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DOE/EIS-0063-D

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Supplement to ERDA-1538, December 1975

Waste Management Operations

Hanford Site

Richland, Washington

Double-Shell Tanks for Defense High-Level Radioactive Waste Storage

JANUARY 1980

U.S. DEPARTMENT OF ENERGY

WASHINGTON, D.C. 20545

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COVER SHEET
DRAFT ENVIRONMENTAL IMPACT STATEMENT
DOE/EIS-0063-D

a) Lead Agency: The Department of Energy

b) Proposed Action: Double-Shell Tanks for Defense High-Level Radioactive Waste Storage, Hanford Site, Richland, Washington

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To Submit Comments on, or to Request Copies of the EIS, Contact: Dr. Goetz K. Oertel at the address noted above.

d) Designation: Draft EIS

e) Abstract: Proposed is the completion of construction and the operation of thirteen tanks for high-level radioactive liquid waste storage on an interim basis until long-term or final disposal of the wastes can be achieved. The scope of the Draft EIS includes the examination of design alternatives for the tanks now under construction. The examination of the alternatives addresssed in this Draft EIS is in compliance with the September 29, 1979 directive of the U.S. District Court for the District of Columbia [Natural Resources Defense Council, Inc., et al., v. Secretary, Department of Energy, et al. (D.D.C. Civ. No. 76-1691)]. The new facilities, now under construction, consist of thirteen 1.0 million gallon high-activity waste tanks and their auxiliaries. All thirteen tanks are being built in the 200 East Area of the Hanford Site. Impacts of the various design alternatives considered in this Draft EIS are assessed on the basis of the effects of the various designs on tank durability, on the ease of waste retrieval from such tanks, on the choices (and on the timing of such choices) for a technology for long-term radioactive waste storage and final disposal, as well as on the environment in general.

f) The review period for this Draft EIS ends 45 days after its availability is announced in the Federal Register weekly report of the Environmental Protection Agency.

FOREWORD

The Federal action under review is the continued construction and proposed operation of new tanks for high-level radioactive waste at the Hanford Site near Richland, Washington. The construction of these tanks which has been substantially completed was authorized in FY-1976, 1977, and 1978. As directed by the Federal District Court for the District of Columbia [Natural Resources Defense Council (NRDC) v. Administrator, ERDA/DOE], this supplemental environmental impact statement (EIS) has been prepared to address the design and safety alternatives of the waste storage tanks for high-level radioactive waste at the Hanford Site.* Specifically, the court ordered on September 29, 1979, that:

> "ORDERED, the defendents (Secretary, Department of Energy, et al.) will prepare with diligence and with all reasonable speed and file with the Court by no later than April 15, 1980, adequate final supplemental environmental impact statements to ERDA-1537, Final Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, and ERDA-1538, Final Environmental Impact Statement, Waste Management Operations, Hanford Reservation, Richland, Washington, discussing the safety and design alternatives for the Fiscal Years 1976 and 1977 double-shell radioactive waste storage tanks at Hanford and Savannah River.
>
> FURTHER ORDERED, that the environmental impact statements shall discuss in detail at least those design and safety feature alternatives identified at note 19, page 13 of the Court of Appeals slip opinion, including the reasonably foreseeable environmental effects of these alternatives, their effect on the durability of the tanks or the ease of waste retrieval from such tanks, and the effect, if any, of these design and safety feature alternatives on the choices of a technology for long-term radioactive waste storage and final disposal, and on the timing of such choices."

This statement goes slightly beyond that court requirement in that one additional tank authorized in a FY-1978 project is also included in the EIS.

The base document, ERDA-1538, Final Environmental Statement, Waste Management Operations, Hanford Reservation, December 1975, gives information on the Hanford waste management operations. This supplemental EIS summarizes, but does not repeat, the information given in ERDA-1538. The format of this supplemental EIS is changed somewhat from that of ERDA-1538 in accordance with the Council on Environmental Quality (CEQ) Regulations for implementing the procedural provisions of the National Environmental Policy Act (40 CFR 1500-1508).

* A similar EIS has been prepared for the Savannah River Plant.

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1.0 SUMMARY

1.0 SUMMARY

The important discussions and conclusions from each chapter of the environmental impact statement are summarized below.

1.1 PURPOSE AND NEED

The scope of this environmental impact statement (EIS)[a] includes the examination of the existing tank design and additional specific design and safety feature alternatives for the thirteen tanks being constructed for storage of defense high-level radioactive liquid waste at Hanford Site, Richland, Washington. The examination of the additional alternatives is in compliance with the directive of Federal District Court for the District of Columbia (NRDC vs. Administrator, ERDA/DOE). Further description of the purpose and need for this EIS are presented in Chapter 2.0.

Construction of these thirteen tanks except for piping and support equipment (authorized during Fiscal Years 1976, 1977, and 1978) will be essentially complete as of January 31, 1980 and utilization of the first of these tanks is scheduled to begin in March 1980.

1.2 PROPOSED ACTION AND ALTERNATIVES

1.2.1. Proposed Action

The action proposed in this EIS is the completion of construction and utilization of the thirteen tank system, without further modification, for defense high-level radioactive liquid waste storage at Richland, Washington, on an interim basis until long-term or final disposal.

The Department of Energy is responsible for management and storage of waste accumulated from the reprocessing of defense reactor spent fuels for plutonium recovery. Until recently these wastes have been stored as liquids and solids in 149 single-shell tanks as described in detail in ERDA-1538. A program is underway to restrict the use of single-shell tanks for storage of solids only. By 1985, it is anticipated that nearly all drainable liquids will be removed from all single-shell tanks and processed for storage in double-shell tanks. This program to eliminate the use of single-shell tanks for liquid waste storage is designed to reduce further the concern about public health and safety by avoiding radioactive liquid waste leakage from the older single-shell tanks. The double-shell tank system is designed to contain the liquid wastes for an interim period with adequate safety. The improved

(a) This EIS is a supplement to ERDA-1538. " Final Environmental Statement on Waste Management Operation:" Hanford Reservation, Richland, Washington (December 1975) United States Energy Research and Development Administration, Washington, DC.

design and safety features of the double-shell tanks over the 149 single-shell and the seven double-shell tanks built before 1976 are summarized below. Further details are presented in Chapter 3.0.

(1) The double-shell tanks are constructed as a primary tank within a secondary tank. This concept provides a secondary barrier to waste contact with the soil. Any leakage from the primary tank can be quickly detected and leaking liquids pumped out and into a spare tank.

(2) The primary tank employs post-fabrication stress relief to reduce stress corrosion cracking of the tank wall during its design life. Stress-relieving reduces or eliminates localized high-stress points at welded joints, which if unrelieved, can contribute to stress corrosion cracking, believed to have been the cause of some earlier leaks in single-shell tanks.

(3) A standard waste tank bottom tolerance was developed to minimize localized high stresses in the tank bottom caused by flatness anomalies.

(4) A higher strength steel was used for both the primary tank and the secondary steel liner.

(5) Tank bottom plate patterns and fabrication sequences used were less susceptible to fabrication deformations and localized high stresses.

(6) Airflow through the annulus for cooling the primary tank was increased over older double-shell designs. This feature was not included in single-shell tanks. Moreover, the bottoms of the double-shell tanks are also cooled.

(7) Dome strength (steel liner integrity) was increased by providing more J-bolts in the dome.

(8) More reinforcing steel for resisting thermal stresses in the concrete dome was installed.

(9) A more comprehensive analysis of the expected operating conditions was performed in order to better assure tank structural integrity.

(10) ASME Code Section VIII, Division 2 was utilized in the design and construction of the tanks.

1.2.2 Design And Safety Feature Alternatives

The alternatives discussed in this statement are:

1. thicker and more chemically-resistant steel plates

2. impressed current cathodic protection system to guard against stress corrosion cracking

3. better waste retrieval equipment and enlarged tank openings to facilitate retrieval

4. cooling coils like those at Savannah River.

Thicker and More Chemically-Resistant Steel Plates. This alternative is examined in detail in Section 3.2.2 of the text. The thicker plate alternative is intended to allow for greater corrosion damage to the tank walls. A more chemically-resistant plate if one could be identified, would provide improved corrosion resistance per se.

The thicker plate alternative has in essence, already been adopted via the earlier change from single-shell tanks of 3/8-in. plates to double-shell tanks, where the primary tanks use 1/2- to 7/8-in. plates for all wetted surfaces, and this is backed up with a secondary tank constructed of 3/8-in. plate, whose design and construction is equal or superior to the original single-shell tanks.

The alternative of more chemically-resistant plates has also been adopted via the change to a normalized (heat-treated) steel and to a post-fabrication stress relieving of the primary tanks. These two measures, significantly increase the steel's resistance to stress-corrosion, since stress-corrosion is believed to be a primary cause of leaks in older single-shell waste storage tanks. (Another alternative to minimize the possibility of stress corrosion cracking, cathodic protection, is discussed on the following page.)

The use of thicker and more corrosion-resistant steel plate has no effect upon either the ease of waste retrieval or on the choices of technology for long-term waste storage and final disposal. It does have a direct and positive effect upon tank durability beyond the system design goal of 50 years.

The conclusion from examining this alternative is that it is highly probable that the steel plates used now in the construction of waste tanks have sufficient thickness and corrosion resistance to provide the desired 50-yr system design life.

The above assessment of the adequacy of existing tank wall material for tank durability is based on the following factors:

- the wastes stored will be similar in composition to that of the double-shell slurry described in this supplementary EIS (Appendix G)
- the maximum mass stored per tank is equivalent to 1,000,000 gallons at a maximum specific gravity of 2.0
- as currently equipped, the maximum heat generation rate will be 100,000 Btu/hr/tank.

These factors and the protective operating procedures to be followed are further elaborated in Section 3.2.6 of the EIS and in Appendix G, and also are summarized on pages 1-5 and 1-6.

Impressed Current Cathodic Protection System. This alternative is examined in Section 3.2.3 of the EIS. The intention of using cathodic protection is to eliminate stress corrosion of the tank wall by impressing an electric current on the tank wall through the stored waste solution via anodes immersed in the solution.

After considerable study, it is concluded that:

(1) Cathodic protection is unnecessary because: a) the required corrosion protection will be provided by implementation of protective operating procedures including adjustment of the composition of the waste solutions, as determined by routine monitoring of the tank surface potential if determined feasible or by sampling the waste for chemical composition, and b) adequate stress relief of the tanks is provided as discussed elsewhere.

(2) Although this is a feasible system to install, the operation of the system is complex and unless extreme care is exercised, the system could induce the corrosion rather than eliminate it, especially in some small part of the tank wall which has a very large volume-surface combination. Further, the very high currents required to provide adequate protection will produce changes in solution composition and also gases such as hydrogen and oxygen. Thus, cathodic protection could produce a tank surface potential conducive to stress corrosion cracking. Also hydrogen embrittlement and explosive potential are significantly enchanced.

The use of the impressed current cathodic protection system would have no effect on the ease of waste retrieval or on the choices of technology for long-term waste storage and final disposal.

Better Waste Retrieval Equipment and Enlarged Tank Openings. As the title indicates, there are two parts in this third alternative. These are examined in Section 3.2.4 of the EIS and in Appendix C.

Adequate and demonstrated equipment for waste retrieval exist at present. These have been used at Hanford. The tanks have three 42-in. diameter openings per tank at present. Also each tank has at least 56 openings of other diameters less than 42-in.

The conclusions from the examination of the alternatives are:

- there is no need, at present, for improved retrieval systems since adequately effective and reliable equipment systems are now available for retrieval
- the tank openings now provided (42-in. diameter) are adequate for retrieval of the double-shell slurry waste projected for storage in the tanks. Therefore enlarged tank openings are not needed.

The use of better waste retrieval equipment and enlarged tank openings would have desirable effects on the ease of waste retrieval, but these desirable effects are not necessary since existing equipment and openings are adequate. There are no effects on choices of technology for long-term waste storage and final disposal.

Cooling Coils As At Savannah River. This is the fourth alternative examined in this EIS. As discussed in Section 3.2.5 of the EIS, the design heat generation rate of Savannah River wastes is about thirty times more than that of Hanford wastes; the actual heat generation may be as high as 60 times.

The air cooling provided in the Hanford tanks is designed to remove 100,000 Btu/hr/tank whereas the actual heat generation is expected to be only half the design value (50,000 Btu/hr/tank). Adequate monitoring will be in place as part of routine operating procedures that would prevent storage of waste with greater than 100,000 Btu/hr/tank. This nominal heat load level is removed uniformly throughout the external surface of the primary tank by air cooling in channels at the bottom and the annuli on the sides. These are some of the technical considerations that provide the basis to reject the need for cooling coils for Hanford tanks. The cooling coils are important to the Savannah River situation, but not for the Hanford situation.

The use of cooling coils would interfere with the ease of waste retrieval, but would have no effect on the choices of technology for long-term waste storage and final disposal.

Overall Results of Evaluation of the Alternatives. In the preceding paragraphs, the results of examination of the four design and safety alternatives were summarized. The examination in the text of this EIS includes a technical discussion of the major aspects of each alternative, followed by its advantages/disadvantages, environmental effects, if any, and effects on tank durability, on ease of waste retrieval and on choice of technology for long-term waste storage and final disposal. Finally, since each alternative was eliminated, the reasons for the elimination are summarized.

As the discussions indicate, the Department of Energy has been aware of the importance of evaluating the issues raised in each of the alternatives and had considered the issues before and during tank construction. It is shown that the 13 new tanks have incorporated many significant design and safety improvements (post-fabrication stress-relieving of primary tank being most fundamental) over the previous single- and double-shell tanks constructed at Hanford. A few examples are:

1. use of higher-strength carbon steel
2. provision of adequate corrosion allowance
3. stress relieving of primary tank after fabrication
4. providing increased dome strength
5. use of more comprehensive nondestructive examination of tanks.

The effectiveness of these improvements is assured and strengthened through the routine operating conditions implicit to such technological enterprises. Operating bases, such as the following, are typically reflected in quality assurance programs, operation and technical manuals, and continued management and operator training:

1. No wastes will be stored in the tanks that would result in total heat generation rates in excess of 100,000 Btu (1.1×10^8 J) per hour per tank.

2. The maximum mass stored per tank will be equivalent to 1,000,000 gallons at a maximum specific gravity of 2.0.

3. The tanks will be used to store compositions similar to double-shell slurry in corrosion potential. Other waste forms will not be stored without adequate corrosion testing to ascertain and modify as needed their corrosion potential.

4. Adequate standby pumping equipment and at least one spare tank will be available so that if a tank leaks, the liquid can be pumped out of the annulus space as soon as possible.

5. The feasibility will be evaluated of routine monitoring of the electromotive force (EMF) of the tank wall with respect to stored solution so that tank content composition can be adjusted to correct any undesirable EMF shifts. This is an anti-corrosion measure, whose feasibility needs to be determined before instituting EMF monitoring.

In view of the protective operating procedures to be followed and the significantly improved design features incoporated in the 13 tank system, it is concluded that the existing provisions for structural integrity and the design philosophy of the tanks are both satisfactory for the planned interim storage of the high-level liquid radioactive wastes. Therefore, the incorporation of the four alternatives is not required based on technical considerations. Further, in Chapter 5 of this statement it is shown that there are no significant environmental benefits to be gained by incorporation of the alternatives. Moreover, there are no cost benefits since incorporation of any alternative would require significant dollar outlays. Therefore, the alternatives can be rejected as unnecessary and not cost-effective. A comparison of the alternatives to the proposed action are summarized in the table on page 3-25 of the text.

1.3 DESCRIPTION OF THE SITE AND ENVIRONMENT

The Hanford Site is a large area, occupying approximately 1,500 km^2 (570 mi^2) in the semi-arid region of Southeastern Washington. Although much of this area is relatively undisturbed, the thirteen waste tanks are being incorporated into an environment already much altered from its original status.

The thirteen tanks are located in the 200 East Area, a portion of the Hanford Site dedicated to fuels processing, waste fractionation, and waste storage. In common with the other developed areas of the site, the tank farm area is, ecologically speaking, virtually barren. The tank farm location has a number of attributes of interest in considering the affected environment and the actual and potential environmental consequences of the construction and operation of the thirteen new tanks for interim storage of waste. The tank farm site is underlain by up to several hundred meters (>1,000 ft) of sands, silts, and clays, lying on a basaltic lava accumulation estimated to be more than 3,000 m (10,000 ft) thick. Annual precipitation (rain and snow) averages only 16 cm (6.3-in.); the upper sedimentary deposits are moisture-deficient, and have a high capacity to absorb leaking liquids from the waste tanks. Most of the chemical elements in the leaked material are adsorbed on to the soil particles by ion exchange similar to the mechanism in water softeners. This action results in permanent retention of adsorbed material in the soil. The water table is deep, ranging from 46 to 100 m (150-325 ft) beneath the ground surface at the tank sites.

With respect to possibly destructive natural forces, the site is located in an area of historically low seismicity. Tornadoes rarely occur in the Hanford region, tend to be small, and produce little damage.

The nearest population center from the tank location is 22 miles. The site is unique in that the geohydrology does not support movement of leaked radioactive wastes to the biosphere. Further details of the affected environment are presented in Chapter 4.0 of the EIS.

1.4 ENVIRONMENTAL CONSEQUENCES

The environmental consequences analyzed are limited in scope to those resulting from the 13 new double-shell high-level waste storage tanks. This information is supplemental to that presented in ERDA-1538 (1975). The environmental consequences are caused by: 1) the construction and operation of the tanks and 2) the hypothetical adoption of the alternatives described in Chapter 3. The consequences relate to the affected environment described in Chapter 4. The alternatives for which potential consequences are analyzed are considered from the viewpoint of the adoption (retrofitting) of the alternatives now when the construction of the tanks is nearly complete.

Since the thirteen new tanks are presently near completion, full adoption of any one of the four alternatives would require: 1) a significant commitment of additional resources and 2) would delay the transfer of liquids from the single-shell tanks of questionable integrity. The environmental consequences of these two actions are considered to be adverse. On the other hand, incorporation of the alternatives in the design stages would not have significantly altered the environmental consequences described for the proposed action, which is the utlization of the tanks as they now exist.

Whether the alternatives had been adopted before construction or are now adopted, the major benefits would be a potential, but not assured, extension of the life and durability of the tanks; there are no reasonably foreseeable major direct benefits in environmental consequences to the affected environment.

Even if the waste tanks were to leak or fail, resulting in waste-to-soil contact, calculations and physical measurements have shown that there would be no significant environmental consequences as discussed in this EIS and in ERDA-1538 (1975). The estimated environmental consequences of the proposed action or the alternatives are not significant. There are no expected consequences of significance from routine operation of the tanks. The worst case accident analysis of a postulated 800,000 gallon tank leak, not a credible scenario, indicates that the whole body radiation dose (70-yr commitment) to the occupational worker or the general population will be insignificant as shown in Table 5.5 of this EIS. This lack of consequences results from two principal reasons: 1) there is no active transport (movement) mechanism for the wastes to the biosphere based on the present climatological data and experience with previously leaking tanks at the Hanford Site and 2) the bottoms of all tanks lie about 50 ft below the ground surface and about 150 ft above the unconfined aquifers in the water table at Hanford. DOE however, considers any waste contact with the soil as environmentally undesirable; one of the major reasons for the construction of the new double-shell tanks is removing the single-shell tanks from active use for liquid waste storage.

This EIS does not address the environmental consequences of using the tanks for long-term storage; the present plans call for utilization of the tanks only on an interim basis. The design life of the new tank system is considered sufficient to contain the wastes pending implementation of long-term disposal.

2.0 PURPOSE AND NEED

2.0 PURPOSE AND NEED

Defense high-level radioactive wastes resulting from the chemical processing of spent reactor fuel for the recovery of plutonium, uranium, and other radioisotopes have been accumulating at Hanford since 1944. These wastes were initially stored in single-shell tanks. Since that time, improved interim storage methods have been developed, and double-shell tanks are being constructed to store the liquid wastes. This interim method was discussed in the Final Environmental Impact Statement on the Waste Management Operations for the Hanford Reservation (ERDA-1538) issued in 1975.

The need for the proposed action, defined as the completion of construction and utilization of double-shell tanks was explained in ERDA-1538 as the base case ("continue present program") in Chapter V, under discussions of "Alternatives to High-Level Waste Treatment." The 13 new tanks, which form the subject of this EIS will supplement the 156 tanks (149 single-shell and 7 double-shell) built at Hanford since 1943 to store the high-level wastes. The new tanks are of double-shell construction and vastly improved design over single-shell tanks (see Section 3.0 for details). The removable liquids from older single-shell tanks will be transferred to the new tanks to provide improved total containment of radioactive materials. As stated in ERDA-1538, these new double-shell tanks are required to minimize the potential for leakage of radioactive liquids from the older single-shell tanks. These 13 new tanks constitute a significant part of the overall waste management operations at Hanford, and will provide for safe, interim storage of the wastes until permanent waste storage is implemented. Construction of 13 tanks will be essentially complete as of January 31, 1980. Introduction of waste into the first of these tanks is presently scheduled to commence on or about March 1980.

This statement responds to the Order of the United States District Court for the District of Columbia to prepare a supplement to ERDA-1538 addressing certain design and safety alternatives[a] to the high-level liquid radioactive waste storage tanks (FY-76 and 77 projects) at Hanford and Savannah River. This statement covers the 13 double-shell tanks at Hanford whose construction is nearing completion. As required by the Court Order, the EIS discusses specific design and safety alternatives to the tanks in detail, including the reasonably foreseeable environmental effect of these alternatives, the effect of these alternatives on the durability of the tanks and on ease of waste retrieval from the tanks, and the effect, if any, of the alternatives on the choices of a technology for long-term radioactive waste storage and final disposal, and the timing of such choices. A separate EIS is being prepared for the waste tanks at Savannah River.

(a) The design and safety features are: thicker and more chemically-resistant steel plates, an impressed current cathodic protection system to guard against stress corrosion cracking, better waste retrieval equipment, enlarged tank openings to facilitate retrieval, and cooling coils (like those at Savannah River) for the tanks at Hanford.

3.0 ALTERNATIVES INCLUDING PROPOSED ACTION

3.0 PROPOSED ACTION AND ALTERNATIVES

In this section the proposed action including the existing design and safety features of the new double-shell tanks[a] are described. The four alternatives to the tank design are examined and the "no action" alternative is described.

3.1 PROPOSED ACTION (PREFERRED ALTERNATIVE)

The proposed action is defined as the completion of construction and the use of the thirteen new double-shell tanks at Hanford for interim storage of high-level liquid wastes. Construction of these tanks is almost completed and the staged utilization is scheduled to begin in March 1980 after operational testing of all mechanical components and control instruments. The specific design features incorporated in the construction of these tanks to insure adequate tank durability and environmental safety are discussed as follows.

3.1.1 Process Description

The Department of Energy is responsible for management and storage of wastes accumulated from the reprocessing of defense reactor spent fuels to recover plutonium. The major elements of the defense fuel cycle and waste management are schematically shown in Figure 3.1. Until recently, these defense wastes have been stored in liquid form in 149 single-shell tanks ranging from 55,000 to 1,000,000 gal in size. A program is currently under way to remove drainable liquid waste from single-shell tanks and to reduce the volume of remaining liquid wastes to as small a quantity as possible, so that the contents are essentially solid. This liquid volume reduction is accomplished by evaporation of the water from the waste in vacuum evaporators. Liquid is first pumped from the single-shell tanks to an evaporator. The concentrate from the evaporators is then returned to a single-shell tank where the crystallized salts, which consist largely of sodium nitrate and nitrite, settle out. The remaining supernatants are recycled back into the evaporator for further concentration. After repeated concentrations, the sodium aluminate concentration reaches the saturation point. The sodium aluminate solids produce a gelatinous material called double-shell slurry, which, because of its very high interstitial liquid content, is not acceptable for storage in single-shell tanks. New double-shell tanks are therefore constructed to provide an interim storage for the gelatinous double-shell slurry. Several conceptual alternatives are being studied for permanent disposal of this material as schematically shown in Figure 3.2. A separate EIS will be prepared by DOE to address this subject.

(a) These were referred to as double-wall tanks in ERDA-1538.

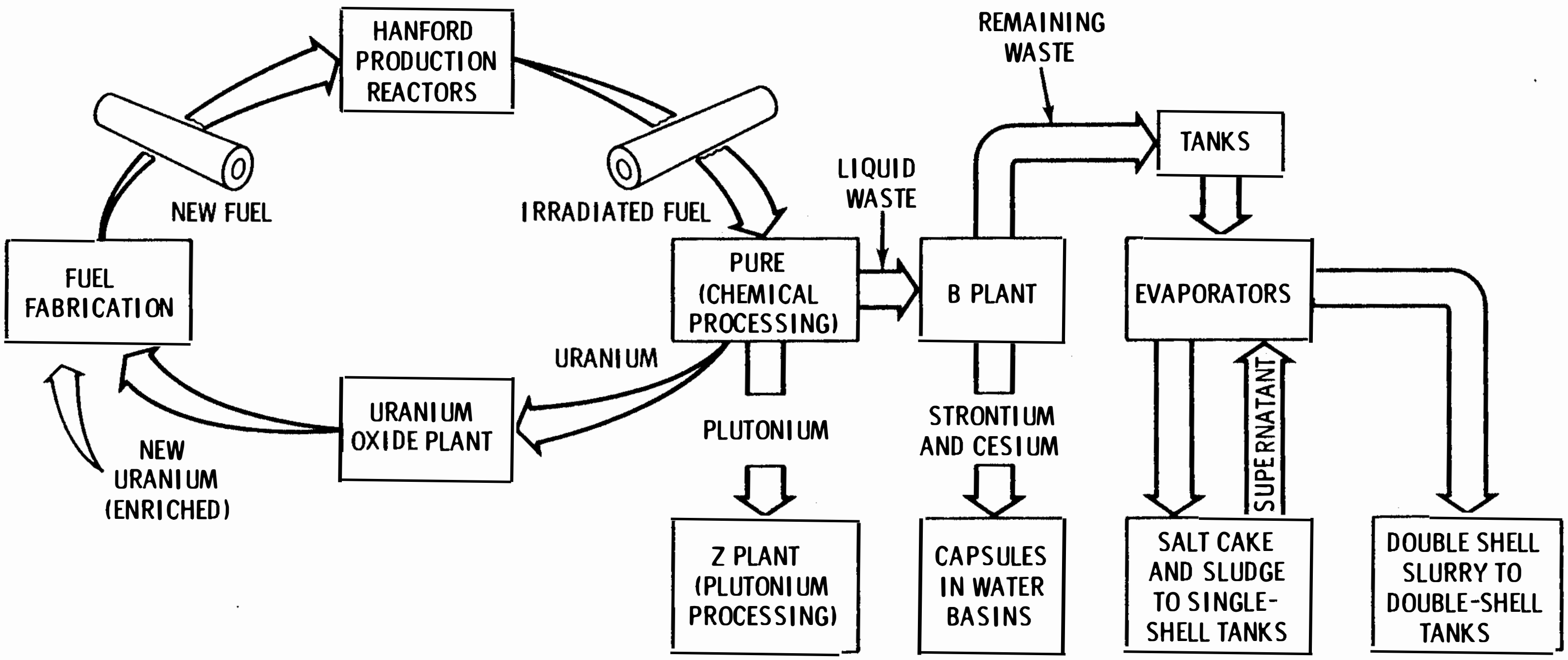


FIGURE 3.1. Hanford Radioactive Waste Management

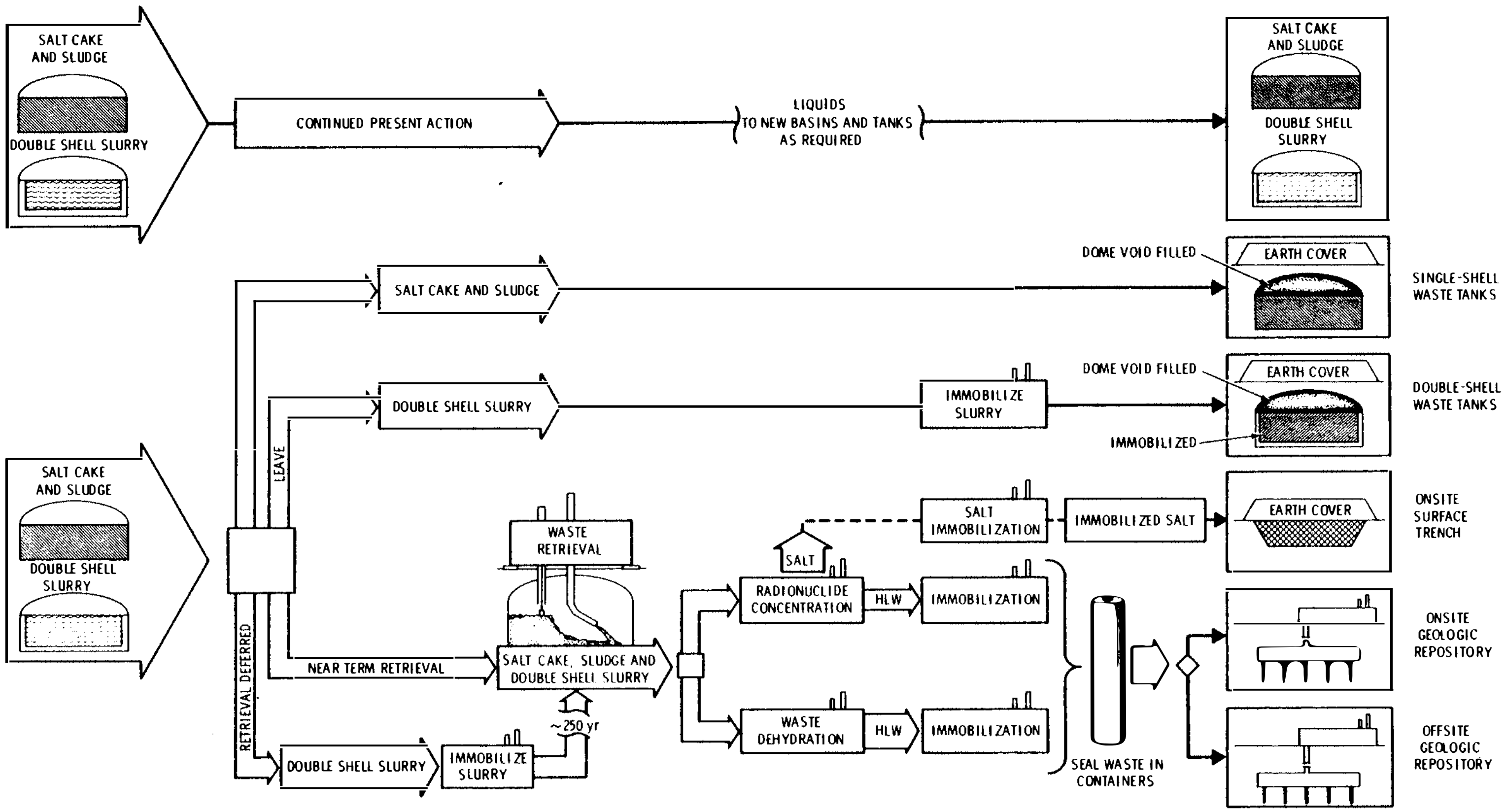


FIGURE 3.2. Major Disposal Alternatives for Hanford Defense High-Level Waste

In addition to double-shell slurry, other types of waste are undesirable for storage in single-shell tanks. These wastes, such as complexant concentrate waste, will also be stored in double-shell tanks. Complexant concentrate wastes are a byproduct of the B-Plant processing of Purex acidified waste (PAW) to remove high-heat radionuclides (Cs and Sr). The complexant wastes contain organic chelating materials, HEDTA and EDTA, which inhibit formation of crystalline solids through evaporation.

