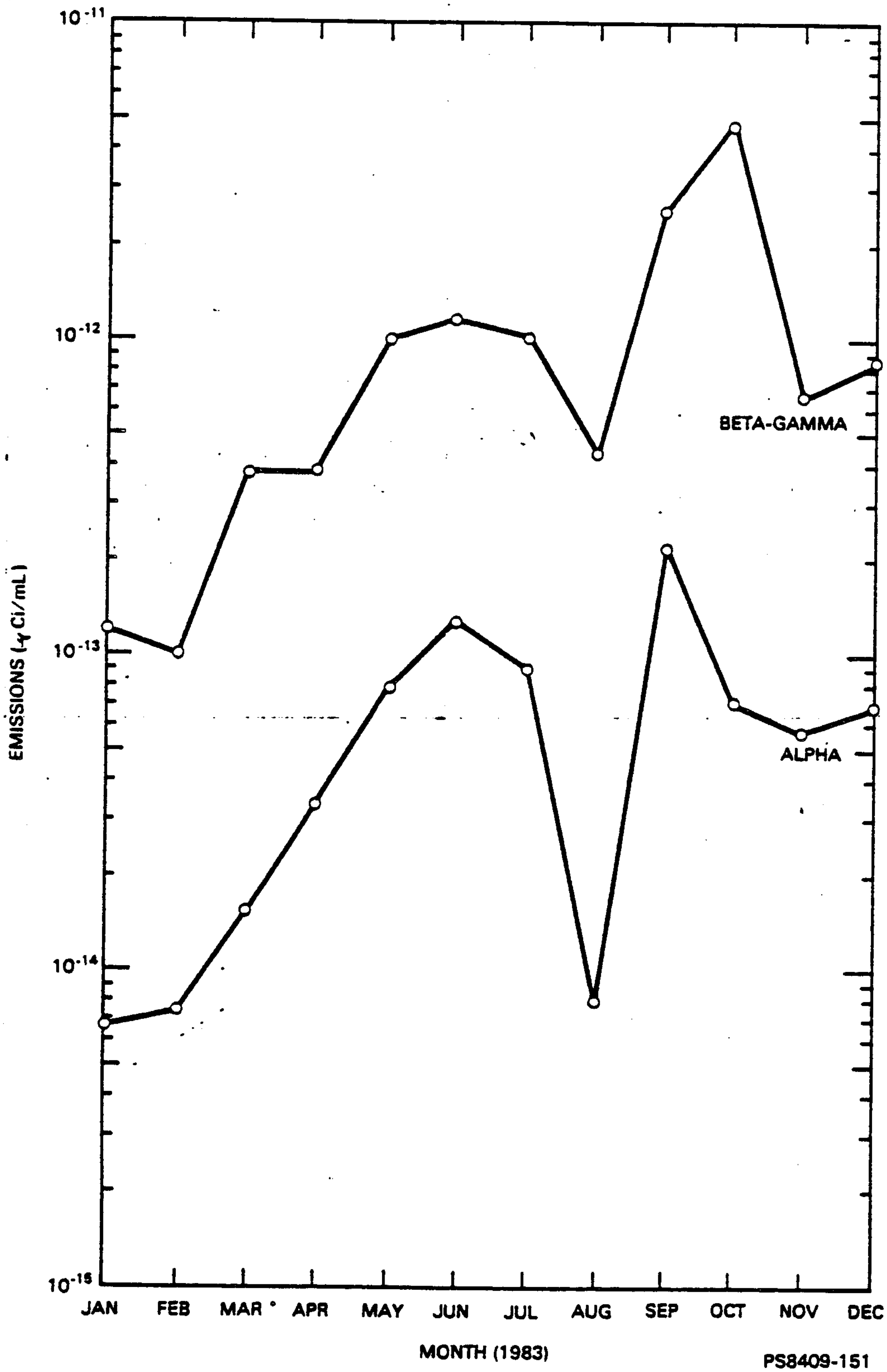

FIGURE 7-4. Stack 296-T-1 Monthly Emissions (1983).

7.2.2 Liquid Radioactive Wastes

The liquid waste system for the building 221-T canyon consists of the arrangement of tanks and piping shown in Figure 7-5. Ultimately, all liquid that drains into this system is transferred to the West Area tank farms. Prior to transfer, the waste is sampled and analyzed to ensure that it meets the chemical specifications of the receiving tank and that the concentration of dissolved ^{239}Pu is within specification.

Equipment within the canyon is drained directly into open-topped waste tanks located in cells 5-R (tank 5-7), 11-R (tank 11-R), and 15-R (tank 15-1). Other active waste tanks include tanks 5-6 and 5-9 in cell 5-L. Liquid waste is transferred by jet pump between tanks 5-6, 5-7, 5-9, and 11-R as needed to allow use of the various decontamination stations. Ultimately, waste from tanks 5-6, 5-7, 5-9, and 11-R is pumped into tank 15-1 for sampling and transfer to the tank farm. The individual cells drain into a common drain header that terminates at tank 5-7 in the deep cell 5-R. Liquid waste from building 2706-T is discharged into cell 6-R, from which it also drains into tank 5-7. The annual volume of liquid waste sent from the T Plant Complex to the tank farm is shown in Figure 7-6.

The building 2706-T liquid waste system is shown in Figure 7-7. All liquid waste produced in 2706-T is collected by floor drains in the automotive and railroad pits. From these pits, the waste drains into a waste collection sump located outside of the building. Liquid is automatically pumped from this sump into the building 221-T canyon.

7.2.3 Solid Radioactive Wastes

Materials used during decontamination as well as objects that cannot be returned to service are placed in waste drums or burial boxes and moved from the T Plant Complex to the radioactive waste burial grounds. Because of the restrictions on alpha-contaminated waste at T Plant, none of the waste transferred is TRU. The T Plant Complex generates approximately 10,000 ft^3 of solid radioactive waste per year.

7.3 NONRADIOLOGICAL WASTES

7.3.1 Chemical and Process Waste

Nearly all of the chemicals used at T Plant are used in either the building 221-T canyon or in building 2706-T, where they are collected and disposed of in the radioactive liquid waste system. A small amount of chemical waste is also produced in other locations, such as building 211-T and the building 271-T chemical makeup room. This waste is also disposed of in the building 221-T canyon liquid waste system. Liquid waste from the various floor drains and sumps in building 271-T, the building 221-T

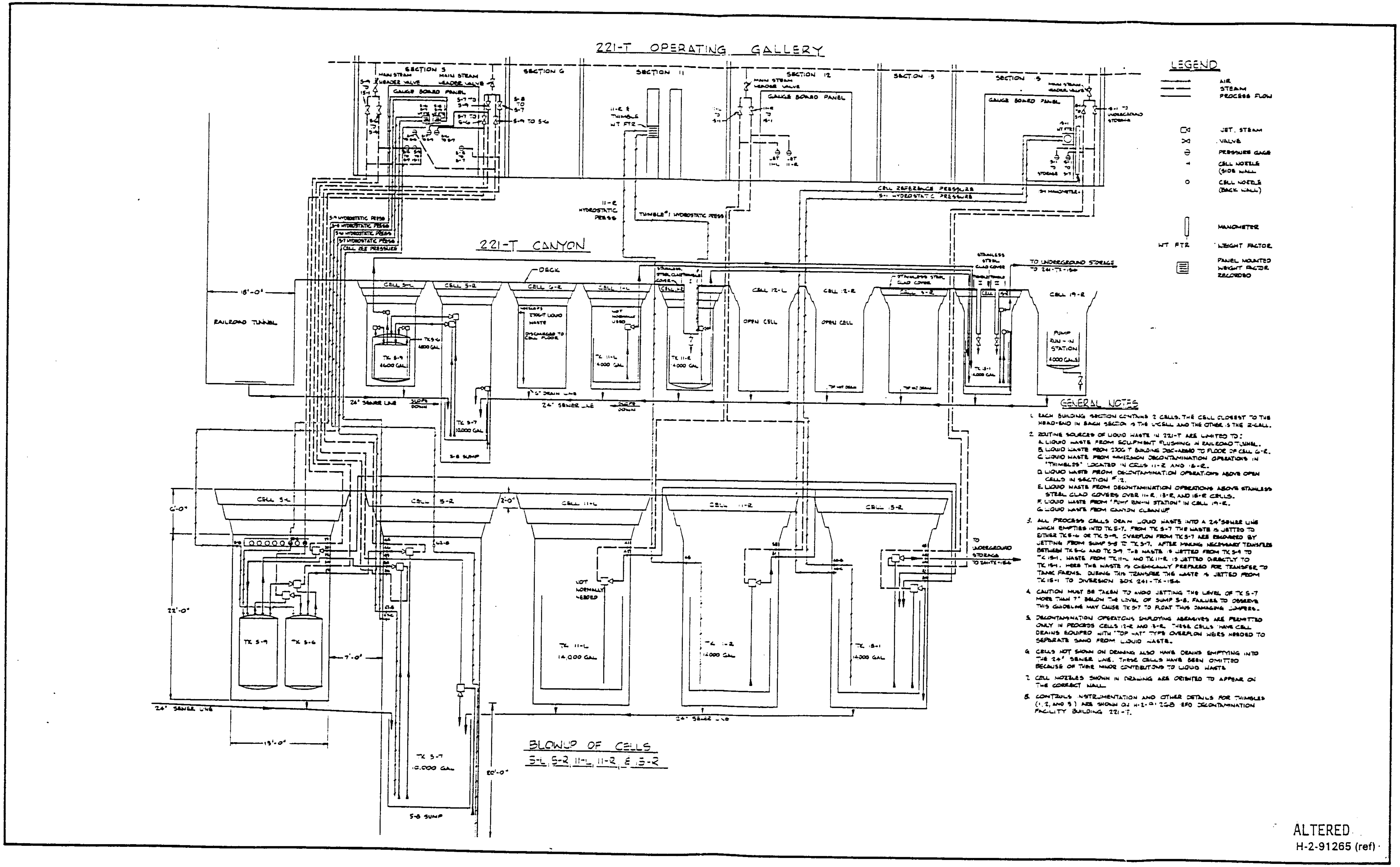

FIGURE 7-5. Building 221-T Canyon Liquid Waste System.

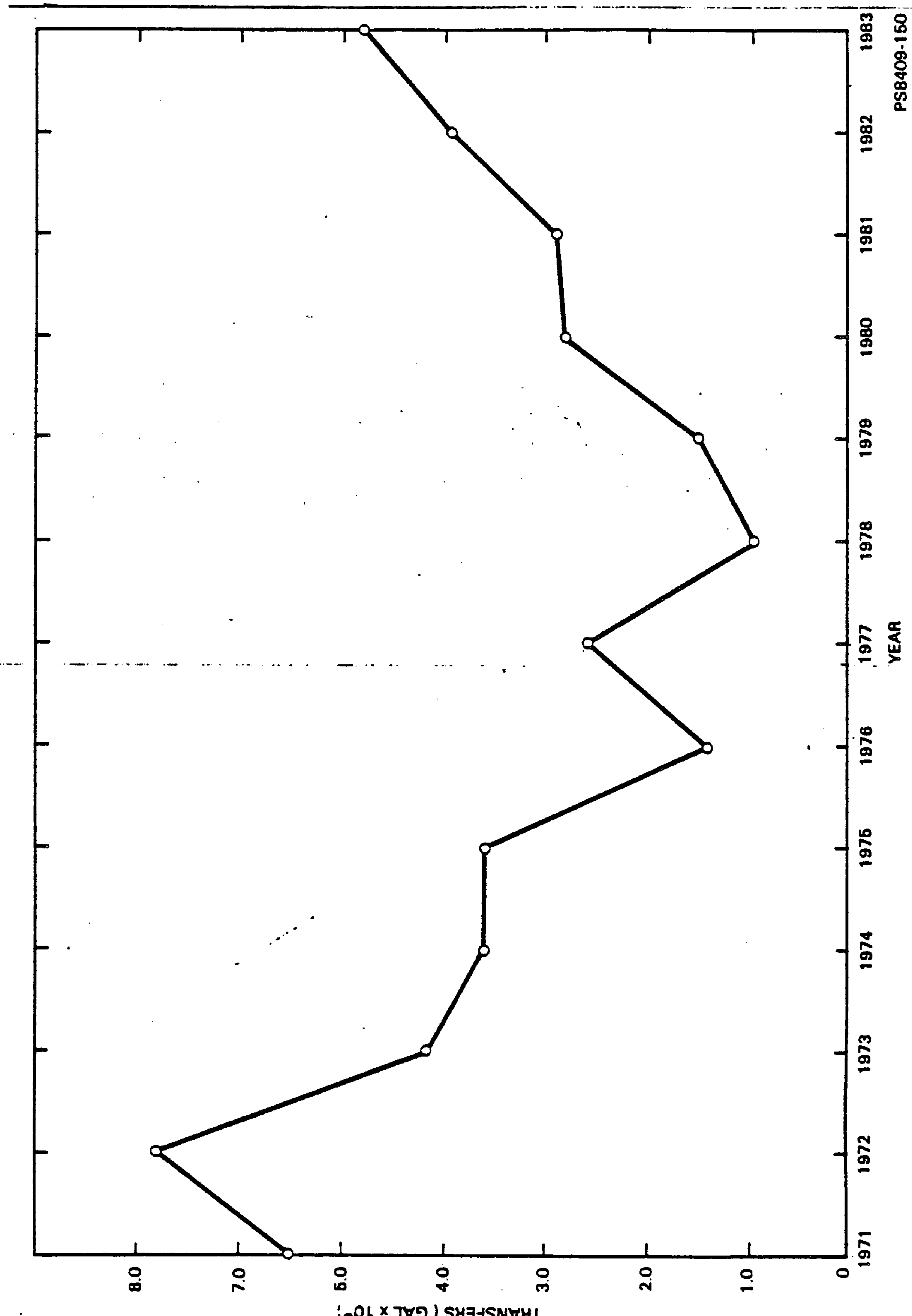

FIGURE 7-6. T Plant Complex Annual Radioactive Liquid Waste Transfers.

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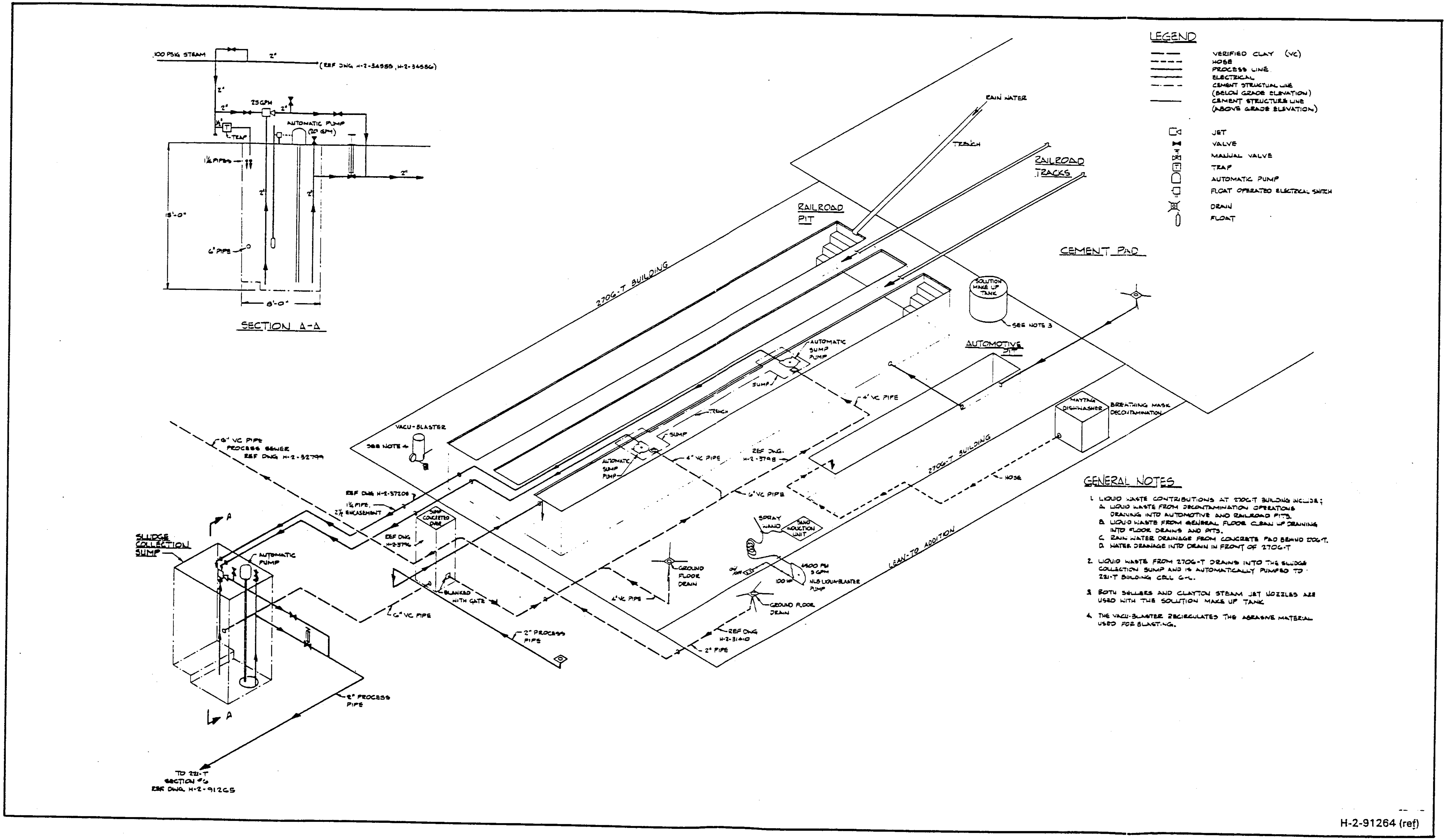

FIGURE 7-7. Building 2706-T Liquid Waste System.

galleries (excepting the section 20 gallery floor drain and the personnel decontamination station drains, which drain into the canyon), and chemical storage area 211-T are collected by chemical sewers. The chemical sewer for chemical storage area 211-T drains to pond 216-T-4. The rest of the chemical sewers drain to retention basin 207-T and from there to pond 216-T-4. All nonradioactive chemical wastes are handled and disposed of in accordance with the procedures shown in T Plant Special Services Procedures.[4]

In 1983, the T Plant Complex disposed of the chemicals shown in Table 7-1. All of these chemicals went into the building 221-T liquid radioactive waste system. No chemicals are normally disposed of into any non-canyon waste streams.

TABLE 7-1. Chemicals Expended at T Plant (1983).

Chemical	Amount
HNO_3	230 gal
NaOH	75,000 gal
$KMnO_4$	1,100 gal
TURCO 4518	3,200 lb
TURCO 4512A	300 gal
TURCO Desealzit	280 gal
TURCO 4521	350 lb
TURCO 4502	1,130 lb
$NaNO_2$	5,000 lb
Caustic soda	900 lb

7.3.2 Sanitary Waste

The sanitary sewer system, which includes T Plant sinks, showers (except the personnel decontamination shower), and toilets, drains into a septic tank and then to a tile field at the southwest side of the building.