3.1.2 Description of Double-Shell Tanks - The DOE Preferred Alternative

The goal of waste management at Hanford is to store and contain all existing and future liquid radioactive wastes in double-shell tanks as soon as practicable, while concurrently seeking methods of long-term storage and/or disposal of the wastes. To meet this goal, 13 double-shell tanks, each of one-million gallon (3.8×10^6 l) capacity, are being constructed at Hanford. Six of these tanks are located in the 241-AW Tank Farm and seven in the 241-AN Tank Farm, shown in Figure 3.3.

The improved design and construction features of these thirteen new tanks, compared with single-shell tanks built before 1968, reflect considerable progress toward achieving greater reliability in the prevention of radionuclide release to the environment. The most important improvement is that the new tanks are constructed as a tank within a tank as shown schematically in Figure 3.4. This concept provides a secondary barrier between the radioactive waste and the environment. The inner or primary tank contains the liquid waste. The primary tank is surrounded by a carbon steel-lined, reinforced concrete shell. A 2.5 ft (0.76 m) annulus exists between the primary tank and the carbon steel liner. If the primary tank leaked, all waste would be contained by the carbon steel liner, after which the contents of the primary tank and any leakage contained in the annulus would be transferred to a spare double-shell tank, thereby preventing any leakage to the surrounding soil. Another important improvement over the pre-1968 single-shell tanks is the adoption of stress-relief of the primary tank following fabrication. Stress-relieving reduces or eliminates localized high-stress points that occur at welded joints, which if unrelieved, may cause stress-corrosion cracking, believed to have caused some earlier leakages in tanks. No leaks have yet been recorded in stress-relieved double-shell tanks at Hanford or Savannah River facilities; although the service experience of stress-relieved tanks is less than 10 years to date.

Although the 241-AW and 241-AN tanks (built during 1975-80 period) are similar to seven double-shell tanks currently in operation at Hanford, a number of further design improvements have been made to upgrade the quality of the latest tanks:

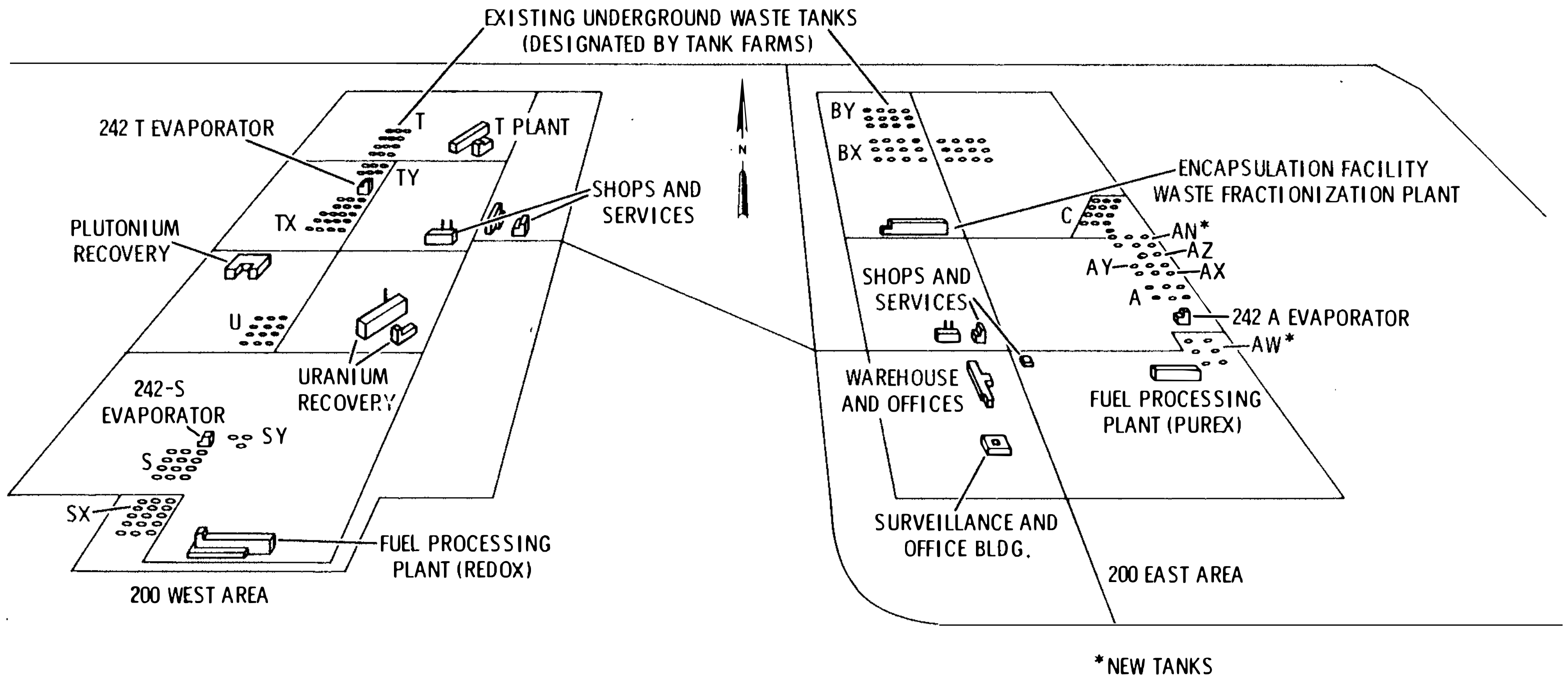


FIGURE 3.3. 200 East Area Tank Farm Location and Location of New Tanks

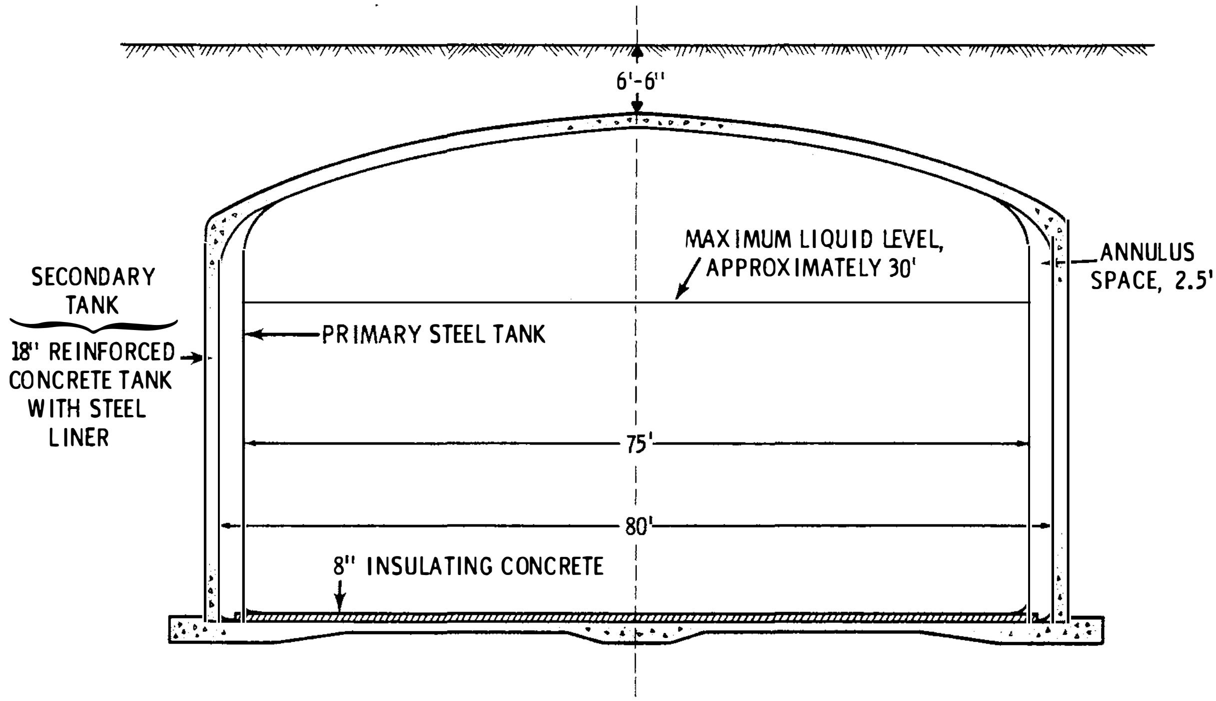


FIGURE 3.4. Schematic Drawing of Double-Shell Tank at Hanford

1) A standard waste tank bottom tolerance was developed to minimize localized high stresses in the tank bottom caused by flatness anomalies.

2) A higher strength steel was used for both the primary tank and the secondary steel liner.

3) Tank bottom plate patterns and fabrication sequences that were used are less susceptible to fabrication deformations and localized high stresses.

4) Airflow through the annulus for cooling the primary tank was increased.

5) Dome strength (steel liner integrity) was increased by providing more J-bolts in the dome.

6) More reinforcing steel for resisting thermal stresses in the concrete dome was installed.

7) More comprehensive analysis of the expected operating conditions was performed to assure tank structural integrity.

8) ASME Code Section VIII, Division 2 was utilized in the design and construction of the tanks.

Design of the 241-AW tank farm was started in February 1976 and completed in April 1977. Construction activity was started in March 1976 and is now completed. Operational testing of all mechanical and instrument systems is underway. The tanks are scheduled to go into operation in March 1980.

Design of the 241-AN tank farm was started October 1976, and completed in April 1978. Construction actvity was started in January 1977, and the tank structures have been completed. The piping and instrumentation systems are scheduled for completion in July 1980. Upon completion of construction, operational testing of all mechanical and instrument systems will be performed. The tanks are scheduled to go into operation in October 1980. A complete schedule for construction and operation will be found in Appendix D.

3.1.2.1 Tank Design Criteria

The following are the principal design criteria of the new double-shell storage tanks (Tanaka 1975a and 1975b, Guenther 1978):

Primary Tank diameter	75 ft (22.9 m)
Liquid Storage Capacity, each tank	10^6 gal (3.8×10^6 l)
Earth Cover (backfill)	6.5 ft, minimum (2 m)
Live loading on backfill over tank	40 lb/ft^2 (195 kg/m^2) uniform, plus 50 tons (45 mt) concentrated
Internal vacuum	6-in. H_2O maximum (1.5×10^{-2} kg/cm^2)
Internal Pressure	60-in. H_2O maximum (1.5×10^{-1} kg/cm^2)
Waste Characteristics:	
Temperature	350°F, maximum (177°C)[a]
Heat generation rate	100,000 Btu/hr/tank, maximum (1.1×10^8 J)
pH	8 to 14
Specific gravity	2.0 maximum
Seismic Acceleration	0.25 g horizontal 0.17 g vertical
Stress Relief (primary tank)	1100°F (593°C) for 1 hr
Design Life	50 yr
Tank Wall Temperature	200°F maximum (93°C)

In addition, the tanks were analyzed for structural effects of thermal cycling and liquid level cycling. Further details of tank design are provided in Appendix A.

(a) Even though wastes may enter the tanks up to 350°F, their temperature will fall quickly to less than the maximum tank wall temperature of 200°F by heat conduction and dilution.

3.1.2.2 Design and Construction Code for Primary and Secondary Steel Tanks

The American Society of Mechanical Engineers (ASME) Code, Section III addresses requirements for the construction of nuclear power plant items while ASME Code Section VIII covers requirements for construction of pressure vessels. These steel tank structures do not fall within either of these classifications.

Section VIII, Division 2 of the ASME Code was concluded to meet best the required design, construction, and quality requirements for these steel tanks. The design and analysis effort required by this code resulted in the most comprehensive analytical study of this tank configuration to date. With the construction of these tanks to ASME Section VIII, Division 2 requirements, the tanks are superior to any tank previously built at Hanford.

3.1.2.3 Steel Tank Material Requirements

The primary and secondary steel tanks were fabricated with ASTM-537, Class I carbon steel plate. On previous double-shell tanks constructed at Hanford ASTM A-516 and ASTM A-515 steels were used. The yield strength of A-537 at 350°F (177°C) is 39,000 psi (2.7×10^3 kg/cm^2) while the yield strength of A-516 and A-515 steel is 30,000 psi (2.1×10^3 kg/cm^2) at 350°F (177°C) (ASME 1974).

Under design operating conditions both A-537 and A-516 steel provide adequate structural tank strength (Basic Technology, Inc. 1977). The higher strength steel was chosen for use since it provides an additional margin of safety when considering the potential for stress corrosion cracking (SCC). This is not to say that A-537 is more immune to SCC than A-516, but that possible advantages exist in using the higher strength steel when the tensile stress requirements for SCC are considered. The proposed mechanism for SCC requires that tensile stress at a discontinuity such as a crack tip be of sufficient magnitude to create localized yielding contributing to crack propagation. Therefore, in a tank constructed of the higher strength A-537 steel, some margin of safety against localized yielding is provided. The cost difference between the two steels is negligible.

A-537 Class I carbon steel has a higher yield strength than any of the low carbon steels with the exception of quenched and tempered steels. No advantages in resistance to SCC have been established for quenched and tempered steels. Since these steels are costly to purchase and fabricate they were not considered for use on the 13 new double-shell tanks.

To date no evidence of stress corrosion cracking in A-537 steel has been observed experimentally in simulated waste solutions at temperatures up to 203°F (95°C) (Payer 1977a).

The general corrosion rate for A-537 steel is based on laboratory data for similar carbon steels in simulated caustic waste solutions at temperatures up to 203°F (95°C) (Payer 1977b, Wilson 1977). Heat transfer analysis for expected tank service has shown that steel skin temperatures will not exceed 200°F (93°C) (Appendix F). For the purposes of design, a 1 mil/yr (0.25 mm/year) average corrosion rate has been used for the primary tank. Based on a 50 yr design life, general corrosion will be 50 mils (1.25 mm). This decrease in thickness is taken into account in the tank structural analysis.

3.1.2.4 Tank Configuration

Each tank consists of three concentric structures as shown in Figure 3.5. The outer tank structure is a reinforced concrete tank designed to sustain soil loadings, dead loads, live loads, and elevated temperatures generated by the radioactive wastes contained within the primary tank. The reinforced concrete tank is lined with a carbon steel liner called the secondary steel tank. The inner, freestanding, completely enclosed carbon steel tank, referred to as the primary tank, is within the secondary steel tank. The steel tanks are separated by an annular space. The primary tank is designed to contain the radioactive waste materials. The secondary steel tank would contain liquid leakage from the primary tank until the tank contents can be transferred to a spare double-shell tank.

Primary tank. The freestanding primary tank is 75 ft (22.9 m) in diameter and is 45 ft, 9-in. (13.9 m) high at the dome crown. The maximum content height is 30 ft, 3-in. (9.2 m). The carbon steel in the bottom of the tank ranges from 1/2-in. (1.3 cm) to 1-in. (2.5 cm) in thickness. The knuckle (the transition section from tank floor to tank wall) is of 7/8-in. (2.2 cm) steel plate. The primary tank wall thickness ranges from 1/2-in. (1.3 cm) to 3/4-in. (1.9 cm) and the dome is 3/8-in. (0.92 cm) thick steel.

Secondary steel tank. The secondary steel tank lines the reinforced concrete tank and extends to the primary tank dome. The secondary steel tank is 80 ft (24.4 cm) in diameter and varies in thickness from 3/8-in. (0.92 cm) to 1/2-in. (1.3 cm). There is an annular space of 2.5 ft (76 cm) between the primary tank and the secondary steel tank to allow for installation of liquid level detection devices, inspection equipment such as periscopes, television cameras, and photographic cameras; ventilation air supply and exhaust ducts; and equipment for pumping liquid out of the annular space.

Insulating concrete. An 8-in. (20.3 cm) slab of insulating concrete (a castable refractory made with an aluminate cement and a slate aggregate) is sandwiched between the primary and the secondary tank bottoms (Figure 3.5). This slab protects the reinforced concrete foundation from excessive temperatures during the stress relief of the primary tank. During operation of the tanks, the annulus ventilation system routes air through slots in the insulating concrete to the annulus. This air flow cools the waste tank and would transport radioactive particulates to an air sampler in the event of a leak in the primary tank. The insulating concrete also has grooves for liquid drainage from beneath the primary tank to the annulus for detection and pumpout.

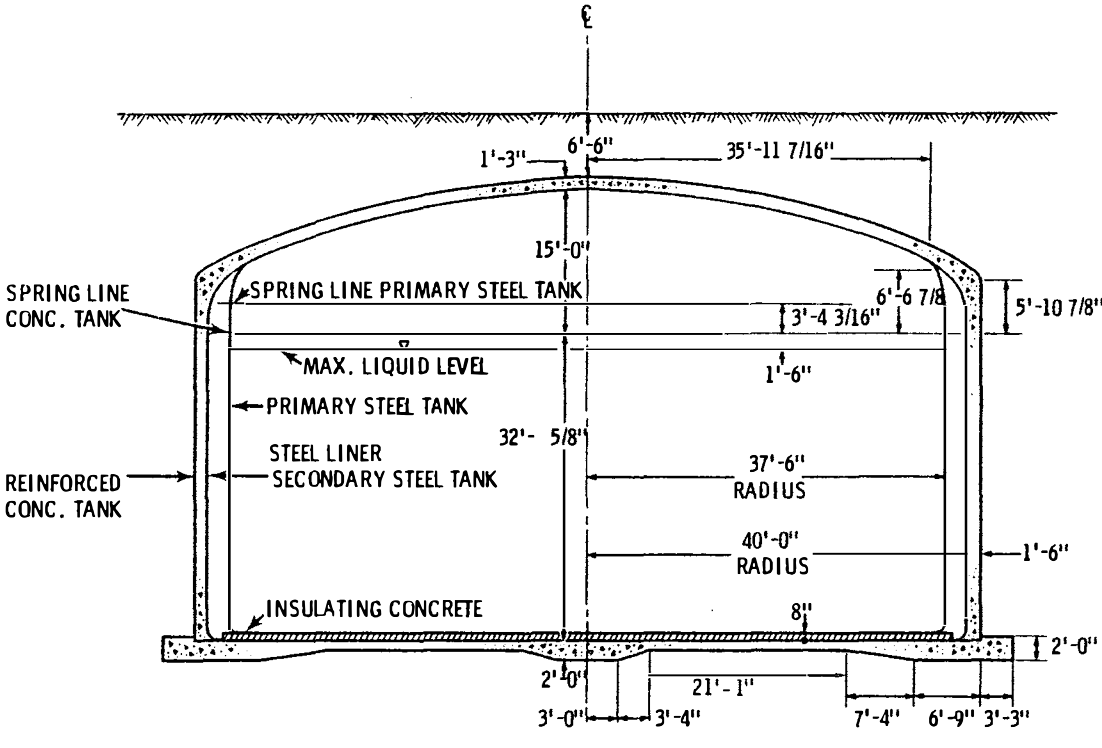


FIGURE 3.5. Vertical Section Through Tank

Welding and stress-relief. All primary and secondary steel tank seams are full penetration butt-welded in accordance with approved weld procedures by certified welders. The welds are first visually inspected. All wetted areas are x-rayed as required and accepted per the requirements of ASME Section VIII, Division 2. In addition, welds in the tank bottom are tested by using magnetic particle and dye penetration procedures. After tank fabrication is completed, the primary tank is filled with water and leak checked. In addition, the steel plate is ultrasonically tested at the mill for plate flaws before it is shipped to the construction site.

Strict attention is paid to the flatness of the tank bottoms since past research has shown that bumps with severe curvatures can cause localized high stress points that may initiate or contribute to stress corrosion cracking. (Anderson 1976a,b). After fabrication, the primary tanks are thermally stress-relieved at 1100°F (593°C) for one hour to relieve residual fabrication stresses.

Reinforced concrete tank. The primary tank is contained within a steel-lined, reinforced concrete structure. The reinforced concrete tank is made up of two independent parts: foundation, and walls and dome.

The foundation varies in thickness from 1 ft (30 cm) to 2 ft (60 cm), and transmits the bearing forces from the tanks and concrete walls to the load-bearing backfill beneath the foundation. The concrete wall rests on a steel slide plate mounted on the foundation footing. The top of the concrete tank foundation is slotted such that any leakage from the secondary steel tank can be routed to a leak detection pit and pumped to another tank. The concrete varies in thickness from 18-in. (45.7 cm) in the walls to 15-in. (38.1 cm) in the dome.

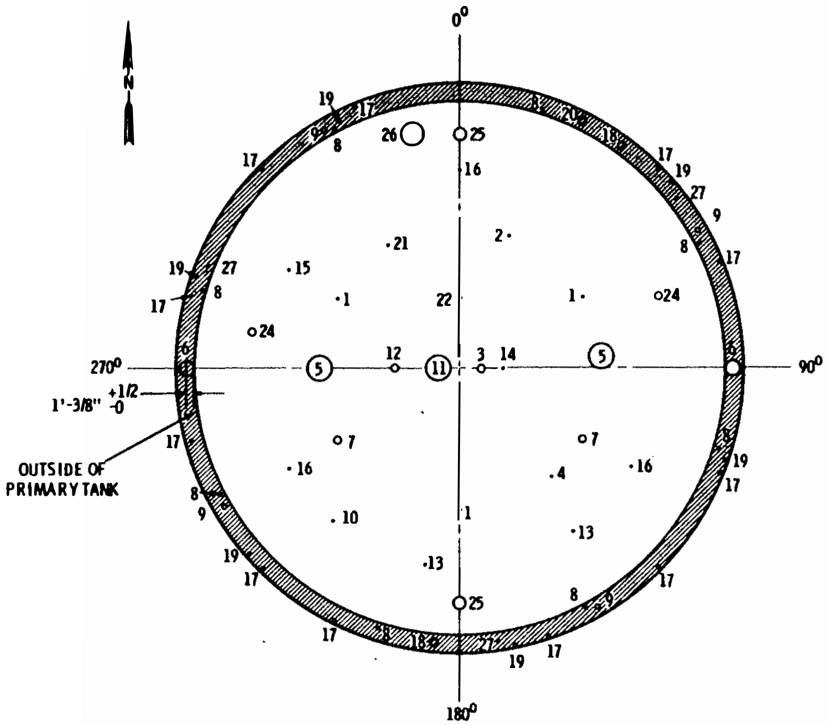
The reinforced concrete structure is designed to withstand the most severe combination of operating and natural forces, including a breach of the primary tank with the resulting loads on the secondary steel tank and reinforced concrete structure.

Design analysis of the concrete structure indicates it will experience nonlinear creep and cracking due to elevated temperature conditions induced by the contents of the primary tank, but that it reaches a stationary condition with a comfortable margin of safety (URS/John A. Blume and Associates 1978).

Tank dome penetrations. There are 64 tank dome penetrations in the primary tank and annulus for monitoring and processing activities. A typical dome penetration arrangement is shown in Figure 3.6, with a schedule of the number and sizes of penetrations. For the primary tank monitoring facilities, penetrations are required for liquid level, sludge level, temperature, and pressure measurements, and for an observation port. Penetrations for the primary tank processing operation include vessel ventilation, slurry distribution, supernatant pumpout, drainage collection from various pits and encasements located on or near the tank, and spares. A minimum of three 42-in. (106.7 cm) risers are required to facilitate future waste retrieval activities.

Penetrations through the tank dome into the annulus area are required for annulus pumpout, ventilation air inlets and outlets, instrument leads, liquid level measurement, annulus inspection, and construction access. All tank penetrations terminating in risers above grade are located to permit crane access for all pit work.

Process pits and risers. Each new tank will have pipes which extend from the tank to grade level and to concrete pits. These risers will allow access to the tank for ventilation, instrumentation, drains, pumps and inspection. The riser diameters range from 4-in. (10.2 cm) to 42-in. (106.7 cm).



PLAN FOR DOME PENETRATIONS

RISER NO.	QTY	SIZE	FUNCTION (REFERENCE ONLY)
1	3	4" SCHED 40	SLUDGE MEASUREMENT
2	1	4" SCHED 40	LIQUID LEVEL (LIT)
3	1	12" SCHED 40	SUPERNATANT PUMP, PUMP PIT DRAIN OR SPARE
4	1	4" SCHED 40	THERMOCOUPLE PROBE
5	2	42" I.D.x1/2" WALL	CONSTRUCTION OPENING
6	2	24" SCHED 20	ANNULUS ACCESS
7	2	12" SCHED 40	TANK VENT, SPECIFIC GRAVITY & SPARE
8	8	4" SCHED 40	AIR INLET TO TANK INSULATION
9	4	8" SCHED 40	ANNULUS AIR OUTLETS
10	1	4" SCHED 40	FLUSH PIT DRAIN OR SPARE
11	1	42" I.D.x1/2" WALL	SUPERNATANT ADD AND SLURRY DISTRIBUTOR
12	1	12" SCHED 40	OBSERVATION PORT
13	2	4" SCHED 40	TANK PRESSURE AND SPARE
14	1	4" SCHED 40	SUPERNATANT RETURN
15	1	4" SCHED 40	SPARE
16	3	4" SCHED 40	SLUDGE MEASUREMENT
17	11	4" SCHED 40	ANNULUS INSPECTION
18	2	12" SCHED 40	ANNULUS ACCESS
19	6	4" SCHED 40	ANNULUS INSTRUMENT LEADS
20	1	12" SCHED 40	ANNULUS PUMP OUT AND ANNULUS PUMP PIT DRAIN
21	1	4" SCHED 40	LIQUID LEVEL (HIGH LE)
22	1	4" SCHED 40	SLUDGE MEASUREMENT
23			
24	2	12" SCHED 40	SUPERNATANT PUMP AND FEED PUMP PIT DRAIN & SPARE
25	2	20" SCHED 40	CLEANOUT BOX AND VALVE
26	1	36" I.D.x1/2" WALL	BLDG DRAIN
27	3	4" SCHED 40	ANNULUS LEAK DETECTION

FIGURE 3.6. Tank Penetrations Schematic

Each tank is equipped with three concrete pits to be utilized in tank contents removal: 1) a central pump pit over the primary tank houses the pump and fill line for each tank, 2) an annulus pump pit provides for pump out the secondary tank in the event of a leak in the primary tank, 3) a leak detection pit, located adjacent to each tank, collects liquid from the slots in the base slab below the liner for pumping back through the central pump pit. The pits consist of reinforced concrete boxes set in the ground above the main risers in the rank. The top of each pit has removable concrete cover blocks which allow equipment access when removed and provide shielding when installed.

Process piping. Process piping is used for two purposes: transporting product from the 242-A Evaporator to the tanks, and transferring material between tanks. For the purposes of discussion, the pipelines from the evaporator to the tanks are called slurry lines (Figure 3.7), and the lines for moving waste between tanks are called supernatant lines (Figure 3.8). One slurry line and one supernatant line are connected to each tank. These lines are routed from the pump pits on each tank to valve pits. Each valve pit consists of a concrete box with removable coverblocks. The valve pits contain valved jumpers used to make transfers to and from the desired tanks. Supernatant lines connect the central pump pit with both the leak detection pit and the annulus pump pit.

All process lines have a minimum average slope of 0.25% to assure proper drainage. The primary lines are encased with a secondary pipe (encasement) as an added precaution against leakage to the environment. All piping is designed to accommmodate thermal expansion. The encasements are sized to permit movement of the primary line. Provisions for expansion and contraction of the buried encasements are made by leaving void spaces in the insulation around the pipe.

The process piping is all full-penetration butt-welded according to qualified (approved) procedure by certified welders. After fabrication, all welds are visually, dye-penetrant, and radiographically inspected. In addition, all piping is hydrostatically tested at 1-1/2 times the design pressure.

After all pipe fabrication is completed and accepted, the piping is covered with a minimum of 2.5 ft (0.76 m) of earth to provide radiation shielding.

3.1.2.5 Tank Ventilation Systems

The ventilation system for each tank farm (Figures 3.9 and 3.10) consists of two completely separate subsystems: the primary tank ventilation system, and the annulus ventilation system. The two systems are capable of together removing 100,000 Btu (1.1×10^8 J) of heat per hour from each tank. The exhaust air streams are filtered to keep the radioactive particulate emissions below release guides defined in ERDA Manual, Chapter 0524 (DOE 1977). Buried 12-in. (30.5 cm) ductwork routes the ventilation air from the primary tank and annulus of each tank to the exhauster fans. Failure of the primary

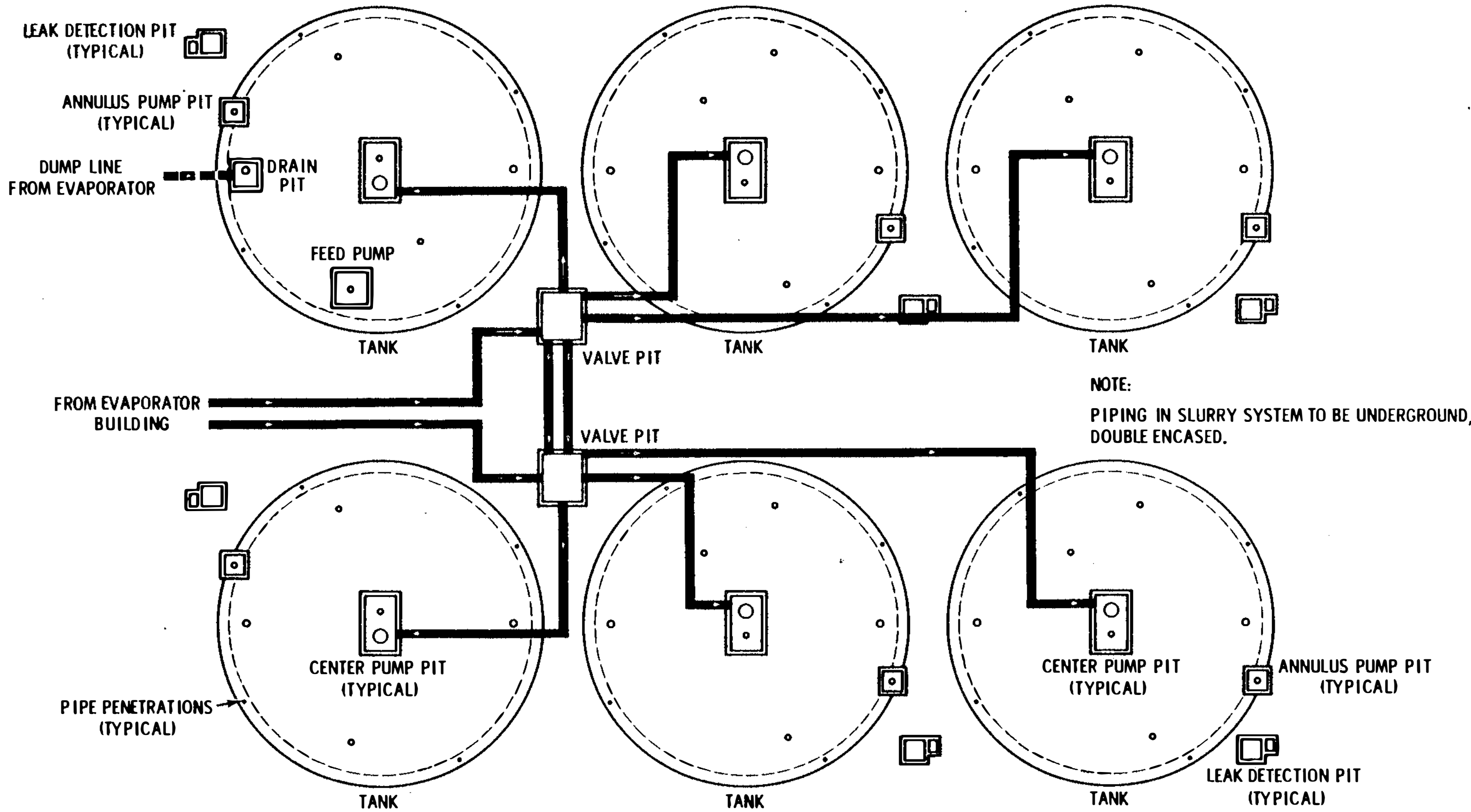


FIGURE 3.7. Slurry Piping

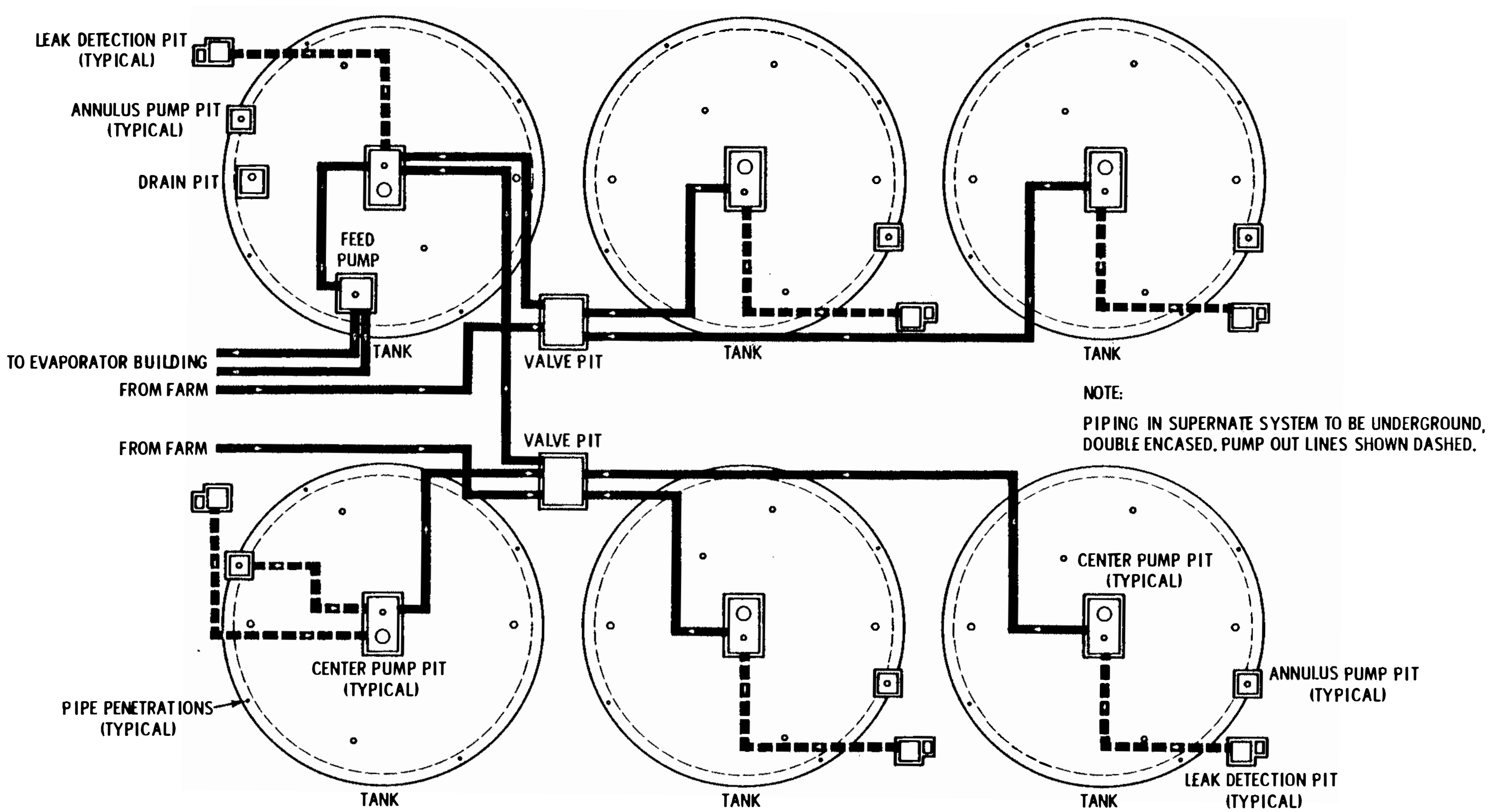


FIGURE 3.8. Supernatant Piping

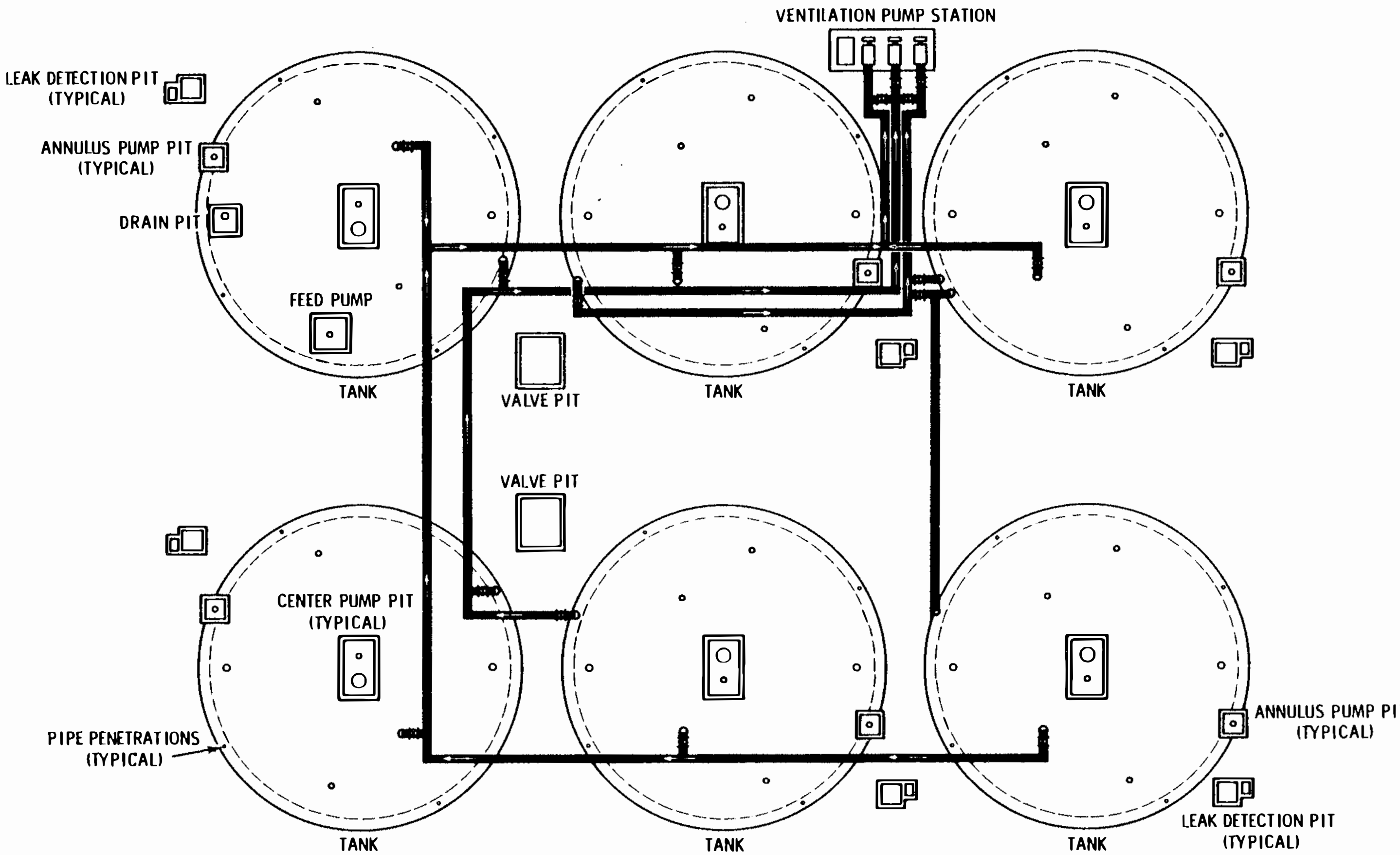


FIGURE 3.9. Tank Farm Ventilation System

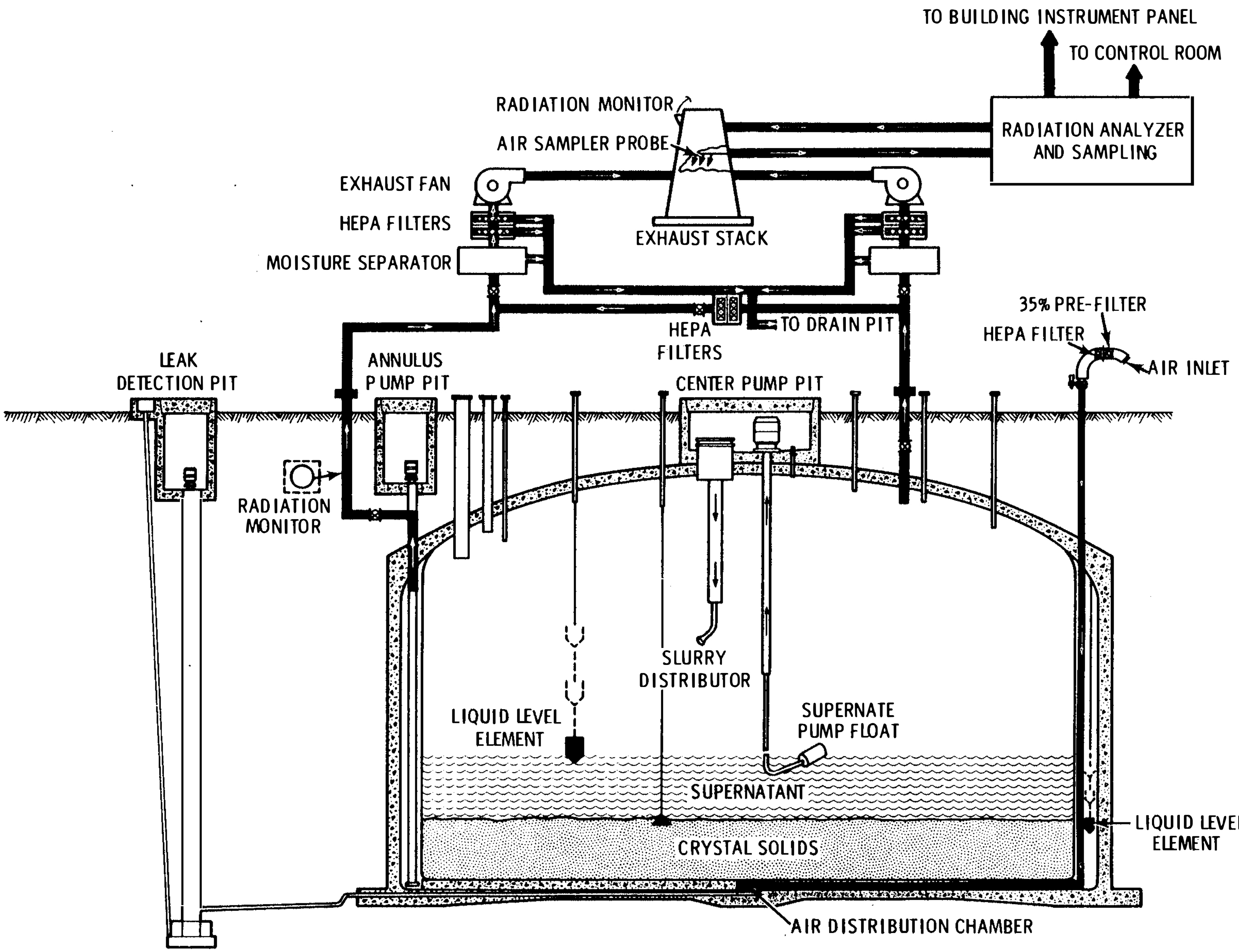


FIGURE 3.10. Tank Ventilation Details

tank exhauster or filter automatically reroutes primary exhaust through the annulus ventilation system. Both systems are equipped with ports in the ductwork which allow in-place testing of the filter integrity. Differential pressure gauges, installed to monitor the pressure drop caused by buildup on the filters, and ports for psychrometric testing of the primary system, are also provided on the ventilation system.

Primary tank ventilation system. This ventilation system is designed to remove vapors from the primary tank and to maintain a pressure inside the tank that is always slightly below the atmospheric pressure outside the tank. This constant negative pressure is maintained inside the tank by exhausting infiltration air from the tank. The exhaust fans are incapable of producing a negative pressure over 5.9-in. (15 cm) of water.

The exhauster unit contains a de-entrainment pad to remove entrained moisture, an electric heater to prevent condensation on the filters, a prefilter, two high-efficiency particulate air (HEPA) filters in series, and an exhaust stack with a flow measuring device, air sampler, and radiation monitor. HEPA filters are commonly used for nuclear service because of their high efficiency. The filters are 99.9% effective in removing 0.3 micron particles.

Annulus ventilation system. The purpose of the annulus ventilation system is to cool the tanks, avoid moisture condensation in the annular space, and serve as a sensitive method of detecting leakage of radioactive materials from the primary tank. The annulus ventilation system, in combination with the primary ventilation system, is capable of removing 100,000 Btu (1.1×10^8 J) of heat per hour from each tank. One air supply unit to each tank annulus has a prefilter, a HEPA filter,[a] and a manual butterfly valve. Outside air will be supplied through eight 4-in. (10 cm) carbon steel pipes located inside the tank annulus and embedded in the insulation material underneath the primary tank bottom. From the center of the insulating concrete, the air will flow radially outward to the annulus through slots provided in the insulation under the primary tank.

Four exhaust ducts, connected to 8-in. (20 cm) risers from the annulus, transport the annulus exhaust air from the top of each tank annulus to a manifold on the annulus ventilation exhaust units. A butterfly valve for adjusting airflow is provided in the ductwork from each tank annulus. An air sampler/radiation detector is installed in the ventilation ductwork to detect any radioactive leakage from each primary tank.

Air flow rates are designed to be 800 cfm (3.8×10^2 l/sec) for each tank annulus, as compared to 150 cfm (70.8 l/sec) in the primary tank. Two exhauster units are used for the annulus vent systems in each tank farm, and one exhauster unit is used for the primary tanks in each tank farm.

(a) The HEPA filter provides protection against release of radioactivity in the event of an airflow reversal.

The exhauster unit filtration system used for the annulus is identical to the primary tank unit with one exception: the pre-filter is not required because the inlet air is filtered prior to entry into the annulus.

3.1.2.6 Instrumentation Systems

Instrumentation systems for each tank are provided to monitor operating parameters such as liquid level, temperature, leak detection, and radiation detection (Figures 3.11 and 3.12). All readouts are at a local instrument building in each tank farm, or in the 242-A Evaporator building, which is continuously manned.

Liquid level. Each tank is equipped with an automatic liquid level gauge. The gauge sits on a tank riser and consists of a plummet suspended on a tape, tape reel, sight glass, control box, air purge, and water flush sprays. In operation, the controls periodically and automatically adjust the plummet position until electrical continuity between the plummet and the liquid surface is achieved. At this point, the tape reading is converted to an electrical signal for readout.

Sludge level. Sludge level detectors are installed in the tanks to detect the height of the solids level in the tanks. The device consists of a weight suspended by a predetermined length of cable from a capped riser. Readings are taken manually by removing the riser cap and attaching a hand-held, calibrated tape to the sludge weight cable and lowering the weight to the solids surface.

Specific gravity. Long half-inch diameter tubes are inserted through a tank riser to measure specific gravity. One tube is located near the bottom of the tank, and the second is positioned 3.25 ft (1 m) higher. Specific gravity data on the waste is obtained by comparing the air pressures required to bubble air through each tube. The pressure signal is transmitted through air lines to the instrument building, where it is converted to an electrical signal and displayed on a panel board. These readings read out continuously in the instrument buildings.

Temperature monitoring. Each tank is equipped with 101 chromel-constantan thermocouples for monitoring temperatures in critical areas of the tank structure (Figure 3.11). A single pipe probe containing 18 thermocouples is used to monitor waste temperatures at various levels in the primary tank. The concrete dome and walls contain 24 thermocouples located at the outer surfaces. Twenty-four additional thermocouples are located on the interior next to the steel in the primary tank dome and the steel liner. Nine thermocouples are located in the concrete base slab. Twenty-four thermocouples are located on the insulation concrete next to the bottom plate of the primary tank. Two thermocouples are located near the bottom of the primary tank in the annulus. All of the thermocouples are strategically distributed, both vertically and radially, to achieve a representative sample of the actual temperatures. All thermocouples read out in the instrument buildings. Important readings are displayed in the 242-A Evaporator, which is continuously manned.

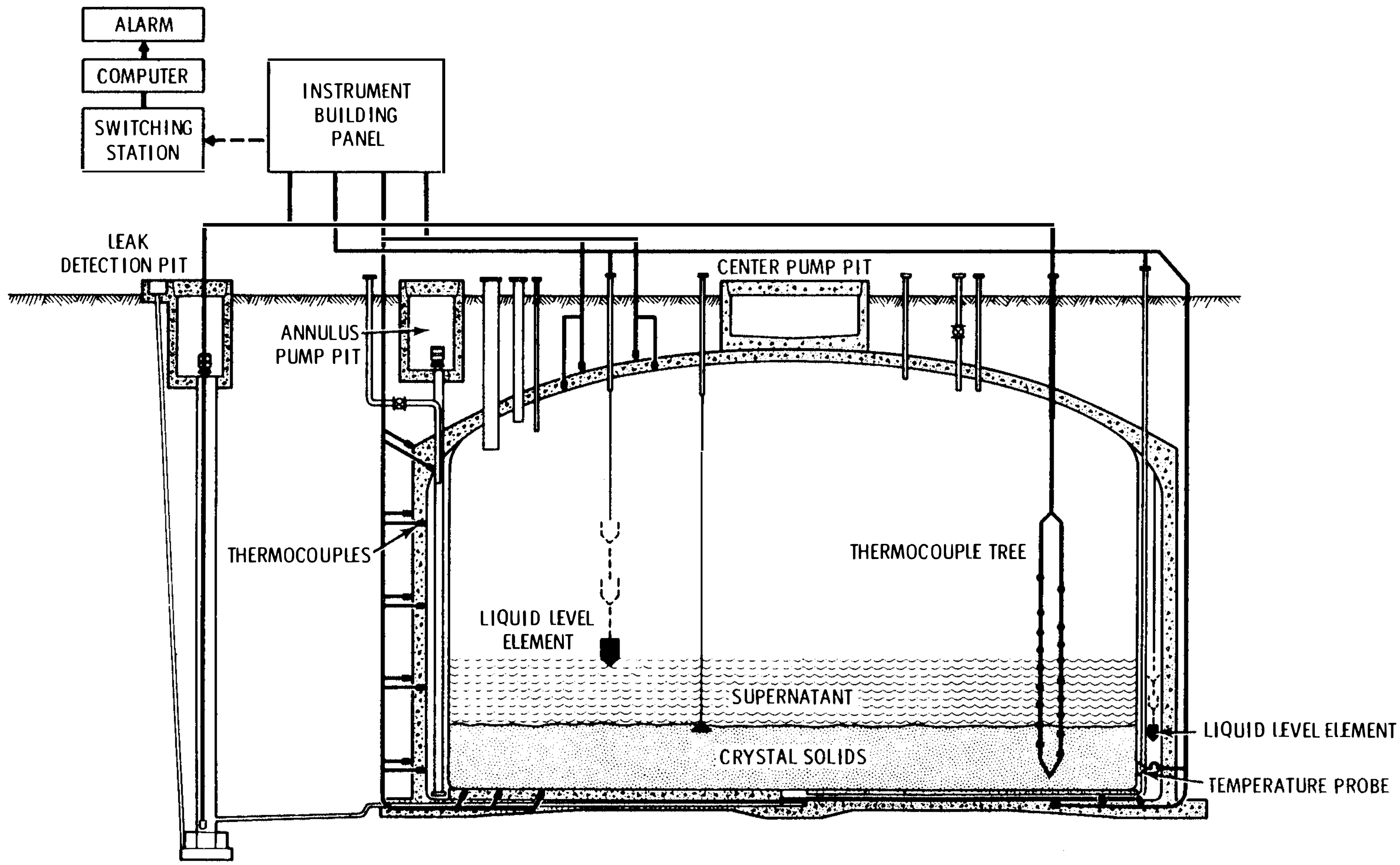


FIGURE 3.11. Tank Instrumentation and Temperature Measuring Systems

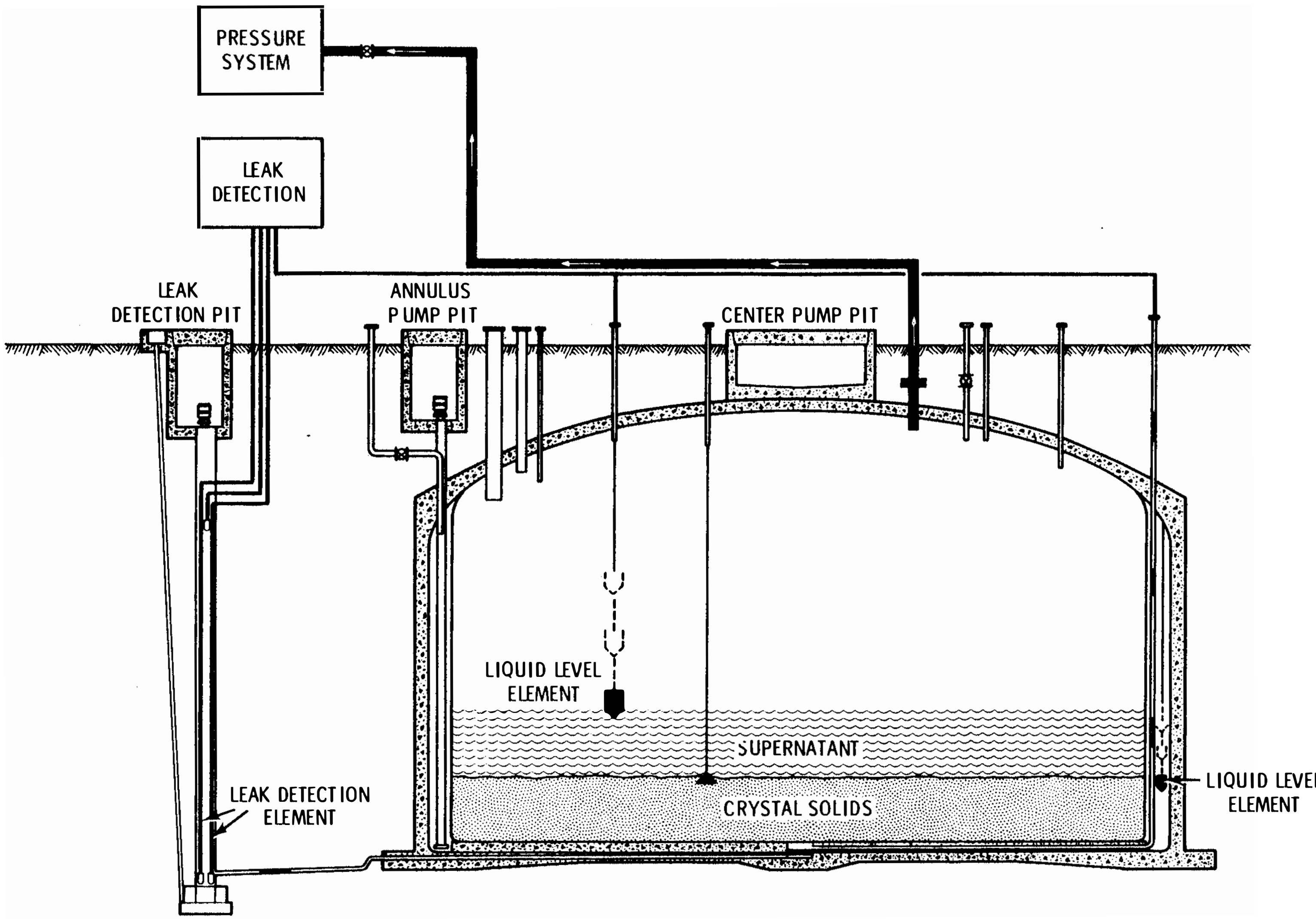


FIGURE 3.12. Tank Leak Detection System

Radiation monitors. Radiation monitors are used to detect radiation in locations that are not normally contaminated, such as ventilation ducts, service pits, and leak detection pits. Overall surveillance of tank farms is provided by area radiation monitors. Alarms and interlocks are provided such that upon detection of radiation, the fans or pumps which could further spread contamination are automatically shut down.

Leak detection. In addition to the leak detection provided by radiation monitors, conductivity probes are installed in the annulus, process pits and encasements. These areas are normally dry; the presence of any liquid would activate the probe to indicate a leak and sound an alarm in the instrument building.

3.1.3 Waste Retrieval Provisions

Waste retrieval from any of the double-shell tanks can be accomplished with currently demonstrated technology. The solids in the tanks are either inherently light and pumpable (as in the case of cladding wastes), or water sluiceable (as in the case of double-shell slurry). Solids precipitated by evaporation of concentrated liquors can be diluted with water and suspended for pumping. Existing slurry distributors can provide the required agitation for the redissolving operations. As shown in the figures in Appendix C, the distributors can direct a stream of water or recycle liquor to any portion of the tank by radial adjustment. The redissolved material can then be pumped with existing pumping equipment. A detailed discussion of waste retrieval is provided in Appendix C. As stated in Appendix C, equipment to remove liquids, slurries, and sludges from underground tanks already exists at Hanford and has been used extensively. In the event that a decision is made to empty a primary tank as quickly as possible, the equipment and know-how are available now.

For the case where the tank contains only pumpable liquid, a multi-stage, deep-well turbine pump has been designed and built for use in the double-shell tanks. Three pumps are available for insertion in the main, annulus, and test well pump pits.

For the case where the tank contains double-shell slurry, two courses of action are available. Either the double-shell slurry can be handled as an insoluble sludge (discussed subsequently), or it can go through a dissolution process. In this latter instance, the same multi-stage, deep-well turbine pump stated above for liquids can be employed. Since double-shell slurry is the product of a 25% volume reduction by evaporation of water from a totally liquid state, it is readily resuspended by adding back this 25% water. This can be accomplished by the controlled addition of hot water at the turbine pump inlet mixing with double-shell slurry (see Appendix C). This hot water discharge at the pump inlet also serves to sink the turbine pump into the double-shell slurry during installation in the pump pit. Since the total waste volume is being increased in this instance, the pumped liquid waste must first be put through an evaporator to return it to double-shell slurry before placing it in a spare tank also of one-million gallon capacity. An evaporator can discharge double-shell slurry at a rate of 75 gpm. This would require an evaporator feed rate of 100 gpm which is within the capability of the turbine pump. At 75 gpm, a one million gallon tank of double-shell slurry can be emptied within approximately ten days at continuous operation.

For the case where the double-shell tanks contain insoluble sludge or double-shell slurry to be moved with minimal dissolution, a heavy-duty centrifugal slurry pump is available which has been used at Hanford in removing sludge from single-shell tanks. One of these pumps shown on Page C-13, Appendix C.

In all cases cited above, final cleanout of the tank would still have to be undertaken. This will require additional time and will also generate an additional volume of waste wash water to be pumped to another location. The equipment available to do this is in the form of sluicers. Sluicers have been used previously in the cleanup of sludge heels in single-shell tanks. They can be used also to wash down the interior walls of the primary tank. Appendix C describes a sluicer.

Any immediate cleanup of a double-shell tank annulus or leak detection pit can be accomplished with one or more hot water flushings and pumpout of the waste water with the turbine pumps previously mentioned.

3.1.4. Summary of Safety Features

Each tank consists of two containment barriers between the waste and the environment. Leakage through either the primary tank or secondary tank can be detected with both radiation monitors and liquid detectors, and corrective action taken.

Separate primary tank and annulus exhaust ventilation systems provide radiation monitoring and cooling. The primary tank is maintained at a constant negative pressure, such that air flow is at all times into the tank. The exhaust fans are incapable of producing excessive negative gauge pressure. Failure of the primary exhauster unit automatically actives a cross-connector to the annulus ventilation system in order to maintain negative gauge pressure in the tank at all times.

Instrumentation in the tank farms is designed and interlocked as necessary to detect abnormal conditions and automatically shut down pumps and sound off alarms. In addition to the tanks, the supporting facilities such as piping, process pits, and utility pits are monitored for leakage. Manually operated valves are equipped with limit switches or mechanical interlocks which assure that the waste streams are not misrouted. Above-ground radiation monitors that detect soil contamination provide continuous surveillance of the surface in the tank farms.

3.1.5 Concluding Remarks

The preceding description of the double-shell tanks provides the details of their design and constuction. In the following section, the alternatives to the proposed action (preferred alternative), including the "no action" alternative, are described.

3.2 ALTERNATIVES

In this section, the following alternatives to the proposed action (preferred alternative) described earlier in Section 3.1 are discussed. The alternatives are:

1. The "no action" alternative implying that the 13 tanks need not have been constructed and that existing (pre-1976) storage tanks would be utilized as part of continued present action. This alternative is discussed and shown to be unacceptable.

2. Use of thicker and more chemically-resistant steel plates.

3. Use of impressed current cathodic protection system to guard the tanks against stress corrosion cracking.

4. Use of better waste retrieval equipment and enlarged tank openings to facilitiate waste removal from tanks at some future date.

5. The pros and cons of using cooling coils (water-cooling of tanks) as against the use of air cooling now provided in the design and construction of the 13 tanks at Hanford.

An overview of the results of the following discussions of the alternatives is provided in Table 3.1. The comparisons provided in the table are necessarily brief and details can be found by referring to the appropriate subsection in this chapter. The important aspect discernible in Table 3.1 is that there are no significant favorable effects that would result from the alternatives; thus the preferred alternative is adequate for the purpose of insuring safe interim storage of the wastes when coupled with specific operating procedures.

3.2.1 No Action Alternative

Discussion of this alternative, included here in conformity with CEQ regulations, is of theoretical interest since the proposed action (construction and utilization of double-shell tanks) is already under implementation, based on discussion of new double-shell tanks in ERDA-1538. A total of 153 tanks had been built as of 1975, as indicated in ERDA-1538 (page II.1-36). Of these, four were double-shell-type built since 1968. Three additional tanks were completed prior to 1978. All single-shell tanks could develop leaks and some did develop leaks (NAS, 1978, page 36); some of these leaks were suspected to be from nitrite stress-corrosion cracking. No double-shell tanks

TABLE 3.1. Comparison of Alternatives to Proposed Double-Shell Interim Waste Storage Tanks

Alternative	Potential Advantages	Potential Disadvantages	Potential Environmental Effects	Potential Effects on Double-Shell Tank Durability	Potential Effects on Waste Retrieval	Potential Effect on Long-Term Storage and Disposal
No Action (continued storage in pre-1975 tanks)	None	Leakage of tank liquids highly probable	Release of radionuclides to environment	Not applicable	Increased complexity and difficulty with continued storage	Leaked waste more difficult and costly to dispose
Proposed Action - Use new double-shell tanks (preferred alternative - Base Case)	Secure interim containment of existing wastes. Tanks immediately available for use. No additional cost.	Small risk of leakage between primary and secondary tanks; insignificant in comparison with single-shell tanks	Elimination of possible leakage from single-shell tanks; no significant adverse effects	Base Case	Will improve later retrievability of waste	No conflict with existing concepts and plans
Thicker and more chemically-resistant steel plates	Possible extension of design life; increased corrosion allowance; reduce risk of leakage; may permit storage of more aggressive wastes	Will require replacement of constructed tanks; increase complexity of fabrication; requires continued storage in single-shell tanks for 4 to 6 years	Possibly further reduce risk of radionuclide release	May increase	Would permit somewhat longer deferral of retrieval	No conflict with existing concepts and plans
Cathodic protection	May reduce risk of stress corrosion and uniform corrosion	May increase risk of accelerated corrosion	No significant positive impacts, probably more negative impacts	May increase or decrease	Uncertain; probably minor	None foreseen
Larger tank openings	Easier, but not necessary for later retrieval	Adverse effect on dome stability, costly retrofit	None	Possible increase in risk of dome failure	Increased flexibility of waste retrieval apparatus	No conflict with existing concepts and plans; may permit additional approaches
Improved waste retrieval equipment	Not applicable since improved retrieval equipment can be developed, if necessary, independent of the tanks and hence is not considered to be an alternative in the sense of the others.					
Cooling coils	Would extend tank capability to self-boiling wastes; decrease corrosion rate	Increase maintenance; interference with waste retrieval	Insignificant	May increase if temperature is lowered	Coils may interfere with waste retrieval	None foreseen

have developed leaks to date. The new double-shell tanks are designed and built to avoid tank wall cracking by: a) using an improved carbon steel for liners; b) reducing stress concentrations during construction, c) heat treating the finished inner tank at 590°C (1100°F) followed by controlled slow cooling to relieve stresses in and adjacent to the welded joints, and d) controlling the caustic/nitrate ratio in the high-level waste (NAS 1978).