7.4 REFERENCES

1. Rockwell, Environmental Protection Standards, RHO-MA-139, Appendix I, Rockwell Hanford Operations, Richland, Washington.

2. Rockwell, Hazardous Material Packaging, Shipping, and Transportation Manual, RHO-MA-201, Rockwell Hanford Operations, Richland, Washington.

3. Rockwell, Hanford Radioactive Solid Waste Packaging, Storage and Disposal Requirements, RHO-MA-222, Rockwell Hanford Operations, Richland, Washington.

4. Rockwell, T Plant Special Services Procedures, Manual Number 26A, B, C, and D, Rockwell Hanford Operations, Richland, Washington (March 1984).

8.0 HEALTH PROTECTION

8.1 RADIATION PROTECTION

8.1.1 General Administrative Requirements

In support of radiation protection, it is the policy and practice of Rockwell management that occupational and population radiation exposures from Rockwell activities will be ALARA. The policy is implemented by an ALARA program[1] and by Radiological Standards and Operational Controls[2] that cover all phases of plant activities (plant design, operating techniques and procedures, radiation surveillance and control programs, training, D&D, and emergency warning and response programs) in accordance with DOE orders:

- DOE Order 5480.1A, Chapter XI, "Requirements for Radiation Protection"[3]
- DOE Order 5484.1A, Chapter I, "Notification of Occurrences"[4]
- DOE Order 5484.1A, Chapter II, "Investigation Requirements"[4]
- DOE Order 5484.1A, Chapter III, "Effluent and Environmental Monitoring Program Requirements."[4]

Additional guidance is provided in DOE/EV/1830-T5, A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable.[5] The specific ALARA requirements for all Rockwell operations are delineated in RHO-MA-278, ALARA Program.[1]

The Director of Plant Operations is responsible for the implementation of and compliance with the ALARA program. The responsibility to develop and implement individual facility ALARA plans is assigned to the facility ALARA team.

Conformance to established radiological standards and plant operational requirements is ensured through the use of RWPs. These RWPs implement the various site-wide or plant-specific radiation protection requirements. Jobs that are ongoing or are performed routinely are covered by extended RWPs, which can be found in RHO-MA-172, Radiation Work Permits.[6] Nonroutine jobs or routine jobs that involve a nonroutine hazard may not be adequately covered by the extended RWP. In these cases, special temporary RWPs are issued for each particular job. It is the responsibility of the cognizant plant Radiation Monitoring supervisor to decide when such temporary RWPs are necessary.

8.1.2 Design Considerations

As discussed in Chapter 5.0, personnel outside of the building 221-T canyon are protected from penetrating radiation by the thick canyon walls. Personnel working inside the canyon are shielded by placing highly radioactive objects into cells, if possible, or by storing them away from work areas. Initial decontamination of these items may then be performed remotely using the overhead crane, by personnel working from behind portable shields, or by other methods discussed in Chapter 6.0.

Additional radiological protection for personnel inside the building 221-T canyon is afforded by SWP clothing, full-face respirators, and strict timekeeping. The minimum protective clothing requirements for canyon entry include two full sets of SWP clothing and a fitted, full-face respirator. In addition, operating personnel must conform to any additional requirements imposed by the cognizant RPT.

Building 2706-T workers are also protected by SWP clothing and a full-face respirator (when required). The principle method for radiation protection in building 2706-T is, however, administrative: highly contaminated or radioactive objects are not allowed in building 2706-T.

8.1.2.1 Building 221-T Ventilation. The design, construction, and operation of the buildings 221-T and 271-T ventilation systems are discussed in detail in Chapters 5.0 and 6.0. A primary design feature of these systems is that the potentially contaminated canyon air system is a completely separate system from the clean air systems of the building 221-T galleries and building 271-T. In addition, the canyon air system is operated at pressures that are negative with respect to the other systems. Because of these design features, only the building 221-T canyon ventilation system will be discussed further.

The original system for the building 221-T canyon was designed to provide downdraft ventilation from the craneway supply fans downward through the individual canyon cells and then out stack 291-T-1. To improve the habitability of the canyon, the craneway supply system was replaced by the 221-TA supply system. Shortly thereafter, a rooftop exhaust system was added to increase the canyon airflow (from approximately 0.8 changes/h to 1.2 changes/h) and to improve ventilation near the roof. The capacity of the original 291-T ventilation system was sufficient to ensure that the advantages of downdraft ventilation for contamination control were not significantly compromised by the addition of the roof exhauster. However, subsequent degradation of the 291-T sand filter has required that the downdraft airflow be reduced. Because of this, the updraft produced by the roof exhaust occasionally causes excessive spread of contamination in the canyon. Therefore, the roof exhauster is normally shut off when decontaminating highly contaminated equipment. During the most radiologically hazardous decontamination work, therefore, the only ventilation normally available in the building 221-T canyon is a slight downdraft through the 291-T system.

Even under these conditions ventilation capacity has been considered large enough to provide airflow from areas outside the building 221-T canyon into the canyon. For this reason, airlock doors are not provided at the canyon entrances.

Aside from an electrical interlock, which prevents operation of the 221-TA supply system independently of the roof exhaust system, the control system for the canyon ventilation consists of the pressure switches described in Chapter 5.0. These switches ensure that canyon pressure remains negative with respect to atmosphere by cycling a supply fan or the roof exhauster as necessary. If signal pressure is lost, the roof exhaust switch fails "on" and the supply fans switches fail "off." The canyon air pressure alarm is set at -0.03 in. WG.

Air activity in the canyon during decontamination operations typically ranges from less than 1×10^{-9} to 5×10^{-8} µCi/mL MFP and from less than detectable to 1×10^{-10} µCi/mL gross alpha activity. The upper limits on canyon air activity are the maximum allowed for respirator use. If high airborne contamination occurs during decontamination activities, work in the canyon is stopped and the canyon is evacuated until the canyon air activity is reduced and the source of the excessive air activity is located and stopped. Abnormal conditions affecting the ventilation system are partial loss of ventilation fans, partial or complete loss of offsite power, and loss of ventilation due to failed filters.

There are two separate exhaust systems, each capable of maintaining proper canyon airflow. No work is allowed in the canyon unless at least one 291-T exhaust fan is running. The 291-T exhaust system is equipped with two fans. In the current sand-filter bypass configuration, both of these fans are running. The 221-TA supply system is also equipped with two fans, only one of which is operating at a time.

The T Plant electrical system allows for manually cross connecting the roof exhauster and the 221-TA systems into either of two incoming lines. The ability to cross connect ensures that partial loss of offsite power would result in only a temporary loss of canyon ventilation. This capability is discussed in detail in Chapter 5.0. Upon complete loss of offsite power, T Plant ventilation systems are inoperable.

Failure of ventilation system filtration could occur as a result of plugged or leaking filters. Filters can be plugged by large amounts of dust resulting from decontamination operations or by soot from fires inside the canyon. To prevent filter plugging, dust-causing operations in the canyon, such as dry sandblasting, are severely restricted. A fire in the occupied canyon would be extinguished before enough soot could be generated to blind the exhaust filters, but a fire that burned unnoticed in the unoccupied canyon overnight or during a weekend or holiday could plug the operating exhaust filters. This would not necessarily result in release of airborne contamination to the environment because the source of airborne contamination (the decontamination activity itself) would not be in process. Leaks in either exhaust system would first be evidenced by high effluent air activity. The respective stack monitors would then alarm, notifying T Plant radiation monitoring.

The building 221-T canyon exhaust systems are large enough to ensure proper airflow through the open section 20 entry (and canyon negative pressure) even when only one system is running. The system is not large enough, however, to provide adequate canyon negative pressure to conduct operations for more than a few minutes when the railroad tunnel door is open. As a result, decontamination activities in the canyon are suspended when the tunnel door is open, and the door is not allowed to remain open any longer than necessary.

Opening the cell cover blocks will not adversely affect the overall canyon pressure, but will disrupt airflow patterns within the canyon. The effect of unsatisfactory canyon airflow patterns is addressed in Chapter 9.0.

In both exhaust systems the fans are placed downstream of the HEPA filters, thus ensuring that the fans and associated ductwork are normally only exposed to filtered air. In addition, the inlet ducting for the roof exhauster is as short as possible. The inlet ducting for the 291-T exhaust systems is longer and is contaminated. With the exception of the filter inlet plenum, however, the most highly contaminated sections of the 291-T inlet duct are either embedded into the structure of building 221-T or are buried underground.

8.1.2.2 Ventilation in Building 2706-T. Building 2706-T ventilation is a 5,000 ft^3/min downdraft system. The facility is only used for low-level decontamination activities and this ventilation is neither filtered or monitored.

8.1.2.3 Remote Decontamination. Items received for decontamination in building 221-T are first surveyed by an RPT to assess the gross surface contamination and radiation levels. Those items that exhibit unacceptably high levels are decontaminated remotely (to the extent possible), as discussed in Chapter 6.0. Remote or semiremote techniques are used as long as radiation levels in excess of 5 R/h in the potential work area are observed at any point around the object or as required by radiation monitoring.

8.1.2.4 Temporary Shielding. As decontamination progresses and the object is disassembled, contamination may be uncovered that will produce locally high exposure rates. When this occurs, distance or temporary shielding is placed between the decontamination operator and the object as needed. Typically, distance or shielding is also required whenever the object produces general work area radiation levels in excess of 100 mrem/h.

8.1.3 Operational Considerations

Operations at the T Plant Complex are governed by company-wide and plant-specific requirements. The company-wide operational requirements are described in 8.1.3.1. Plant-specific requirements are listed in 8.1.3.2.

8.1.3.1 Company-Wide Requirements

8.1.3.1.1 Manuals and Standards. Radiochemical processing has been carried out at the Hanford Site for over 35 yr. This long experience has produced detailed, written RWPs and protection standards that comply with the guidelines of the ALARA Program for maintaining radiation exposures ALARA.(1) The procedures and standards are documented in the following manuals.

- Environmental Protection Manual(7)

  This manual details the standards for controlling the release of radioactive and nonradioactive materials into the air, water, and soils; the environmental surveillance program; and the effluent sampling and monitoring program.

- Radiation Monitoring Manual of Standard Practices(8)

  This manual is a documented collection of methods, routine practices, controls, exposure guides, supporting data, and other information developed to serve as a guide to radiation monitoring personnel in performing and maintaining a uniform and sound radiation control program. The technical bases of the limits and procedures contained in the manual stem principally from authoritative bodies such as the National Council on Radiation Protection and Measurements, the now defunct Federal Radiation Council, and the International Commission on Radiological Protection. In addition, requirements of DOE and other federal regulations have been included where appropriate.

- Radiation Work Permits(6)

  This manual sets up regulations and practices for radiological protection in various phases of work in radiation zones. The RWPs for the T Plant are contained in this manual.

- Radiological Standards and Operational Controls(2)

  This manual details the radiation protection standards and controls in effect at Rockwell.

- Health Physics Procedures[9]

  This manual contains specific procedures followed primarily by Radiological Engineering and Effluent Control personnel and includes instrument calibration, and supplemental dosimetry.

In addition to the preceding manuals, there is constant updating of existing procedures and initiation of new procedures when necessary. These procedures are known as SOPs and plant operating procedures (POPs) and are developed to assure that operators can complete all assignments concerned with the collection, containment, storage, and transport of radioactive materials without undue risks of personnel exposure or release of contaminants to the environment. The Operating Documents Group of the Process Engineering Department of the Research and Engineering Function keeps the SOPs and POPs up to date.

8.1.3.1.2 Occupational Exposure Controls. To maintain personnel radiation exposures ALARA, Rockwell has adopted radiation control levels that are lower than DOE limits. The Rockwell radiation control levels, along with the limits of DOE, are presented in Table 8-1. Rockwell annual and quarterly control levels can be exceeded only after obtaining a written approval from the Manager, Radiological Protection. Exposures above control levels without prior written approval are considered as radiation occurrences, and an evaluation of the event is necessary. When the exposure status of an employee becomes uncertain or an exposure control level is likely to have been exceeded, that individual is restricted from entering posted radiological areas until the exposure has been determined. Surveys of all radiation and contaminated areas are conducted on a scheduled basis (i.e., daily, weekly, monthly, etc., depending upon the frequency of use and hazard potential).[8] Current practice for T Plant surveys is shown in Table 8-2.

8.1.3.2 Plant-Specific Requirements.

8.1.3.2.1 Radiation Control During Decontamination. All decontamination work in buildings 221-T and 2706-T is performed in accordance with RWPs, as well as SOPs developed for each task.[10] In addition to the extended RWP, special jobs that are not performed routinely in T Plant or jobs that involve unusual radiation or contamination hazards require a temporary RWP.

TABLE 8-1. Occupational Exposure Limits and Controls (rem).[a]

Organ	DOE limits		Rockwell control levels		
	Annual	Quarter	Annual	Quarter	Week
Whole body (head and trunk, gonads, lens of eye, red bone marrow, blood-forming organs)	5	3	3	1.25	0.3
Skin (except hands and forearms)	15	5	9	3	0.9
Other organs (except bone)	15	5	7.5	-	-
Bone	30	10	15	-	-
Forearms	30	10	15	5	-
Hands	75	25	15	5	1.5[b]
Feet	75	25	15	5	1.5[c]

[a]As measured by: (1) the "unfiltered" chip in the record thermoluminescent dosimeter (TLD), (2) an "unfiltered" supplementary TLD, or (3) timekeeping with open window cutie pie (CP).

[b]As measured by: (1) finger rings worn with TLD chip oriented toward the source, or (2) an open-window CP and timekeeping.

[c]As measured by a closed-window CP and timekeeping.

The entire building 221-T canyon area is posted as a radiation area, airborne radioactivity area, and surface contamination area. Minimum requirements for entry are two full sets of SWP clothing and a respirator. Building 2706-T is permanently posted as a radiation-surface contamination area. Minimum requirements for entry into building 2706-T are laboratory coats, cotton gloves, and shoe covers. Respiratory protection in building 2706-T is specified for each job by the RPT, but is not generally required. The entrance to the building 221-T canyon is staffed by radiation monitoring whenever personnel are exiting the canyon. An RPT is also available for building 2706-T whenever decontamination work is being conducted in the building or personnel are in areas requiring full SWP clothing. If required by the RWP, an RPT will be present at the job site.

TABLE 8-2. The T Plant Complex Routine Radiological Surveys.

Location	Survey frequency	
	Removable surface area radiation (alpha and beta-gamma)	General area radiation (beta-gamma)
Building 221-T		
Galleries	Monthly	Monthly
Tunnel	Monthly	Monthly
Canyon	Yearly[a,b]	Yearly[b]
Canyon stairwells	Quarterly	Quarterly
SWP lobby	Weekly	NA
Building 271-T	Yearly	NA
Building 2706-T		
Building	Monthly	NA
SWP lobby	Weekly	NA
Crane cab	Weekly	NA
Railroad cut	Quarterly (beta-gamma only)	Quarterly

[a]Contamination survey taken by direct reading from P-11 probe or PAM, as applicable.

[b]Informal surveys taken frequently during operation, annual survey documented.

8.1.3.2.2 Radiation Monitoring. As mentioned in 8.1.2.3, each incoming item for buildings 221-T and 2706-T is surveyed by an RPT for surface contamination and contact radiation levels. Additional surveys must be performed by an RPT whenever the measured (self-monitoring by operator) radiation level exceeds 100 mrem/h or whenever the item is to be released from radiological control or transported through uncontrolled areas. Occasional surveys are also taken in both buildings 221-T and 2706-T during decontamination work. The cognizant RPT determines the location and frequency of these surveys based on the contamination levels and the method of decontamination involved.

8.1.3.2.3 Radiation Protection Instrumentation. Air activity in the building 221-T canyon is continuously monitored by five CAM units. Three of the CAMs are fixed-filter Eberline BG (beta-gamma) and two are fixed-filter Eberline Alpha-V. As shown in Figure 8-1, the CAM sample points are located near the locations of most decontamination activities within the canyon. For ease of maintenance and operation, the CAM units themselves are located in the operating gallery. Two beta-gamma CAM units are installed in the operating gallery to monitor gallery air activity (see Fig. 8-1). A beta-gamma CAM unit is also installed in the crane cab.

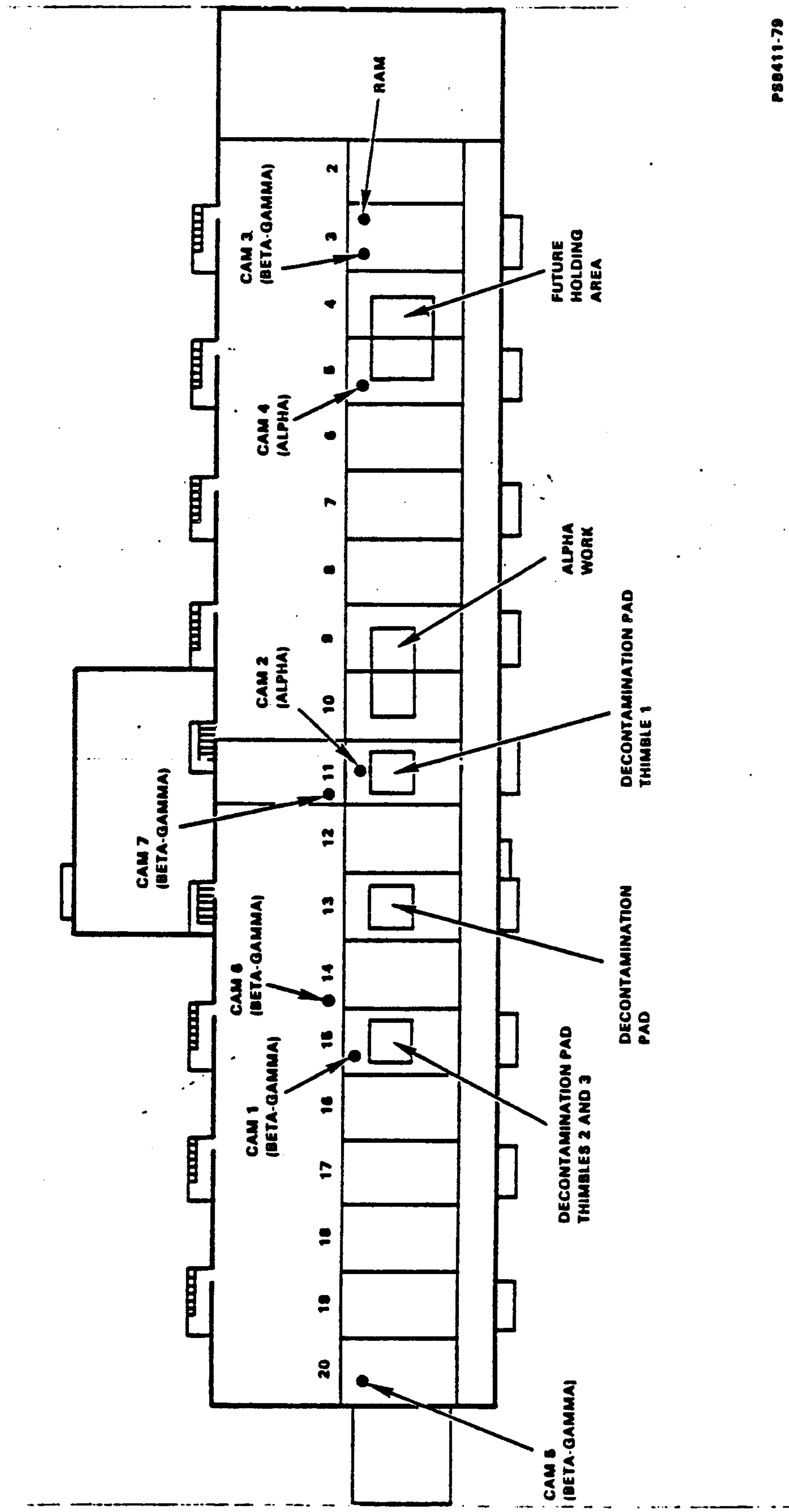

FIGURE 8-1. Building 221-T Continuous Air Monitors.

The beta-gamma CAMs for the building 221-T canyon are set to alarm when the canyon air activity level reaches 5×10^{-8} µCi/mL for 4 h. The alpha CAMs are set to alarm whenever the canyon air alpha activity level reaches 1×10^{-10} µCi/mL for 4 h. The CAM alarms can be seen and heard inside the canyon. The gallery and crane cab CAM units will alarm when airborne beta-gamma radioactivity levels reach 1×10^{-9} µCi/ml for 4 h. All CAMs are checked for proper response monthly and are recalibrated at least annually.

The filters from the five canyon CAM units, the two operating gallery CAMs, and the crane cab CAM are changed weekly. The filter from a stationary continuous air sampler at the section 20 entrance to the canyon is also changed weekly. Used filters are delivered to the 222-S counting laboratory for analysis. The results of these analyses are kept on permanent file.

Continuous stationary air samples are taken at building 2706-T. Samples are taken from each end of building 2706-T and from the SWP lobby area. These air filters are also changed weekly and delivered to the 222-S counting laboratory for analysis. The results of these analyses are kept on permanent file. Air samples are also taken in the decontamination pits, at the discretion of the RPT. There are no CAMs in 2706-T, however.

A RAM was installed in the building 221-T canyon, section 2, to warn canyon occupants of high radiation fields during PWR core II fuel-handling operations (see Fig. 8-1). The Eberline Model RMS-2 RAM is set to alarm at 1,000 mrem/h, is calibrated annually, and source checked monthly.

8.1.3.4 Health Physics Program. The general characteristics and requirements for the Rockwell Hanford health physics programs are well documented in the PUREX Final Safety Analysis Report (FSAR).[11] Applications of the health physics program that are specific to T Plant are discussed in the following paragraphs.

Protective clothing in use at T Plant includes coveralls, head covers, cloth and rubber shoe covers, rubber gloves, cloth gloves, and plastic suits. This clothing is readily available in the men's change area in building 221-T or in the women's change trailer. Used clothing is cleaned, decontaminated, and sanitized by the Protective Equipment Decontamination Department.

Respiratory protection available for use in T Plant consists of full-face cartridge respirators, constant-flow supplied-air respirators, and self-contained breathing apparatus.

Full-face respirators are used for all canyon entries and are used for all routine work in building 221-T canyon. These respirators are available in both SWP change areas. Constant-flow supplied-air respirators and self-contained breathing apparatuses are used at T Plant in emergency situations only. Both types of units are available at the section 20 entrance. A single decontamination station is provided at the section 20 entrance to the building 221-T canyon. This station is equipped and supplied in accordance with the requirements of the Radiation Monitoring Manual of Standard Practices.[8] It is for personnel decontamination only.

An RPT office is located in the building 221-T operating gallery, section 19. This office contains the necessary equipment and supplies to maintain radiation and contamination survey records and other T Plant health physics program documentation. A radiation alarm panel is also located in the office. This alarm panel is connected to the two stack monitor alarms (296-T-13 and 291-T-1) and the canyon CAMs. One of the building 221-T canyon air pressure manometers and the canyon air pressure alarm are located in the office near this alarm panel. The T Plant health physics staff consists of one unit manager, three RPTs for building 221-T, and one RPT for building 2706-T. During normal operations, however, only one RPT is available for building 221-T and one for building 2706-T. This is because the T Plant RPTs are assigned other duties in addition to the T Plant Complex.

Sufficient radiation survey instrumentation is available to conduct the T Plant operations and respond to emergencies. The instrumentation is stored at the section 20 entrance, the radiation monitoring office, and in certain cases, in the building 221-T canyon or crane cab.

Stationary (semiportable) air samplers are also used at T Plant. One unit is installed at the section 20 canyon entrance, a second at building 2706-T (samples from 3 areas), and a third in the crane cab. The filters from these units are changed and analyzed weekly as discussed in 8.1.3.2. The filter from the crane cab air sampler is normally only used as backup for the CAM filter and is not retained as a permanent record.

Radiation and contamination surveys are conducted at T Plant in accordance with standard practices and approved procedures.[2,8] The location, frequency, and type of surveys routinely conducted are shown in Table 8-2. Survey records are maintained on file in the RPT office for 12 mo and then sent to permanent record storage. These are the minimum required surveys for T Plant. In addition to these, special radiation and contamination surveys are taken at the discretion of the cognizant RPT.

Controlled access areas have been established at T Plant in accordance with the requirements of RHO-MA-220.[2] All of the following area designations are in use at T Plant.

- Radiation Area

  An area where an individual could receive an exposure between 1 and 100 mrem in 1 h.

- Radiation Area--Surface Contamination

  An area in which the removable surface contamination may exceed 200 dpm/100 cm^2 for alpha radiation and 2,000 dpm/100 cm^2 for beta-gamma radiation.

- Radiation Area--Airborne Radioactivity

  An area where radioactive air concentrations exist which, if averaged over the number of hours in any week during which individuals are in the area, would exceed 25% of the concentrations specified in Appendix B of RHO-MA-220.(2)

- High Radiation Area

  An area where an individual could receive an exposure in excess of 100 mrem (but less than 5 rem) in 1 h.

- Radioactive Material Area

  An area or enclosure where radioactive material is present in a form such that no protective clothing is required.

- Restricted Access Area

  An area that requires special safety precautions when entering or where an individual could receive in excess of 5 rem/h.

Building 2706-T decontamination floor and pits are permanently posted as radiation--surface contamination areas. The maximum allowable removable surface contamination in building 2706-T is 200 cpm/100 cm^2 alpha or 1,000 dpm/100 cm^2 beta-gamma on the main floor.(6) In addition, the surface must be decontaminated whenever background radiation levels in the work area exceed 6 mrads/h on the main floor or 25 mrads/h in the pits.(6) All areas within buildings 221-T and 271-T are maintained as clean areas (unrestricted access), except for the building 221-T canyon.

The building 221-T canyon is permanently posted as a radiation--surface contamination--airborne radioactivity area and entry without Radiation Monitoring permission is prohibited. Within the canyon, certain areas are posted as either high radiation or limited access areas, depending on the radiation levels around the equipment in the area. Although no specific contamination limits exist within the canyon, the canyon is kept as clean as possible. Pursuant to this, certain areas within the canyon are posted as special surface contamination areas. Section 2, for example, is posted as a clean area, and clean shoe covers must be put on before entry is allowed. Sections 3 and 4 are occasionally posted as alpha-contaminated areas and shoe covers must then be removed before leaving this area. The results of a recent canyon survey are shown in Figure 8-2.

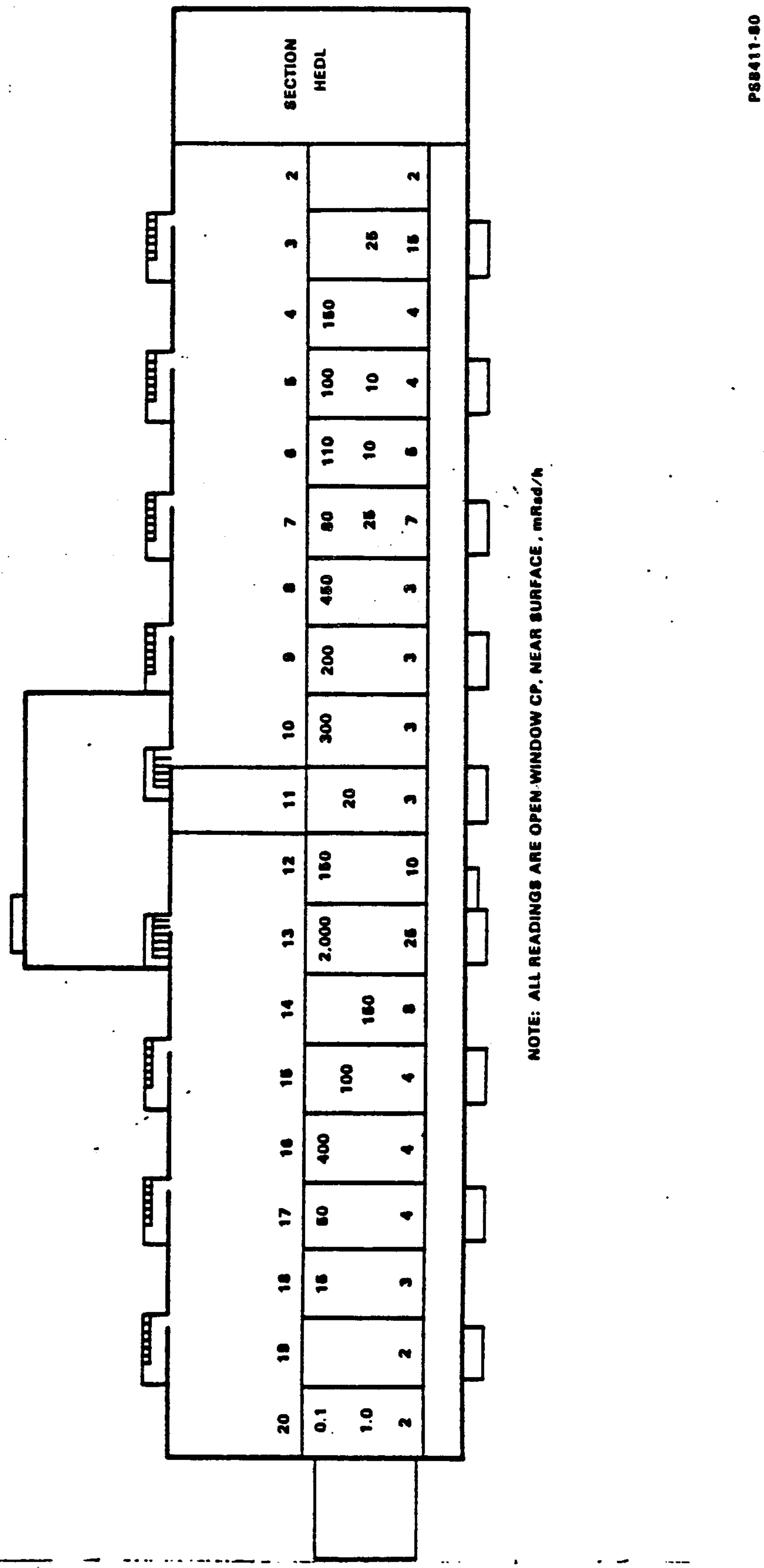

FIGURE 8-2. Building 221-T Canyon Surface Contamination.

Outdoor sites surrounding the T Plant Complex also follow the physical and administrative requirements stated to control access and stay time in radiation areas. The following sites are identified with appropriate postings and barriers:

- Underground radioactive waste storage tanks and diversion boxes
- Burial trenches, cribs, and ponds
- Underground pipelines
- Permanent, stabilized burial plots
- Roads and other paved areas covering radioactive contamination.

The operating procedures for the T Plant Complex do not allow introduction of significant quantities of fissile material and, therefore, the T Plant has been designated as a limited control facility. The possibility of a nuclear excursion in T Plant is considered to be incredible (not expected during the life of the plant). The possible effects of a nuclear excursion in building 221-T are discussed in Chapter 9.0.

8.1.4 Dose Commitments

The major sources of contamination and radiation in the T Plant Complex are the contaminated equipment itself and residual radiation or contamination from the $BiPO_4$ process. Other sources include the equilibrium canyon air activity and the T Plant liquid radioactive waste. These sources are summarized in Table 8-3.

TABLE 8-3. Sources of Radiation Exposure in the T Plant Complex.

Source	Average concentration (μCi/mL)	Total source (Ci)
Canyon air		
Alpha	1.0 E-10	1.0 E-05
Beta-gamma	5.0 E-08	5.4 E-03
Liquid waste*		
^{90}Sr	6.1 E-03	4.6 E-01
^{239}Pu	1.4 E-03	1.0 E-01
^{137}Cs	2.4 E-02	2.0 E+00

*Assumes 20,000 gal in T Plant.

The information in Table 8-3 was developed using maximum allowable activities for canyon air and actual sample analysis results for the liquid waste.[11] As can be seen from the table, the easily dispersible radionuclide inventory in T Plant is small.

8.2 INDUSTRIAL HEALTH AND SAFETY

Protection of T Plant operators from toxic materials and industrial safety hazards is under the cognizance of the Industrial Hygiene and Safety (IH&S) Department of the Safety and Quality Assurance (S&QA) Function. The IH&S Department operates in accordance with RHO-MA-221, Accident Prevention Standards,[12] as well as DOE Order 5480.1A, Chapter X,[3] and 5483.1A, Occupational Safety and Health Program.[13] The organization of IH&S with respect to T Plant is discussed in detail in 8.2.3.

8.2.1 Design Considerations

8.2.1.1 Canyon and Gallery Exits. Emergency exits from the building 221-T canyon (Chapter 5.0) can normally only be opened from the canyon and are used for emergency exit only. The emergency exits are used whenever hazards exist in the canyon that cannot be guarded against by normal protective equipment. Operators are alerted to evacuate the canyon by means of the canyon evacuation alarm (canyon klaxon). Operators can exit the 221-T operating galleries or buildings 271-T or 2706-T by means of the normal building entrances. As noted in Chapter 4.0, the building 221-T gallery exits are not in compliance with the Life Safety Code.

8.2.1.2 Canyon and Gallery Ventilation. The ventilation systems in buildings 221-T, 271-T, and 2706-T are relied upon to provide adequate ventilation for control of any hazardous vapors, fumes, or mists that are produced by T Plant operations. Fume hoods, area exhausters, etc., are not used at T Plant; instead, general ventilation is used in conjunction with special protective equipment (see 8.2.3.3) to provide personnel safety and keep concentrations of hazardous chemical vapors within acceptable limits.

8.2.1.3 Chemical Distribution System. As discussed in Chapters 5.0 and 6.0, liquid chemicals are mixed and transferred in closed tanks and piping to the extent practical. Bulk mixing is done outside of the canyon, in building 271-T. The chemicals are then stored in closed tanks for use as necessary in the canyon. When required, the bulk chemicals can be distributed to the various thimbles or tanks inside the canyon from valve and pump control centers located both inside and outside the canyon; operation normally occurs from inside the canyon. Many liquid chemicals are used as they are received from the manufacturer (Chapter 6.0). Drums of these chemicals are brought into the canyon as needed via the railroad tunnel or the section 20 entrance. The chemicals are then used directly from the drum.

8.2.1.4 Liquid Waste System. All chemicals used in both the building 2706-T and the building 221-T canyon are flushed down into the radioactive liquid waste disposal system as soon as they are used. This system is described in Chapters 5.0 and 7.0.

8.2.2 Operational Considerations

8.2.2.1 Hazardous Material Control. Many of the chemicals used for decontamination at T Plant are considered to be hazardous or toxic. The hazard classification of each of the chemicals in use at T Plant is shown in Table 8-4. All of these chemicals require special storage and handling procedures, as discussed in Chapters 5.0 and 6.0.

TABLE 8-4. The Hanford Environmental Health Foundation Hazard Classification of Chemicals Used At T Plant.[14]

Chemical identity or name	Fire rating	Reactivity rating	Toxicity rating
NaOH	1	3	2
$NaOH/KMnO_4$	0	1	3
Turco TD-4501A	0	1	1
Turco TD-4501	0	3	3
Turco TD-4512A	1	0	3
Turco TD-4518	0	0	2
Turco TD-4521	0	0	2
Turco TD-4306D	0	1	2
Clayton cleaners	0	0	2
Turco Desealzit 2	3	1	(Benzene) 4
Westlode degreaser	2	0	1
HNO_3	0	4	3
Kleno bowl	0	3	1
Acetone	3	2	1
Safety solvent	2	0	1
Sodium bisulfite	0	0	2
Turco T-5589	0	0	1
Turco T-Plaudit	1	2	1
Turco T-Alkl rust remover	0	3	2

NOTE: The HEHF classification is based upon the NFPA number system that was developed for the identification of fire hazards. The numerical rating system assigns relative hazard ratings to the material in question for the categories of flammability, reactivity, and toxicity. Each of the hazard categories is rated on a scale of 0 to 4 with 4 representing the most serious hazard. Chemical mixtures were categorized by the primary constituent. Toxicity of chemicals diluted with water were downgraded appropriately.

8.2.2.2 Special Procedures. The use of decontamination chemicals in T Plant is covered by operating procedure DO-120-009.[10] This procedure covers the normal use of reagents for routine decontamination work. Occasionally, special decontamination jobs will be required that involve the use of chemicals not normally found in T Plant, or that involve the use of regular decontamination chemicals in unusual ways. These situations are covered by special procedures that are written for and apply to a specific job, as discussed in 8.2.3.5.

8.2.2.3 Control of Adverse Chemical Reactions. It is possible to mix certain decontamination reagents together, either before use or during application, that may react with each other to produce toxic or noxious fumes. Various combinations of reagents that are capable of producing these fumes are shown in Table 8-5.[15] The hazards presented to the operator by these fumes are mitigated by the canyon ventilation system. The possibility of inadvertent mixing is minimized by requiring that all tanks used to mix or store these chemicals be flushed prior to reuse and by only using one mixture at a time when decontaminating equipment. For multistep decontamination, the equipment is flushed with water between steps.

TABLE 8-5. Toxic Fume Hazards.

Mixture	Toxic fumes
Turco TD-4502 with Turco TD-4512A	PO_x, phosphine, H_3PO_4
Turco TD-4521 with Turco TD-4502	NH_3
Turco TD-4521 with NaOH	NH_3
Turco TD-4512A with $NaOH/KMnO_4$	PO_x, phosphine, H_3PO_4
Turco TD-4512 with $NaOH/KMnO_4$	NH_3
$NaOH/KMnO_4$ with HNO_3	NO_x, HNO_3

8.2.3 Industrial Hygiene Program

8.2.3.1 Organization. The IH&S Department is divided into three disciplines: Fire Protection, Industrial Hygiene, and Safety Engineering. Within the Industrial Hygiene group there are two Industrial Hygienists. These two are responsible for the industrial hygiene of the entire Rockwell operation.