The proposed action includes all of the above improvements, whereas the "no action" approach would imply continued storage of mobile (liquid) waste in older tanks, thereby allowing the risks of leakage of radioactive waste into the soil. Thus, the "no action" alternative would run counter to the goal of responsible waste management. The Department of Energy is committed to contain the radioactive wastes in adequately designed containers to the best possible extent until permanent disposal technology is developed and implemented. This goal requires rejection of the no action alternative.

The alternatives are discussed below under the following categories as applicable:

- their advantages and disadvantages
- reasonably foreseeable environmental effects
- effect on tank durability
- effect on ease of waste retrieval from tanks
- effect, if any, on choices of technology for long-term radioactive waste storage and its final disposal, and on the timing of such choices
- reason for rejecting the alternative, if rejected.

The Department of Energy has been aware of the importance of evaluating the issues raised in each of the alternatives and had considered the issues before and during tank construction.

3.2.2 Thicker and More Chemically-Resistant Steel Plates

The alternative of using thicker and/or more chemically-resistant plates to enhance resistance to corrosion and tank life is examined in this section. The thicker plate alternative has, in essence, already been adopted via the earlier change from single-shell tanks of 3/8-in. plate to double-shell construction, where the primary tanks use 1/2- to 1.0-in. plate for all wetted surfaces, and this is backed up with a secondary tank constructed of 3/8-in. wall and 1/2-in. knuckle plates, whose design and construction are equal or superior to the original single-shell tanks.

The alternative of more chemically-resistant plates has been adopted via the change to a normalized (heat-treated) steel and post-fabrication stress relieving of the primary tanks. These two measures, significantly increase the steel's resistance to stress-corrosion, believed to be a primary failure mode for waste storage tanks. (Another alternative to minimize the possibility of stress corrosion cracking, cathodic protection, is discussed in the next section.)

As shown later in this section the only practical means to incorporate this alternative would be to build a new set of tanks since the construction of present tanks is almost complete and in situ modifications are impractical. Available corrosion data and structural analyses indicate that the steel plates used in the existing tanks will provide the fifty-year design life. If a tank leaks, however, the secondary tank and the spare tanks are available for restorage of the waste to prevent waste leakage to the soil. Therefore, there is no justification to abandon use of these tanks.

In theory, the use of thicker and more corrosion-resistant steel plate would have no effect upon either the ease of waste retrieval or on the choices of technology for or timing of long-term waste storage and final disposal. It could increase tank durability and, hence, reduce the potential for adverse environmental effects in the event of containment failures. The use of substantially thicker plate or more chemically resistant plate would increase the complexity and difficulty in fabrication and also increase costs. If future tanks are constructed, the use of thicker and more chemically resistant plate could be considered based on the data and needs of the situation then.

The technical discussions in the following paragraphs provide support to the above conclusion.

3.2.2.1 Comparison with Previous Single- and Double-Shell Tanks

Single-shell tanks were constructed of ASTM A283, Grade B carbon steel, whose minimum room temperature yield strength is 24,000 psi (1,687 kg/cm^2). This is an intermediate strength carbon steel intended for welded pressure vessels.

Previous double-shell tanks were constructed of ASTM A-516 carbon steel, with yield strength of 35,000 psi (2460 kg/cm^2) at room temperature. The latest double-shell tanks under discussion (241-AN and 241-AW) were constructed of ASTM A-537 Grade I carbon steel plates. This is a heat-treated carbon steel of fine grain size for-fusion welded pressure vessels. To qualify as Grade I, it must be a normalized steel. Normalizing is a heat treatment (analogous to annealing) that refines grain size and improves the toughness of the steel plate. Thus, each subsequent design of the tanks has consistently used higher strength carbon steels. Additionally, with double-wall construction, the inner primary tank is stress-relieved after fabrication (see Section 3.1.1.5), an important factor affecting resistance to stress corrosion, as discussed later.

These improvements permit two changes in construction and operation:

- allows bumps in the tank floor due to fabrication and stress-relief distortions while keeping stresses below acceptable limits
- allows higher operating temperature for the same wall thicknesses because of higher steel strengths at operating temperature.

Sidewall thicknesses for the single-shell tanks were generally 3/8-in. (0.95 cm), although some used 1/4-in. (0.63 cm) plate. Double-shell tank designs utilize 3/8-in. to 1-in. (2.5 cm) steel plates. Use of 3/8-in. plate is limited to the primary tank dome and secondary liner; 1/2-in. or thicker plate is used in all regions contacting the waste. Thus, historically, double-shell tanks have used thicker steel plates than the single-shell tanks. A schematic of the tank wall thicknesses is shown in Figure 3.13.

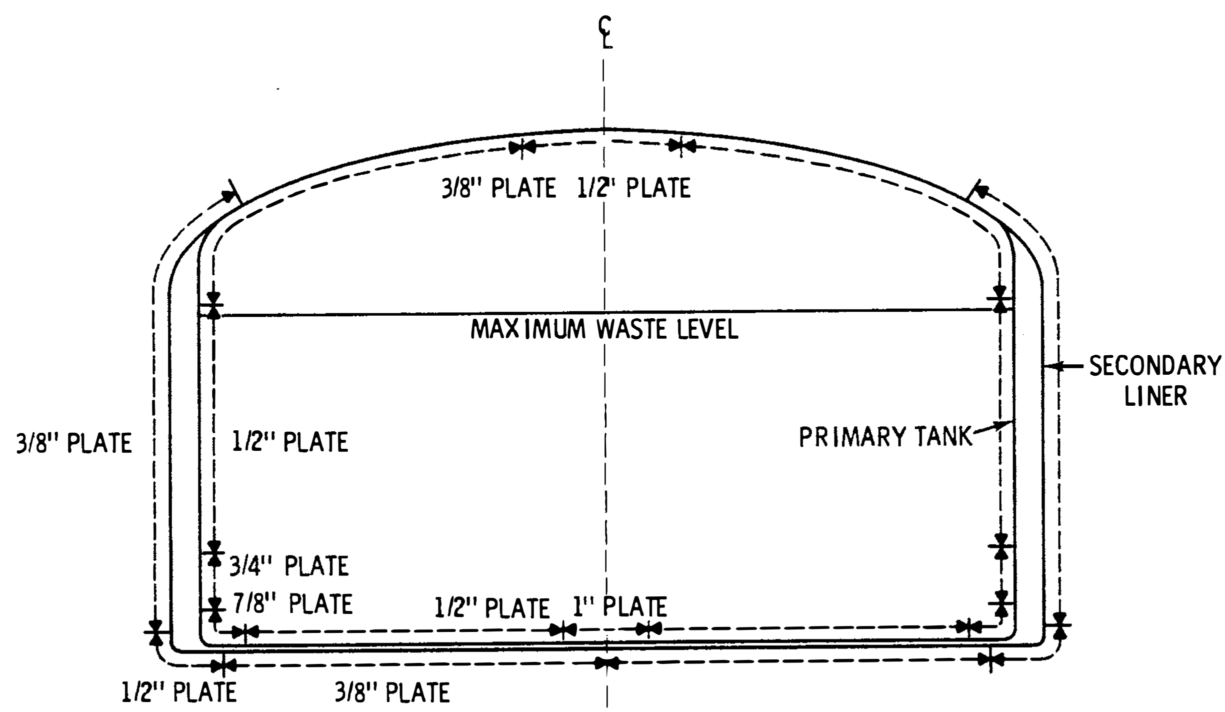


FIGURE 3.13. Primary Tank and Secondary Liner Wall Thicknesses

3.2.2.2 Potential Advantages of Using Thicker and More Chemically-Resistant Plate

The construction of the 13 tanks is almost completed. However a theoretical discussion of the advantages of using thicker and more chemically resistant plates is provided in the following paragraphs. In general, the advantages are: 1) thicker plates reduce the stresses in the structure by providing additional load carrying steel, 2) thicker plates provide more allowance for corrosion, 3) more chemically resistant steel plates better withstand the corrosive effects of waste solutions. To assess whether these advantages, which can be provided only by constructing new tanks are needed, the structural integrity and corrosion behavior of the present tanks are reviewed below.

Two separate structural analyses have been completed on the subject tanks. Both studies (Basic Technology, Inc. 1977; URS/John A. Blume 1976; URS/John A. Blume, 1978) conclude that tank stresses are less than allowed by ASME Code, Section VIII, Division 2 limits. Thus, no additional steel thickness is required for the structural integrity of the tanks, provided corrosion damage does not exceed the allowances included in these analyses. In this case, additional steel serves only to increase the already existing margin of safety between the tank stresses and allowable stress limits. The design stress report for the tanks by Basic Technology, Inc. (1977) assumed a uniform corrosion allowance of 50 mils (0.05-in.), based on a 1-mil/yr corrosion rate and a design life of 50 years.

When discussing the appropriate corrosion allowance for the tanks, three types of corrosion need to be considered: pitting corrosion, stress corrosion cracking, and uniform corrosion. The first two types of corrosion are local types of corrosion. The third type of corrosion affects broad sections of tank in contact with the waste. The main concern in the first two types of corrosion is tank leakage, if corrosion breaches the wall. The third type of corrosion affects the overall stress-carrying capability of the tank by reducing the thickness of steel capable of sustaining loads.

Available pertinent corrosion data are summarized in Appendix B. Data exist for carbon steel corrosion in several types of Hanford waste. The tests are on other similar carbon steels, but are considered indicative of A-537 carbon steel. Of the projected types of waste to be placed in the tanks, data on simulated wastes whose compositions are similar to double-shell slurry are presently available; no data are available for concentrated complexant or cladding waste sludge compositions. These other waste types will be stored in only four of the thirteen tanks. The present assessment of tank durability is based solely on storing waste compositions similar to double-shell slurry or slurry feed. For wastes of different chemical compositions, additional corrosion testing is necessary to augment existing data. At that time, allowed composition ranges will be adjusted for the other waste forms to keep expected corrosion rates compatible with the 50-yr of the tank system.

The available data support the assumed 1-mil/yr uniform corrosion allowance for double-shell slurry compositions within the specified range. On the other hand, the data are insufficient to conclusively rule out the possibility that one or more tanks may have uniform corrosion in excess of 1-mil/yr. Based on the available data, the 1-mil/yr assumed corrosion rate is an acceptable reasonable engineering judgment. In the event that a primary tank does leak, the tanks are designed to contain waste leaking from the primary tank in a secondary liner for a limited time until the waste can be removed to a spare tank. If the double-shell slurry composition departs significantly from that indicated in Appendices F and G, a severe penalty in increased uniform corrosion rates would result.

As regards to pitting corrosion, the only available data for carbon steel in Hanford wastes are for much more severely caustic waste forms and are not directly applicable to double-shell slurry. Also, no data of sufficient duration to predict carbon steel pitting rates in double-shell slurry are available. Based on the minimum wetted wall thickness of 1/2-in., a substantial operating life is still predicted, even under the out-of-specification severe caustic conditions. Higher lives yet would be predicted for the 3/4-in. and 7/8-in. steel plates, which are used where the hydrostatic pressures are the greatest. It is expected that pitting in double-shell slurry will occur at a substantially lower rate than the rates assumed here and therefore a fifty year design life can be predicted for the tank system.

The possibility of a third type of corrosion, stress corrosion cracking, must be reviewed. Stress corrosion cracking, once it occurs, may progress rapidly. It is unlikely that moderate increases in plate thickness will significantly extend the tank life if stress corrosion cracking occurs.

Besides an aggressive environment, the other necessary condition for stress corrosion cracking is the presence of tensile stresses in the metal. Tensile stresses from the working load are limited by design to 90% of yield stress, which is more stringent than ASME limits. The concrete pours of the tank dome are performed in stages while the primary steel tank is filled with water for support to minimize permanent prestress conditions associated with construction loads. Basic Technology, Inc. (1977) indicates maximum primary tank tensile prestresses (located in the dome) on the order of 2,000 psi (141 kg/cm^2), which is acceptably low for construction loads.

Perhaps most significant are the residual stresses, those short range stresses due to fabrication procedures such as welding and deformation to make parts fit together. Welding of the plates involves heating the metal to its melting point, and with subsequent cooling and solidification, contraction of the metal occurs in a localized, relatively small region. This thermal contraction is non-uniform and can lead to high localized stresses that can exceed the yield stress of the material. These residual stresses can be relieved by uniformly heating a structure to a sufficiently high temperature (approximately 1100°F in mild steels) to allow the metal to relax and relieve the residual stresses. This post-fabrication stress relief is an important defense against stress corrosion cracking of double-shell waste tanks.

The use of higher yield stress carbon steel does not appear by itself to reduce the susceptibility to stress corrosion cracking for a given level of net section stresses in the tank. Payer (1977a) provides experimental evidence that the threshhold overall stresses, required for stress corrosion cracking to occur, are similar for both ASTM A-516 (a minimum room temperature yield stress of 35,000 psi) and ASTM A-537 (a minimum room temperature yield stress of 50,000 psi).

In summary, the main potential advantage of using even thicker steel plate than that used in the thirteen new tanks (which can only be practically done by building new tanks) would be an increase in allowable corrosion damage. This is not a significant advantage for tanks storing double-shell slurry, since the present tank designs have adequate corrosion allowance as discussed previously. Use of more chemically resistant steel plate would reduce corrosion and would increase tank life. This also can be practically done only by building new tanks and is not a significant advantage for those tanks containing double-shell slurry because the existing designs expected life is adequate. This would be more of an advantage for tanks containing more corrosive waste than double-shell slurry within the specified composition range.

3.2.2.3 Potential Disadvantages of Using Thicker and More Chemically-Resistant Steel Plate

The only practical means of providing thicker steel plate at this time is to construct new tanks. If additional steel were added by some welding or cladding process, it would negate the primary tank stress relief. The tank cannot be stress relieved again because the concrete dome is in place and would be damaged severely since it cannot be insulated from the primary tank. Similarly, use of more chemically-resistant steel can only be accomplished by constructing new tanks. Cladding the inside of the primary tank with new chemically-resistant steel would again negate the primary tank stress relief.

Of all the alternatives discussed in this EIS, this alternative would have the greatest impact on commitment of resources. The tanks presently under construction are nearly complete and could not be easily retrofitted with thicker or more chemically resistant steel plates. An additional commitment of resources in excess of those already committed would be required since the entire 13 tanks would probably have to be reconstructed. This would involve removing the existing tanks and complete reconstruction. None of these additional resources would be projected to be recoverable. If the possibility exists that the existing tanks could be used for some other application, additional land would be required for the reconstructed tanks.

Were thicker or more chemically-resistant plate to be used in new tanks there are several potential disadvantages. Possible disadvantages of using thicker steel plate include:

a) Use of thicker plate may increase local residual weld stresses in the primary tank although these stresses will be relieved in the post-weld heat treatment. Substantially thicker plate will increase welding difficulty by necessitating tank preheating.

b) The need to increase the soak time in the stress relief temperature (1100°F) to account for the thicker plate may have an adverse effect on the insulating concrete below the primary tank.

c) Concrete dome stresses may increase, caused by the mismatch between the primary tank thermal growth and the concrete dome thermal growth. The thicker, hence stiffer, primary tank will cause increased loads on the concrete haunch.

Possible disadvantages to the use of more chemically-resistant steels:

a) The more chemically-resistant steel may have a lower strength. This would require additional wall thickness to keep stress levels acceptable. For example, the room temperature strength of 304L stainless steel, ASTM A-167 (a likely candidate for use) is 28,000 psi, compared to 50,000 psi for ASTM A-537 carbon steel. This will result in substantially greater wall thicknesses. Other austenitic (300 series) stainless steels have room temperature strengths varying from 32,000 psi to 45,000 psi.

b) Little, if anything, is known about the behavior of other steels in Hanford waste. Austenitic stainless steels are themselves subject to caustic corrosion cracking and chloride stress corrosion cracking at temperatures higher than the expected tank service temperatures. Data for stainless steel corrosion rates in the various tank waste forms are essentially nonexistent. One datum point, Maness (1975), indicates substantial 304L corrosion rates in boiling Hanford Defense Waste Liquor (HDWL) (1 to 12 mils/yr) for 304L stainless steel, but this datum is too limited to be conclusive.

c) Use of stainless steel would result in more difficult fabrication welding and stress relief.

d) More corrosion resistant steels (e.g., stainless steel) would increase tank costs.

3.2.2.4 Reasonable Foreseeable Environmental Effects

If the use of the thicker plate alternative be selected, the major environmental effects would be associated with the delay in using the existing new tanks and continued storage of wastes in single-shell tanks.

Use of the existing carbon steel tank design should provide adequate waste containment for double-shell slurry within the specified composition ranges. In the event, however, that corrosion rates exceed the rates predicted by existing experimental data, several consequences can be identified.

As the uniform corrosion loss exceeds the design corrosion allowance, tank stresses will eventually exceed the threshold stress, thereby initiating stress corrosion cracking followed by leakage of waste from the primary tank. The secondary liner is designed to contain this waste for a limited time until the tank contents can be removed to a spare tank. Excessive pitting corrosion would also result in leakage from the primary tank to the secondary liner.

If for some other reason the leaking tank is not emptied, the waste could ultimately breach the secondary liner. This may possibly occur fairly rapidly, since the secondary liner is not stress-relieved and is similar in design to the older single-shell tanks. On the other hand, the present secondary liner design has eliminated the 90-degree weld (used in some designs) where the side-wall joins the bottom, and improved welding and weld inspection procedures (including radiographic inspection) have been adopted since the single-shell tanks were constructed. Thus, the secondary liners should be much more resistant than the single-shell tanks which experienced early failure.

In any event, if the waste is not removed, the secondary liner will in time fail. In this event, the waste would escape to the surrounding soil through a somewhat tortuous path. The impact of this escape is evaluated in Chapter 5. The waste must leak through defects in the primary tank, the secondary liner, and either the sliding foot of the concrete containment or through cracks in the concrete.

3.2.2.5 Effect on Tank Durability

The main advantage of this alternatives is a potential increase in tank durability (See 3.2.2.2).

3.2.2.6 Effect on Ease of Waste Retrieval From the Tanks

None are foreseen.

3.2.2.7 Effects, if any, on Choices of Technology for Long-Term Radioactive Waste Storage and Its Final Disposal and on the Timing for Such Choices.

No significant effects are foreseen within the 50-yr design life of the tank system. Long-term disposal options are being considered and additional double-shell tanks can be built if necessary.

3.2.2.8 Reason for Rejecting the Alternative

The existing tanks cannot be practically modified. Incorporation of these alternatives would require construction of new tanks. For double-shell slurry tanks, this is unnecessary. For other waste types to be stored, corrosion data will be obtained. Based on the results of this corrosion data, the composition ranges of other waste types to be stored will be controlled to maintain expected uniform and pitting corrosion rates compatible with the 50-yr tank system life.

3.2.3 Impressed Current Cathodic Protection System to Guard Against Stress-Corrosion Cracking

The alternative of employing cathodic protection to prevent corrosion of the primary steel tank is examined in this section. A technical discussion of the cathodic protection mechanism is presented that describes the results of the technical and engineering feasibility studies on cathodic protection of radioactive liquid high-level waste tanks. This is followed by discussion of the advantages and disadvantages of cathodic protection, the environmental effects, effects on tank durability, on ease of waste retrieval, and on technology choices for long-term radioactive waste storage and final disposal. The conclusions of this section are:

1) Cathodic protection is unnecessary because: a) the required corrosion protection will be provided by careful implementation of adequate operating procedures including periodic adjustment of the composition of the waste solutions, if required, with routine monitoring of the tank surface potential, and b) the tanks are adequately stress-relieved, as discussed elsewhere.

2) Unless extreme care is exercised, cathodic protection could produce a tank surface potential conducive to stress corrosion cracking. Also the potential for hydrogen embrittlement and explosion are significantly increased.

The technical basis for these conclusions are discussed in the following paragraphs. Additional technical data and supporting information are presented in Appendix B.

3.2.3.1 Technical Discussion

Corrosion of a metal can be defined as loss of metal by a chemical reaction in which the metal is converted to an oxidized state. This reaction is accompanied by loss of electrons from the metal to the surroundings in the form of an electric current. Suppression of this current, by impressing an external electric potential (such as from a battery or rectifier), prevents the corrosion. This process of suppression is called cathodic protection. Methods to implement cathodic protection generally involve the use of active metal anodes (such as magnesium or aluminum) that supply electrons by corroding preferentially to suppress the corrosion of the desirable structure. However, a combination of chemically inert anodes and power rectifiers can also be used. In the case of the tanks, the latter method would be employed and the inert anodes would be immersed in the waste solution in the tank and the current impressed between them and the tank as shown in Figure 3.14.

Cathodic protection is used to protect metal surfaces that are exposed to moist or wet corrosive conditions. Two factors control the effectiveness of cathodic protection: the surface potential of the metal (the amount of force needed to drive electrons from the metal as it is being oxidized or corroded, measured as V[olts] (SCE)[(a)] and the current density (the amount of electrical current in milliamperes per unit area resulting from the surface potential on the metal surface). The relationship between these two factors is primarily influenced by the composition of the metal, but it is also influenced by the

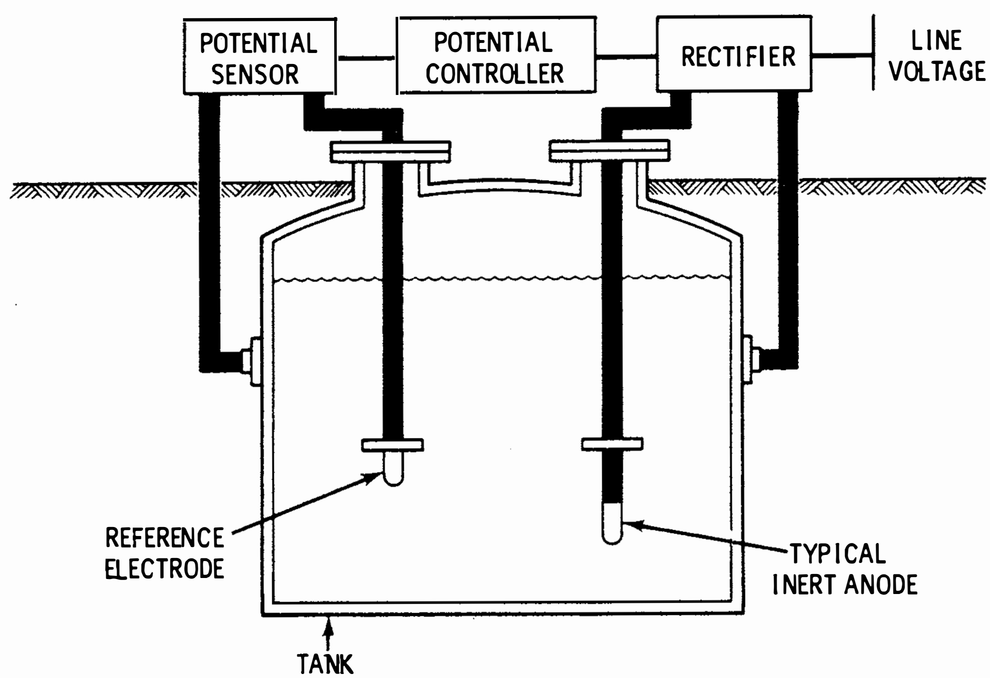


FIGURE 3.14. Schematic of a Conceptual Cathodic Protection System

(a) Saturated calomel electrode, a standard electrode used in electrochemical work.

oxidized corrosion surface layer (rust) on the metal, crevices and pits in the metal surface, stress on the metal, and the temperature of the metal and the surrounding solution. The current flow required for successful cathodic protection alters the chemical compounds where the metal and solution meet, but at the low current densities usually required for satisfactory corrosion control, this effect is insignificant, unless the metal is very sensitive to the altered environment.

Two studies have been conducted to determine the feasibility of cathodic protection against general corrosion (not pitting corrosion) for the Hanford waste tanks. The first study, by Norton Corrosion Limited and Pacific Northwest Laboratory (Moore 1977) analyzed the feasibility of applying cathodic protection to the interior of the tanks. Preliminary results from this study indicated that cathodic protection was feasible; however, this study was terminated when the results from a second study (Payer 1977b) showed that cathodic protection could accelerate stress corrosion cracking if it were not carefully controlled and maintained. The first study also showed that the potential of the metal shifted with time to reduce its tendency for stress corrosion cracking.

The second study, conducted by Battelle-Columbus Laboratories, was to determine the effects of solution composition on stress corrosion cracking (Payer 1977b). The study showed that the simulated double-shell slurry waste solutions generally led to the formation of an oxidized metal layer (passivation) which inhibited further corrosion; thus, such solutions would not normally promote stress corrosion cracking if cathodic protection were not used.

The surface potential of the metal tanks is affected by the composition of the double-shell slurry solution. Payer (1975, 1977b) concluded that solutions with compositions similar to double-shell slurry would not promote stress corrosion cracking of carbon steel if the surface potential of the metal remained slightly less negative than -0.7 V (SCE). Maness (cited by Moore 1977) found that steel samples placed in simulated double-shell slurry arrived at surface potentials of about -0.55 V (SCE), after the steel samples were corroded. Thus, the surface potential value places the steel comfortably above the stress corrosion cracking range. Payer (1977b) also found that alkaline nitrate, nitrite, and aluminate solutions spontaneously passivate steel to a surface potential that does not promote stress corrosion.

Minor variations in solution composition can produce severe corrosion. For example, Savannah River Laboratories (1973) found that the presence of about 0.01 M mercuric nitrate would cause nitrate stress cracking in alkaline nitrate, nitrite, or aluminate solutions somewhat more dilute than Hanford waste. Similarly, Payer (1975) found that addition of 30 ppm of chloride to simulated double-shell slurry solution produced severe increases in uniform corrosion rates, while 3000 ppm addtion produced only mild corrosion rate increases. Donovan (1977) found that extreme dilution (10^4) of the waste solution produced very rapid pitting of mild steel, even at low temperature.

Maness (1974) found that concentrating Hanford wastes to 15% water produced substantial uniform and pitting corrosion. These data stress the importance of careful control of solution compositions.

The proposed complexant waste concentrate is of substantially lower concentrations in hydroxide, nitrite, and aluminate than the solutions examined by Payer. Comparison of the low hydroxide and nitrite compositions for the complexant concentrate solution (Appendix F) with the data in Figure 3.15 shows this solution could fall in the shaded area of crack growth and be potentially capable of causing nitrate stress cracking if the metal surface potential, stress, and other conditions are favorable. Data for cladding waste sludge were not found.

Application of the corrosion data obtained with double-shell slurry and Hanford liquor to the corrosion of the waste tanks obviously requires that the composition of the wastes remain within the tested chemical compositions and temperatures.

Further supporting data for the above discussion are presented in Appendix B.

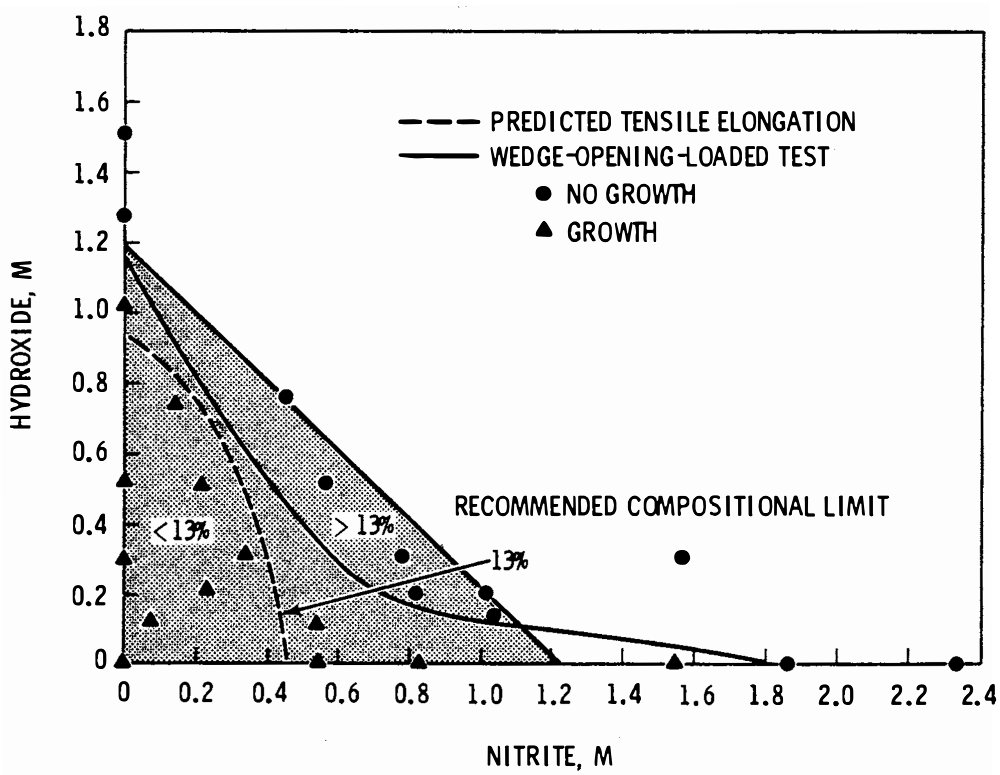


FIGURE 3.15. Comparison of Electrochemical Tensile Test with Wedge-Opening-Loaded Specimens in 5 M $NaNO_3$ at 97° C

SOURCE: Ondrejcin (1978)

Engineering feasibility studies were conducted by PNL and Norton Corrosion Limited (Moore 1977) to determine if it would be possible to install anodes and protect the tanks from stress corrosion cracking cathodically. These studies showed the Hanford Defense Waste Liquor (HDWL) solutions and wet sludges had sufficient electrical conductivity to be useful for cathodic protection, but that the solid phase was about 1.7 times more resistant than the liquid phase. This difference in electrical conductivity can be overcome by overprotecting part of the tank to insure adequate protection in other areas. Corrosion tests showed that cathodic protection at 10 $\mu A/cm^2$ eliminated uniform and pitting corrosion of mild steel samples in the liquid and reduced corrosion to 0.8 mil/yr in the wet solid wastes, compared to an unprotected 4 mil/yr (Maness 1974). Lini (1975) reported that 10 $\mu A/cm^2$ cathodic protection prevented stress corrosion cracking in a test mild steel tank filled with simulated alkaline purex waste without nitrite ion for two years while 1 $\mu A/cm^2$ did not protect it in a comparison experiment.

3.2.3.2 Advantages of Cathodic Protection

Properly designed and adjusted cathodic protection systems will nearly eliminate uniform and pitting corrosion. Such systems would prevent stress corrosion cracking and would add an ability to cope with undesirable tank contents from a corrosive point of view.

3.2.3.3 Disadvantages of Cathodic Protection

Cathodic protection must be designed to insure that the potential of the entire tank with respect to the waste solution is clearly more negative than -1.05 V (SCE); this is because the resistivities of material in the tank (i.e., waste solution, solids, corrosion product layers, debris, etc.) tend to keep the potential of the tank at more positive values. This can require very large current (30 to 300 $\mu A/cm^2$), i.e., 200 to 2000 amperes. These values can be calculated using Figure B.1 in Appendix B. At these currents, the production of new chemical species (i.e., hydrogen, oxygen, ammonia, nitrite, etc.) will become substantial and their removal from the tank by ventilation will be required to prevent reactive or explosive atmospheres. Many of these products are gaseous and may swell the volume of waste gel reducing tank capacity. If any of the tank surface potential falls below the -1.05 V (SCE), that area will be much more suceptible to SCC than it would have been without cathodic "protection." In addition to chemical production, the high currents will consume electricity and produce heat of the same order of magnitude as the radioactive waste. Cathodic protection will not protect the vapor space. If any regions in the steel are hard enough to be damaged by hydrogen absorption, the cathodic protection system will supply ample nascent hydrogen to crack them. Current requirements should reduce as surface films build up.