8.2.3.2 Audits and Inspections. The following walk-through audits are conducted by the IH&S Department on all major facilities: (1) annual fire protection, (2) annual audit by Quality Assurance (QA), and (3) annual IH&S Department audit. A record is kept of these audits by the group that conducted the inspection. Audit findings are entered into the

Automatic Action Tracking System. Additional audits are conducted at the request of T Plant management or as a result of a formal employee complaint.[13]

8.2.3.3 Protective Equipment. Operators who are working with acids or caustics are required to wear a full acid suit consisting of rubber trousers, shoe covers, gloves, jacket and head cover, and a full-face shield. Protective equipment such as gloves, acid goggles, a chemical respirator, etc., must be worn when mixing or handling other chemicals, as required by procedure.[10] The appropriate chemical respirator cartridge for use at T Plant is chosen by the IH&S Department. The chemical respirator cartridge currently in use at T Plant is a general purpose GMD-H cartridge. This equipment is available at the SWP change areas, in the RPT office (for chemical cartridges), or at the job site. Sixteen safety showers are outside of the building 221-T canyon in T Plant. These showers are located near areas where operators could be exposed to chemical hazards. Each of these showers is checked for proper operation at least weekly.

8.2.3.4 Work Place Monitoring. Monitoring the T Plant Complex for the presence of hazardous mists, dusts, or fumes is the responsibility of the IH&S Department. Surveys are taken by HEHF at the request of IH&S. To date, no such surveys have been documented.

8.2.3.5 Worker Training and Orientation. In addition to the training described in Chapter 10.0, the T Plant operators are given lectures on control of hazardous substances and the hazards associated with specific substances they may encounter in their jobs. Jobs that have a high hazard potential must have a formal job safety analysis (JSA) performed.[13] This is normally done by the Process Engineering Department. Based on the results of the JSA, IH&S will then provide additional worker training as needed. Nonroutine jobs that are also of high hazard potential but are of short duration (i.e., entry into a closed space to change a valve lineup) are covered by a hazardous work permit (HWP) in lieu of a formal job safety analysis. For routine jobs, such as normal activities in T Plant, the JSA/HWP process is incorporated into individual procedures.

8.3 REFERENCES

1. Rockwell, ALARA Program, RHO-MA-278, Rockwell Hanford Operations, Richland, Washington.

2. Rockwell, Radiological Standards and Operational Controls, RHO-MA-220, Rockwell Hanford Operations, Richland, Washington.

3. DOE, "Requirements for Radiation Protection," DOE Order 5480.1A, Chapter XI, U.S. Department of Energy, Washington, D.C. (November 1981).

4. DOE, Environmental Safety and Health Protection Information Reporting Requirements, DOE Order 5484.1, U.S. Department of Energy, Washington, D.C. (February 1981).

5. DOE, A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable Guide, DOE/EV/1830-T5, U.S. Department of Energy, Washington, D.C.

6. Rockwell, Radiation Work Permits, RHO-MA-172, Rockwell Hanford Operations, Richland, Washington.

7. Rockwell, Environmental Protection Standards, RHO-MA-139, Rockwell Hanford Operations, Richland, Washington.

8. Rockwell, Radiation Monitoring Manual of Standard Practices, RHO-MA-145, Rockwell Hanford Operations, Richland, Washington.

9. Rockwell, Health Physics Procedures, Rockwell Hanford Operations, Richland, Washington.

10. Rockwell, T Plant Special Services Procedures, Manual Number 26A, B, C, and D, Rockwell Hanford Operations, Richland, Washington (March 1984).

11. K. J. Patterson to J. P. Hinckley, "Analysis of T Plant Sludge Sample," Internal Letter, Rockwell Hanford Operations, Richland, Washington (July 12, 1984).

12. Rockwell, Accident Prevention Standards, RHO-MA-221, Rockwell Hanford Operations, Richland, Washington.

13. DOE, Occupational Safety and Health Program, DOE Order 5483.1A, U.S. Department of Energy, Richland, Washington (June 1983).

14. HEHF to A. W. Lilly, "Chemical Classifications, 221-T Chemical Products," Letter C08838, Hanford Environmental Health Foundation Richland, Washington (July 19, 1984).

15. S. R. Coleman to A. W. Lilly, "Chemical Compatibility Matrix, 221-T Building, 220-W Area," Letter, Rockwell Hanford Operations, Richland, Washington. (May 18, 1984).

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9.0 SAFETY ANALYSIS

The safety analysis of the T Plant Complex was performed with an understanding of the limitations of the estimates of probabilities and consequences of accidents associated with any industry. In performing the analysis, the characteristics of the principal building within the T Plant Complex, building 221-T, were also considered. These characteristics include the original plant construction (heavy shielding walls), geographical isolation, history of safe operation, and the small amount of hazardous material contained within the facility.

The T Plant safety analysis was performed for the following reasons:

1. To establish a baseline risk for the T Plant operation in terms of risks to both the maximum onsite personnel and offsite individual

2. To document and, to the extent practical, quantify the residual risks accepted by Rockwell from T Plant operations

3. To identify key areas which, if aggravated by system degradation or by increased system demand (i.e., increased plant throughput), may produce unacceptable risks

4. To determine if there are any previously unidentified risks pertaining to the T Plant operation and, if so, provide for the establishment of appropriate barriers.

Areas for analysis were identified by three criteria:

1. The presence of significant hazards

2. The chemical or physical nature of the hazard

3. The presence of working conditions that could cause a loss of control of these hazards and result in an accident.

Based upon these criteria, the following areas were selected for analysis:

1. Operations in building 271-T

2. Operations in the building 221-T galleries

3. Decontamination operations in building 2706-T

4. Decontamination operations in building 221-T.

9.1 PRELIMINARY HAZARDS ANALYSIS

A preliminary hazard analysis (PHA) was conducted to identify the broad range of possible risks associated with the operation of T Plant. The PHA was then used to identify those hazards that could produce an accident with significant consequences to either T Plant operation personnel, onsite workers, or to the general public. The probability and consequence for each of these accidents were then assessed and a determination made of the risk represented by that hazard.

The PHA was conducted using the operating history of T Plant, experiences of similar operations not involving radioactive hazards, and extensive peer review by T Plant personnel. The PHA for T Plant is shown as Table 9-1. An abbreviated energy barriers analysis was included in the PHA. The results of this analysis are also shown in Table 9-1. The table has been divided into the following areas.

- Operation--a brief description of the specific operation of concern.
- Accident--a brief description of the various possible accidents and hazards associated with the operation.
- Barriers--preventative barriers (engineered or administrative), either on the hazard, on the target, or between the target and the hazard, that must fail for an accident to occur.
- Consequence--a qualitative statement of the impact the hazard might have on the target in the event that it develops into an accident. The meaning of the descriptive words used here is shown in Tables 9-2 and 9-3.
- Failure Probability--a qualitative statement of the likelihood that a specific barrier will fail or prove to be inadequate. A high probability suggests that this barrier has failed often in the past, if not at T Plant, then in a similar operation at a different facility. Conversely, a low probability suggests that the barrier has rarely been known to fail. In some cases the same barrier has been assigned different failure probabilities for different potential accidents. For example, a procedural barrier can fail either because the procedure was not followed (a moderate or high probability, depending on the procedure and how it is used) or because it did not adequately anticipate the particular accident under consideration (a low or high probability--it either does or it doesn't). This is done because any given barrier will not be as effective for certain accidents as it is for others.

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 1 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Receiving contaminated equipment into building 2706-T	1. Normal industrial hazards of falls and pinched or crushed limbs.	1. Training 2. Procedures (DO-020-005, -021-012) 3. Access to timely first aid (mitigative)	III	1. Moderate 2. High 3. Low
	2. Exposure to high radiation or contamination.	1. Radioactive Shipment Records indicate potential for problem 2. RPT survey of all incoming material before work is started 3. For contamination only - SWP clothing is worn at all times while in building 2706-T	Low	1. High 2. Low 3. Moderate
	3. Structural damage and spread of contamination caused by railcar or vehicle overshooting decontamination pit.	1. Speed limits 2. Overtravel stops 3. Procedures (DO-020-005, -021-012) require use of air tugger	Low	1. High 2. Moderate 3. High
Decontamination operations in building 2706-T	1. Normal industrial hazards of tripping, falls, steam burns, cuts, and abrasions from high pressure (4,500 lb/in²) water, electric shock.	1. Training 2. Procedures (DO-021-003, -008, -011, and -014) 3. Protective design features such as high-pressure hoses, relief valves, "dead man" type control valves 4. Standard electrical safety procedures, controls	III	1. Moderate 2. High 3. Low 4. Low
	2. Chemical hazards of chemical burns, skin irritation, and inhalation of toxic fumes.	1. Training 2. Procedures (DO-120-009, -021-002) 3. Use of protective equipment such as chemical respirators, acid-proof clothing 4. Ventilation	III	1. Moderate 2. High (most procedures do not require a chemical respirator unless vapors are detected) 3. Moderate 4. High (ventilation must be turned on by operator before decontamination work begins)
	3. Spread of contamination by careless work habits or ignorance of contamination levels involved (i.e., lack of adequate survey, assumption that high radiation levels are not from fixed surface contamination, or defective equipment).	1. Training 2. Procedures (DO-020-004, -021-011) 3. RPT Training 4. Radiation Shipment Records 5. Ventilation 6. Personnel survey on exit	Low	1. Moderate 2. High 3. Moderate 4. High 5. High 6. Low

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 2 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Decontamination operations in building 2706-T (cont.)	4. Exposure to heat, smoke, and radioactivity from fire.	1. Automatic fire alarms 2. Portable fire extinguishers 3. Low combustible loading 4. Low levels of contamination 5. Ready availability of exits	Low/III	1. Low 2. Low 3. Moderate 4. Moderate 5. Low
	5. Exposure to high radiation (see Sheet 1).			
Use of building 271-T	1. Exposure to heat and smoke from fire.	1. Fire alarms 2. Easy egress 3. Portable fire extinguishers	II	1. Moderate 2. Moderate 3. Low
	2. Exposure to airborne chemicals and/or radioactive contamination from operations in building 2706-T.	1. Dilution by distance from building 2706-T 2. Dilution by building 271-T ventilation	Mod/IV	1. Low 2. Low
	3. Exposure to chemical vapors from improper mixing of chemicals in tanks M-101 and M-102.	1. Procedures (DO-120-007, -008, -009, -020, and -022) 2. Ventilation 3. Operator only--chemical respirator	IV	1. High 2. Low 3. Low
Use of chemical storage area 211-T	1. Chemical spills producing fumes or burns.	1. Dilution by outside air 2. Protective equipment 3. Procedures (DO-120-012, -002-001) 4. Training 5. Safety shower (mitigative)	III	1. Low 2. Low 3. High 4. Moderate 5. Low
	2. Structural damage, chemical spill caused by railcar derailment or travel past tank area and into building 271-T.	1. Speed limits 2. Overtravel stops 3. Training	III	1. High 2. Moderate 3. Low
	3. Mixing bulk acid with caustic.	1. Procedures 2. Training 3. Different systems	III	1. High 2. Moderate 3. Low
Operations in building 2715-T	1. Exposure to heat and smoke from fire.	1. Automatic fire alarms 2. Proper storage of combustibles 3. Portable fire extinguishers 4. Easy egress	IV	1. Low 2. High 3. Low 4. Moderate
	2. Normal industrial hazards associated with the use of the shop.	1. Training 2. Protective equipment, machine guards	IV	1. Moderate 2. Moderate

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 3 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Operations in women's change trailer	1. Exposure to heat and smoke from fire.	1. Proper storage of combustibles 2. Portable fire extinguishers 3. Easy egress	IV	1. High 2. Low 3. Moderate
	2. Exposure to contamination brought in with used SWPs.	1. Survey of clothing at control point 2. Routine survey of building	Low	1. Low 2. Moderate
Operations in building 221-T galleries	1. High airborne radioactivity from operations in building 221-T canyon.	1. Canyon DP 2. Single entry point at section 20 3. Dilution by building 221-T gallery exhaust 4. Canyon air monitors 5. Gallery air monitors	Low	1. Low 2. Low 3. Low 4. High (CAMs warn of high canyon air activity, not necessarily high gallery air activity) 5. Low
	2. Exposure to smoke and heat from fire.	1. Manual fire alarms 2. Portable fire extinguishers 3. Easy egress	II	1. Moderate 2. Low 3. Moderate
	3. Exposure to chemical vapors from spills or improperly stored chemicals.	1. Procedure (DO-120-009) 2. Training 3. Ventilation 4. Distance (chemicals are stored away from normally occupied spaces and are mixed in areas separate from storage)	III	1. High 2. Moderate 3. Low 4. Low
	4. Industrial hazards associated with use of shops and electrical switch gear.	(See Sheet 1, industrial hazard decontamination in building 2706-T)		
	5. Hazards of use or work on deactivated equipment: electrical shock, chemical burns, and spread of contamination.	1. Lock-out/tag-out procedures 2. Supervision 3. Pre-job safety briefing, safety inspections	Low/III	1. Moderate 2. Moderate 3. Moderate
	6. Radioactive contamination from used SWP clothing worn in galleries.	1. Survey at control plant 2. Routine survey of galleries 3. Control of used SWPs	Low	1. Low 2. Moderate 3. Low
	7. Chemical burns, inhalation from use of chemical distribution system.	1. Procedures (DO-120-021, -022) 2. Personal protection equipment 3. System integrity 4. Safety showers (mitigative)	II	1. High 2. Low 3. High 4, Moderate

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 4 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Operations in building 221-T galleries (cont.)	8. Hazards associated with high-pressure steam (burns, inhalation).	1. Relief valves 2. System integrity 3. Insulation on exposed hot pipes 4. Labeling	III	1. Low 2. Low 3. Moderate 4. High
Receipt of contaminated equipment into building 221-T canyon	1. Loss of ventilation and/or contamination control when tunnel door is open.	1. Procedure DO-020-042 2. System integrity	Low	1. High 2. Moderate
	2. Spread of contamination, structural damage from railcar travel beyond the end of the canyon.	1. Speed limits 2. Overtravel stops 3. Structural integrity of building 221-T and waste container on railcar	Low	1. High 2. Moderate 3. Low
	3. Industrial hazards (see Sheet 1).			
	4. Exposure to high radiation levels while unloading cask or container.	1. Procedures (DO-021-009, and others (job specific)) 2. Continuous RPT coverage 3. Personnel dosimetry (mitigate only) 4. RSR and pre-job planning	Low	1. High 2. Low 3. Low 4. Low
	5. Spread of contamination while unloading.	1. Procedures (RWP-T-9) 2. SWP clothing (for personnel only) 3. RPT coverage 4. Use of plastic sheeting (for structure and container only)	Low	1. High 2. Low 3. Low 4. Moderate
Decontamination operations in building 221-T canyon	1. Industrial hazards associated with use of high-pressure water, electrical equipment, steam, and overhead crane transfer of large, heavy objects (see Sheet 1, industrial hazard).	1. Procedures, training 2. SWP clothing 3. Other protective equipment (see Sheet 1, industrial hazard)	II	1. Moderate 2. Moderate 3. Low
	2. Exposure to noxious fumes or mists from mixing incompatible chemicals.	1. Procedures (DO-120-022), training 2. Chemical respirators 3. Canyon ventilation	II	1. High 2. Moderate (not required by procedures) 3. Moderate
	3. Spread of contamination caused by improper transfer of chemical solutions and/or mixing with other incompatible solutions.	1. Procedures (DO-120-021), training 2. See also Item 4 (spread of contamination)	Low	1. High

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 5 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Decontamination operations in building 221-T canyon (cont.)	4. Spread of contamination.	1. Procedures, training 2. RPT supervision 3. SWP clothing (for personnel only) 4. Ventilation	Low	1. Moderate 2. Low 3. Low 4. High
	5. Exposure to excessive levels of airborne contamination.	1. Ventilation 2. Respirators 3. CAM units 4. Survey of respirator canisters (mitigative only)	Moderate	1. Moderate 2. Low 3. Moderate 4. High
	6. Release of contaminated air a. Release to the environment through reverse infiltration (craneway supply fans, other wall penetrations).	1. Ventilation (negative pressure) 2. Canyon structure	Low	1. Moderate 2. Low
	b. Release to the environment through exhaust stack.	1. Ventilation (HEPA) 2. Effluent air activity monitors (mitigative)	Low	1. Moderate 2. Low
	7. Exposure to high radiation levels.	1. Procedures, training 2. RPT supervision 3. Barrier ribbons, signs 4. Dosimetry (mitigative only)	Moderate	1. Moderate 2. Low 3. Moderate 4. Low
	8. Release of contaminated liquid a. Release to environment from flooding in the canyon.	1. Training 2. Waste system design and integrity 3. Large cell volumes	Low	1. Moderate 2. Low 3. Low
	b. Release to environment from improper transfer of waste, piping system leaks, etc.	1. Procedures (DO-100-004, -017) and training to prevent improper transfer 2. Waste system design and integrity	Moderate	1. High 2. Low
	9. Exposure to heat and smoke from fire.	1. Noncombustible structure and material 2. Ease of egress 3. Portable fire extinguishers	III	1. Moderate 2. Low 3. Low
	10. Release of contamination to environment from dropped roof-top HEPA.	1. Procedures (DO-060-006), training	Low	1. High

TABLE 9-1. T Plant Complex Preliminary Hazard Analysis. (Sheet 6 of 6)

Operation	Accident	Barriers	Consequence*	Failure probability
Decontamination operations in building 221-T canyon (cont.)	11. Nuclear excursion in waste system.	1. Shielded cell cover blocks 2. Low plutonium inventory in system (below minimum critical mass) 3. Limit on fissile content allowed in plant: 4. Ventilation	High	1. Low 2. Low 3. Moderate 4. Low
	12. Contaminated injuries.	1. Training 2. SWP clothing 3. Prompt first aid (mitigative only)	Low	1. Moderate 2. Moderate 3. Low

*See Tables 9-2 and 9-3 for an explanation of these ratings.

TABLE 9-2. Radiological Consequence Rating.

Descriptive word	Description
None	No radiological impact to onsite personnel, offsite individuals, or the environment.
Low	Minor onsite and negligible offsite radiological impact to individuals or to the environment. (Short-term exposure of onsite people to radioactivity above MPC values--but not enough to represent a moderate or worse hazard--is in this category.)
Moderate	Considerable radiological impact onsite but minor radiological impact to offsite individuals or the environment. (Chronic exposure of onsite personnel to levels of radioactivity slightly above MPC values is in this category.)
High	Major radiological impact both onsite and offsite individuals or the environment. (Loss of life, significant loss of property, or loss of facility use for extended periods are in this category).

SOURCE: DOE Order 5481.1A.(1)

TABLE 9-3. Nonradiological Consequence Rating.

Category	Description
IV	Industrial accidents or injuries such as cuts and sprains, or short-term exposure to toxic chemicals above ceiling or threshold limit value (TLV) values, but not high enough to result in a category III accident or worse.
III	An event causing minor injury or minor occupational illness, but no system damage. (Accidents resulting in temporary disability, chronic exposure to toxic chemicals slightly above ceiling or TLV values, etc., are in this category.)
II	An event causing severe injury, severe occupational illness, or minor system damage. (Accidents resulting in permanent disability or exposure to chemical carcinogens, mutagens, etc., are in this category.)
I	An event causing death, significant loss of property, or loss of facility use for extended periods.

SOURCE: MIL-STD-8824.(2)

Table 9-1 indicates that most of the hazards at the T Plant Complex are either of low consequence or are provided with enough barriers to give a low probability of accident. Certain hazards were identified, however, that have a reasonable probability of accident and that could produce moderate or higher consequences to personnel, equipment, or the environment if the barriers failed. Certain other hazards represent a maximum credible baseline risk for the T Plant operation. These hazards were developed into the potential accident scenarios discussed in 9.2. The methodology for this selection and development follows.

1. All potential accidents with a consequence rating of "high," "moderate," "I," or "II" were taken from Table 9-1 and developed into accident scenarios.

   NOTE: In certain cases a potential accident that was thought to produce significant consequences turned out, upon analysis, to produce "low" or "III" level consequences. This is the case for scenario 9.2.1, for example.

2. The consequences for each potential accident scenario were assessed. For radiological consequences, the assessments were performed using applicable computer codes. The consequences of potential nonradiological accidents were assessed using safety data from the nonnuclear industry, operating records, and professional judgment.

3. The scenario for each potential accident was further refined and justified to estimate the likelihood of occurrence. Generally, no attempt was made to define the probability of occurrence beyond the categories of the Safety Analysis and Report Preparation Guide, RHO-HS-MA-1 REV 1.[3] That is, the probability of occurrence was either (1) incidents or events of moderate frequency that may occur several times during the life of a facility (i.e., at least once in 10 yr), (2) infrequent incidents or events that may occur once in the lifetime of a facility, or (3) events that are not expected to occur during the life of a facility.

9.2 ANALYSIS

9.2.1 Airborne Radioactivity in Building 271-T

9.2.1.1 Scenario. The occupants of the offices and shops in building 271-T are exposed to airborne radioactivity resulting from decontamination operations in building 2706-T. The contamination is produced as a result of the sandblasting of a contaminated tank car in building 2706-T. The contamination, consisting of the FP ^{137}Cs and $^{90}Sr/Y$, is entrained into the building 2706-T exhaust system and is blown into the building 271-T ventilation supply by a north wind. The unfiltered and unmonitored building 2706-T exhaust stack is directly north of, and approximately 30 ft below, the building 271-T inlet. The 271-T ventilation system, in turn, distributes the contamination throughout the building. The occupants of building 271-T are exposed to the contamination for the entire duration of the release, or about 4 h.

The source consists of fixed contamination on the undercarriage of the rail car. There is sufficient contamination (approximately 10 Ci) to produce a uniform dose equivalent rate of 100 mrem/h near the surface. All of the contamination is subsequently removed by vacuum sandblasting. This operation releases the radioactivity directly into the air both at the surface of the car and from the sand-collecting bag on the machine.

9.2.1.2 Consequences. The maximum onsite individual for this analysis is an occupant of building 271-T. This individual was chosen over the worker in building 2706-T for two reasons: (1) in accordance with the definition of "onsite worker" in RHO-HS-MA-1,(3) as the worker in the nearest adjacent facility, and (2) the occupants of building 271-T are not protected from this accident at all, nor would they be warned that a dangerous condition existed. There are no CAMs or other air sampling devices in building 271-T.

The consequences of this accident were analyzed and found to be relatively minor, on a "per event" basis.(4) Even for a source strength of 10 Ci of FP or 10 Ci of ^{60}Co, the dose equivalent to the maximum onsite worker did not exceed the guidelines of RHO-HS-MA-1 REV 1 for acceptable risks.(3) The actual calculated dose equivalents are shown in Table 9-4.

TABLE 9-4. Maximum Onsite Dose Equivalent From Operations in Building 2706-T* (per event).

Source	Time (yr)	Organ dose (mrem)		
		Total body	Bone	Lung
FP	1	7.0 E-02	1.0 E+00	6.7 E-01
	50	8.2 E-01	1.21 E+01	6.7 E-01
^{60}Co	1	<1.0 E-02	<1.0 E-02	1.2 E-02
	50	<1.0 E-02	<1.0 E-02	1.2 E-02

*Assume 0.01% release fraction.

It was estimated(4) that only 0.01% of the material removed from the railroad car would get into the ventilation system as respirable particulates. This is an extremely small amount. Even if this release fraction were increased by two orders of magnitude to 1.0%, the dose equivalent to the building 271-T occupants would not constitute an unacceptable risk. The consequences of this accident were lower than anticipated in Table 9-1.

The estimated maximum dose to the worker in building 2706-T from this postulated accident would be approximately 500 times the dose to the building 271-T occupants. This would happen only if the building 2706-T pit ventilation was not operating properly and if the work space airborne activity levels were not being monitored at least occasionally as the work progressed.

9.2.1.3 Probability of Occurrence. This accident can be expected to occur at least once every 10 yr during the life of the facility. Railroad cars are routinely decontaminated in building 2706-T. The RWP pertaining to this activity suggests that rail cars that produce radiation levels below 100 mR/h do not pose a significant hazard.(5) Therefore, unless the shipping records clearly warn of the presence of fixed surface contamination, this operation would be treated in a routine manner. However, calculations(4) show that for this accident to give a whole-body dose equivalent of 100 mrem/yr to the maximum individual, the source strength at the railroad car surface would need to be in excess of 140 R/h. If the release fraction were 100 times higher than estimated, the source strength would still have to be in excess of 1.4 R/h. A railroad car with radiation levels of this magnitude would be decontaminated in the building 221-T canyon. Therefore, even though it is anticipated that operations in building 2706-T will result in occasional exposure of building 271-T occupants to minor amounts of airborne radioactivity, an operation in building 2706-T that would pose an unacceptable risk to building 271-T occupants is not expected to occur during the life of the facility.

9.2.2 Rupture in the Building 221-T Chemical Distribution System

9.2.2.1 Scenario. A rupture occurs in the chemical distribution system as a result of pumping against a closed valve. The rupture occurs at the point in the building 221-T pipe gallery shop where the potential for a vulnerable target is greatest. The rupture results in $NaOH/KMnO_4$ solution being sprayed out of the rupture and into a shop worker's eyes.

9.2.2.2 Consequences. A solution of $NaOH/KMnO_4$ introduced into the eyes can cause permanent blindness within minutes. For the purpose of analysis it was postulated that a failed flange gasket sprays $NaOH/KMnO_4$ directly into the eyes of a shop worker. The ability of flange guards, even properly installed, to prevent this is questionable and was discounted. The worker was wearing safety glasses, but the glasses were not designed to protect the eyes from sprays or splashes and were also discounted. The safety shower works, but does not have an eyewash system. Consequently, the worker is blinded by the accident and is placed on permanent disability.

9.2.2.3 Probability of Occurrence. Because the system is not regularly maintained or tested and normally operates at relatively low pressures compared to the pump shutoff pressure (about 100 lb/in^2), it was assumed that given an overpressurized system, at least one gasket in the system will fail. The probability that the failed gasket will be in the shop area is the ratio of the number of gaskets in the shop area to the total number of gaskets in the system. Since there are approximately 70 gaskets in the system, 26 of which are in the shop area, this probability is 26/70 or 0.37 per overpressurization error. To estimate the probability that the leak from the gasket will strike a worker, this failure probability must be multiplied by an area occupancy factor. This takes into account that fact that a worker will not be in the immediate area around the gasket for more than a few hours each day. For work in the gallery shop, an occupancy factor of 0.1 was assumed. The probability of an accident, given an overpressurization, is as follows:

$$(0.37)(0.1) = 0.037 \text{ accidents/error}$$

To calculate the annual error probability for overpressurization, it was postulated that the error occurs as a result of the failure to open a thimble valve before starting the pump in step 8 of procedure DO-121-021.(6) Errors of this type can be expected to occur with a frequency of 0.01 per trial.(7) The probable annual frequency for overpressurization errors is then just 0.01 x annual number of trials. The $NaOH/KMnO_4$ system is currently being used approximately 5 times per week or 250 times per year (assuming 50 operating weeks per year). The expected annual error rate is as follows:

$$(0.01 \text{ errors/trial})(250 \text{ trials/yr}) = 2.5 \text{ errors/yr}$$

The annual probability of accident is then:

$$(0.037 \text{ accidents/error})(2.5 \text{ error/yr}) = 0.09 \text{ accidents/yr}$$

The effect of system perturbations on the accident risk can be evaluated using the risk equation. That is,

$$\text{Risk} = (0.37 \text{ accidents/error})(0.1)(0.01 \text{ error/trial})$$
$$(250 \text{ trials/yr}) = 0.09 \text{ accidents/yr}$$

For example, if T Plant throughput were doubled, it can be assumed that the chemical distribution system would be used twice as often and that the shop occupancy factor would also double (even though it can never exceed unity). The new risk then becomes

$$(0.37)(0.2)(0.01)(500) = 0.36 \text{ accidents/yr}$$

Thus it can be seen that doubling the amount of material decontaminated in T Plant will approximately quadruple the accident risk for the chemical distribution system.

9.2.3 Toxic Fumes in the Building 221-T Canyon

9.2.3.1 Scenario 1. An operator is to charge 1,000 gal of 60% HNO_3 into thimble 2 in preparation for decontaminating a stainless steel object. Thimble 1 is being used to decontaminate an object using a $NaOH/KMnO_4$ soak (25% NaOH, 2% $KMnO_4$, 190°F). The valve lineup is wrong and the operator charges the HNO_3 into thimble 1 instead of thimble 2. Consequently, thimble 1 contains approximately 500 gal of hot $NaOH/KMnO_4$ to which the HNO_3 is added.

9.2.3.2 Scenario 2. An operator is decontaminating an object using the three-step process of a $NaOH/KMnO_4$/water/acid flush. The acid is Turco 4512A (25% phosphoric acid, 150°F). The operator omits the water flush. Approximately 5 gal of $NaOH/KMnO_4$ remain on the object or inside of it and are reacted with the acid.

9.2.3.2 Consequences. A preliminary analysis of the reaction kinetics for these mixtures[8] shows that the primary hazard in both cases would be acid and caustic fumes released by the heat of reaction, rather than toxic gases noted in Table 8-4. For the case of charging HNO_3 into the $NaOH/KMnO_4$, the rate of evolution of the acid and caustic fumes would be severe. Addition of a 2% solution of $NaOH/KMnO_4$ to concentrated HNO_3 (or vice versa) would cause immediate ignition; therefore, it is postulated that this accident would quickly saturate the atmosphere around the thimble 2 with HNO_3 vapor. The vapor would then spread throughout the canyon and be diluted by the large volume of canyon air. Inhalation of HNO_3 vapor for the length of time required to notice the problem and leave the canyon could be expected to produce discomfort but no permanent injury.[9] Some contamination would also be introduced into the canyon and would increase canyon air activity as well as surface contamination (by deposition).

The alternative scenario would have similar consequences but they would not be as severe as the previous one. The area around the operation would be contaminated with vapors of H_3PO_4 and $NaOH/KMnO_4$. These vapors would be moved throughout the canyon and into the crane cab by the canyon ventilation. Operators exposed to the fumes, without proper respiratory protection (such as operators in the canyon who are not involved with this job and, therefore, do not have chemical cartridges in their masks), would experience discomfort but would probably not suffer injury.[9] The consequences of these accidents were lower than anticipated by Table 9-1.

9.2.3.3 Probability of Occurrence. The first scenario, mixing HNO_3 with $NaOH/KMnO_4$, is not expected to occur during the lifetime of T Plant. The HNO_3 is no longer used in bulk quantities at T Plant and has largely been replaced by less hazardous acids such as phosphoric acid (Turco 4512A).

The second scenario, however, is expected to occur frequently during the lifetime of the T Plant. As discussed in 9.2.2.3, operators can be expected to omit certain steps in a given procedure at least once in every 100 trials. The oxidation-reduction decontamination technique is one of the predominant methods of decontamination in use at T Plant. This technique is used at least 5 times per week at the current level of operation, or 250 times per year. Thus, operators in building 221-T can be expected to be exposed to this hazard at least two to four times a year. The duration and intensity of the exposure depends on the location of the operator in the canyon relative to the source of the hazard, but in any case, the TLV for H_3PO_4 fumes (1 mg/m^3) is below even the short term exposure level limit of 3 mg/m^3 for 15 min and, therefore, the degree of hazard will not be large.(9) As soon as the operators notice the presence of the fumes, they will leave the area.

9.2.4 High Airborne Radioactivity Levels in the Building 221-T Canyon

9.2.4.1 Scenario. Recognizing the inherent limitations of general ventilation, the American Conference of Governmental Industrial Hygienists has recommended that general ventilation be used only in cases where the toxicity of the contaminants are low and their evolution is fairly uniform within the ventilated space.(10) Further, because of worker discomfort and the difficulty of maintaining an adequate seal over extended periods, the Occupational Safety and Health Administration (OSHA) recommends that respirators be used as normal operating equipment only in situations where effective engineered control of the hazard is not feasible, or while controls are being implemented.(11) Although these limitations were developed for, and strictly apply to, airborne chemical or biological hazards, caution suggests that they be applied to airborne radiological hazards as well. The risk of continued, routine use of full-face respirators in the building 221-T canyon has, however, been accepted as necessary for T Plant operation.

9.2.4.2 Consequences. Calculations have shown that work air activity may be considerably higher than the activity seen by air monitors located away from the immediate area.(12) In general, local air activity exceeds measured general area activity approximately according to the relation

$$C_1 = C_2 \left(\frac{X_2}{X_1}\right)^{1.75}$$

where

C_1 = local air activity

C_2 = air activity at CAM location

X_1 = distance from source to worker

X_2 = distance from source to CAM

This calculation is subject to the following conditions:

a. Uniform eddy diffusion coefficients

b. Constant source

c. Operator, source, and CAM at approximately the same elevation

d. Slow (i.e., 40- to 50-ft/min) airflow in the direction of the CAM.

The ratio of theoretical-to-measured work area air activity is shown for various workers and CAM configurations at T Plant in Figure 9-1.

If an operator in the building 221-T canyon remains in the airflow path long enough, the operator can receive a significant internal dose from airborne activity before being alerted to the danger by an alarming CAM, even under the most favorable conditions. This is illustrated by the following scenarios.

9.2.4.2.1 Scenario A. An operator is decontaminating a piece of equipment contaminated with plutonium located at the boundary between canyon sections 9 and 10. The operator is standing approximately 6 ft from the object, directly between it and the alpha CAM at section 11. It is approximately 60 ft from the CAM to the object. The consequences of this scenario in terms of minimum dose to the critical organ are shown in Table 9-5.[13] The dose rates were postulated under the assumption that the operator remains fairly stationary and that airflow direction is constant (toward the CAM) until the CAM alarms and the operator leaves the area.

TABLE 9-5. Estimated Lung Dose From ^{239}Pu for Scenario A.[a]

Air activity at CAM (µCi/mL)	Time to alarm (h)	Dose to lung (mrem)[b]
1 E-10	4	1.2 E+02
2 E-10	2	1.2 E+02
3 E-10	1.33	1.2 E+02
4 E-10	1	1.2 E+02

[a]Estimated annual dose for first year.
[b]Exposed in mask until CAM alarms.

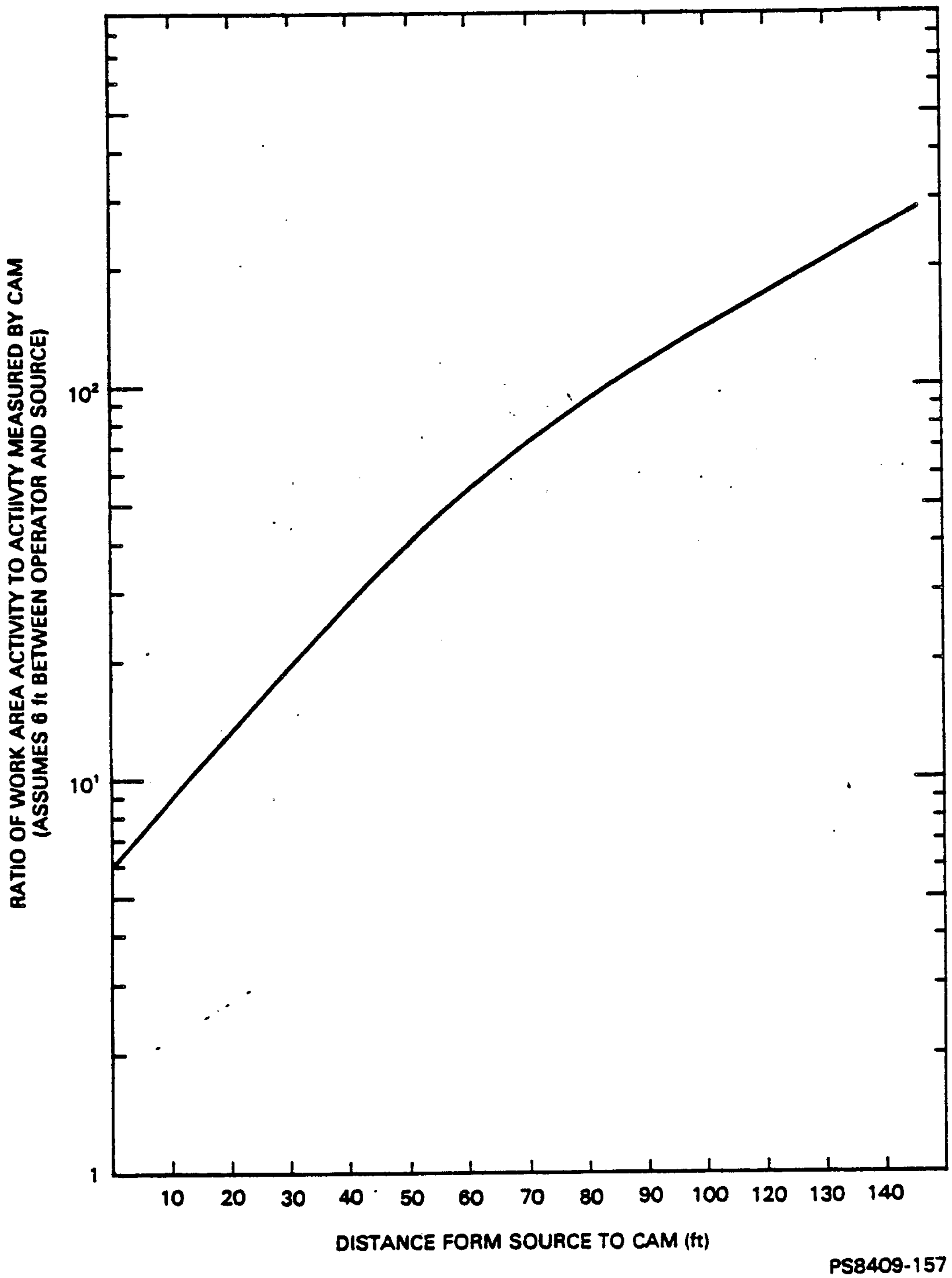

FIGURE 9-1. Theoretical Ratio of Actual Work Area Air Activity to that Measured at the CAM.