3.2.3.4 Reasonably Forseeable Environmental Effects

The primary environmental effect would be the consumption of electicity and the production of reactive gases with their requirement for higher ventilation rates. The current required for cathodic protection will produce hydrogen, oxygen and ammonia as volatile gases occupying the tank vapor space. If the gas mixture contains more than 4% hydrogen or more than 16% ammonia in air, it will be explosive. Thus increased ventilation of the tank vapor space would be necessary. These ventilation gases would have insignificant environmental effects.

3.2.3.5 Effect on Tank Durability

If no areas are subject to damage by hydrogen, the cathodic protection system could extend the tank life.

3.2.3.6 Effect on Ease of Waste Retrieval

The effect of cathodic protection on waste retrieval is to alter the composition of the waste by electrically converting water in the waste to H_2 and O_2, nitrate to nitrite, nitrite to nitrogen or ammonia and converting more sodium hydroxide to sodium carbonate because the increased ventilation will bring more carbon dioxide to the waste surface. In the case of double-shell slurry, it may produce a lower density form and dry the material out by consuming water. Easily platable cations such as ruthenium, copper, and nickel will be reduced to metal on the tank wall and may adhere thus making their retrieval difficult.

3.2.3.7 Effect of Choices on Technology for Long-Term Radioactive Waste Storage and its Final Disposal and on the Timing for Such Choices

There are no reasonably foreseeable effects.

3.2.3.8 Reasons for Eliminating Cathodic Protection

Cathodic protection for guarding against stress corrosion cracking is not recommended because:

1. It is unnecessary; waste solutions will be adjusted in composition and the tank potential will be monitored to assure low corrosion rates.

2. It is dangerous because it could produce a tank surface potential conducive to stress corrosion cracking and may induce some hydrogen cracking.

3. It can produce reactive gases which require removal and may complicate waste storage by reducing its density and changing its physical characteristics.

4. It will consume electrical energy which can be conserved by careful adoption of other equally effective methods which are not as energy-intensive.

3.2.4 Better Waste Retrieval Equipment and Enlarged Tank Openings

Waste retrieval capability must be considered under both normal and abnormal circumstances for the primary tank and secondary tank. Normal circumstances include interim removal for further waste processing or final retrieval at the end of the useful life of the tank. Abnormal circumstances involve nonscheduled retrieval such as leaks or unanticipated changes in the tank contents. The primary difference between the two sets of circumstances is the element of time. Scheduled retrieval will occur over a period of months or even years, while unscheduled retrieval may have to be completed as quickly as possible. Scheduled retrieval may occur only in the primary tank. Unscheduled retrieval may be required in both the primary and secondary tanks.

Improved waste retrieval equipment and enlarged tank openings are discussed in separate subsections below for clarity. Cases where improved waste retrieval equipment is dependent upon enlarged tank openings are included in the discussion of improved waste retrieval equipment.

Based on the technical considerations presented in Appendix C and in the following paragraphs, it is concluded that:

a) the tank openings now provided (42-in.) are adequate for waste retrieval.

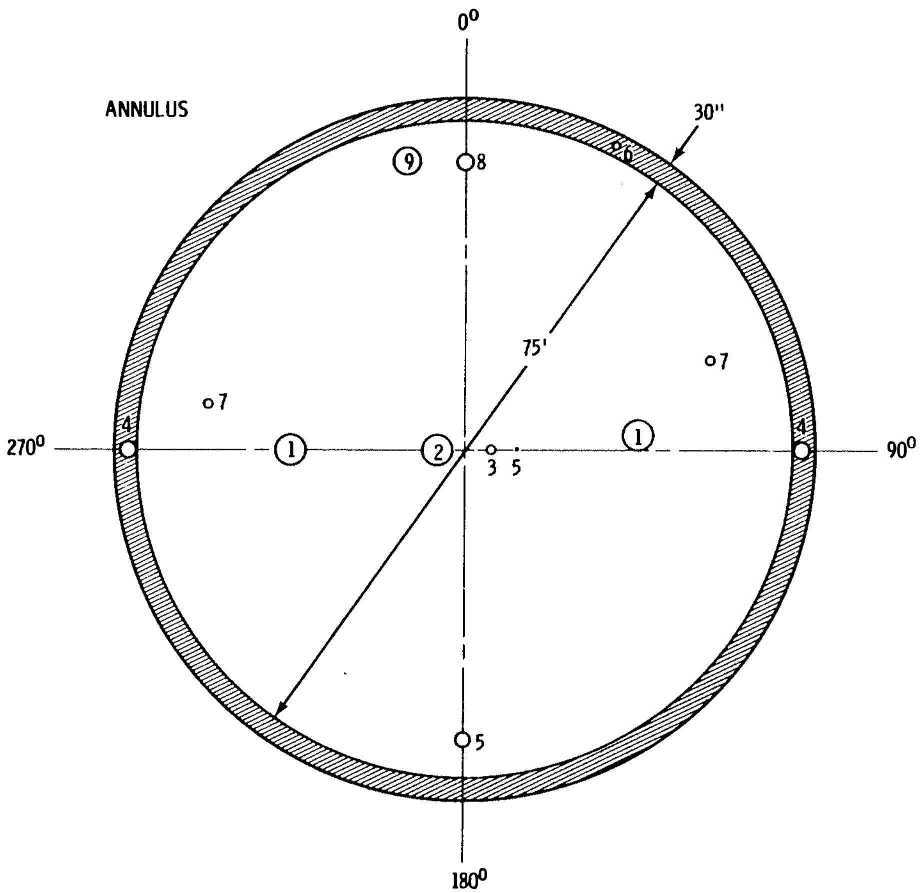
b) improved retrieval systems are not needed since adequately effective and reliable equipment systems are now available for that purpose. No environmental effects are associated with this alternative.

3.2.4.1 Enlarged Tank Openings to Facilitiate Waste Retrieval

The penetrations in all tanks are circular in cross section. The inside diameter of the largest dome penetrations on the double-shell tanks at Hanford is 42 inches. Three 42-in. diameter penetrations exist in each tank. The number of penetrations in 12 of the 13 tanks is 59. The remaining tank (AN-107) has an additional 21 dome penetrations for airlift circulators if needed. The penetrations (12 in. or larger) that are either dedicated to waste retrieval or other future use are shown in Figure 3.16 for both the primary tank and the annulus.

Factors associated with tank openings that can directly influence the rate or effectiveness of waste retrieval include:

- size of opening
- configuration
- location with respect to both tank geometry and to other openings
- structural strength of risers above the tank dome
- total number.



POSITION	DIAMETER (in)	QUANTITY	FUNCTION	ANGLE FROM 0°	RADIUS
1	42"	2	CONSTRUCTION OPENING	85° & 270°	20'-0"
2	42"	1	SUPERNATANT AND SLURRY DISTRIBUTOR	270°	3'-0"
3	12"	1	SUPERNATANT PUMP, PUMP PIT DRAIN OR SPARE	90°	3'-0"
4	24"	2	ANNULUS ACCESS	90° & 270°	38'-6 3/8"
5	4"	1	SUPERNATANT RETURN	90°	6'-0"
6	12"	1	ANNULUS PUMP OUT & ANNULUS PUMP PIT DRAIN	26°	38'-9"
7	12"	2	SUPERNATANT PUMP & FEED PUMP PIT DRAIN & SPARE	70° & 280°	30'-0"
8	20"	2	CLEANOUT BOX & VALVE PIT DRAIN	0° & 180°	33'-0"
9	36"	1	BLDG DRAIN	35° & 348°	33'-8"

FIGURE 3.16. Dome Penetrations Dedicated to or Available For Waste Retrieval Operation

The relative importance of these factors is highly dependent upon the method of waste retrieval. Direct pumping systems are virtually independent of all of the factors above when the waste is to be retrieved from a flat-bottomed tank. Waste forms with sufficiently low viscosity and solids content can be directly pumped. These liquids will flow to the pump as long as the intake remains submerged. A single penetration less than 12-in. in diameter located in the tank dome is generally adequate for installation of a pump with ample capacity for retrieval under both normal and emergency circumstances.

Slurrying methods for retrieval are somewhat more sensitive to the above factors. Location with respect to both the tank geometry and with respect to other openings can be important. Location is important because the sluicing process does not necessarily convey all the products to be retrieved from the tank bottom to a single location. The diameter of the opening is generally less important than the location. The diameters of presently planned penetrations are adequate for all planned and projected slurrying equipment.

Potential Advantages and Disadvantages

The potential advantages of initially providing enlarged tank openings with respect to waste retrieval include:

- more flexibility in choice of retrieval equipment and systems (particularly mechanical retrieval)
- facility to install relatively large in-tank (presently undefined) processing or retrieval systems
- facility to install equipment with increased capacity.

Potential disadvantages include:

- Adverse effect on dome stability
- Higher cost
- Optimum size, configuration, and location not presently known.

Reasonably Foreseeable Environmental Effects

No significant environmental effects, either positive or negative, can be foreseen if the size of the present openings are enlarged by about 50%.

Effect on Tank Durability

Enlargement of the openings may reduce the structural stability of the tank dome and possibly the haunch area if the openings are relocated and significantly offset from the center of the dome.

Effect of Ease of Waste Retrieval from Tanks

Present waste retrieval systems involving direct pumping and slurrying have been used in the past at Hanford. These systems and future improvements can be accommodated within the size range of presently planned tank openings. If characteristics of the waste change in the future to the point that larger or more numerous pumps are required or mechanical retrieval systems become necessary, changes in the size or relocation of tank openings can be done at that time. Existing openings can be enlarged or new openings added to the dome at any time in the future as the need arises. Such need cannot be now foreseen.

Penetrations into the primary or secondary tank in locations other than the dome, such as near or on the bottom of the primary tank, might facilitate waste retrieval. However, the very significantly increased potential for leakage and environmental release inherent with any penetration below the liquid line in the tank precludes further consideration of this alternative.

Effect, if any, on Choices of Technology for Long-Term Radioactive Waste Storage and Its Final Disposal and on the Timing of Such Choices

No significant effect is foreseen because the openings could be enlarged in the future in time to accommodate new technologies.

Reason for Rejecting Alternative

Enlarged tank openings are not recommended at the present time because the characteristics of all the radioactive waste products projected to be stored in the double-shell tanks are such that they can be adequately retrieved through presently planned openings for all scheduled and nonscheduled events. Initially enlarging the openings would constitute "putting the cart before the horse" because the design of improved waste retrieval systems should dictate parameters associated with the size of openings rather than the reverse.

3.2.4.2 Improved Waste Retrieval Equipment

Alternative methods for retrieval of waste materials fall within three categories: 1) hydraulic, 2) pneumatic, and 3) mechanical systems. Hydraulic systems are presently employed at Hanford and will be used for any future retrieval.

Hydraulic systems include both direct pumping and slurrying (entrainment in a liquid suspension). The slurry is conveyed in a pipe. Hydraulic retrieval systems are relatively inexpensive and flexible and have been used exclusively for waste retrieval from the radioactive waste storage tanks at Hanford and Savannah River. Hydraulic systems are capable of retrieving all of the radioactive waste forms that are projected for storage in the double-shell tanks under consideration, either in a direct pumping mode or by slurrying. The only types of materials that would not be suited to direct pumping or slurry formation are nonsoluble solids or semi-solids that could not be effectively entrained as sufficiently small particles in a liquid. The maximum size for suspension is approximately 1/4-in. equivalent diameter. Sand and gravel mixtures can readily be slurried. Slurrying becomes necessary when the waste products are highly viscous or contain suspended solids in excess of a few percent.

Equipment to remove liquids, slurries, and sludges from underground tanks already exists at Hanford and has been used extensively. In the event that an improved retrieval system was not yet available and the decision was made not to wait for its availability but to empty a primary tank as quickly as possible, the equipment and know-how to do it are available.

For the case where the tank contains only pumpable liquid, multi-stage deep-well turbines have already been designed for use in the double-shell tanks. Three pumps are available for insertion in the main, annulus, and test well pump pits. The three pumps have capacities of 160 gpm at 150.9' TDH, 100 gpm at 95.7' TDH, and 10 gpm at 60.1' TDH, respectively. The main pump would thus be capable, once installed, of emptying a one million gallon primary tank within approximately five days at continuous operation.

For the case where the tank contains double-shell slurry, two courses of action are available. Either the double-shell slurry can be handled as insoluble sludge which will be discussed subsequently, or it can go through a dissolution process. In this latter instance, the same multi-stage, deep-well turbine pump as described above for liquids can be employed. Since double-shell slurry is the product of a 25% volume reduction by evaporation of water from a liquid state, and is readily soluble, adding back this lost water will return it to a liquid state. This can be accomplished by the controlled addition of hot water at the turbine pump inlet. This hot water discharge at the pump inlet also serves to sink the turbine pump into the double-shell slurry during installation. Since the total waste volume is being increased in this instance, the pumped liquid waste must first be put through an evaporator to return it to double-shell slurry before placing it in a spare tank also of one million gallon capacity. An evaporator can discharge double-shell slurry at a rate of 75 gpm. This would require an evaporator feed rate of 100 gpm which is within the capability of the turbine pump. At 75 gpm a one million gallon tank of double-shell slurry can be emptied within approximately ten days at continuous operation.

For the case where the double-shell tanks contain insoluble sludge or double-shell slurry is to be moved with minimal dissolution, a heavy-duty centrifugal slurry pump is available which has been used at Hanford in removing sludge from single-shell tanks. One of these pumps is shown in Figure 3.17. The pumps are Hazleton pumps built by Barrett Jaentjens of Hazleton, Pennsylvania and generally have given years of service under extreme operating conditions. These single-stage pumps, weighing nearly six tons, are capable of moving 350 to 400 gpm of heavy slurry. The intakes of the slurry

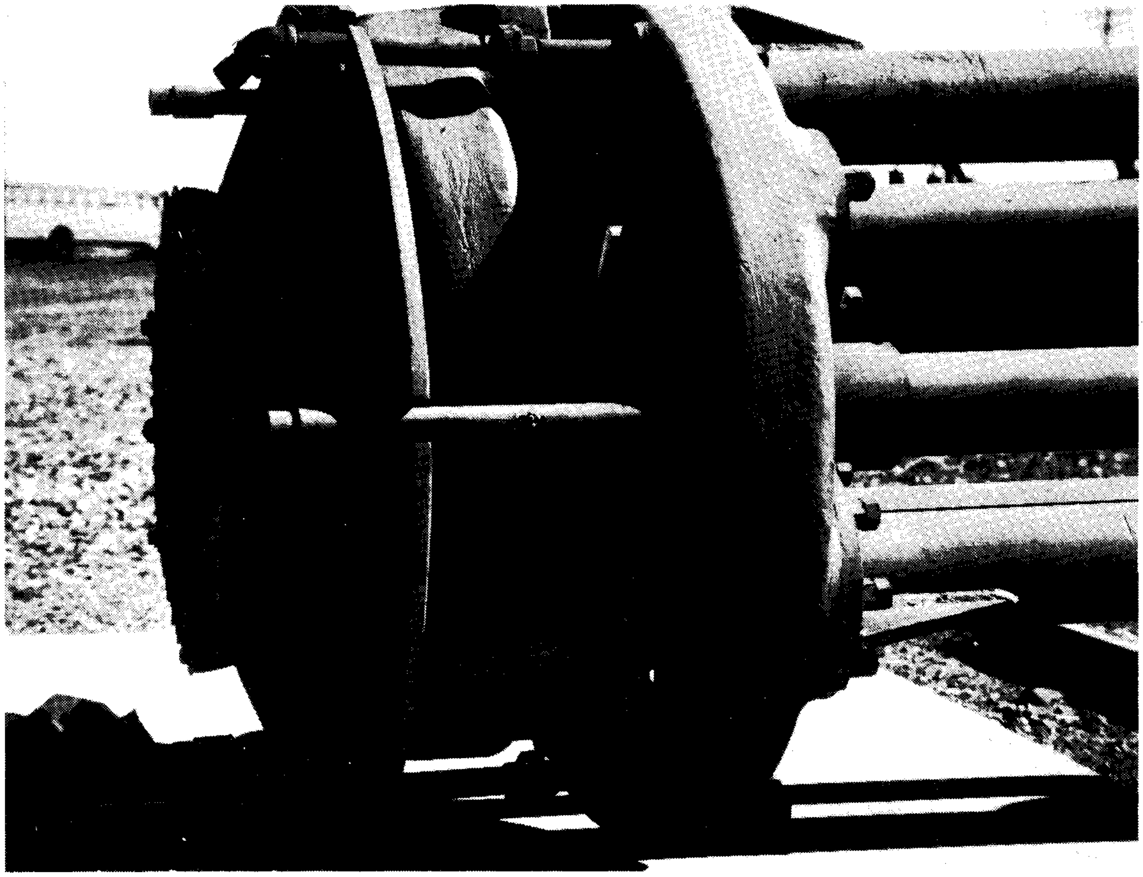


FIGURE 3.17. Intake and Impeller Casing of Centrifugal Slurry Pump

pumps are funnelled to permit operations at low liquid levels. High pressure water nozzles are used to sluice the pump into the sludge during initial installation. These same nozzles could be used during pumping operations, also, to facilitate moving sludge or slurry into the inlet of the pump. At 350 gpm the bulk of one million gallons of sludge or slurry could be pumped out of a tank and into a neighboring tank within approximately two days at continuous operation.

In all of these cases cited above, final cleanout of the tank would still have to be undertaken. This will obviously require additional time and will also generate an additional volume of wash waste water to be pumped to another location. The equipment available to do this is in the form of sluicers. Sluicers have been used previously in the cleanup of sludge heels in single-shell tanks. They can be used also to wash down the interior walls of the primary tank. Figure 3.18 describes a sluicer. Cranes are normally used to install sluicers and pumps in the underground tanks. A sluicer is designed to

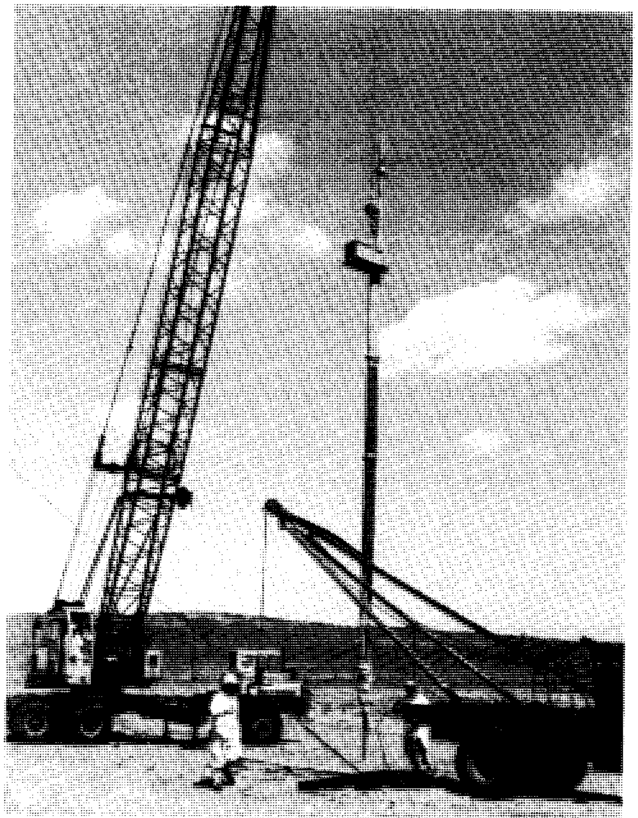


FIGURE 3.18. Sluicer

be installed in a 12-in. dia riser and has remote horizontal and vertical control of the sluicing stream. The pump available and to be used in conjunction with a sluicer for final pumpout of a tank is shown in Figure 3.19. These are specially modified multi-stage turbine pumps satisfactory for pumping liquids and slurries containing less than approximately 5% solids. The intakes of the pumps are modified with metal skirts to allow sluicing at the lowest possible liquid levels. These final cleanout slurry pumps are designed to be installed in 42-in. dia risers.

Any immediate cleanup of a double-shell tank annulus or leak detection pit can be accomplished with one or more hot water flushes and pumpout of the wash waste water with the turbine pumps designed for installation in these spaces as previously mentioned.

Improved methods for future waste retrieval and the possible need for enlarged tank openings are discussed in the following paragraphs. Considerations which are important for the evaluation of alternative approaches include:

- type and characteristics of the radioactive waste to be removed, projected over the life of each tank
- nature of retrieval operation (i.e., scheduled or unscheduled)
- functional use of tank (waste storage, feed storage, etc.)
- the effect of retrieval methods on subsequent waste processing, or handling operations (pumping rates, effects of dilution, etc.)
- the time frame associated with retrieval (emergency, sustained or intermittent removal for processing over many years, one time removal following terminal storage, etc.).

Hydraulic systems, as presently employed, have already been discussed. Evolutionary improvements in these can be anticipated; revolutionary improvements are probably unlikely. Major improvements may require use of one of the other alternatives.

Pneumatic systems entrain the waste material in a relatively high velocity stream of gas (generally air) and convey the suspension through a closed tube to the destination. Pneumatic retrieval systems, although simple and inexpensive, have not previously been used for handling of radioactive waste products at Hanford, but have been employed at other DOE facilities. Some potential exists for airborne contamination from pneumatic systems; therefore they cannot be considered as an improved waste retrieval alternative.

Mechanical retrieval systems entail capturing the waste in an open container, tranporting the laden container to a point of destination, and transferring the contents to another container at the point of destination. Waste retrieval by purely mechanical means is a time-consuming and inefficient

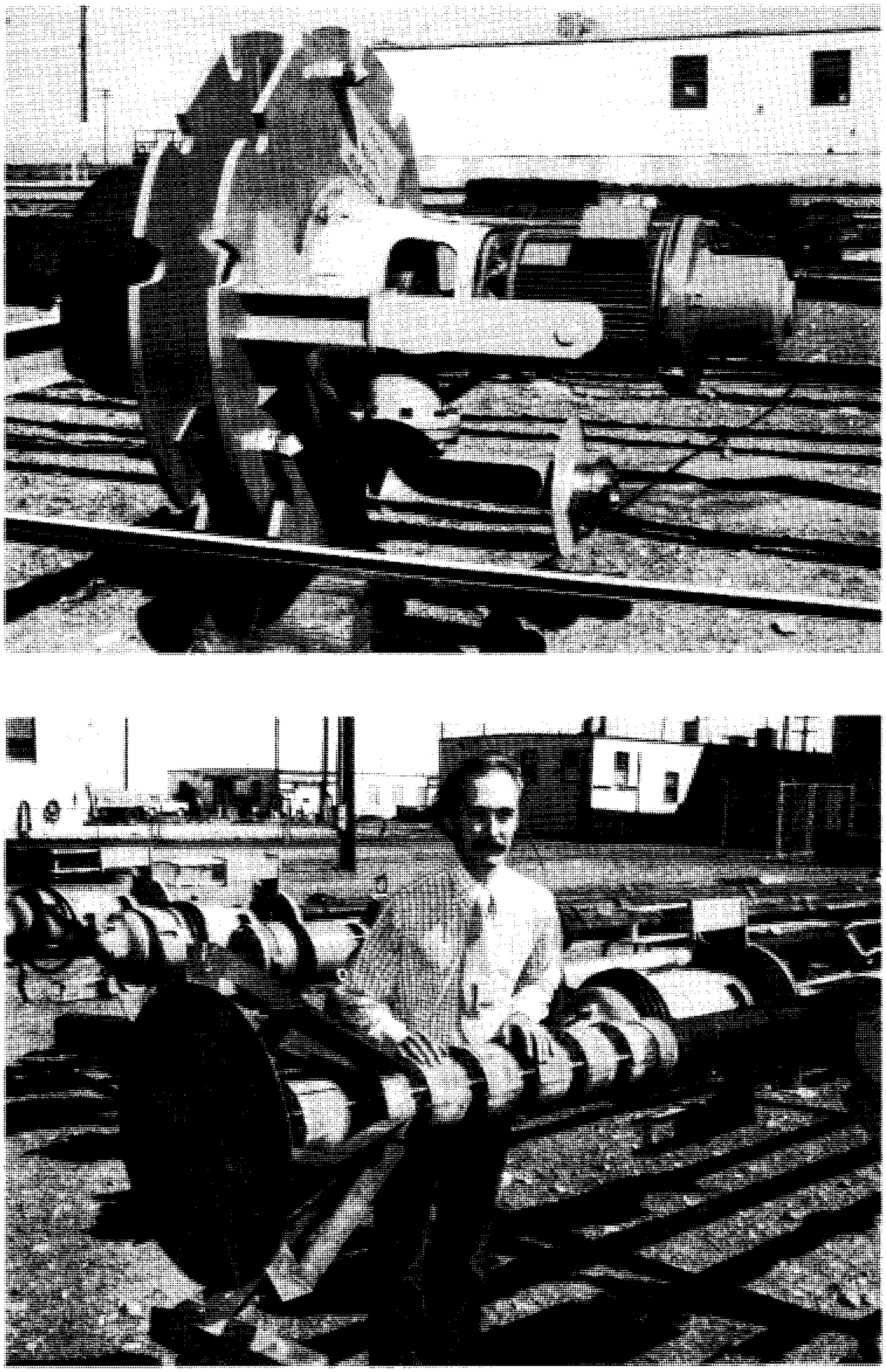


FIGURE 3.19. Final Cleanout - Slurry Pump

process. However, it would be the only method available if the waste included large solids that could not be put in suspension for slurrying or dissolved effectively. Storage of radioactive wastes with these characteristics are not projected for the tanks under consideration. Mechanical retrieval might also be the best alternative in the highly improbable event of a breach in both the primary and secondary containment vessels because liquids would not have to be added to effect retrieval, as might be the case for direct pumping or slurrying.

Improvements to waste retrieval equipment that will reduce or minimize potentially adverse effects can be conceptualized from several standpoints such as:

- more efficient and reliable equipment
- reduction in the total number of components or subsystems
- more flexible or adaptable units (multi-purpose)
- higher capacity units
- systems which reduce or eliminate undesirable changes in the radioactive waste (such as dilution) that could adversely affect subsequent processing or storage.

Three primary considerations influence the options available for waste retrieval:

- storage tank configuration
- physical/chemical characteristics of the radioactive waste (form, viscosity, solubility, etc.)
- duty cycle of the retrieval system.

The present configuration of the radioactive waste storage tanks is not optimum from a purely waste retrieval standpoint. The flat bottom complicates waste retrieval, making it a time consuming process, particularly as the solids content of the wastes increases. Normally a sludge "heel" at least one-inch thick remains in the tank. However, a sloping tank bottom in the primary tank or false bottom is not practical from either a structural or fabrication standpoint. The older tanks at Hanford that were constructed with a sloping bottom have historically been among the worst "leakers."

The duty cycle of the retrieval system can essentially be condensed to three cases:

- one-time retrieval at the end of storage (which applies to most of the tanks under consideration)
- intermittent retrieval of the wastes for further processing over a period of many years which is the case of the two feed tanks and, possibly, the spare tank
- nonscheduled or emergency retrieval in the event of a leak or unanticipated change in tank contents.

A description of radioactive waste characteristics pertinent to retrieval is contained in a letter included in Appendix F. All of the wastes presently projected for storage in the double-shell tanks can be either pumped or slurried. Therefore, mechanical removal is not considered an improved retrieval system. Direct pumping is a very simple and straightforward process that can be carried out with a large number of commercially available pumps. Improved systems for direct pumping can be expected to evolve in the future, but the need for immediate development is not indicated.

The majority of the waste stored in the double-shell tanks will be retrieved by slurrying. Improvements in retrieval needed in the future will be in slurry formation and handling systems. Systems may also be needed to reduce the sludge or liquid "heel" (residual). Research is underway at both Hanford and Savannah River to develop improved slurrying systems. Most research efforts are concentrated on development of single central units to effect both sluicing and slurry removal.

Advantages and Disadvantages of Improved Retrieval Equipment

Potential advantages could include:

- safer and more reliable processing operations
- reduced time for retrieval (if required)
- reduced decontamination efforts due to minimization of equipment needs.

Potential disadvantages could include:

- presently developed systems that may not be applicable to future waste forms
- increased costs that may not be justifiable.

Reasonably Foreseeable Environmental Effects

Apparent environmental benefits to be gained from improved retrieval systems are related to increased rate of removal in the event of a leak in the primary and/or secondary tank, and less equipment discarded and packaged for radioactive burial in the event of equipment failure.

Effect on Tank Durability

The improved waste retrieval equipment is expected to have insignificant effects on tank durability.

Effect on Ease of Waste Retrieval From Tanks

The ease of waste retrieval could be aided with improved systems. However, development of more effective retrieval equipment will require further knowledge of future waste properties. Programs are planned to conceptualize and develop improved systems in the future for the double-shell storage tank wastes.

Effect, if any, on Choices of Technology for Long-Term Radioactive Waste Storage and its Final Disposal, and on the Timing of Such Choices

There are no effects. Improved waste retrieval systems can be developed in ample time to accom- modate future changes in technology. The existing systems are adequate for the present.

Reason for Rejecting Alternative

There is no present need to develop improved retrieval systems. The presently available and proven equipment for direct pumping and slurrying are simple and reliable, and are expected to suffice for the foreseeable future. Future improvement in equipment could evolve as the physical characteristics of waste products (such as double-shell slurry) are better defined.

3.2.5 Cooling Coils

This alternative is examined in this section beginning with a technical discussion of cooling coils and followed by its advantages and disadvantages, environmental effects, effects on tank durability, on ease of waste retrieval, and on technology choices for long-term waste storage and final disposal. The conclusions resulting from this examination are:

1. Since the design heat generation rates from Hanford wastes will be about one-thirtieth part of the rates from Savannah River wastes, cooling coils are not needed for Hanford waste storage tanks. The actual heat generation of Hanford waste may be as low as a sixtieth part of the heat generation rate of Savannah River waste.

2. Since the Department of Energy will insure that adequate monitoring will be in place as part of routine operating procedures that would prevent storage of wastes with greater than 100,000 Btu/hr/tank heat generation rate, the air cooling now provided for the tanks constitute adequate cooling provisions.

3.2.5.1 Technical Discussion

Cooling coils function as part of a system for heat removal from waste tanks by pumping water at ambient temperature through the coils. The purpose of cooling coils is to lower the temperature of the waste. In general, lowering the waste temperature results in lowering the corrosion rates and increasing tank durability.

Cooling coils are used in some waste tanks at Savannah River facilities, but will not be used at Hanford; the primary reason for this being the difference in the heat generation rate by the wastes at the two facilities. For example, for the Type III Savannah River tanks, the design heat load per tank is 3,000,000 Btu/hr (33 x 10^8 J), and their cooling coils are capable of removing 6,000,000 Btu/hr. However, at Hanford, the average heat generation rate of double-shell slurry proposed for storage in the 13 new tanks is 50,000/Btu/hr/tank (Honeyman 1978). Thus, the design heat generation rate of Savannah River wastes is about thirty times that at Hanford.

The tanks constructed most recently (1962 to present) at Savannah River are designed as Type III. Each primary tank holds 1,300,000 gallons, is 85 ft in diameter and 33 ft high. The primary tank sits on a 6-in. bed of insulating concrete within a secondary containment vessel. The concrete bed is grooved radially so that ventilating air can flow under the primary tank. The liquid waste and sludge in some Type III tanks is cooled by means of the replaceable cooling coil bundles. The remainder of the Type III tanks have the permanently-installed cooling coils, similar to those in Type I and Type II tanks. In Type III tanks, the total heat removal capability for either cooling coil design is 6,000,000 Btu/hr (ERDA 1977b).