9.2.4.2.2 Scenario B. In scenario B, an operator is decontaminating an object contaminated with FP. The object is located on the decontamination pad at section 11, approximately 160 ft from the beta-gamma CAM at section 15. The operator is between the object and the CAM, approximately 6 ft from the object. Other assumptions and conditions are the same as for the previous scenario. The dose consequences(13) in terms of minimum dose to the critical organ are shown in Table 9-6.

TABLE 9-6. Estimated Bone Dose From Fission Products for Scenario B.[a]

Air activity at CAM (μCi/mL)	Time to alarm (h)	Dose to bone (mrem)[b]
5.0 E-08	4	1.6 E+03
1.0 E-07	2	1.6 E+03
1.5 E-07	1.33	1.6 E+03
2.0 E-07	1	1.6 E+03

[a]Estimated annual dose for first year.
[b]Exposed in mask until CAM alarms.

9.2.4.3 Probability of Occurrence. No engineered or administrative barriers exist to protect operators from this hazard. Nonetheless, bioassays have never shown any significant internal contamination in T Plant workers. This can be explained by the fact that local air currents in the canyon are not static, but tend to spread in various directions during any given hour, and by the fact that operators in the canyon do not remain in one place for very long. Thus, even though the local air activity in the general direction of airflow may be considerably above acceptable levels, operators are not exposed long enough to receive significant internal contamination. Without detailed information on time/motion behavior of operators in the building 221-T canyon and data on actual canyon airflow patterns, it is not possible to predict the probability of occurrence for this scenario. It should be noted, however, that the time an operator is exposed to this hazard is cumulative. That is, an operator will receive approximately the same dose in four 15-min exposures during the year as in a single hour-long exposure.

9.2.5 Exposure to High Radiation in the Building 221-T Canyon

9.2.5.1 Scenario. Objects that produce radiation fields of several hundred mR/h from a distance of a few feet are frequently stored on the building 221-T canyon deck. Personnel are protected from overexposure from these objects primarily by the administrative controls of distance and time. A barrier with ribbons and placards surrounds the object and strict timekeeping and RPT supervision is enforced for work on or near the objects. This method of radiation exposure control involves certain inherent risks.

9.2.6.2 Consequences. A structured, systematic assessment of the radiological risk to T Plant operators was conducted using techniques described in the Risk Management Guide.[14] Specifically, the radiation exposure records for T Plant operators for the periods 1971 through 1974 and 1982 through 1983 were examined by using extreme-value, log-normal, and log-log analysis. The period between 1975 and 1981 was omitted because T Plant activity was low during this period and is not considered typical of its current operations. These techniques are commonly used to assess the operating risk to a facility from such things as fires, accidents, and radiation exposure. They can also be used to assess the effectiveness of a control program (such as radiation control) in comparison with the program of other operations or facilities, and to predict the probability of occurrence of specific events, such as a $100,000 fire or a single exposure of 1,000 mrem. This probability is expressed in terms of a "return period," which is simply the amount of time that would have to pass before a particular event can be expected to occur. In other words, if a return period for a particular event (i.e., 5 rem annual exposure to an individual) is given as 100 yr, then that event is the expected maximum (annual exposure) for the next 100 yr.

Monthly exposure records for the T Plant operators over the 2-yr period 1982 and 1983 were evaluated using the method of extreme values. The results of this analysis are shown in Figure 9-2. The highest recorded exposure for each of the 24 mo of concern was plotted on logarithmic extreme value paper. A best-fit straight line was then drawn through the points and several inferences were made from this line, as discussed in the Risk Management Guide.[14] The fact that the data forms a smooth curve with no outliers shows that these exposures are characteristic of the radiation control system and are not the result of isolated unanticipated events. Individual monthly exposures of up to a maximum of 500 mrem can be expected to happen at least once every 2 yr but not more often than once every 6 mo (assuming an error of plus or minus 100% in the curve, which is typical for this type of extreme value projection) at T Plant, with its current method of radiation exposure control and at its current level of operation.

The curve in Figure 9-2 can also be used to predict the effect on the baseline radiological risk of an increase in the amount of radioactive equipment handled by the plant. This is accomplished by adjusting the return period (shifting the curve to the left) in proportion to the increased workload at the plant. For example, if the amount of equipment handled were to double, then the return periods in Figure 9-2 would be one

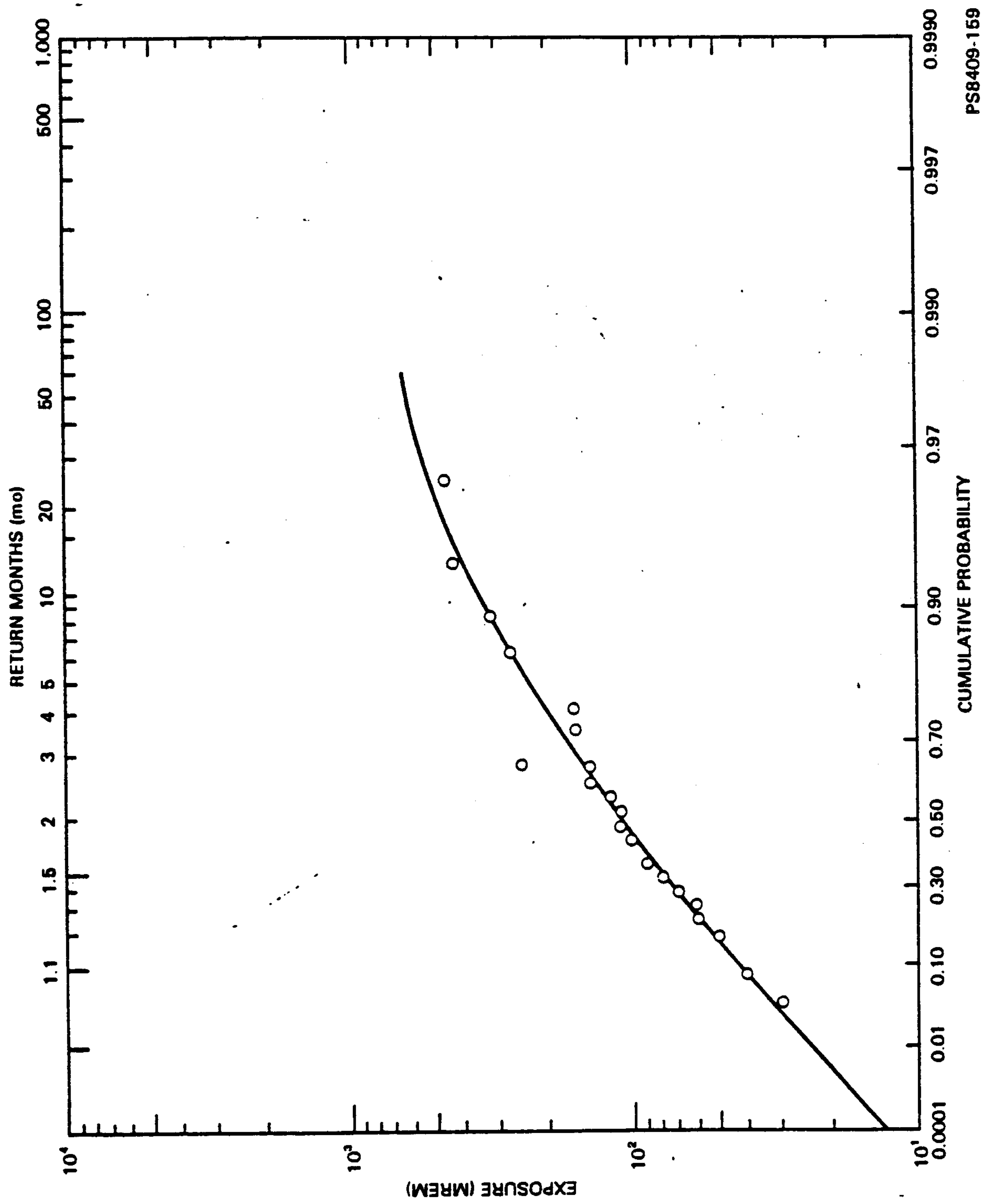

FIGURE 9-2. T Plant Complex Radiation Exposure Risk (1982 to 1983).

half of what they are now. A single monthly exposure of 500 mrem would then be expected to occur approximately twice per year, and the annual maximum monthly exposure risk (the monthly exposure that corresponds to a return period of one year) would be 700 mrem. To decrease this risk, the radiological control system at T Plant would have to be changed.

Annual exposure records for the years 1971 through 1974 and 1982 through 1983 were examined using the log-log and log-normal methods discussed in Reference 14. The results of this analysis are shown in Figures 9-3 and 9-4. Figure 9-3 was constructed by plotting all of the annual exposure records for the 6 yr. Figure 9-4 was constructed by plotting the curve of Figure 9-3 on log-log scales. For this construction, a "percent over" (one minus the percent under) scale was used from Figure 9-3. That is, the probability of an individual worker at T Plant receiving an annual dose of 1,000 mrem or more is 1.0 - 0.9 = 0.1 (from Fig. 9-3). This value is plotted on the vertical axis of Figure 9-4, and corresponds with 1,000 mrem on the horizontal axis. As with Figure 9-2, several inferences can be taken from these curves.

The steeper slope of the lower section of the log-normal curve (Fig. 9-3) indicates that the radiation control program at T Plant is significantly more effective at controlling exposures above approximately 1,000 mrem/yr than it is at controlling smaller annual exposures. This is typical of DOE facilities. The fact that all of the annual data fit a straight line fairly well is an indication that there have been no measurable changes in the T Plant radiological control program over the period studied (12 yr).

The area under Figure 9-4 represents the annual average individual radiation exposure risk at T Plant. This area is approximately 300 mrem. Without changes in the radiological control system, this should be taken as the baseline radiological risk at T Plant. The exposure range of maximum risk is that point on the curve of Figure 9-4 where the tangent is 45 degrees. This is in the region of 300 to 500 mrem. Thus, changes in the T Plant exposure control system directed at reducing the number of people who receive between 300 to 500 mrem per year will have the greatest effect on the system.

9.2.5.3 Probability of Occurrence. Based on the conclusions of a limited statistical analysis of the T Plant operation, exposure of personnel to whole-body penetrating radiation in excess of legal limits is not expected to occur during the lifetime of the facility, although monthly exposures of 300 to 500 mrem can be expected to happen at least annually.

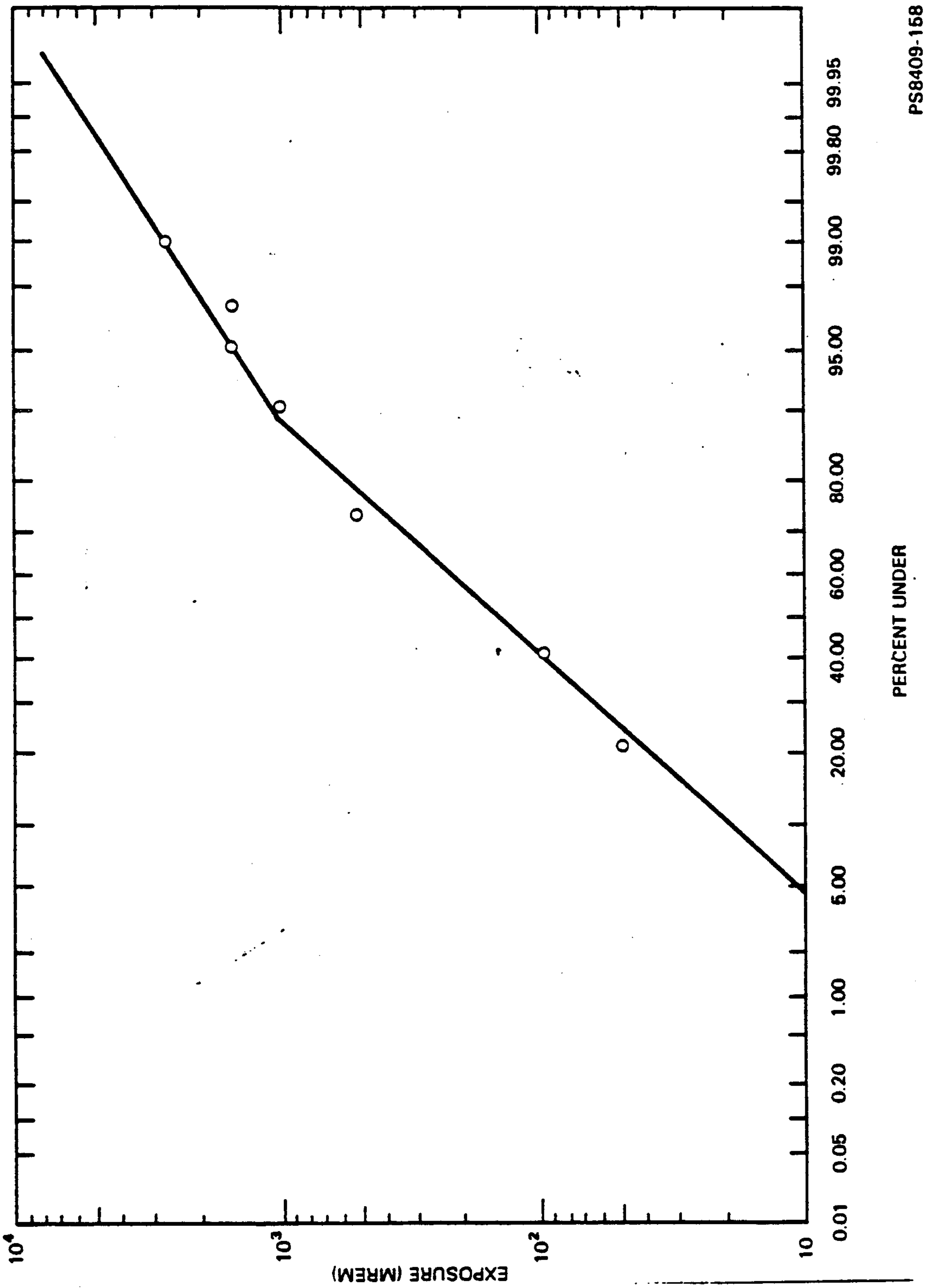

FIGURE 9-3. T Plant Complex Annual Exposures, Log-Normal Plot (6-yr data).

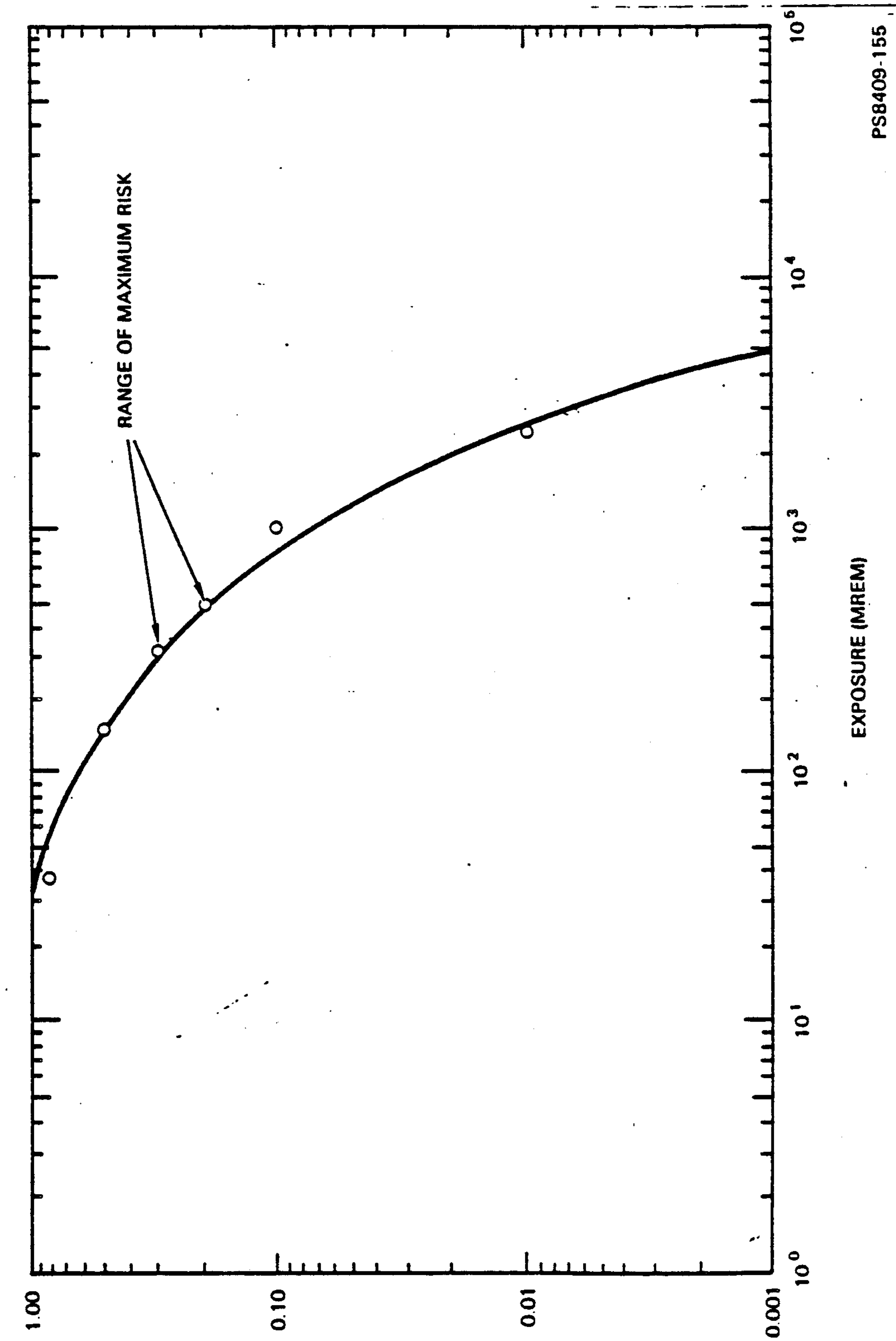

FIGURE 9-4. T Plant Complex Annual Exposure, Log-Log Plot (6-yr data).

9.2.6 Release of Contaminated Liquid to the Environment

9.2.6.1 Scenario. The contents of tank TK-15-1 are jetted to the tank farms. The valve lineup is wrong, and the waste is jetted against a closed pipe. The pipe ruptures outside the canyon, between the canyon and the first diversion box, and the entire contents of the tank are released before the rupture is noticed.

9.2.6.2 Consequences. The possible environmental effects of a large release of radioactive effluent from the waste transfer system is addressed in some detail in the Waste Management Operations Final Environmental Statement (FES).(15) The accident analyzed involved a leak of 100,000 gal of B Plant process radioactive waste. About 25,000 gal of this waste was postulated to reach the surface and form a pool while the remainder of the waste was released to the soil beneath the pool. This accident would result in a first-year dose to the maximum offsite individual of 130 mrem (lung) and a 50-yr dose of 260 mrem. This accident represents a spill of approximately ten times that possible from T Plant, and shows that, even then, population doses are within acceptable limits for extremely unlikely events. Thus, further analysis of a spill while transferring T Plant liquid waste is not warranted. The consequences of this accident were lower than anticipated by Table 9-1.

9.2.6.3 Probability of Occurrence. This accident is not expected to occur during the life time of T Plant for the following reasons. The entire waste system outside the canyon is either double-wall pipeline or is inside a concrete encasement. The encasement is checked for contamination, which would indicate a pipe leak, on a quarterly basis. The piping system is sloped to drain to successive pipeline diversion boxes, each of which is equipped with a liquid level alarm and an 8,000-gal-capacity (minimum) catch tank. Therefore, even if a rupture did occur in the pipeline and the entire contents of tank 15-1 were pumped out, the waste fluid would flow into the catch tanks and diversion boxes and would not escape to the environment.

9.2.7 Nuclear Excursion in the Building 221-T Canyon

9.2.7.1 Scenario. A nuclear excursion in waste tank 15-1 is initiated when waste from tank 5-7 (or others) is transferred into it. For the scenario, it is postulated that there is enough ^{239}Pu already in tank 15-1 from long-term accumulation that the addition of a slight (a few grams) amount of plutonium from the other tank is enough to achieve a minimum critical mass at the bottom of tank 15-1. It is postulated that the extra plutonium got into the other tank from a recent decontamination of a PUREX Plant component that contained residual PuO_2. For the purposes of analysis, the design basis criticality discussed in NRC Regulatory Guide 3.35 was used as the basis for calculation of the consequences of the accident.(16) That is, the initial burst consists of 1×10^{18} fissions, followed successively at 10-min intervals by 47 bursts of 1.9×10^{17} fissions each. The excursion is eventually shut down by loss of solution from splashing and by loss of moderator by evaporation. It was further assumed that the noble gas and radioiodine generation rates combine with the effective removal rate of decay and in-cell ventilation such that a radioactive cloud 1 m in diameter and containing 50% of the initial burst activity is continuously present above the tank 15-1 (but below the cell coverblocks).

9.2.7.2 Consequences. A design basis criticality(13) at T Plant was analyzed. The maximum exposed individual was assumed to be a worker standing directly above the tank. The worker is unaware of the excursion in the tank below him and is consequently exposed to higher-than-normal radiation levels for the entire duration of the excursion--approximately 7 h. The evolved FP gases were assumed to be completely scavenged from the cell by the 291-T exhaust system before they can leak from the cell into the canyon. The total exposure to the worker was then calculated to be approximately 54 rem.

The consequences to the environment outside T Plant were estimated using data from a postulated excursion at Z Plant.(13) These consequences are shown in Table 9-7 and represent an elevated release from the 291-T stack.

9.2.7.3 Probability of Occurrence. This accident is not expected to occur during the life of T Plant. Items from PUREX Plant that have the potential of containing significant quantities of plutonium (without accompanying FP) are not normally accepted at T Plant. Further assurance against receipt of significant quantities of fissile material is provided by the limitations on the amount of fissile material that can be shipped in onsite shipping containers(17) and by regular sampling of tank 15-1.

The requirements for criticality control at T Plant are shown in detail in Chapter 11.0.

9.2.8 Industrial Accident in the Building 221-T Canyon

9.2.8.1 Scenario. The overhead crane is being used to lift an object out of a decontamination thimble. When the object is above the thimble the lifting gear fails and drops the object back into the thimble, splashing operators with hot radioactive $NaOH/KMnO_4$ solution. Two operators and an RPT are exposed.

9.2.8.2 Consequences. The consequences for this accident are not expected to be severe (i.e., causing death or long-term disability) and would result primarily in extensive skin contamination and caustic and thermal burns. The operators and RPT are protected by two pairs of coveralls and full-face respirators, and could exit the canyon and get into a decontamination shower fairly quickly. The consequences of this accident were lower than anticipated in Table 9-1.

TABLE 9-7. Worst Case Maximum Individual Dose Commitments From T Plant Criticality.

Location	Dose time (yr)	Organ dose (rem)			
		Total body	Bone	Lung	Thyroid
Maximum offsite, ingestion included	1	1.2 E-03	2.4 E-03	1.3 E-03	1.4 E-01
Farmer at 12,500 m	50	1.3 E-03	2.7 E-03	1.3 E-03	1.5 E-01
Maximum offsite, no ingestion	1	8.4 E-04	1.2 E-03	1.2 E-03	9.8 E-03
Farmer at 12,500 m	50	8.4 E-04	1.2 E-03	1.2 E-03	9.8 E-03
Onsite worker located at 730 m	1	1.6 E-01	1.6 E-01	2.0 E-01	5.3 E-01
	50	1.6 E-01	1.6 E-01	2.0 E-01	5.3 E-01

NOTE: Estimates are based on building 234-5Z design basis criticality.

9.2.8.3 Probability of Occurrence. This particular accident is not expected to occur during the remaining life of T Plant. Crane accident statistics[18] have shown the probability of a dropped load caused by poor rigging or slings, failures of control systems, and inadequate maintenance or inspection is approximately 6.8 x 10^{-05} per lift. If this accident probability is tripled, to account for the facts that the lifting/rigging gear in the building 221-T canyon is not maintained or inspected (except incidently as it is used), higher than normal corrosion damage is caused by repeated exposure to decontamination chemicals, and there is relatively poor visibility in the canyon (which can lead to deficiencies being overlooked), the accident probability becomes 2.0 x 10^{-04}. This probability is comparable to that postulated for dropped crane loads during waste disposal operations[19] of 1.0 x 10^{-04} per lift. A probability of 2.0 x 10^{-04} thus assumes that the likelihood of failed lifting gear is only twice as high for the building 221-T canyon as it is at the burial grounds.

At its current level of operation, T Plant uses the decontamination thimbles approximately twice per week. The probability of occurrence for this accident is then just (2 lifts/wk)(50 wk/yr)(2 x 10^{-04} drops/lift) = 0.02 accidents/yr or once every 50 yr. As the crane/thimble use rate increased, the frequency of occurrence for this accident will increase proportionally.

The probability of a load being dropped somewhere else in the canyon can be estimated in the same way. For example, the present crane use rate of approximately 10 lifts per week would result in expected drop rate of

$$(10 \text{ lifts/wk})(50 \text{ wk/yr})(2\ 10^{-04} \text{ drops/lift}) = 0.1 \text{ drop/yr}$$

or one drop every 10 yr. That is, at this rate of crane usage, T Plant should expect to drop an object at least twice in a 20-yr operating life.

9.2.9 External Occurrences

9.2.9.1 Scenario. The external events discussed in this section include earthquake, tornados, and volcanic action.

9.2.9.1 Consequences. The radiological impact to the environment from the effect of external occurrences at T Plant is not expected to be significant. This is because of the relatively small radionuclide inventory of the facility and by the fact that nearly all of this inventory is contained in underground tanks or is present as surface contamination on stored objects inside the building 221-T canyon. Preliminary seismic analyses[20,21] have shown that although the structure of building 221-T would be severely damaged by the Hanford Site DBE, the integrity of the process cells themselves would probably remain. Thus, even under the worst of conditions, the radioactive liquid at T Plant would still be contained within the structure. It is assumed that the only other source of contamination, building 2706-T, would be completely demolished by either an earthquake or a tornado. The radioactive inventory in building 2706-T is, however, even smaller than the inventory of 221-T.

Studies have shown that the 291-T ventilation stack and sand filter at T Plant would not survive a tornado.(21) It may also be assumed that the roof exhaust system at T Plant would fail. However, again because of the small inventory of readily dispersible material contained in the canyon, this would have only a minor effect on the environment. The risk of a tornado with respect to the 291-T sand filter is negligible because of the very large dilution/dispersion characteristics of a tornado and because of the extremely low probability of interaction between the tornado and the filter (less than 10^{-07}/yr).

The effect of volcanic action on T Plant would be to plug the building 221-TA ventilation supply system with ash. This would have the effect of a loss of supply air, which does not constitute an emergency at T Plant. No adverse environmental effect is foreseen for this occurrence.

9.2.10 Fires at T Plant

According to the Fire Protection Survey of 1981,(22) the consequences of fires in the various T Plant buildings are as follows:

- Building 271-T: $1,000,000; 1-yr programmatic loss
- Building 2706-T: negligible dollar loss; unknown but minor programmatic loss

It has been estimated that a fire in the building 221-T galleries would have a 4- to 6-mo programmatic loss as well as property loss in the range of tens of thousands of dollars.(22) If, however, the fire were to occur in the electrical switchgear, and the switchgear contained polychlorinated biphenyls (PCB) or mercury, the consequences of a building 221-T gallery fire may increase considerably. According to Utilities Management records however, none of the transformers outside the buildings 221-T and 271-T contain PCBs. The safety analysis assumes, therefore, that the interior electrical components are also free of PCBs and significant quantities of mercury. This assumption was made because of the similarity in size, type, and age of interior/exterior electrical components. The consequences of a fire in the building 221-T gallery, therefore, are proposed to be $100,000 and loss of facility use for 4 mo.(22) Neither building 221-T nor building 271-T are in compliance with the Life Safety Code. Because of this, a fire that occurred in the facility during working hours could present a life-threatening situation. Insufficient data exists, however, to predict the probability or severity of personnel injury, given a fire.

A maximum credible fire has already occurred in the building 221-T canyon. The fire caused about $85,000 damage to the ventilation system (plugged HEPA filters) and loss of facility (canyon) use for approximately 1 wk. The maximum credible fire in the building 221-T canyon, therefore, is proposed to be $100,000 and loss of the facility use for 1 wk.

The amount of radioactivity released from a fire at T Plant would be small. There are no radioactive materials in building 271-T and only minor amounts in building 2706-T. The radioactive material in building 221-T is either in water solution in underground tanks or is fixed on noncombustible objects stored in the canyon or on the internal walls of the structure. The maximum credible fire in building 221-T would release very little of this contamination.

9.3 REFERENCES

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13. L. N. Sutton to J. P. Hinckley, "Evaluation of Three Proposed T Plant Accidents," Internal Letter 72322-84-WU-319, Rockwell Hanford Operations, Richland, Washington (July 19, 1984).

14. EG&G, Risk Management Guide, DOE 76-45/11, SSDC-11, Revision 1, prepared by EG&G Idaho, Inc. for the System Safety Development Center and the U.S. Department of Energy, Washington, D.C. (September 1982).

15. ERDA, Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington, ERDA-1538, U.S. Energy Research and Development Administration, Washington, D.C. (December 1975).

16. NRC, Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Plutonium Processing Plant or Fuel Fabrication Plant, Regulatory Guide 3.35, U.S. Nuclear Regulatory Commission, Washington, D.C. (July 1979).

17. D. L. McCall, Hazardous Material Packaging, Shipping and Transportation Manual, RHO-MA-201, Rockwell Hanford Operations, Richland, Washington.

18. NRC, Control of Heavy Loads at Nuclear Power Plants, NUREG-0612, U.S. Nuclear Regulatory Commission, Washington, D.C., January 1980.

19. G. M. Christensen, Active and Retired Radioactive Solid Waste Burial Ground Safety Analysis Report, RHO-CD-1554 REV 1, Rockwell Hanford Operations, Richland, Washington (April 1984).

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21. Rockwell, B Plant Natural Forces Hazards Study, RHO-CD-1582, Rockwell Hanford Operations, Richland, Washington (October 15, 1981).

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10.0 CONDUCT OF OPERATIONS

10.1 POLICY

All Rockwell operations are to be conducted in a manner which ensures that personnel and environmental exposure to radioactive or otherwise hazardous materials is ALARA.[1] All operations are to be conducted in accordance with applicable health and safety standards of the DOE and will adhere to generally recognized and accepted high standards for environmental protection and nuclear, radiological, industrial, and fire safety.[2,3]

10.2 T PLANT ORGANIZATION

The T Plant Complex operation consists of the activities of five separate functional units, as shown in Figure 10-1. These units involve engineering design, process engineering, crafts and maintenance, radiological protection, and plant operations. The work done by these functional units is coordinated through the Chemical Processing Program. Thus, T Plant operations result from a complex relationship between separate functional groups whose activities are coordinated by both a common budget source (T Plant Project) and common planning and scheduling (Services Production Control Group).

Intergroup communication is achieved on a day-to-day basis through a daily planning meeting attended by representatives from each of the five units. Intergroup coordination, however, is achieved only by way of the program planning document, which is provided weekly.

10.3 OPERATIONS PERSONNEL

Performance of the primary T Plant Complex mission (decontamination of equipment) is the responsibility of the T Plant operations functional group. T Plant operators are responsible to two shift support managers, who, in turn, are responsible to the T Plant Operations Manager.

T Plant operators include Operator Trainees, Nuclear Operators, and Nuclear Process Operators. A list of the general responsibilities of these operators follows.

- An operator trainee must demonstrate fundamental knowledge of the following:
  - General radiochemical operations
  - Specific T Plant operation
  - Emergency procedures and abnormal plant conditions.

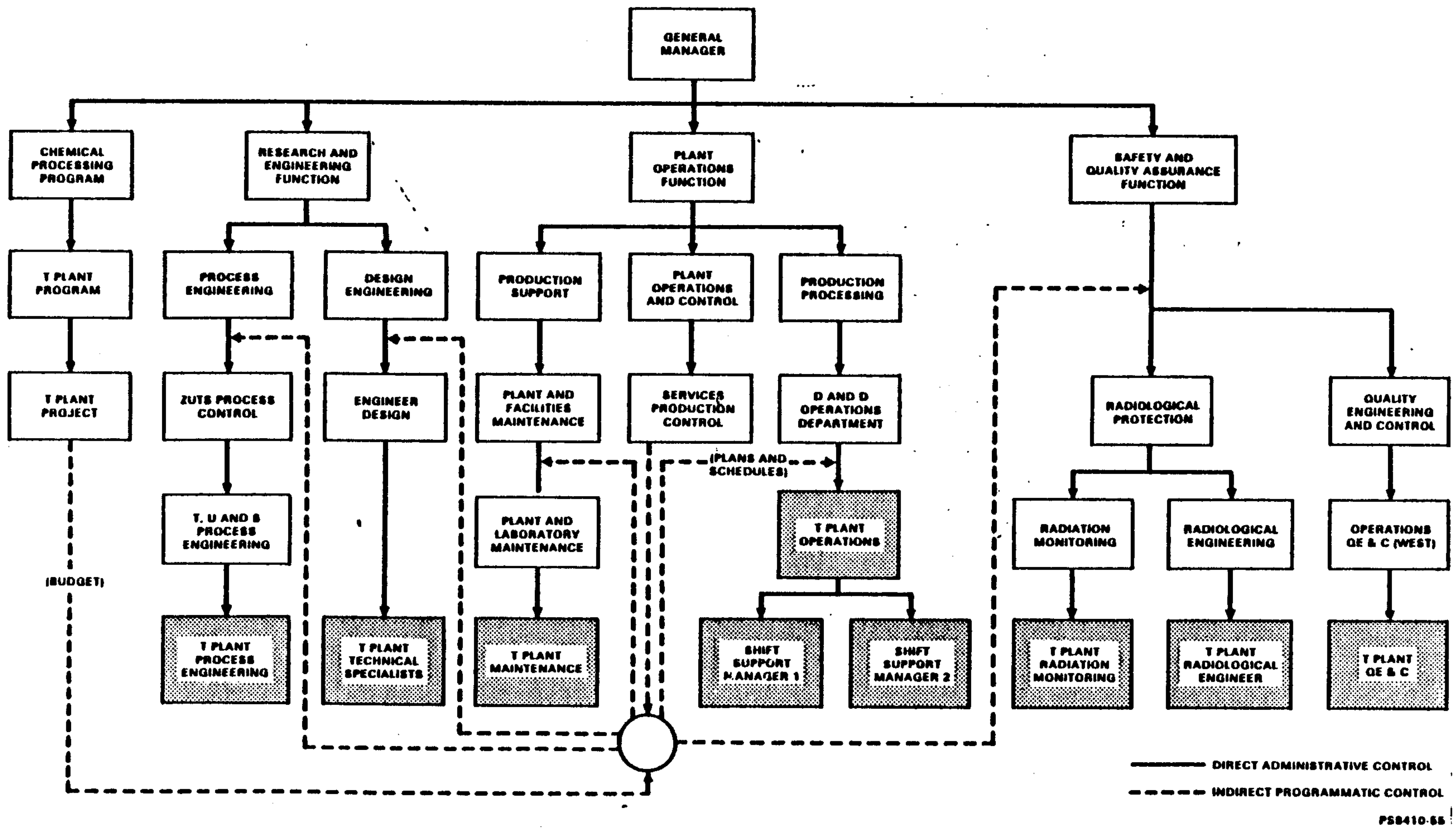

FIGURE 10-1. T Plant Complex Organization.

- The Nuclear Operators and Nuclear Process Operators must demonstrate comprehensive knowledge of the following:
  - General radiochemical operations
  - Specific T Plant operations
  - Emergency procedures and abnormal plant conditions.

10.4 OPERATIONS PLANNING AND EXECUTION

The Services Production Control Group of the Chemical Processing Program plans and schedules all T Plant activities. Plans and schedules are provided to T Plant on a weekly basis.

Most of the work at T Plant is accomplished with the aid of SOPs.[4] These procedures are prepared by the T Plant Process Engineering team and cover all normal T Plant operations, including operations in building 2706-T, use of the Partek spray cleaner, and transfer of liquid radioactive waste. Temporary procedures are also prepared by the Process Engineering Department for any activity in T Plant that involves special hazards or unusual requirements.

10.5 TRAINING

All T Plant operating personnel receive New Employee, Operator Trainees, Nuclear Operators, and Nuclear Process Operators training as described in the PUREX FSAR.[5] In addition to this training, on-the-job training is provided. Operators are required to complete a written examination and a walk-through evaluation demonstrating competence in performing specific jobs in T Plant.

Special training seminars are given to all operators whenever a job involves new procedures or unusual hazards such as higher-than-normal radiation or contamination levels or new decontamination methods. Prejob safety meetings are also held in conjunction with, or instead of, training seminars whenever specified by Operations or Process Engineering.

T Plant operations shift supervisors are required to qualify as T Plant Nuclear Operators, in addition to completing the requisite Rockwell management training courses.

T Plant process engineers must complete phase II qualifications for process engineers,[6] which are plant specific.

10.6 REFERENCES

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2. DOE, Environmental Protection, Safety, and Health Protection Program for DOE Operations, DOE Order 5480.1A, U.S. Department of Energy, Washington, D.C. (November 2, 1981).

3. DOE-RL, Environmental Protection, Safety, and Health Protection Program for Richland Operations, DOE-RL Order 5480.1, U.S. Department of Energy, Richland, Washington (May 21, 1982).

4. Rockwell, T Plant Special Services Procedures, Rockwell Hanford Operations, Richland, Washington (October 31, 1983).

5. C. W. Manry, PUREX Plant Final Safety Analysis Report, SD-HS-SAR-001, Rockwell Hanford Operations, Richland, Washington (September 1982).

6. S. D. Godfrey and L. E. Thomas, T-Plant Specific PCET&C - Phase II, Plant Specific, SD-RE-TR-007 Rockwell Hanford Operations, Richland Washington (February 1983).