As regards Hanford, the 241-AW and 241-AN tanks, built during 1976, 1977, and 1978, have some design similarity with the Type III tanks at Savannah River in that the Hanford tanks contain a primary tank sitting on an 8-in. bed of insulating concrete within a secondary containment vessel. The insulation concrete has slots cut in it to allow for flow of ventilating air under the primary tank. The amount of ventilating air in the annulus in 800 standard cubic feet per minute (SCFM). According to design, this air circulates uniformly around the tank, thereby providing heat removal. The air cooling system (consisting of the annulus cooling and in-tank ventilation) is designed to remove 100,000 Btu/hr, while the typical heat generation is 50,000 Btu/hr, thus providing an acceptable reserve capacity.

The design heat generation rate for the 241-AW and 241-AN tanks is 100,000 Btu/hr with a tank capacity of 1,000,000 gallons. Typical heat generation rate for the Hanford double-shell slurry is about 0.05 Btu/hr/gal or 50,000 Btu/hr for each full tank.

Advantages and disadvantages of cooling coils. The advantages of using cooling coils in high-heat generating wastes, as at Savannah River facilities, are related to reduced corrosion rates and gains in tank durability. Proper design and placement of cooling coils in such waste tanks would help insure that the temperatures in the tanks remain at acceptable levels. Limiting the tank temperatures may have several advantages: 1) lower tank temperatures typically reduce rates for general corrosion pitting, corrosion, and stress corrosion cracking of carbon steel, 2) by reducing the corrosion rate of the primary tank, an increase can be gained in the useful life of the tank or in the built-in safety factor, and 3) reduction of differences in expansion of steel and concrete components will minimize the induced stresses in the tank components.

The disadvantages of placing cooling coils in the tanks relate to: 1) increased maintenance program, and 2) interference with waste retrieval. While cooling coils help reduce the corrosion of the primary tank, the coils themselves are subject to corrosion, as indicated by experience at Savannah River (ERDA-1537). Leaking coils would provide a path for the release of contaminated material from the tank. Installation of cooling coils may require additional penetrations through the dome. Including cooling coils in the tanks would complicate the waste retrieval operations, unless they were of the removable type. Cooling coils that are used for bottom cooling are not of the removable type and may hinder waste retrieval.

Reasonably foreseeable environmental effects. A leak in the cooling coils could possibly release contaminated cooling water to the environment. This is a nonbounding scenario with minimal environmental consequences as discussed in Chapter 5.0 of this statement. There would be a slight increase in resources required and the decontamination and decommissioning effort would be greater.

Effect on tank durability. The use of cooling coils could increase the durability of the tanks by lowering the overall tank temperature and thus reducing the wall corrosion rate. This is unnecessary since adequate corrosion allowances have been made in the design of the tanks for the expected service life.

Effect on waste retrieval from tanks. If nonremovable cooling coils are installed in the tanks, they would probably interfere with the retrieval of waste. If the waste stored in the tanks were to form a cake or solid, bottom cooling coils would present more difficult problems to waste retrieval.

Effect, if any, on choices of technology for long-term radioactive wate storage and its final disposal, and on the timing of such choices. There would be no major effect on the choices of technology for long-term radioactive waste storage and its final disposal with the exception of the greater difficulty of removing waste from tanks equipped with cooling coils.

Reasons for rejecting the use of cooling coils. Installation of cooling coils is not recommended for the Hanford tanks, primarily because they are not needed. The major benefit from using cooling coils would be to reduce the corrosion of the primary tank by lowering the tank temperature. A thermal analysis of the tanks predicts that the maximum temperature in the primary carbon steel wall will be less than 200°F (93°C) for a heat generation rate of 100,000 Btu/hr (1.1 x 10^8 J/hr) with the air cooling now provided (Appendix F). Based on a corrosion allowance of 50 mil (1.3 mm) which was included in the design of the tank (Basic Technology, Inc. 1977), a design service life of 50 years for the primary tank is predicted. Stress corrosion cracking can be reduced by reducing the temperature. However, since the primary tank has been stress relieved to minimize residual stresses and tank waste composition will be controlled, stress corrosion cracking is not expected to present a problem.

In summary, since wastes with heat generation rates higher than 100,000 Btu/hr/million gallons are not planned for storage in these tanks, there is no reason to install cooling coils to handle the extra heat load. However, it is necessary to monitor and insure that no wastes with greater than 100,000 Btu/hr/million gallons are stored in these tanks. This is provided in the tank operating procedures.

3.2.6 Overall Results of Evaluation of Alternatives

In the preceding Sections 3.2.2 to 3.2.5 four design and safety alternatives were examined. The examination included a technical discussion of the major aspects of each alternative, followed by its advantages/disadvantages, environmental effects, if any, and effects on tank durability, on ease of waste retrieval and on choice of technology for long-term waste storage and final disposal. Finally, since each alternative was rejected, the reasons for the rejection were summarized.

The 13 new tanks have incorporated many significant design and safety improvements over the previous single- and double-shell tanks con- structed at Hanford. A few examples are:

1. use of higher-strength carbon steel
2. provision of adequate corrosion allowance
3. stress relieving of primary tank after fabrication
4. providing increased dome strength
5. more comprehensive nondestructive examination of tanks.

These improvements will be further strengthened by adoption of carefully monitored operating procedures some of which are listed below:

1. No waste will be stored in the tanks that have heat generation rates exceeding 100,000 Btu (1.1 x 10^8 J) per hour per tank.
2. Steps will be taken to insure that the maximum mass stored per tank will be 1,000,000 gallons at a maximum specific gravity of 2.0.

3. The tanks will be used to store compositions similar to double-shell slurry in corrosion potential. Other waste types will not be stored without adequate corrosion testing to ascertain and modify as needed their corrosion potential.

4. Adequate standby pumping equipment and at least one spare tank will be available so that if a tank leaks, the liquid is pumped out of the annulus space as soon as possible.

5. The feasibility will be evaluated of routine monitoring of the electromotive force (EMF) of the tank wall with respect to stored solution so that tank content composition can be adjusted to correct any undesirable EMF shifts. This is an anti-corrosion measure whose feasibility is not evaluated at present.

In view of the protective operating procedures to be followed and the significantly improved design features incoporated in the 13 tanks, it is concluded that the existing provisions for structural integrity and the design philosophy of the tanks are both satisfactory for the interim-storage of the high-level liquid radioactive wastes. Therefore, the incorporation of the four alternatives can not be justified based on technical considerations. In Chapter 5 of this statement, it is also shown that there are no significant environmental benefits to be gained by incorporation of the alternatives. There are no cost benefits since incorporation of any alternative would require significant dollar outlays. Therefore from all standpoints, the alternatives should be rejected as unnecessary and non-beneficial; the operating procedures listed above are meant to insure that tank durability and public health and safety are protected adequately.

In the next two chapters are presented the affected environment and the environmental consequences from the proposed action and the four alternatives.

4.0 AFFECTED ENVIRONMENT

4.0 AFFECTED ENVIRONMENT

The material presented in this chapter is primarily an updated summmary of the descriptions of the Hanford Site environment that was published in the Final Environmental Statement, Waste Management Operations, Hanford Reservation, (ERDA-1538 1975). This Chapter gives a general background of some of the Hanford site-specific environmental characteristics that relate directly to the new tank sites and their potential effects on the environment. Detailed site and waste characterization information is presented in ERDA-1538 while updated characteristics of the Defense High-Level Waste presently being stored at the Hanford Site can be found in ERDA-77-44 (1977).

4.1 HANFORD SITE LOCATION

The Hanford Site (Figures 4.1 and 4.2) occupies approximately 1,500 km^2 (570 $mile^2$) of a semi-arid region in the southeastern part of the State of Washington. The site extremities measure approximately 52 km (32 miles) north to south and 42 km (26 miles) east to west. The nearest population center, Richland, Washington (1970 population = 26,290), is approximately 5 km (3 miles) south of the southernmost site boundary and about 35 km (22 miles) southeast of the present high-level waste management and storage facilities. Population within a 50-mile radius was estimated to be 246,000 in 1970; this is expected to increase to approximately 277,000 by 1980 (Yandon 1979).

The tank farm, in which the thirteen new tanks are located, is contained in the 200 East area (See Figure 3.1). This area is already dedicated to fuels processing, waste fractionation and waste storage, and ecologically speaking, is virtually barren. Ecological effects on the tank farm area are minimal.

4.2 LOCAL INDUSTRIAL, TRANSPORTATION, FEDERAL AND SITE-SPECIFIC ACTIVITIES

The areas near the Hanford Site have been developing and expanding with increased industrial and agricultural activities. Non-nuclear industrial facilities located in the area include a meat packing plant, food processing facilities, fertilizer plants, a pulp and paper mill, a chemical plant, and several metal manufacturing plants. A wide variety of support and supply facilities exist in the area to serve the industrial base. Agriculture in the region includes a wide variety of dryland and irrigated crops and plays a major role in the local economy.

Highway access to the region is available via State Highways 14, 24, and 240; U.S. Highways 12 and 395; and when completed in the mid-1980s, Interstate Highways I-82 and I-182. Rail service includes the Burlington Northern, Union Pacific, and the Chicago, Milwaukee, St. Paul, and Pacific Railroads. Air transportation is available through three local airports including one suitable for small commercial jet aircraft. In addition, commercial traffic on the Columbia River may travel to the North Richland dock area nearest the southern Hanford Site boundary.

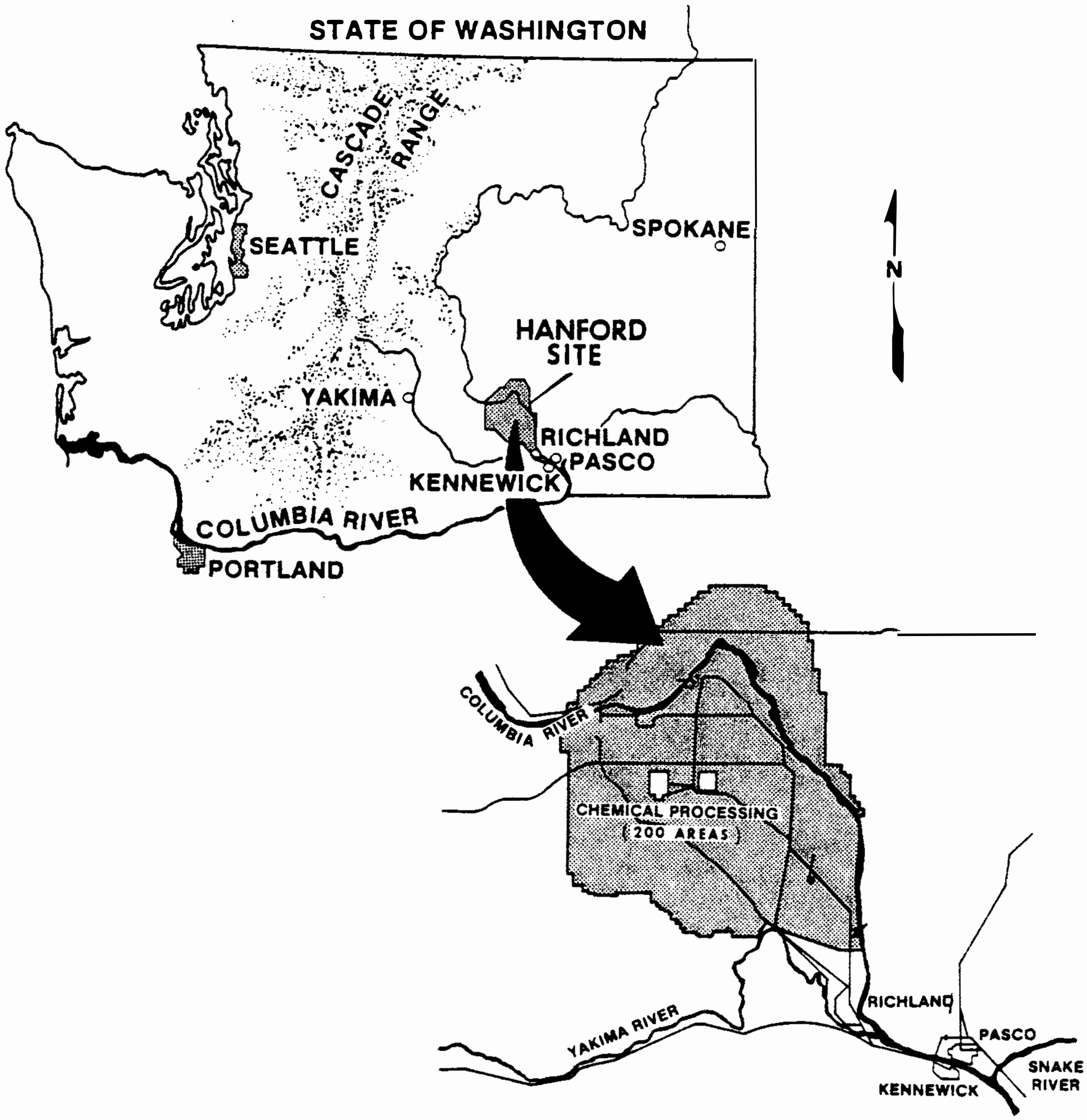


FIGURE 4.1. Location of the Hanford Site

Several regional power dams are located on the Columbia River including the Priest Rapids, Wanapum, and McNary dams. Siting a power dam (tentatively named Ben Franklin) about 16 km (10 miles) upstream from Richland has been considered (Harty 1979); however, no action to construct the dam is anticipated at this time.

The U.S. Army Yakima Firing Range used for training Army Reserves is located in an undeveloped area beginning approximately 16 km (10 miles) west of the Hanford Site boundary.

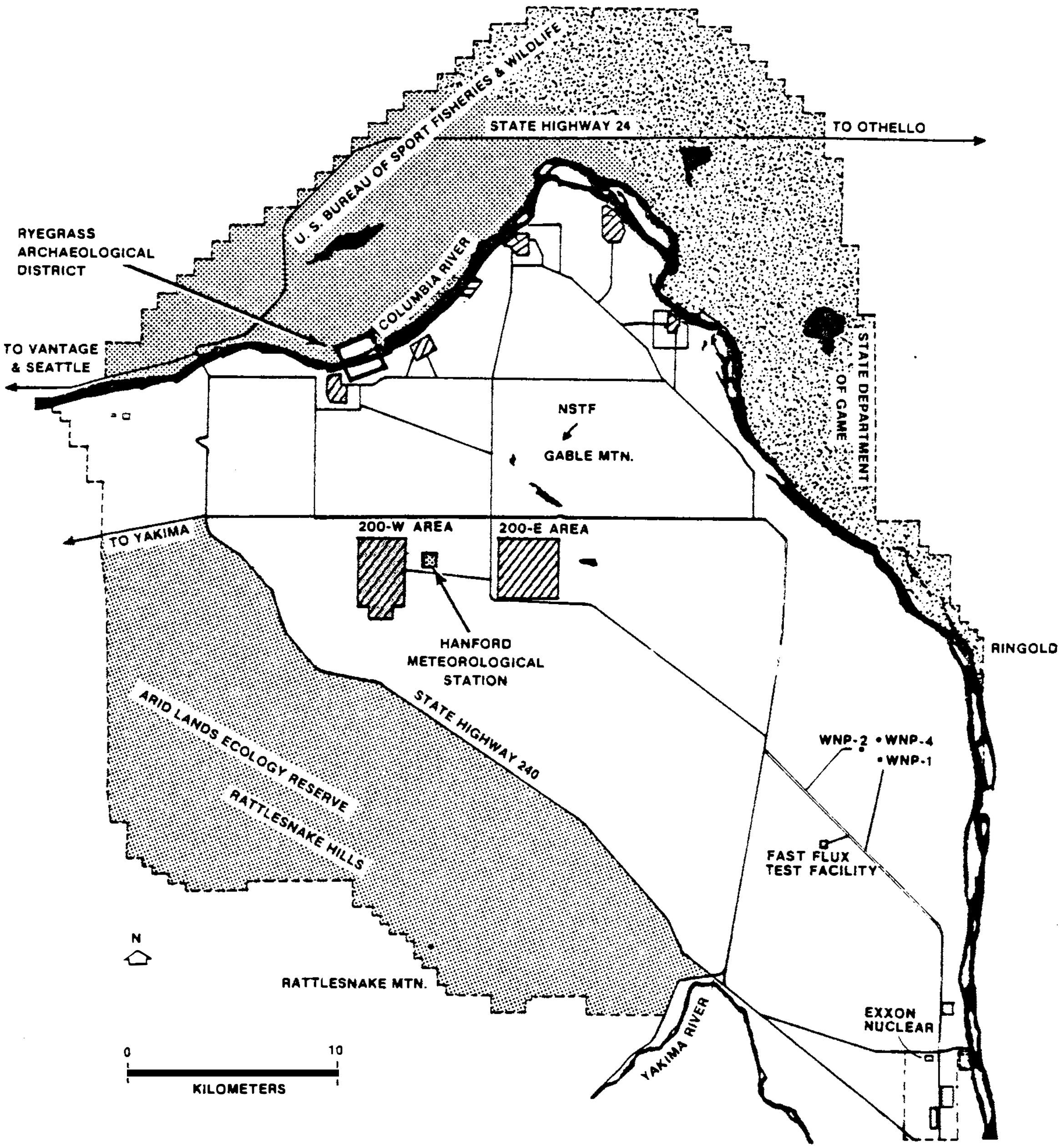


FIGURE 4.2. Hanford Site

A number of Government-owned nuclear facilities are located on the Hanford Site and include production and waste management buildings, research laboratories, waste disposal facilities, and nuclear material storage areas.

In addition, the dual-purpose N reactor is operated onsite, producing both nuclear materials and by-product steam which is sold to the Washington Public Power Supply System (WPPSS) for commercial power generation. The Fast Flux Test Facility (FFTF), a test reactor owned by DOE is scheduled for startup operations in 1980. Eight other reactors, formerly used for production of nuclear materials, now are retired and shutdown. Commercial nuclear facilities onsite include a low-level waste burial area, and three commercial nuclear power stations presently under construction that are owned by WPPSS. The Exxon Nuclear Corporation fuel fabrications plant is located just south of and adjacent to the site boundary.

4.3 SOCIOECONOMICS

Socioeconomic parameters of concern include employment, personal income, population, demographic characteristics, housing, recreation, health care, public finance, and relationship to other major construction activities which may occur concurrently.

The extensive nuclear-related development work initiated by the U.S. Government in 1943, and now administered by the U.S. Department of Energy has been a prime influencing factor in the socioeconomics of the areas surrounding the Hanford Site. Construction activity has been significant for many years and the influx of personnel, both permanent and temporary, has already had major effects on the rate of community growth, patterns of indirect business development, and social structure. In recent years, the communities have stabilized and adjusted to varying project activities at the Hanford Site. The Tri-Cities have plans in place for community development associated with the influx of new project workers and transitions from construction to operation of new facilities.

Total employment involved with activities for the U.S. Department of Energy at the Hanford Site is approximately 12,000 (August 1979), of which approximately 3,500 are employed by Rockwell Hanford Operations (RHO). RHO has the responsibility for the design and construction of the new tanks.

The new high-level waste tank construction program is only one of many construction projects concurrently ongoing at the Hanford Site and in the surrounding communities. The manpower level identified for this project (approximately 100 persons for the peak construction period and operation) will not measurably affect the socioeconomic parameters discussed above. No socioeconomic concerns which can be identified or quantified for this action (see Chapter 5, Section 5.2 for details of the labor force involved).

4.4 SUMMARY OF ENVIRONMENTAL CHARACTERISTICS

The following sections summarize the Hanford Site environmental characteristics. More extensive and detailed technical information about the site and the surrounding region is available in ERDA-1538 (1975).

4.4.1 Geology-Topography

The Hanford Site is located in southeastern Washington State in the Pasco Basin (a portion of the Columbia Plateau) which is composed of large quantities of basalt overlain by thick layers of sedimentary material. The Hanford Site overlies the structural low point of the Pasco Basin and is bounded to the southwest, west and north by large ridges that trend eastward from the Cascade Range, enter the Pasco Basin and die out within its confines. The Site is bounded to the east by the Columbia River and the steep White Bluffs of the Ringold Formation. To the southeast the Site is bounded by the confluence of the Yakima and Columbia Rivers and by the City of Richland.

The earth materials beneath the site consist of a thin mantle of wind-blown silts and sands which cover layers of coarse sands and gravels up to 61 m (200 ft) thick that were deposited by ice age floods (ERDA 1975). Finer sands, silts, and clays lying beneath the gravels were deposited up to 305 m (1,000 ft) thick over a long period. An accumulation of basaltic lava extruded over periods extending from 6 to 16 million years ago lies beneath the top sediments. This layer is estimated to be more than 3,000 m (10,000 ft) thick. The water table in the tank areas lies in the finer material 46 to 91 m (150 to 300 ft) below the land surface (ERDA 1975, ERDA 1977).

The sedimentary deposits described above are moisture deficient and have a high capacity to absorb and retain leakage from the high-level waste tanks; furthermore, most of the chemical elements are permenantly adsorbed to the soil particles by ion exchange. Precipitation will penetrate the ground to only a short distance and is lost to the atmosphere by evaporation during the dry summers (ERDA 1977). There is no transport mechanism to the underlying water table. The combination of these characteristics acts to prevent any significant quantities of the radionuclides resulting from leaks or spills from reaching the ground water.

Detailed stratigraphic and geologic data are available to characterize the Hanford Site Environment (Tallman et al. 1979, Atlantic Richfield Hanford Company 1976) and have allowed subdivision of the basalts into a number of formations, members, and flows. Details concerning these flows can be found in the following references: Jones (1978), Reidel (1978), Fecht (1978), Geoscience Research Consultants (1978), Swanson (1977), and Goff (1977). Details of the sedimentary layers and soils at the Hanford Site can be found in the following references: ERDA (1975), Baker (1973), Hajek (1966), and Routson (1973).

4.4.2 Seismicity

Hanford is located in an area of historically low seismicity (Algermissen 1969, 1976). The greatest earthquake intensity historically registered in the Pasco Basin was of Modified Mercalli (MM) intensity V or VI (approximately

Richter magnitude 4.5 to 5.0) that occurred November 1, 1918, near Corfu, 35 km (22 miles) north of the center of the Site (Coffman 1973). The largest recorded earthquake in the entire Columbia Plateau was of MM intensity VII (Richter 5.5), on July 15, 1936, near Milton-Freewater, Oregon, approximately 100 km (62 miles) southeast of the Hanford Site (Berg 1963). On the assumption that a very low probability MM-VII quake (Richter 5.5) were to occur at the northwest end of the Rattlesnake-Wallula fault zone, ground acceleration of 0.13 g could be expected beneath most of the Hanford Site (ERDA 1538). A design basis of 0.25 g (acceleration level for the "Safe Shutdown Earthquake") for the high-level tanks at Hanford allows for an MM-VIII (Richter 6.8) earthquake epicentered at the same site. No such quake has ever been recorded in eastern Oregon or Washington and such a magnitude is not considered probable (Blume 1971, ERDA 1975).

4.4.3 Climatology

For general climatological purposes, meteorological data from the Hanford Meteorological Station (HMS) are representative of the Hanford Site. The HMS tower is located between the 200E and 200W tank areas (Figure 4.2) and has continuously produced data since 1944. Detailed climatological data is found in Stone (1972). The Cascade Mountain Range to the west (Figure 4.1) greatly affects the climate of the Hanford area and forms a barrier to eastward-moving Pacific Ocean storm fronts. The mountains form a rain shadow producing mild temperatures and arid climatic conditions throughout the Pasco Basin region.

Average maximum and minimum temperatures recorded at Hanford for the month of January (the coldest month) are 3°C (37°F) and -6°C (22°F), and those for July (the warmest month of the year) are 33°C (92°F) and 16°C (61°F). Average annual precipitation is 16 cm (6.3 in.). The estimated average annual evaporation rate is 134 cm (53 in.) which essentially eliminates infiltration in the soil. Projections from available precipitation data indicate that a maximum accumulated annual rainfall of approximately 46 cm (18 in.) can be expected to have a recurrence interval of 1,000 years (ERDA 1977a) with a maximum soil penetration of 4 m (13 ft).

Tornadoes are rare in the Hanford region, tend to be small, and produce little damage. Because of the underground nature of the tank farms, tornadoes would not be expected to have any appreciable effect on the tanks themselves, although surface damage to the ventilation and above-ground facilities could occur.

4.4.4 Hydrology

The Columbia River is the dominating factor in the Hanford Site hydrology, and flows through the northern part and along the eastern boundary. The Yakima River is situated along part of the southern boundary. Groundwater exists beneath the site in an unconfined aquifer, and in confined aquifers composed of interbeds and interflow zones within the underlying basalt flows.

The Columbia River is normally about 75-90 m (250-300 ft) below the plateau where the 200E and 200W tank farms are located. Under maximum probable flood conditions for the Columbia River Basin, the U.S. Corps of Engineers (1969) has estimated that the tank farms would still be 60-75 m (200-250 ft) above the highest probable water elevation. The 100-year and 500-year floods are not discussed since the probable maximum flood is more severe than the 500-year flood. Submersion of the Columbia River Wetlands as a result of such flood conditions would have no direct affects on the tank farms. Studies of a hypothetical 50% breach of the upstream Grand Coulee Dam, which would result in the devastation of downstream cities including Pasco, Richland, Kennewick, and Portland, show a flood elevation at 45-60 m (150-200 ft) below the tank farm facilities (ERDA 1976).

The water table, representing the upper limit of the unconfined aquifer, ranges from 46 to 100 m (150-328 ft) beneath the ground surface at the tank sites and slopes toward the river. Near the Columbia River the water table fluctuates in response to river level changes and, in general, is within a few meters of the ground surface. Studies at Hanford indicate that precipitation does not directly reach the water table from the flat desert plains surrounding the tank sites (ERDA 1975).

The unconfined aquifer occurs within sand and gravel deposits referred to as the Hanford and Ringold Formations. The aquifer receives natural recharge from the Cold Creek and Dry Creek Valleys west of the Hanford Site and from runoff along the Rattlesnake Hills. Artifical recharge enters the aquifer from two groundwater mounds created by waste processing and disposal activities in the 200E and 200W areas. Groundwater flows in a general west to east direction from the recharge areas and discharges into the Columbia River.

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

Extensive details of the subsurface hydrology are presented in two reports (ERDA 1975 and Atlantic Richfield Hanford Company 1976).

4.4.5 Ecology

The Hanford Site is a large area, much of which is relatively undisturbed. There are numerous plant and animal species suited to the semiarid environments of the area. The Columbia River also provides a habitat for aquatic species. The major facilities and activities occupy only about 6% of the total available land area and the surrounding wildlife is little affected by these facilities. A very extensive discussion of the site ecology, including detailed descriptions of the aquatic ecology, Columbia River biota, terrestrial ecology, plant species, animal species, insects, and rare or endangered species is presented in ERDA-1538 (1975). A brief summary of some of this information is presented below:

Vegetation. The Hanford Site is within boundaries of the sagebrush vegetation zone as it occurs in the State of Washington (Daubenmire 1970). Approximately 40% of the ground area is occupied by plants at the peak of the spring growing season. Site vegetation is not regarded as being indigenous because of the introduction of large amounts of cheatgrass with the advent of livestock grazing, agriculture, and fire.

Sagebrush/cheatgrass vegetation is the prevalent type in the 200 Areas plateau (Figure 4.3). Typically, cheatgrass provides half of the total plant cover. Sagebrush is conspicuous because of the plant's relatively large size, with its combined plant canopies covering an estimated 18% of the ground (Cline 1977). Tumbleweeds are of interest because they are an early invader of any cleared surface areas and continue in abundance until competition from other plants reduces their number.

Over 100 species of plants have been collected and identified for the 200 Area plateau. Mosses and lichens appear abundantly on the soil surface; lichens are commonly associated with shrub stems (ERDA 1975).

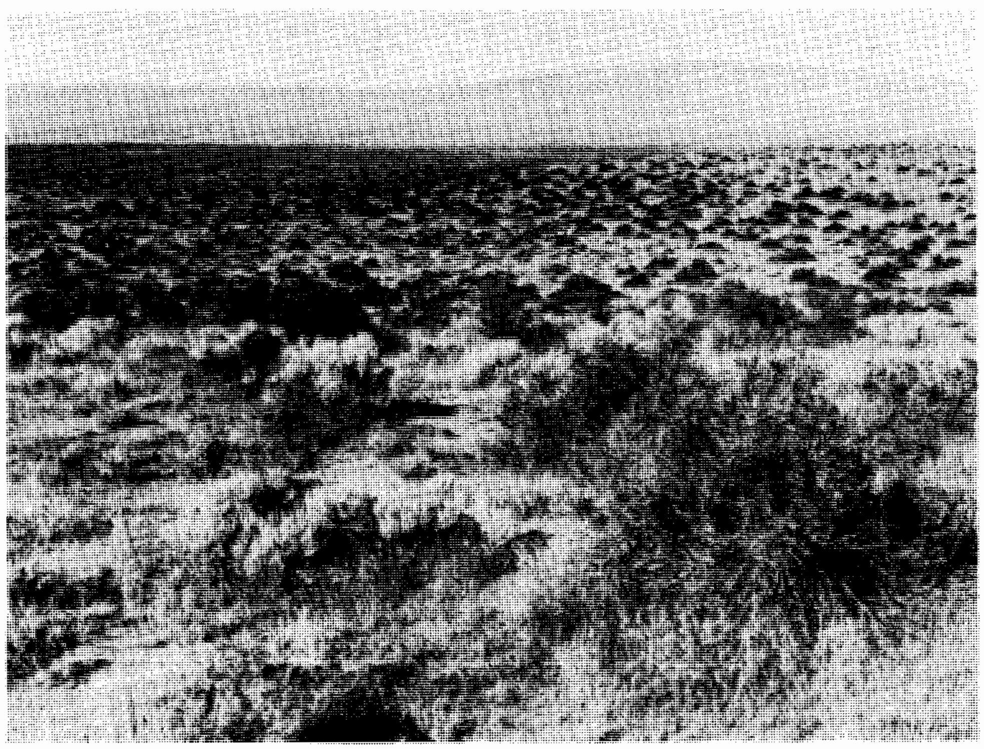


FIGURE 4.3. Sagebrush and Cheatgrass, Typical Vegetation in the Central Part of the Hanford Reservation (the "200 Area Plateau")

Since there are now no grazing livestock on-site, the amount of vegetation eaten by animals is small. Jackrabbits, pocket mice and birds probably consume less than the insect species. The decomposer organisms, bacteria and fungi, consume most of the primary production after the plant parts die and fall to the ground.

Mammals. Over 30 different mammal species have been observed on the Hanford Site. Most of these are small and nocturnal (ERDA 1975).

The mule deer is the only big game mammal present in significant quantities and, while not abundant, it uses some of the pond areas for watering and feeding. Deer tagged near the Columbia River have been observed as far as 48 km from the site (Fitzner 1973).

The cottontail rabbit is present with populations scattered throughout the site. The jackrabbit is also widely distributed and is an important food item for coyotes and birds of prey. Ponds and ditches support muskrat and beaver; porcupine and raccoon are also observed while badgers occur in low numbers. The dominant small mammal is the Great Basin pocket mouse.

Coyotes are the most important mammalian predator and roam over large areas, consuming a variety of prey.

Birds. Over 125 species of birds have been observed at the Hanford Site (ERDA 1975). The chukar partridge is the most important game bird and is concentrated primarily in the Arid Lands Ecology (ALE) Reserve portions of the site and the Rattlesnake Hills. Local populations exist in the Gable Mountain and White Bluffs area.

The Canadian goose is probably the most important of the nesting waterfowl. Its nesting habitat is confined to the islands in the Columbia River. The river also provides a resting sanctuary for migratory flocks of ducks and geese (Fitzner 1973).

Birds associated with waste water ponds on the 200 Area plateau have been studied (Fitzner 1973, 1975). Small perching birds and others are attracted to the ponds with tree-shrub communities. Shore birds were observed at all ponds and the major migrating birds stop at the ponds for rest and forage.

Birds of prey use the site as a refuge from human intrusions and the golden eagle and bald eagle are both winter visitors (Fitzner 1975).