11.0 OPERATIONAL SAFETY REQUIREMENTS

11.1 INTRODUCTION

The OSRs identify the conditions, boundaries, and management and design controls at T Plant that ensure safe operation of the facility without serious risk to the public, the environment, or operating personnel. These requirements provide a degree of safety that is reasonably achievable and acceptable. Operation of the plant outside of these requirements may lead to unknown hazards. Therefore, any revisions to the limits and controls, or any changes in operating conditions, or facility and/or equipment modifications that involve unreviewed safety questions or may increase the probability or consequences of an accident require a revision or supplement to these OSRs.

11.2 SAFETY LIMITS AND LIMITING CONTROL SETTINGS

The safety limits (SL) apply to the receiving or accumulation of fissile material within T Plant, which is defined as a "limited control facility."(1) Operations outside of these SL may lead to serious safety-related consequences. Violation of a SL constitutes violation of the OSR. The limiting control settings (LCS) are established within the SL to allow for the alerting of responsible personnel and subsequent corrective action before the SL is reached.

Exceeding an LCS is not an OSR violation, but failure to respond to the agreed recovery plan for an LCS violation is an OSR violation.

Violation of a SL or LCS shall be dealt with according to the specific recovery plan provided with the requirements, as well as with the administrative actions listed in 11.4.

11.2.1 Nuclear Criticality Accident Prevention

These requirements apply to radioactive waste collected in the T Plant Complex radioactive waste system. The objective of these requirements is to prevent the accumulation of fissile material within the radioactive liquid waste system.

11.2.2 Safety Limit

The radioactive liquid waste in tanks TK-15-1 and TK-5-7 shall be limited to 0.05 g of dissolved plutonium/gal* and radioactive sludge in the tank shall be limited to 3.76 g of plutonium/gal*.

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*Or an equivalent amount of other fissile material.

11.2.3 Limiting Control Settings

1. T Plant shall maintain a trend analysis on tank TK-15-1 radioactive waste to indicate increasing concentrations of plutonium in the waste system and to limit liquid waste dissolved plutonium concentrations to 0.025 g of plutonium/gal and sludge waste plutonium concentrations to 1 g of plutonium/gal. Tank TK-15-1 samples (both liquid and sludge) shall be taken and analyzed whenever waste is transferred to the tank farms.

2. The T Plant Complex shall take representative samples of tank TK-5-7 sludge once every 6 mo. These samples shall be analyzed for plutonium and for the fissile isotopes of uranium. The limit for sludge waste fissile material concentrations in tank TK-5-7 shall be 1 g of plutonium or equivalent per gallon of sludge.

11.2.4 Requirements for Compliance

The T Plant Operations shall take liquid and sludge samples from tank TK-15-1 before each transfer of tank contents to the tank farm to provide data for a trend analysis of potential plutonium accumulation. An ongoing trend analysis shall be conducted by T Plant Process Engineering (or others) to show that there has been no statistically significant increase in the amount of plutonium in tank TK-15-1. T Plant operations shall also obtain biannual samples of tank TK-5-7, as outlined in 11.2.3, item 2.

11.2.5 Basis

According to the Nuclear Criticality Safety Standards,(1) T Plant is a limited control facility. This is defined as a facility that may contain more than one-third of a minimum critical mass of fissile material, but in a form or distribution that prevents a critical configuration without detailed control, allowing for credible contingencies.

Bases for plutonium concentration in tank TK-15-1 are derived from the criticality prevention specifications outlined in RHO-MA-136.(1) The criticality prevention specifications limits set forth were established to reduce the possibility of a nuclear criticality while handling radioactive waste solutions that were originally generated in chemical processing plants and that may contain minor amounts of fissile material. Sampling and trend analysis requirements for tanks TK-15-1 and TK-5-7 are designed to allow for the alerting of responsible personnel and subsequent corrective action before the SL is reached.

The trend analysis is maintained to indicate a potential accumulation of plutonium in tank TK-15-1 and, hence, the entire liquid radioactive waste system. Samples are taken of tank TK-5-7 to verify that the sampling of tank TK-15-1 is adequate to detect accumulations of fissile material in the waste system.

11.2.6 Response and Recovery

11.2.6.1 Safety Limit. If the SL is violated, operations shall be immediately suspended and the area shall be isolated. The violation shall be immediately brought to the attention of the cognizant manager who will in turn notify the responsible operating manager and the manager, CE&A. An evaluation and recovery plan shall be prepared according to the requirements listed in 11.4.1. Resumption of operations shall be based on the evaluation and recovery plan.

11.2.6.2 Limiting Control Setting. In the event an increase in the concentration of plutonium or other fissile material in tank TK-15-1 is verified, or if the concentrations of plutonium or other fissile material in tanks TK-15-1 or TK-5-7 exceed the limits of 11.2.3, use of the building 221-T liquid radioactive waste system will be suspended until an appropriate recovery plan is developed and implemented and CE&A management approval for resumption of operations has been obtained.

11.2.7 Audit Point

Records of tanks TK-15-1 and TK-5-7 sample analyses shall be maintained by T Plant Operations for a period of 3 yr after each sample was taken. Records of the trend analysis for the concentration of plutonium in tank TK-15-1 shall also be maintained by T Plant Operations.

11.3 LIMITING CONDITIONS FOR OPERATION

The limits in this section define the minimum acceptable operating conditions and practices consistent with the required assurance of safety to the public, the environment, and operating personnel.

The limiting conditions for operation (LCO) are generally operating restrictions or requirements as opposed to specific limitations. An infraction could constitute the breaching of a safety barrier or, if repeated frequently, could lead to a violation of SL or LCS that could lead to serious hazards.

An infraction of a LCO requires immediate investigation, corrective action, and notification of appropriate Rockwell management.

11.3.1 Contaminated Equipment

11.3.1.1 Applicability. This requirement applies to contaminated equipment received from the PUREX Plant or other facilities.

11.3.1.2 Objective. To prevent the receiving and accumulation of fissile material within the T Plant waste system.

11.3.1.3 Requirement for Compliance.

1. T Plant shall not receive equipment from the following locations within the PUREX Plant unless prior approval is obtained from Production Operations, Process Engineering, and CE&A.

   - First decontamination and partitioning cycle (equipment associated with the HA-T-H2 column, IBX-T-J6 column, and the IBS-T-J4 column, H and J cells)
   - All equipment in the second and third plutonium cycle and plutonium concentration (L cell)
   - Plutonium oxide line (N cell).

2. T Plant shall not receive equipment known to be contaminated with plutonium or other fissile material from any facility without prior approval from Production Operations, Process Engineering, and CE&A.

3. The PUREX Plant shall provide T Plant with documentation of point of origin for all process equipment and an estimate of the amount of fissile material contained within the equipment prior to shipment to T Plant or U Plant. Other facilities shall provide documentation stating expected or measured levels of plutonium or other fissile material contamination on the equipment to be shipped, prior to shipment to T Plant.

11.3.1.4 Bases. The restriction on receipt of equipment contaminated with plutonium or other fissile material at T Plant is intended to minimize the possibility of a single large addition of fissile material to the T Plant liquid radioactive waste system. It is also intended to reduce the possibility of unnoticed long-term accumulation of fissile material in the waste system. In addition, T Plant and PUREX operations periodically use the building 221-U canyon as a storage location for PUREX Plant equipment prior to decontamination operations. The above requirement reduces the possibility of violating the SL or LCS because of equipment shipments to T Plant via U Plant.

11.3.1.5 Response and Recovery. In the event of an infraction of this requirement, the shipment, handling, or decontamination (as applicable) of the equipment shall be suspended. The infraction shall be reported to the proper Rockwell management. An evaluation of the situation shall be made by T Plant Operations, Process Engineering, and CE&A.

11.3.1.6 Audit Point. Records, including estimated plutonium content, of all equipment received at T Plant for decontamination shall be maintained. These records shall be kept in the T Plant Operations Department files for a period of 3 yr before being archived.

11.4 ADMINISTRATIVE CONTROLS

11.4.1 Violation of the Safety Limit

When a violation of the SL is confirmed, the following action shall be taken.

- Immediate action will be taken to initiate a prompt and orderly shutdown of the building 221-T canyon. This may require a shutdown of the entire facility.
- Rockwell management will be notified in accordance with Rockwell procedures, and an unusual occurrence report shall be initiated.
- Circumstances of the violation will be investigated, the cause will be established, and the appropriate corrective action determined. A report will be prepared by the Rockwell investigation team for review and approval by Rockwell management.
- As determined by the T Plant Operations, Process Engineering, and CE&A and approved by Rockwell management, facility startup will be permitted only after the following action items have been completed satisfactorily:
  - Action has been taken to return facility, system, or process to a safe condition
  - Action or controls have been established to minimize the probability of a recurrence.

11.4.2 Violation of a Limiting Control Setting or Limiting Condition for Operations

When a violation of an LCS or LCO requirement is detected, the following action will be taken.

1. Immediate and followup actions will be in accordance with the recovery statement provided with the requirement. Continued operation without implementation of the above recovery actions within 24 h is considered an OSR violation and must be treated as a SL violation.
2. Notification of Operations, Research and Engineering, and CE&A shall be made as soon as possible, and a nonconformance report shall be written.
3. If the incident involved shutdown of a portion of the operations, restart will require approval of CE&A management.

11.5 REFERENCE

1. C. L. Brown, Nuclear Criticality Safety Standards, RHO-MA-136, Rockwell Hanford Operations, Richland, Washington.

12.0 QUALITY ASSURANCE

12.1 SCOPE

This Quality Assurance chapter is provided to identify quality assurance elements associated with the operating programs, decontamination, and reclamation of contaminated equipment in T Plant. The Quality Assurance Program was established through a Quality Assurance Program Plan to confirm that engineered quality requirements for T Plant have been accomplished in a safe and reliable manner.

12.2 ORGANIZATIONS

Organizational structures and respective charters for Rockwell Functions participating in this operation are contained in RHO-MA-100, Policies.(3) These policies identify functional responsibilities, lines of communication within the individual organization, and the interface with peer groups for activities affecting quality and safety. The Quality Assurance organizational structure is represented in Figure 12-1.

12.3 QUALITY ASSURANCE PROGRAM

The Quality Assurance Program for T Plant is based on the ANSI/ASME Standard NQA-1,(1) as endorsed by the DOE-RL Order 5700.1A.(2)

A series of policies and procedures prepared collectively by Rockwell functions as a proper response to the quality and safety aspects of the endorsed Standard, is represented in Table 12-1.

Elements and events described in the Quality Requirements Control chart (see Table 12-1) for T Plant are imposed as applicable by program management with functional management concurrence.

12.4 PERSONNEL TRAINING

Quality Assurance shall ensure that personnel scheduled to perform or observe operations associated with T Plant are trained and qualified as specified by Plant Safety Policies.(3) As a minimum, those performing tasks in radiation areas shall have successfully completed training requirements specified in section 6.0 of the Radiological Standards and Operational Control.(9)

TABLE 12-1. Quality Assurance Policies and Procedures.

Quality Assurance elements	Design and construction support	Facility operation	Maintenance operation	Material and equipment procurement
Element developed and implementation	Construction management (1-4, 7)	Facility management (1-3)	Maintenance management (1-3, 14)	Materials management (1-3, 11)
	Codes and standards (10)	Personnel training and qualification (3)	Production support (15, 16)	Supplier control (4, 5, 11)
	Drawing preparation (4, 10, 13)	Engineering (3, 10)	Fabrication control (4, 5, 15, 18, 19)	Purchase requisition control (4, 5, 11, 22)
	QA levels (4, 13)	Plant operations controls (5, 14, 16)	Calibration control (4, 17, 24)	PQA surveillance and receiving controls (4, 5, 11)
	Design review (10)	Radiological controls (3, 9)	QE&C planning and inspection verification (3-5, 18)	Material certification (4, 5, 10, 11)
	Test plans (10)	Waste handling (3)		
	Plant safety (3, 9)	QE&C planning and surveillance inspection (3-5)		
		Analytical laboratory (4, 6)		
		Plant safety (3, 9)		

Implemented Element Evaluation

Readiness Review (3, 4, 10)

Safety Analysis (3, 10)

Scheduled QA Audits (3, 4)

Scheduled S&QA Joint Audits (3, 5, 12, 20, 23)

Note: Numbers in parentheses identify Paragraph 12.11 references.

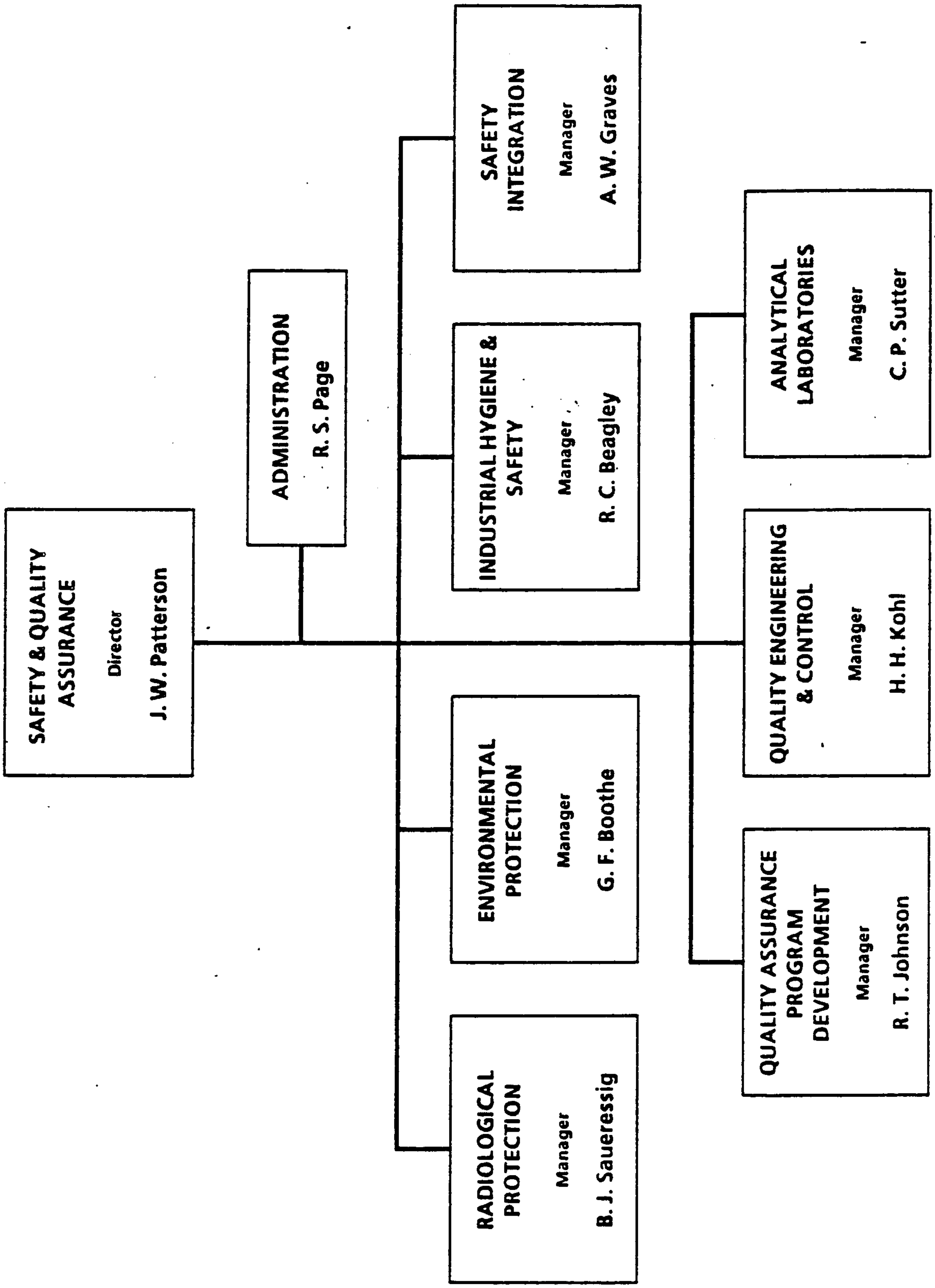

FIGURE 12-1. Safety and Quality Assurance Organization.

Quality Assurance personnel shall also be trained as specified in the Quality Assurance Manual,[8] Procedure 4-201, in accordance with Plant Safety Policies.

12.5 DESIGN SUPPORT

Engineering provides an effective design support system in the Engineering Procedures Manual[10] that addresses the quality and safety aspects associated with T Plant.

Quality Assurance groups review and approve design documentation and utilize released documents to prepare quality verification plans for the acceptance of prescribed design attributes in accordance with the instructions in Quality Assurance Manuals.[4,5,6,7]

12.6 PROCUREMENT

Procurement Quality Assurance (PQA) conducts surveys of potential suppliers and monitors the performance of suppliers under contract to ensure that the level of quality is planned for and maintained commensurate with the quality and safety standards designated to T Plant programs.

The Materials Function and PQA maintain procedural manuals[4,5,11,22] that provide the necessary procurement guidance for ensuring that all technical elements associated with T Plant are performed as ordered by engineering documentation.

The PQA maintains a quality verification system that confirms compliance of the received product.

12.7 INSPECTION

Quality Assurance Manuals[4,5] dictate the planning for inspection and the practices to be used by inspectors to ensure compliance with design requirements.

Verification media may range from visual surveillance to complex machine setups, the prime consideration being the documented acceptance of quality and safety requirements. To that end, inspections are performed in the following manner:

- Planned in a concise manner to minimize the potential for error
- Take place at the earliest practical point in the work sequence

- Recorded and maintained as readily available when significant to the history of the item or applicable to subsequent operations

- Applied commensurate with the potential impact on personnel or environmental protection.

12.8 CALIBRATION AND CONTROL

Instruments, test equipment, and working standards are calibrated to recognized national standards. Instruments in use, other than those identified for "indication only," shall have valid evidence of a current calibration.

Laboratory instrument calibration is conducted to approved laboratory procedures.(6) Recalibration frequency is determined by the Applied Technology staff based on the instrument manufacturers' recommendation and equipment performance records. Actual calibration work is performed by trained technicians or chemists.

12.9 INCIDENTS, NONCONFORMANCES, AND CORRECTION ACTION

Nonconforming conditions noted by Quality Assurance during material, component, or equipment acceptance are reported and dispositioned on the Nonconformance Report (NCR) in accordance with Quality Assurance Procedures.(4,5)

Incidents that occur during the T Plant operational phase that could affect safety are reported as Unusual Occurrences according to Accident Prevention Standard 32,(12) or Off-Standard Conditions when noted in the Analytical Laboratories.(6)

When corrective action is required to prevent a discrepancy recurrence beyond the scope of the NCR disposition, Corrective Action Requests(4,5) are generated by the individual recognizing the need, coordinated by Quality Engineering, and responded to by responsible management.

12.10 QUALITY ASSURANCE LABORATORY

Analytical Laboratories are responsible for maintaining a safe and effective operation in accordance with approved plans and procedures.(4,6) Analytical Laboratory Management reviews Analytical Laboratories operations on a continuing basis to maintain the safe condition status.

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