Insects. Almost 300 species of insects have been identified at the Hanford Site (ERDA 1975). Of the insects, the darkling ground beetle and the grasshopper are probably the most important and prevalent. Dramatic natural fluctuation of these species has been noted over the observation years.

Reptiles and Amphibians. Approximately 16 species of amphibians and reptiles have been observed at the Hanford Site (ERDA 1975). When compared with the southwestern United States desert areas, the occurrence of these species is infrequent. The side-blotched lizard is the reptile found in greatest abundance and can be found throughout the site. Horned and sagebrush lizards are also found but not commonly seen. The most abundant snake is the gopher snake, but the yellow-bellied racer and the Pacific rattlesnake are common. Striped whipsnake and desert night snakes appear occasionally and are an important food item for birds of prey. Some toads and frogs are observed near the 200 Area ponds and ditches.

Aquatic Ecology. The Columbia River supports the dominant aquatic ecosystem and presents a very complex set of trophic relationships which are discussed extensively in ERDA-1538 (1975). There are several small ponds resulting from effluent discharge on the 200 Areas plateau. The largest of these, Gable Mountain Pond, supports a simple food web based mainly on sedimented organic matter and sustains introduced goldfish. This is the only species found and the only pond onsite where fish exist.

Rare or Endangered Species. No species of plant or animal registered as rare, threatened or endangered is known to exist or depend on the habitats unique to the 200 Area plateau. However, the presence of open water as well as birds of prey attracts and supports many species of plants and animals normally rare or unknown in the general plateau area. The prairie falcon nests in several regions on the site, and long-billed curlews nest in cheatgrass fields and are relatively abundant. The western burrowing owls are rather common and do not seem to be affected by the presence of human activity.

4.4.6 Demography

The 1970 census estimate of the population within an 80 km (50 mi) radius of the Hanford Meteorological Station (HMS) is 246,000. The HMS is located directly between the 200E and 200W Areas. The population is projected to grow to about 314,000 by the year 2000. Local population centers are shown in Figure 4.4. Details of population distribution and the projection methodology will be found in Yandon (1976) and Yandon (1979). These population projections have been updated from the information found in ERDA-1538 (1975).

4.4.7 Historical Sites and National Landmarks

The U.S. Department of the Interior (1979) lists 20 historic sites for Benton, Grant, and Franklin Counties. Among these, the Ryegrass Archaeological District is listed as being in the "Hanford Works Reservation" (since 1978 designated as "Hanford Site") along the Columbia River. Other historic sites listed are: Paris Archeological Site, Hanford Island Archeological Site, Hanford North Archeological District, Locke Island Archeological District, Rattlesnake Springs Sites, Snively Canyon Archeological District, Wooded

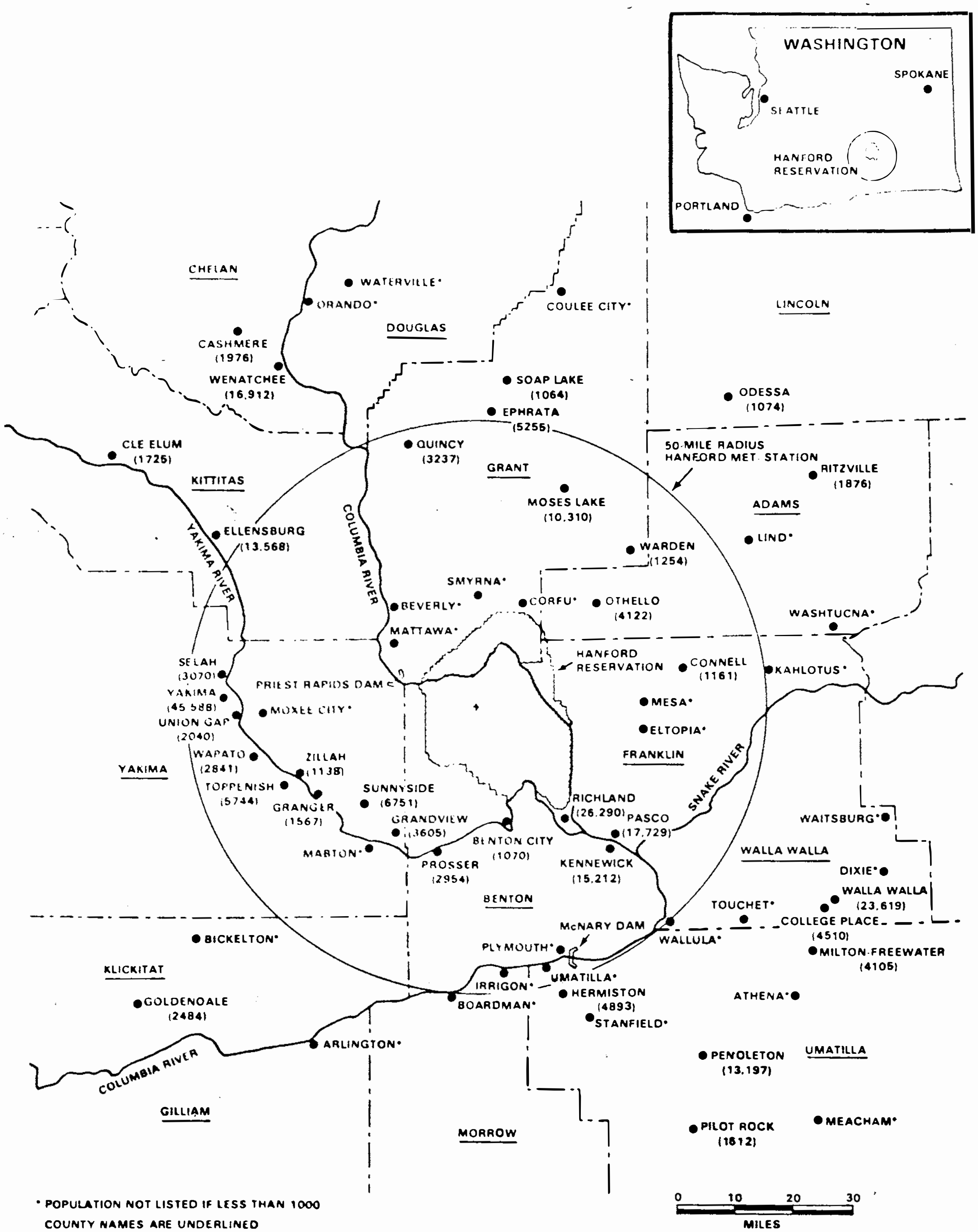


FIGURE 4.4. 1970 U.S. Census Populations of Communities in the Hanford Site Vicinity

SOURCE: ERDA-1538

Island Archeological District, and Savage Island Archeological District. A number of archaeological sites within the site boundaries have been identified (Rice 1968a, 1968b) and are described in detail in ERDA-1538 (1975).

The Arid Lands Ecology (ALE) Reserve with the rest of the Hanford Site, exclusive of the operating areas (approximately 6%) was recently designated as a National Environmental Research Park (NERP). Areas of prime scientific interest include the Rattlesnake Hills and the Columbia River shoreline. The nuclear waste management areas are excluded from the research park.

4.4.8 Background Radiation and Environmental Monitoring Program

Natural background radiation includes both cosmic and terrestrial sources which vary slightly with location and altitude (United Nations 1962). The calculated annual background radiation dose received by the average person living in the vicinity of the Hanford Site is approximately 100 mrem per year: 75 mrem from cosmic radiation (gamma 69 mrem; neturon 6 mrem), and 25 mrem from internal radiation. More details on natural background radiation in the Hanford vicinity may be found in Speer (1976), Houston (1978, 1979) and National Academy of Science (1978). The dose to the average individual from the entire Hanford Site operations has been estimated to be about 0.01 mrem/year (ERDA-1538 1975). Dose from the waste management operations would be a small fraction of this value (prime contributor to dose is the N reactor). These dose contributions are imperceptible when compared to the normal 10 to 15% fluctuations which occur annually in the natural background radiation levels.

Radiological surveillance of the Hanford Site began with the first reactor startup in 1944 and has played a significant role, not only in evaluation of the waste management programs but also in providing significant scientific data not otherwise available. Many of the details have been published in the open literature (Becker 1973) as well as in topical reports or in annual reports to the Department of Energy. In recent years, the routine surveillance program results have been documented and published in a series of annual reports of radiological conditions in the site environment (Houston 1979a) and of the radiological status of the Hanford Site (Houston 1979b).

5.0 ENVIRONMENTAL CONSEQUENCES

5.0 ENVIRONMENTAL CONSEQUENCES

The environmental consequences analyzed in this chapter are limited in scope to those resulting from the 13 new double-shell high-level waste storage tanks and are supplemental to the information presented in ERDA-1538 (1975). The environmental consequences are caused by: 1) the construction and operation of the tanks and 2) the hypothetical adoption of four alternatives described in Chapter 3. The consequences relate to the affected environment described in Chapter 4. The alternatives for which potential consequences are analyzed are considered from the viewpoint of hypothetical adoption (retrofitting) the alternatives now, when the construction of the tanks is essentially complete.

Since the thirteen new tanks are presently near completion, full adoption of any one of the alternatives would require: 1) a significant commitment of additional resources and 2) would delay the transfer of liquids from the single-shell tanks of questionable integrity. The environmental consequences of these two actions are considered to be adverse. On the other hand, incorporation of the alternatives in the design stages would not have significantly altered the environmental consequences described for the proposed action, which is the utilization of the tanks as they now exist.

Whether the alternatives had been adopted before construction or are now adopted, the major benefits of either action would be limited to a potential extension of the life and durability of the tanks; there are no reasonably foreseeable major direct benefits in environmental consequences to the affected environment.

Even if the waste tanks were to leak or fail, resulting in waste-to-soil contact, calculations and physical measurements have shown that there would be no significant environmental consequences as discussed later in this chapter and in ERDA-1538 (1975). This lack of consequences results from two principal reasons: 1) there is no active transport (movement) mechanism for the wastes to the biosphere based on the present climatological data and experience with previously leaking tanks at the Hanford Site and 2) the bottom of all tanks lies about 50 feet below the ground surface and about 150 feet above the unconfined aquifers in the water table at Hanford. One of the major reasons for the construction of the new double-shell tanks is removal of single-shell tanks from active use for liquid waste storage.

This EIS does not address the environmental consequences of using the tanks for long-term storage; the present plans call for utilization of the tanks only on an interim basis. The design life of the new tanks is considered sufficient to contain the wastes for up to 50 years pending implementation of long-term disposal options.

5.1 ENVIRONMENTAL IMPACTS

5.1.1 Proposed Action

The proposed action is the utilization of 13 new double-wall carbon steel tanks within the 200 East area of the Hanford Site. The tanks are specifically designed and constructed to store the wastes and thereby minimize, to the extent technically achievable, the kinds of environmental impacts of concern to public health and safety. This section addresses the environmental impacts for the proposed action and for the four alternatives. In this EIS, the proposed action is the base case. Particular attention is given to detailed evaluation of resource commitments, environmental impacts, and consequence analyses of abnormal events and accidents where identified. The period of concern is limited to the 50-yr design life of the tank system. Tank utilization during waste processing functions and for interim storage may cover a period significantly less than 50 years.

5.1.1.1 Construction Effects

Construction activities related to the proposed action are now nearly complete and have resulted in emission of dust and gases. Sources of these emissions were concrete production, land grading and excavation, storage of excavated material, and equipment and vehicle operations. The preparation of the new tank sites required the removal and replacement of several thousand cubic meters of sand, soil, and outwash gravel and was the major construction impact. Empirical measurements at construction sites (PEDCO, 1974) show that annual particulate emissions from grading and excavation operations can be as much as 33 MT/ha. Assuming that the Hanford Site is similar to other construction sites where large quantitites of earth materials are moved, calculations indicate that the National Ambient Air Quality Standard (NAAQS) for particulates (40 CFR 50) might have been exceeded up to 1 km downwind of the construction site, in the absence of control measures. Standard practice at the Hanford Site requires fugitive dust control by water spraying. Impacts to biota and man have been negligible, however, because the tank site area has experienced previous disturbances and is under intensive management. No impacts to the general public have been detected because of the distance to the nearest population center (35 km, 22 miles). Air quality standards would not be exceeded off-site or at distances greater than 1 km (0.6 mile) from the construction site with standard construction procedures.

Vehicle emissions of concern are from construction machinery and worker transportation. Based on gasoline and propane consumption during construction and the emission factors published by the U.S. Environmental Protection Agency (U.S. EPA 1975), the computed ground-level concentrations for the five important pollutants did not exceed the appropriate standard at the 200 area boundary as shown in Table 5.1. Also, based on similar construction involving larger work forces (URS Company 1977), emissions from vehicles used by workers commuting to and from the construction site would not be expected to violate air quality standards.

TABLE 5.1. Comparison of Construction-Related Estimated Air Pollutant Concentrations with Standards

Pollutant	Estimated Concentration in Air ($\mu g/m^3$)	National Ambient Air Quality Standard ($\mu g/m^3$)[(a)]
Carbon monoxide (CO)	340	10,000 (8-hr)
Hydrocarbons (HC)	15	160 (3-hr)
Nitrogen Oxides (NO_x)	16	100 (AAM)[(b)]
Sulfur Oxides (SO_x)	0.65	80 (AAM)
Particulates	1.1	75 (AGM)[(c)]

(a) Source 40 CFR 50
(b) Annual Arithmetic Mean Concentration
(c) Annual Geometric Mean Concentration

5.1.1.2 Operating Effects - Normal Operation

The double-shell waste storage tank facilities that have been designed and constructed can be operated without undue risk to property and the health and safety of employees and the general public. Practical safety controls have been included in the design and planned operation of the double-shell waste storage tank facilities, which meet or exceed the operational safety standards of the ERDA Manual (DOE 1977). The facilities, equipment, and personnel are subject to the hazards normally associated with the chemical processing and mechanical handling of radionuclides.

The 13 waste storage tanks are covered with a minimum of 2 meters (6.5 ft) of earth cover and the tank top is designed to withstand concentrated live loads of 45 MT (50 short tons). All new structures, equipment, and piping are classified as falling within quality assurance Level I (Guenther 1978). All other structures and components are constructed in accordance with the Uniform Building Code for Seismic Zone II (ERDA-1538). The tanks and piping systems are designed to withstand a 0.25 g Safe Shutdown Earthquake (SSE) without any impact to structural integrity or release of radioactivity to the environment which would result in undue risk to public health and safety (Mirabella 1977).

The engineering design parameters are selected to result in negligible environmental impact to air, land, and water under normal operational mode. Tank ventilation air, steam, and raw water supplies are provided by tested and existing systems. Raw water requirements are estimated at 600 m^3 (158,000 gal) per year and electrical requirements are estimated to be 7.3×10^6 KVA-hr/yr. Both are considered minor additions to the existing requirement at the facilities.

The concentrations and release rates of radioactive materials in the tank and process effluents will be within the limits specified in ERDA Manual 0524.

Gaseous discharges are filtered through a series of high efficiency particulate air (HEPA) filters. Noncondensible vapors are filtered and are released only when discharges are within concentration limits specified in ERDA Manual, Chapter 0524 (DOE 1977). HEPA filters are routinely checked for performance each day and are changed regularly as required.

The dose offsite to the average individual from the entire Hanford Site operations has been estimated to be about 0.01 mrem/yr (ERDA 1975). Dose contributions offsite from the normal operations of the tank facilities would be a small fraction of this value and would be unmeasurable.

Occupational Radiation Exposures. The operation necessary to implement any waste management plan may result in small amounts of radiation exposure to the operating personnel. The maximum exposures allowed by DOE radiation protection standards are 5 rems to the whole body each year, or 3 rems each calendar quarter (DOE 1977). Extensive efforts are made to reduce worker exposure to amounts that are as low as reasonably achievable (ALARA) under these limits. These efforts include detailed planning of all work which involves radiation exposure potential to reduce exposure time, to provide adequate shielding, and to preclude radionuclide intake.

Radiation monitoring devices are located within 100 ft of the storage tank to ascertain that the surface radiation dose rates are within prescribed limits in ERDA Manual, Chapter 0524. Operating personnel exposure to radiation is limited to 1.0 rem/year/individual by providing a concrete cover block over the HEPA filter housings and the tank penetrations. At the 200 East area site boundary fence, tank-related radiation is not anticipated to be detectable above the normal background level (approximately 100 mrem/yr).

Table 5.2 gives the exposure experience for workers involved in tank farm activities during 1978. The dose per monitored employee for all operating groups during the same period of time was 0.44 rem.

TABLE 5.2. Hanford Tank Farm Operations Whole Body Occupational Exposure for 1978

Group	Number of Employees Monitored	Total Exposure (rem)	Average Exposure per Monitored Employee (rem)
Maintenance	49	46	.94
Tank Farm Operations	69	30	.44
Surveillance	12	5	.43

The shielding for the double-shell waste storage tanks and related mechanical systems was designed to limit worker radiation levels to no more than 0.5 mrem/hr, except in areas adjacent to the filter banks. Personnel working in the pits may also be subjected to higher radiation levels.

In summary, the environmental impacts of normal operation of the tanks are estimated to be insignificant as long as 1) tanks are properly monitored, 2) waste stored in the tanks is in accordance with design specifications for chemical and radioactive element compositions which control corrosion and heat generation, 3) gaseous effluents are filtered, and 4) tank failure does not occur. The operation criteria for the tanks should insure that these conditions will be met.

Security and Sabotage Prevention. The new double-shell tanks pose no new or unique risks due to security or sabotage-related events. A discussion of sabotage and security procedures is presented in ERDA-1538 (1975).

5.1.1.3 Operating Effects - Abnormal Events

The consequences for several postulated accident scenarios which could conceivably prevail during the operation period after loading of the new double-shell tanks were evaluated (Mirabella 1977) for the older, but similar double-shell tanks already in operation. The probability of any of the accidents occurring within the 50-yr design life of the tanks is very low. Events evaluated are listed as follows:

1. Routing of acid waste to underground storage
2. Seismic activity
3. Loss of utilities
4. Excess vacuum
5. Tank failure
6. Dome failure
7. Accumulations of hydrogen in underground storage tanks
8. Organic fire in a waste storage tank
9. Explosion of nitrate compounds
10. Failure of vessel ventilation exhaust filters
11. Tornado destruction of above ground tank farm facilities.

The events were separately evaluated for existing and fresh wastes because of differences in nature of the consequences for the two forms. In general, as is to be expected, the consequences are less for existing aged wastes than for fresh wastes because the latter contain more of the short-lived isotopes than the former.

Since there is only a small possibility that one of the thirteen new tanks would ever be used for storing fresh waste and such use would require extensive internal and external modifications; this statement does not examine use of the tanks with fresh waste.

ERDA-1538 postulated dome failure as the maximum credible accident. Reanalysis, based on the new double-shell tank design indicated that the maximum credible accident is a failure of the vessel ventilation exhaust filters (Mirabella 1977).

For the following analysis, the isotopic inventory has been updated to reflect current knowledge about the potential composition of double-shell slurry (Appendix F, Table 8). For existing or double-shell slurry wastes, all of the other listed accidents are of significantly less consequence than the failure of vessel ventilation exhaust filters (tornado destruction of the filters would have essentially the same consequence).

There are several postulated mechanisms of failure for the HEPA filters on the tanks related to the filters becoming damp or subjected to excessive pressure loading. Extensive design and safety features are incorporated in the tank design to preclude the event itself or to quickly alarm operating personnel if the failure were to occur. Emergency procedures in such an event are outlined in an Emergency Procedures Manual (Wilson 1977). Precautions include the following: vessel ventilation systems in the tank farms are provided with a number of pairs of HEPA filters in parallel. The systems are designed such that any defective filter pair can be isolated and replaced and the tanks placed on portable exhaust systems while the filters are being repaired. The sources that could create a positive pressure inside the tanks are highly controlled and alarms are provided; hence this failure mode has minimal possibility of occurrence.

Failure of the vessel ventilation exhaust filters would release to the environment the radioactive contamination contained in one pair of HEPA filters (Mirabella 1977). This release is limited by adminstrative control limits for the maximum amount of radioactive material that can build up on a HEPA filter. Under the controls, the inventory of Cs-137 in the pair of filters would be 0.03 Ci. The inventory of the other critical isotopes are: Sr-90 (0.0015 Ci), Ru-106 (0.0075 Ci), and Sb-125 (0.001 Ci). Assuming ground-level releasing of the total inventory collected on a filter pair which has a surface dose of 0.2 r/hr, the calculated doses are shown in Table 5.3.

TABLE 5.3. Dose from Tank Ventilation Exhaust Filter Failure

	Maximum Indivdual (rem)[a]		Population (person-rem)	
	1 yr	70 yr	1 yr	70 yr
Whole Body	3×10^{-4}	7×10^{-4}	1	2
Bone	3×10^{-4}	7×10^{-4}	1	2
Lung	6×10^{-6}	2×10^{-4}	0.2	0.7

(a) A hypothetical individual located such that he would receive the maximum dose.

Due to uncertainties in (1) the exact geometry of the activity which is collected on the filters, (2) the buildup factors, and (3) the mechanism for the release of activity from the tank solution to the filters, the values in the above table should be multipled by a factor of 2 for an assured conservative estimate. Even with the uncertainty multiplication factor, the doses are significantly lower than the radiation protection standards of 5 rem/yr to the total body of individuals in controlled areas (DOE 1977). This dose is also considerably below standards for individuals of the general public.

Range Fires. Range fires are fairly common on the Hanford Site in the cheatgrass desert shrub community at the rate of about 12 fires per year with extent ranging from less than one acre to less than 32,000 acres (ERDA-1538). In addition to fire fighting equipment on site, there is in place a management program to inhibit vegetational growth for the tank farm areas. Vegetational litter fires are not expected to have any impact on the integrity of the tanks or associated surface structures.

Postulated 800,000 Gallon Tank Leak. This scenario describes a "worst case" leak of 800,000 gallons of double-shell slurry to the soil medium. This leak would be many times greater than any previous leak at Hanford. The engineered design, engineered barriers, leak detection, and pumping systems currently incorporated in the new tanks virtually make it impossible for such an accident to occur unless catastrophic loss of institutional control and associated catastrophic destruction of a tank containing liquid (flowable) solutions would also result. Thus, while this scenario is not credible, it is discussed for its theoretical value.

A previous conservative analysis of a catastrophic 800,000 gallon leak from a waste tank as presented in ERDA-1538 (1975). That analysis was similar except:

- The inventory of nuclides for this scenario has been adjusted for double-shell slurry (see Appendix F).
- The depth of water table for current leak scenario is 291 feet (McGhan 1977) compared to 170 feet used in ERDA-1538. This depth of 291 feet is the actual depth of the water table under the new tanks in the 200 East Area.
- An undated dose code (PABLM) was used for the dose calculations. Approved quality assurance procedures were used in the dose code.

Other conservative assumptions made in ERDA-1538 are equally conservative for this case. A 2-yr travel time for the liquid down to the water table, soil retention of 2% of the total column volume, 1-year duration of flow into the water table followed by a 20-year travel time down the fastest flowpath to the river were assumed. Dispersion effects were neglected and the assumption was made that the tank liquor, which is much more viscous than water and is likely to react with the soil in such a manner as to immobilize it or greatly retard its movement, moves like water through the soil column. All of these assumptions are conservative.

The analyses of known ion sorption in the soil column from previous single-shell tank leaks indicate that cesium and strontium will never reach the river and would probably travel no more than a few tens of feet in the soil column. Of the nonsorbed or slightly sorbed radionuclides, only technetium (see following table) reaches the river undiminished. The remaining nuclides, ruthenium, tritium, antimony and iodine, are discharged to the river at negligible concentrations because of the small quantities initially present, radioactive decay, soil sorption, and the large dilution factors in the Columbia River.

Since the nuclides reaching the river do not include nuclides involved in chain decay, the ERDA-1538 results can be adjusted by multiplying by the ratio of the current inventory to the ERDA-1538 inventory value for the isotope. An added measure of conservation has been introduced into this study because only 41% of the waste reaches the water table as compared to 59% for ERDA-1538. The estimated total amounts of nuclides reaching the river are shown in Table 5.4.

TABLE 5.4. Source Term for the Postulated Waste Tank Leak to Ground

Isotope	Quantity[(a)] Released To River (Ci)
^{3}H	270
^{125}Sb	9.3×10^{-13}
^{106}Ru	0.044
^{99}Tc	2000
^{129}I	3.2

(a) Assumed to be released in 1-yr period following a 22-yr travel time from the tank site based on double-shell slurry inventory.

The radiation dose via river transport was computed to a hypothetical maximum individual and to the population (Yandon 1979) within 50 miles of the postulated accident. The effective half-lives of all of the nuclides involved are short enough in the body that essentially all of the dose is received within the first year. The total potential dose was calculated by summing the contributions from consumption of potentially contaminated foods, fish, water and immersion from recreational acivities (ERDA-1538 1975). An updated dose model, PABLM (Napier 1979) was used to compute the doses in Table 5.5.

TABLE 5.5. Radiation Dose from Postulated 800,000 Gallon Tank Leak for a Projected Population of 336,011 Within 80 km of the Tanks in the Year 2010

	Dose	
	Maximum Individual (rem)[(a)]	Population (man-rem)[(b)]
Whole Body	8.5×10^{-6}	1.8
G.I. Tract	8.9×10^{-4}	23.0
Bone	1.7×10^{-5}	2.1
Thyroid	1.1×10^{-3}	13.0

(a) 70-year dose commitment from 1 year intake, based on double-shell slurry inventory. Note that the allowable dose for occupational worker is 5 rem per year and 0.5 rem/year for individuals of the general public, both for whole body.
(b) There are no set standards for population dose, but genetic effects are postulated to occur at the rate of 50 to 300 per one million man-rem or 50-500 fatal cancers per one million man-rem (DOE 1979).

Although the doses to man are essentially inconsequential, a soil column 50 ft below ground of 8.4×10^4 m^3 (3×10^6 ft^3) would remain contaminated for several hundred years and would pose a potential hazard to any other use. Aquifer water quality could similarly be affected for an extended period of time because of sorption not accounted for in the example computation.

Contamination of the soil column via a large volume leak to the ground is clearly unacceptable. Leak collection sumps and radiation and conductivity monitors will allow detection of less than 100 gallons at the inner and bottom outer walls of the double-shell tanks. The detection system along with the annulus pump pit and the outer sump collector pump will assure that the probability of undetected leakage to the soil will be highly insignificant.

5.1.1.4 Decommissioning Impacts

At the end of the useful tank life or the adoption of a long-term isolation program, it is assumed that the tanks will be internally decontaminated, removed, and the site backfilled with clean fill. Contaminated tank components will be packaged and buried in a conventional manner. Excavated contaminated soil and concrete rubble will be transported to burial trenches. Clean backfill materials will be taken from a borrow pit. Dust control and revegetation of the borrow pit and backfilled material will be required.

This approach assumes the availability of decontamination equipment developed specifically for this operation. Other decomissioning options are possible, including in-situ disposal, superficial decontamination and filling of the empty tanks with sand and gravel, and entombment. These and other options will be considered at the time a decision is required for disposal of the retired tanks.

Non-nuclear environmental impacts associated with decomissioning will be negligible. The principal potential impact would be inadvertent release and disperson of radioactivity from the decomissioning operations.

One other impact for consideration is the permanent commitment of land space and possible conflict of land use if the tanks were to be isolated in place. The decision to be made depends on the judgment of possible additional radiation exposure and the commitment of repository space if the tanks were to be dismantled, packaged, and isolated elsewhere.

5.1.1.5 Irreversible and Irretrievable Commitment of Resources

The largest and most diverse commitment of resources is associated with the tank farm construction. An additional 3.5 hectares of land were required for the placement of the 13 tanks. The 5,100 MT of steel used in the tank liners and reinforcement rod and the 9,300 m^3 of concrete are a major commitment but with little impact on present resources or economy. Commitment of fuels was relatively significant, but was a one time use. All other usages are minor and will have no effect on critical depletable or renewable resources.

It is estimated that little of the construction materials will be recoverable because of present decontamination technology. Ultimate burial or entombment will probably be required.

Operating requirements are minimal. The electrical requirements are readily available and a minor part of the present Hanford Site utilization. This usage rate is not expected to increase or to pose a significant conflict with other electricity users for the present expected life of the tanks.

Decommissioning requirements are minimal with an estimated 6 ha (15 acres) to be dedicated to borrow pit and burial ground. Manpower estimate for decommissioning activities are estimated to be 78 manyears.

5.1.2 Alternatives to Proposed Action

The major adverse impact of adopting any of the alternatives (described in Chapter 3) is related to the continued storage of liquid high-level wastes in existing single-shell tanks of questionable integrity, due to the delay in the availability of the new double-shell tanks. Delay in the adoption of the preferred alternative would result in the increased risk of a leak. With the adoption of any of the alternatives to the proposed action, the environmental effects addressed in this section show some additional minor stresses to the environment from increased resource utilization in terms of land, materials and energy and from emissions. The major impact would be from implementing the alternative of using thicker and more chemically resistant steel plates, if the tanks need to be rebuilt or relined. The overall environmental benefits of full adoption of any of the alternatives do not appear to be advantageous since only interim usage is planned for these tanks. There are no other foreseeable environmental effects.

5.1.2.1 Thicker and More Chemically Resistant Steel Plates

Hypothetically, this alternative would involve the construction of thirteen additional tanks and the abandonment of the present ones unless a new use can be found. If an alternative use cannot be found, the major impact becomes the expenditure of the approximately $75 million dollars worth of labor and materials already spent in the design and construction of the existing tanks, along with the necessity of spending an even larger sum for their replacements.

Other impacts resulting from the adoption of this alternative, minor in comparison, would include the additional commitment of approximately 10 ha (25 acres) of land for new tank construction as well as the additional land required for decommissioning and isolation if the tanks were dismantled at the end of their useful life.

Operational impacts would be similar to those for the proposed action.

Abnormal events would be similar to those for the proposed action, however in the event additional new tanks had to be constructed, longer surface transfer pipe conditions may pose some additional potential hazard for pipe leaks and consequent ground contamination.

This alternative would have the greatest impact on commitment of resources. The tanks presently under construction are nearly complete and could not be easily retrofitted with thicker or more chemically resistant steel plates. An additional commitment of resources in excess of those already committed would be required since the entire 13 tanks would probably have to be reconstructed. This would involve removing the existing tanks and complete reconstruction. None of these additional resources is projected to be recoverable. The possibility exists that the existing tanks could be used for some other application. This would require additional land for the reconstructed tanks.

5.1.2.2 Cathodic Protection System

The effective cathodic protection of the primary tank would require the placement of large rectifier units, associated wiring, and control equipment. Operation of this equipment will generate reactive gases (O_2, H_2, NH_3) which will be flushed out from the tank vapor space by the ventilation system. Generation of hydrogen increases the explosive hazards if the tank ventilation system were to fail.

This alternative would require some modification to the existing tanks for the placement of anodes and associated wiring. Additional minor resource commitments would be required. Most of these additional resources would not be considered as recoverable.

No additional significant impacts are expected.

5.1.2.3 Better Waste Retrieval Equipment and Enlarged Openings

This alternative is not expected to add appreciable adverse impacts unless major tank modification might indirectly result in shortening the tank life and integrity due to installation of major penetrations to the top of the tank. Additional or larger penetrations could also result in slightly increased emissions from new sealing problems, and increased complexity.

Extensive modification of the present tank tops to accommodate the larger openings would be required. At the present stage of construction this would require considerable expenditure of resources to accomplish and might result in structural damage to the tanks. In any event, the additional resources committed would not be considered as recoverable.

5.1.2.4 Cooling Coils

The major effect is indirect since tank top modification would affect the integrity of the tank containment. No major construction or operational effects are expected except for the possibility of slightly increased emissions from additional tank penetrations. Potential for occupational radiation exposure would be significantly increased at the time of dismantlement for decomissioning. There would also be a significant increase in cumbersome and highly contaminated piping to be packaged and isolated as well as interference with any waste retrieval system.

The presence of cooling coils in the tanks introduces the possibility of leak in the coils with subsequent external transport of the waste; this requires corrosion penetration into the coils combined with a loss of pressure in the cooling lines. Radiation monitors could detect this type of contamination and therefore the resulting direct environmental consequences would be minor. In this event, the cooling system would need decontamination or replacement or both.

The addition of cooling coils would require significant modification to the top of the tanks to accommodate insertion of the coils as well as providing feed-throughs for the necessary water supply. At the present stage of construction, these modifications would require considerable expenditure of resources and might result in structural damage to the present tanks. The requirement of from 2 to 4 miles of 2 in. steel pipe per tank would be an additional resource commitment.

5.2 SOCIOECONOMIC EFFECTS

This section deals with labor availability and community income aspects associated with project development, the indirect effects of secondary employment in surrounding communities and the physical and institutional requirements to supply the needs of additional workers coming into the region as a result of the proposed action and alternatives. The discussion is fairly brief, since the number of persons involved is small, an insignificant percentage of the present work force, and socioeconomic effects are minimal for all alternatives.

Indirect effects are usually proportional to the direct effects unless the influx of manpower puts significant stress upon local support resources and institutional bodies. Small increases of less than 5% of the present workforce has been determined to have little effect (HUD 1976). For the Hanford Site, the major socioeconomic impacts have already occurred because of many activities over the decades.

5.2.1 Construction Effects

Construction of the new tanks has extended over a four year period and will have required, upon completion early in 1980 approximately 258 man-years of effort. The peak employment of 104 people during the third year is less than 3% of the current Rockwell employment level and less than 1% of the total workforce involved with the Hanford Site Operations. At this level, no direct or indirect effects were detectable. It is probable that many of the workers on this project came from and will transfer to other projects running concurrently at the Hanford Site.

5.2.2 Operating Effects

The estimated staff requirements to operate the new tank facilities are 117 persons on a permanent basis. This labor requirement, like the construction manpower requirements, would have negligible impact on the economy, services, or traffic in the area. Thirty-four percent of the required staff will be involved with security of the facility. These staff will be incorporated into the standard safety, security, and antisabotage training programs in force at the time operations begin and will serve to protect other areas of the waste disposal facilities as well as the 13 specific tanks addressed in this EIS.

5.2.3 Decommissioning

It is estimated that at the end of the interim storage period, and after retrieval of the wastes for long-term storage period, 78 manyears of effort would be required for decontamination, disassembly, packaging, and burial of the subject AN and AW tanks. At that time, the employment impact is expected to be minimal; however, if other major projects have ceased at the Hanford Site, the decontamination and decomissioning effort could prove beneficial to the economy and the local communities.

5.2.4 Alternatives

Except for the alternative requiring the construction of 13 new tanks, the implementation of the other alternatives discussed in this EIS will have essentially no impact on socioeconomic issues. Implementation would require additional materials usage and/or retrofitting which would require program delays, increased costs, increased manpower, and delays in removing leaking tanks from service. These factors would not impact signficantly on the socioeconomic issues, however there would be a direct effect on the waste management program resulting from the accompanying program delays.

5.3 RELATIONSHIP BETWEEN SHORT-TERM USE OF MAN'S ENVIRONMENT AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

There are tradeoffs between the short-term and long-term benefits and costs. "Short-term" is used here to denote the construction and storage period (operation lifetime) for the 13 new high-level storage tanks.

The use of the tanks described in this EIS for interim storage of high-level waste (until long-term isolation programs are defined and placed into operation) will provide increased protection of the off-site environment and will remove only a small portion (approximately 8.6 acres, 3.5 ha) of the on-site environment for the long-term. Current Hanford waste management operations have defined certain areas (primarily the 200 Area of about 5,100 acres, 2,065 ha) for continued long-term use in waste disposal or storage. The 8.6 acres of land required for the proposed action (13 tanks) is only a small fraction of the Hanford site's total of 570 square miles or 365,000 acres (148,000 ha). Possible construction of a long-term basalt repository will add only slightly to the overall land requirement for waste management operations. Most of the Hanford Site and all of the land, water, and air resources surrounding the waste disposal areas are protected for possible long-term uses since the waste disposal and storage sites are few in number and are centrally located on the site.

Large portions of the land on the Hanford site are being put to other productive uses:

- Arid Land Ecology Reserve
- Washington State Game Reserve
- commercial low-level waste burial ground
- commercial nuclear power plants
- Research and development facilities for energy
- National Environmental Research Park (NERP)

Over the past years many changes of varying degree of impacts have occurred within the dedicated portion of the site. Installations of fences, telephone lines, and transmission lines are regarded as sight changes where the construction effects were minor. Some longer-term effects resulting from road and structure construction are present; however these could be removed at moderate costs, allowing the land to revert naturally over several decades to its original state. Some major changes involve the constructon of massive concrete buildings and the installation of the underground waste storage tanks, including those discussed in this EIS. In most cases, little incentive or reason exists to attempt total restoration of these areas since the use of the land for any other conceivable use could not produce a cost effective reason for restoration.

Considering all effects on man's environment from the operation of the 13 new tanks, a very small long-term effect is forecasted for the productivity of man's environment. The direct effects result from the very small areas of land permanently removed and dedicated to waste storage and isolation. Since the new tanks are located in a (currently) heavily managed area, the loss of habitat for wildlife is not significant or detectable for the long-term, if ever, in view of the preponderance of large areas of similar habitat on the site and on adjacent lands. Under routine conditions, the release of radioactive materials to the biosphere will be undetectable and will not manifest any impact on local biota.

The unique climatological, geological and geohydrological features of the Hanford Site which have contributed to the isolated status of the area until it was selected for nuclear material production beginning 1943 include: the low rainfall (6.3 in./yr), the unusually deep water table (250 ft below the surface), the excellent sorption capacity of the soil for most radionuclides, and the vast thickness of the stable underlying basalt formation, all of which uniquely qualify the site for the utilization as presently planned.

Future plans for the Hanford Site call for the continuation of the present use as an area dedicated primarily to energy activities. Thus, the use of man's environment at the Hanford Site is planned to be long-term; unless loss of institutional control occurs, energy-related activity will continue at the Hanford site for the foreseeable future. On the long-term, additional site land may be dedicated to other nuclear or other energy facilities or activities. To balance this usage, some current activities will cease, releasing some areas for future use. The direct net effect will probably be a slightly increased encroachment upon the environment over the long-term.

The primary activities on the Hanford Site are planned and carried out with the overall objective of benefiting man's social/economic environment. The short-term storage of high-level wastes in tanks will provide an overall benefit by reducing substantially the potential environmental effects that would result from unprogrammed releases of waste materials to the environment. Continued storage of liquid wastes in leaking tanks is clearly not acceptable and the use of the new tanks is required to contain these wastes for an interim period until the long-term waste management program has been defined and executed.

5.4 RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS

The continued operation of the Hanford waste management facilities, including the 13 new tanks under consideration in this EIS, will not conflict with national, state, or local plans and programs. Implementation of the action proposed in this EIS (i.e., utilization of double-wall tanks to store liquids to be transferred from older single-wall tanks to provide improved total containment of waste radioactive materials and to keep their release to the environment to the lowest level technically and economically feasible), calls for limited dedicated land use as described in Chapter 3. All of the land in question is currently dedicated to this use and the long-term plans call for continued dedication of the land for the foreseeable future. All land is and will continue to be managed consistently with federal regulations to assure the safety and well being of the public.

The establishment of the National Environmental Research Park (NERP) at the Hanford Site has dedicated a majority of the land for research purposes. This prohibits the use of much of the Hanford Site for commercial, public, and agricultural resource utilization in the long-term. The operating and waste management areas are specifically excluded from the NERP areas.

5.5 CONCLUDING REMARKS

The preceding examination of the environmental consequences of the proposed action and the alternatives shows that whether the alternatives had been adopted before construction of the 13 new tanks, or, are now adopted, the major benefits of either action would be limited to a potential, but not assured, extension of the life and durability of the tanks, and there would be no reasonably foreseeable major reduction in environmental consequences to the affected environment. Even if the tank contents were to contact the soil, the absence of an active underground transport mechanism for the radionuclides at the Hanford Site would prevent any significant environmental consequences. The design life of the existing new tanks is considered sufficiently long to safely contain the wastes pending implementation of long-term disposal options, so long as the planned administrative control of waste compositions and tank farm operating procedures are implemented.

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GLOSSARY

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ALARA	As low as reasonably achievable
ALE	Arid Lands Ecology Reserve
annulus	Space between the primary and secondary tanks of the double-shell tanks
anode	positively charged electrode
ANSI	American National Standards Institute
aquifer	underground source of water
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
B-plant process	a process for removing and ecapsulating cesium and strontium from defense high-level waste
background radiation	the radiation in man's natural environment including cosmic rays and radiation from the naturally radioactive elements both inside and outside man and animal
BCL	Battelle, Columbus Laboratories
bounding	a worst case situation
Btu	British Thermal Units(s)
°C	degree(s) centrigrade
caustic	usually sodium hydroxides implies high pH (alkaline range)
caustic/nitrate ratio	a molar ratio of caustic to nitrate in the the high-level waste
CCW	complexant concentrate waste
CEQ	Council on Environmental Quality
cfm	cubic feet per minute
CFR	Code of Federal Regulations

Ci	Curie(s), the basic unit used to describe the intensity of radioactivity
cm	centimeter
decommissioning	removal from service decontamination of a nuclear facility
DOE	the Department of Energy
EDTA	ethylene diamine tetracetic acid
EIS	Environmental Impact Statement
EMF	Electromotive Force
ERDA	Energy Research and Development Adminstration
°F	degree(s) Fahrenheit
FFTF	Fast Flux Text Facility
ft	feet, foot
g acceleration	Acceleration of gravity
g/l	gram(s) per liter
gal	gallon(s)
ha	hectare(s)
HEPA	Filter-high efficiency particulate air filter
hr	hour(s)
kwh	kilowatt-hour(s)
HMS	Hanford Meteorological Station
in.	inch(es)
km	kilometer(s)
knuckle	transition area between the bottom and wall of the double-shell tanke
liquid level cycling	changes in the liquid level of the tanks

m	meter(s)
maximum individual	a hypothetical individual located such that he receives the maximum possible radioactive dose
mg	milligram(s)
microbiota	microorganisms
μg	microgram(s)
mil	1/1000 inch
mill scale	oxidized layer left on the steel by the milling process
Molar	M, a measure of concentration used by chemists
mrem	millirem(s), 10^{-3} rem
MT	Metric ton(s) tonne(s) ∿ 2200 lb
mv	millivolt
NAAQS	National Ambient Air Quality Standard
NAS	National Academy of Sciences
NBS	National Bureau Standards
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NRDC	National Resources Defense Council
PAS	Purex Acidified Sludge
pH	A measure of the acidity or alkalinity of a solution
PNL	Pacific Northwest Laboratory
psi	pounds per square inch
radionuclide	an unstable isotope of an element, which decays and emits radiation
refractory	heat resistant material
rem	roentgen equivalent man, unit of dose of an ionizing radiation

SCE	Standard Calomel Electrode, a standard electrode used to measure potentials in metallic corrosion
SCFM	standard cubic feet per minute
self-boiling waste	high-level waste that boils spontaneously because of its high concentration of short-lived radionuclides
seismic acceleration	acceleration caused by earthquakes
sludge	the solid matter that settles out of the high-level waste
sluice	dissolution and removal of high-level waste with water
sorb, sorption	assimilation of a gaseous or liquid substance either interstitially or on the surface of a solid
source term	the quantities of radionuclide present in the waste given for a specific accident
specific gravity	density (mass per unit volume) of a material relative to the density of water
SSE	Safe Shutdown Earthquake
stress corrosion	chemical corrosion such as of pressure vessels that is accelerated by stress concentration, either built into or resulting from a load
supernatants	the liquid portions of the high-level waste
thermally stress-relieved	heating of fabricated primary tanks to relieve their internal stresses
thermocouples	devices to measure temperature by converting temperature differences to an electrical signal
transport, transport mechanisms	movement of radionuclides to the environment
200 Areas	Hanford Waste Management Operations Center
WPPSS	Washington Public Power Supply System
viscosity	the degree to which a fluid resists flow

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LIST OF PREPARERS AND REVIEWERS

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B.S. Mathematics and Physics, Williamete University
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Mr. Albaugh came to ARHCO in 1975 and was the Project Engineer responsible for various phases of detailed design on the new double-shell tanks. Prior to coming to ARHCO he was a Design Engineer for Ebasco Services and worked on the analysis and design of structures in support of nuclear power plant construction. Mr. Albaugh's experience includes structural analysis, ASME Code design and construction, nondestructive testing and ANSI B.3.1 pipe design and fabrication.

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M.S., Metallurgical Engineering, Univ. of Washington, 1957
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Mr. Anderson has 27 years of professional experience (12 years with BNW) in the technical areas of fracture mechanics, civil structures and structural joining concepts with particular emphasis on interaction between fatigue and corrosion processes of structural degradation.

He has conducted interdisciplinary studies of metal fracture and fatigue at NASA, Langley Field, and collaborated with Professor Egon Orowan in studies of fatigue mechanisms at Boeing Scientific Research Laboratories. Mr. Anderson was on temporary assignment at Wright-Patterson Air Force Base from 1973-1975, where he performed analyses in the areas of structural fatigue, crack propagation, and damage tolerance during an Air Force Study of structural problems with the C-5A aircraft.

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Mr. Alzheimer has been employed at Battelle, Pacific Northwest Laboratories, since graduation from college. His primary areas of involvement have been mechanical testing and structural and thermal analysis. He has successfully completed the Engineer in Training examination.

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B.S., Chemical Engineering, Univ. of California/Berkeley, 1961
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Dr. Divine joined Battelle-Northwest in 1965. He was primarily concerned with studying corrosion mechanisms and kinetics in high-temperature fluids. He contributed significantly to programs aimed at establishing the effects of process parameters, such as fluid hydraulics, heat flux, and radiation, on corrosion processes, and on corrosion product transport and deposition within these systems. He has also been closely associated with studies on the removal of uranium and plutonium oxides from reactor cores. He has performed fundamental studies to elucidate the effects of process parameters on stress corrosion cracking of steel. Dr. Divine has also studied corrosion processes in nonaqueous solvent systems -- primarily concentrated mineral acids.

He is a registered professional engineer in the State of Washington, and is a Corrosion Specialist accredited by the National Association of Corrosion Engineers.

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Since joining the Battelle staff in 1947, Mr. Ewing has participated in a variety of programs in the fields of nuclear energy and environmental systems. Current responsibilities involve the technical supervision of and participation in various aspects of environmental systems research, particularly in pollution control technology. Mr. Ewing is a member of the American Institute of Chemical Engineers, and he is a registered professional engineer in the State of Ohio.

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Mr. Griffiths served in the U.S. Navy for 4 years as a nuclear propulsion engineer with the Division of Naval Reactors in Washington, DC, from 1973 through 1977. His responsibilities included preparation of component specifications and review of design reports, test reports, and procurement documents for nuclear power plant components used in Naval vessels and land-based prototypes. In August 1977, Mr. Griffiths joined Battelle-Northwest. His responsibilities here have included structural analysis of a variety of complex structures including nulear waste cansiters, nuclear waste calcination equipment, electrical transmission lines, surface dragline mining equipment, and power plant cooling towers.

B GRIGGS — Staff Scientist, Pacific Northwest Laboratory.

B.S., Chemistry, Univ. of California/L.A., 1953
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Mr. Griggs has been involved in trouble-shooting plant corrosion problems on the Hanford Site. This work has been primarily on the corrosion of aluminum, zircaloy, steel, and inconel. He has also been active in the development of chemical processes for reactor decontamination and waste handling.

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Mr. Landstrom has directed and participated in a wide range of programs at Battelle involving analytical testing and analysis, materials characterization, mathematical modeling of environmental threats, technology transfer, environmental impact statements, radiation dose estimates, nuclear safety, rocket and space sytems impact, air pollution studies, and thermal analysis of cooling water plumes for power plants. He is active in the solar energy field and is directing a major solar energy collector development program. He is skilled in the communication of technical information, and has produced several motion pictures for training and documentation purposes.

JT MCGINNIS — Research Leader, Ecology and Ecosystems Analysis Section, Battelle-Columbus Laboratories.

B.S., Botany, Eastern Illinois University, 1956
M.S., Botany, University of Tennessee, 1958
Ph.D., Biology, Emory University, 1964

Dr. McGinnis has been a Battelle staff member since 1969. Prior to and since 1969, he has worked with the systems analyses of elemental and hydrologic budgets of Isthmian tropical forests related to the sea level canal feasibility studies. More recently, he has been involved in interdisciplinary programs on environmental impact assessment, including nuclear power plants, major impoundment, and Arctic pipeline construction. He has extensive experience in program management and technical program participation ranging in activity from ecological characterizations to program evaluations.

Dr. McGinnis is a member of the following honorary and professional societies: Sigma Xi (full member), American Association for the Advancement of Science (Fellow), Ecological Society of America, Association of Southeastern Biologists, Ohio Academy of Science, Association for Tropical Biology, American Men and Women of Science, and Personalities of the South and Southwest. He has coauthored one book, and published 21 technical articles.

KS MURTHY — Research Leader, Environmental Assessment Section Water and Land Resources Department, Pacific Northwest Laboratory.

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B.S.Ch.E, Indian Institute of Chemical Engineers, Calcutta, India, 1966
M.S., Environmental Engineering, University of Cincinnati, 1974

Mr. Murthy has been working for Battelle since September 1973. Some of the projects to which Mr. Murthy has contributed at Battelle are: the development of an approach to identify emerging environmental control technologies, the cost of clean air project, environmental considerations of oil shale development, the engineering analysis of the fluidized-bed combustion of coal, generic environmental impact statement for management of commercially generated radioactive waste, and programmatic environmental statements on long-term disposal options for Hanford defense wastes (in preparation). Mr. Murthy has published 16 papers and numerous technical reports. He is a registered professional engineer in Ohio.

APPENDIX A

APPENDIX A

This Appendix contains supporting information for Section 3.1.1 (description of double-wall tanks). Included are criteria and specifications governing design, fabrication, material selection and non-destructive examination procedures used in conjunction with the new double-shell tanks. In addition, sections on project Quality Assurance and Utilities Requirements are included.

TABLE A.1. Primary Tank Design Criteria

Design Element	Criteria Value	Basis and Comments
Primary Tank		• Maximum Tank size utilized at Hanford
Capacity	1,000,000 gallons	• Present 75' diameter tanks have a proven free-standing, self-supporting dome design
Specific Gravity	2.0	• Tanks to be utilized primarily for double-shell slurry sp. g 1.6 • Reference: ARH-CD-362, ARH-CD-304, ARH-CD-549
pH	8 to 14	• Based on the dilute to concentrated caustic nature of Hanford wastes that are stored in carbon steel tanks • pH greater than 7 precludes storage of acid waste which would require more extensive stainless steel tanks • Caustic concentrations from concentrated wastes are expected to be from 2M to not greater than 8M • Reference: Letter, R.C. Roal to K.S. Murthy, "Characterization of Future Waste to be Stored in AW and AN Tank Farms, December 7, 1979, in Appendix F
Temperature Tank Contents Tank Wall	 300°F Max. 200°F Max.	• Based on transfer of heat in the waste and considered potential high-temperature processes such as wiped film evaporation with a product temperature greater than 300°F • Projected tank skin temperatures less than 200°F with maximum content temperature approximately 300°F
Heat Generation	100,000 BTU/hr	• Based on the concentration of 6.0 Ci/gal. of ^{137}Cs Actual concentration anticipated is less than 1.5 Ci/gal of ^{137}Cs • Rate is conservative due to the fact that the rate will decrease the longer the waste is stored • Reference: Letter, R.C. Roal to K.S. Murthy, "Characterization of Future Wastes to be Stored in AW and AN Tank Farms, December 7, 1979, in Appendix F

TABLE A.1. (contd)

Design Element	Criteria Value	Basis and Comments
Corrosion	1 mil/yr	• A conservative average general corrosion allowance based on laboratory data that indicated corrosion rates up to 0.6 mil/yr for 5.75M caustic (synthetic) waste solutions with various concentrations of sodium nitrate and sodium nitrite at temperatures up to 95°C (203°F). This chemistry is typical of waste to be stored in double-shell tanks. (Payer 1975). - Based on 50-yr tank life, general corrosion would be less than 10 percent, which is within design allowances - Basis is conservative because waste will cool with age and decay. Laboratory data indicated corrosion less than 0.1 mil/yr at 25°C - Stress Corrosion Cracking (SSC) has not yet been demonstrated on test samples with these solutions - Tanks still require stress relief to minimize potential for SCC - Tensile stresses will be kept below 90% of yield strength as a precaution against SCC
Pressure		• Pressure and vacuum were based on experience on other tanks
Positive	+60 in.	• These critieria have been adequate and are applicable to new tanks
Negative	- 6 in. water	• Pressure excursions can result from uneven heating caused by hot spots, chemical mixing, or barometric changes • A slight vacuum is required on all tanks for vapor containment

TABLE A.1. (contd)

Design Element	Criteria Value	Basis and Comments
Seismic	0.25 g horiz 0.17 g vert. (SSE)	• Earthquake loads for category 1 facilities requires design for the SSE to assure a safe and orderly shutdown of the facility • The design basis for the ground acceleration is stated in ERDA-1538 "Final Environmental Statement Waste Management Operation Hanford Reservation, Richland, Washington" December 1975, Volume 2, Appendix II.3-C.
Liquid Level Cycling	- Ten cycles per year* - 7 foot daily fluctuation - max. fill and drain rate = 150 G.P.M. * applies only to feed tank	• Complete cycle defined as filling an empty tank to 1,000,000 gallons and drain till empty

TABLE A.2. Secondary Tank (Liner) Design Criteria

Design Criteria Element	Criteria Value	Basis and Comments
Reinforced Concrete Tank with Secondary Liner		
Pressure Temperature Heat Generation Seismic	Same as for Primary Tank	• Same as for primary tank (Table I) • Reference: ARH-CD-362, ARH-CD-304, ARH-CD-549
Dead Load	6.5 ft earthcover	• Earthcover was based on radiation shielding requirements over the tank and facilities on top of the tank • Reference: ARH-CD-362, ARH-CD-304, ARH-CD-549
Live Load	40 lb/ft^2 uniform, 50 ton concentrated	• Live loading on the tank was based on previous tank criteria which allows for a crane plus the heaviest movable equipment • Reference: ARH-CD-362, ARH-CD-304, ARH-CD-549
Thermal Concrete Creep	Max. heat = 3°F/day Max cooling = 3°F/day Determine max. allowable temperatures and cycles	• Heat up and cool down rates to be included in Operating Procedure • Unlimited cycling allowed in upper concrete haunch if temperature kept below 236°F • Steady state temperture of 320°F allowed in upper haunch. • Expected haunch temperatures are less than 200°F • Reference: ARH-C-17, Additional Analysis of Underground Waste Storage Tanks 241-AW, Hanford Wash, May, 1978

TABLE A.3. Material and Fabrication Specifications

Element	Specification	Reference and Comments
Steel Plate	ASTM A537 Class I	Construction Specification, B-120,C4, B-130-C4
Piping	ASTM A53, Type S, Grade A or ASTM A160, Grade A or B	Construction Specification, B-120-C4, B-130-C4
All other steel	ASME Section VIII, Div. 2	Construction Specification, B-120-C4, B-130-C4
Welding/Full Penetration on all joints	Hanford Plant Standard (HPS) HPS-220-W HPS-240-W	Construction Specification, B-120-C4, B-130-C4
Stress Relieving	ASME, Section VIII, Div. 2, Art. F-4	- Conducted on Primary Tank - 1100°F for one hour
Welding Materials	Certified per ASME, Section II, Part C.	Construction Specification, B-120-C4, B-130-C4
Fabrication	ASME Section VIII, Div. 2, Part AF, Except AF-235, AF-410.1, AF-410.2, AF-410.3, AF-410.5 and Article F-5, F-6 and F-7	Construction Specification, B-120-C4, B-130-C4
Cement	ASTM C150, Type II	Construction Specification
Aggregates	ASTM C33 Max. Size = 1.5 in	Construction Specification
Mixing	ASTM C94	Construction Specification
Proportion	ACI Sec. 3.8, Method 2	Construction Specification
Minimum Compressive Strength	Foundation - 4500 psi @28 days Shell - 5000 psi @28 days	Construction Specification
Reinforcing Steel	ACI 301	Construction Specification
Form Construction and Removal	ACI 301	Construction Specification
Curing	Foundation - ACl 301 Sec. 12.2 Shell - ACI 301, Sec. 12.1, 12.2, 12.3	Construction Specification
Testing	ACI 301	Construction Specification

TABLE A.4. Non-Destructive Examination/Steel Tanks

Method	Reference	Comments
Visual Inspection of all welds	HPS-220-W HPS-240-W	• Visual inspection of each weld pass on all welds
Liquid Penetrant Examination	ASME Sect. VIII Div. 2, App. 9	• Examine all welds on internal surface of tank bottoms on primary and secondary tanks • Examination conducted before and after bottoms are set in place and after stress relief
Magnetic Particle Examination	ASME Sect. VIII Div. 2, App. 9	• Conducted on areas where clips, lugs, etc. have been removed and all areas where plate damage has been repaired by filing, grinding, welding, etc
Radiographic Examination	ASME Sect. VIII Div. 2, Art. 1-5	• Conducted on all welds in primary and secondary tank excluding dome
Hydrostatic Test	B-120-C4 B-130-C4	• Conducted in primary tank by filling to a depth of 35 ft for 24 hours
Ultrasonic	ASTM A-578	• Testing conducted on plates at mill
Chemical and Physical Certification	Per requirements of ASTM A-537	• Complete traceability back to mill is a requirement
Dimensional tolerances	Construction specifications	• Includes bottom flatness tolerances developed by PNL "Recommended Bottom Flatness Tolerances for Million Gallon Waste Storage Tanks," W.E.Anderson, et al. 1976

A.1 QUALITY ASSURANCE

A.1.1 Scope

The Quality Assurance requirements for double-shell tank design and construction meet the requirements of DOE-Manual, RL Appendix 6101, Part III, B.3.6 (b). The Quality Assurance plans for the projects under which the double-shell tanks are being built are as follows:

B-120, 241-AW Tank Farm	ARH-CD-544
B-130, 241-AN Tank Farm	ARH-CD-786
B-179, 241-AN-107 Tank	RHO-CD-36

These documents delineate the broad quality requirements of the project in the activities of all contractors involved in the performance of this project. In addition, Rockwell Hanford Operation (Rockwell), Vitro Engineering Corporation (Vitro) and J. A. Jones Construction Services Company (J. A. Jones) are responsible for adherence to an approved quality program that complies to ERDA MC-0820. RL Appendix. J. A. Jones subcontractors shall meet the specific quality requirements defined in the "Special Conditions" of any contract.

Periodic reviews of the Quality Assurance Plans are performed to ascertain and document that specified quality requirements are current and complete. All revisions to these plans receive the same level of review as the original.

A.1.2 Quality Assurance Levels

Rockwell Hanford Operations has established three Quality Assurance (QA) Levels which define the quality effort applied to verify conformance to design requirements. These Quality Assurance Levels are designated as QA Level I, QA Level II or QA Level III.

A.1.2.1 Quality Assurance Level I Systems

Quality Assurance Level I Systems are those systems, or portions of systems, structures or components, whose failure might cause, or increase the severity of, a release of radioactivity or a release of hazardous or toxic materials in the environs, structures, and components vital to the safe shutdown or isolation of the process or system.

Examples of QA Level I items are: Final containment systems for radioactive service, final exhaust systems up to, and including, the High Efficiency Particulate Air (HEPA) filter package, nuclear safety instumentation, effluent monitors and shipping containers.

A.1.2.2 Quality Assurance Level II Systems

Quality Assurance Level II Systems are those systems, or portions of systems, structures or components that are important to the operation of the process of system, but are not essential to safe shutdown and isolation.

Examples of QA Level II items are: Process vessels, jumpers, in-cell piping and process equipment, control instrumentation and fire detection systems.

A.1.2.3 Quality Assurance Level III Systems

Quality Assurance Level III items are those structures and equipment that are related to the process or system operation which are not essential to safe shutdown, but which do provide a function or service to the facility.

NOTE: Quality Assurance Level III also applies to those items that are commercial, off-the-shelf items for which existing commercial quality control practices are adequate. (Quality Assurance Level III commercial items may be used in QA Level I and QA Level II systems with appropriate testing or documentated analysis to verify utility in the particular application.)

Examples of QA Level III items are: Heating and air conditioning systems, portable water systems, sewage systems, cold drain systems, low-pressure steam systems and lighing systems.

A.1.2.4 Assignment of Quality Levels

Specific Quality Assurance Levels are as follows for the double-shell tank design and construction:

Quality Assurance Level I

A) Primary steel portions of tanks
B) Secondary steel portions of tanks
C) Pump pits
D) Annulus pump pits
E) Valve pits
F) Drain pit
Note: Compaction tests will be required for soils under tanks and all Level I Pits - items C, D, E and F.
G) All slurry piping encasements
H) All supernatant piping encasements
I) Encasement on piping from annulus pumps to pump pits
J) Clean out boxes and associated piping
K) Encasement on floor drain piping to the drain pit
L) Encasement on floor drain piping from leak detection pits to the pump pit wall
M) Leak detection pits
N) Leak and radiation detection components and systems
O) All primary tank risers
P) Tank farm ventilation system and containment components up to and including HEPA filters and HEPA filter housings
Q) All drain line encasements
R) All unencased drain lines
S) Flush Pits 241-AN-A and B.

Quality Assurance Level II

A) Concrete tank shells
B) Concrete structural foundations
C) Insulating concrete
D) Thermocouple conduit
E) Air supply piping, retainer and distribution ring
F) Jumper piping in the valve pits
G) Tank farm ventilation system and components not included in the preceding category
H) Instruments, including instrument air and electrical systems
I) All slurry and supernatant primary piping
J) Primary piping from the leak detection pits to their pump pits
K) All primary floor drain piping from Clean Out Boxes to Drain Pit 241-AN-02D
L) All remote pit jumpers
M) All secondary tank risers
N) All pumps and electrical equipment (including heat tracing)
O) Test risers

Quality Assurance Level III

All items not covered by Quality Assurance Levels I and II shall be considered Quality Assurance Level III.

A.1.3 Required Project Records

Project records include the following documentation:

A.1.3.1 Design Records

Applicable Codes and Standards Used in Design	(1)
As-Constructed Drawings	
Design Calculations and Record of Checks	
Design Changes Requests	
Design Deviations	
Design Procedures and Manuals	(2)
Design Reports	
Design Review Reports	
Drawing Control Procedures	
Purchase and Design Specifications and Amendments	
QA System Audit Report	
Reports of Engineering Surveillance of Field Activity	
Safety Analysis Report	(4)
Stress Reports	
Systems Descriptions	
System Process and Instrumentation Diagrams	
Technical Analysis, Evaluations, and Reports	

Comments:

1. Applicable codes and standards used in design are referenced in the project specifications and are available on request.
2. Architect-Engineer design procedures and manuals are on file and available on request.
3. Architect-Engineer drawing control procedures are on file and available on request.
4. The operating contractor assesses risks as part of the conceptual design. After the completion of design, the operating contractor performs a formal "Hazards Review." These documents will be included as part of the project files rather than a "Safety Analysis Report."

A.1.3.2 Procurement Records

Audit Reports
Procurement Procedures
Procurement Specification
Purchaser Order (unpriced) including Amendments
Purchaser's Pre-Award Quality Assurance Survey
Receiving Records
Supplier's Quality Assurance Program Manual

Comments:

1. Procurement procedure for all ERDA contractors are on file and available upon request.

A.1.3.3 Manufacturing

As-Built Drawings and Records
Certificate of Inspection and Test Personnel Qualification
Certificates of Compliance
Heat Treatment Procedures
Heat Treatment Records
Liquid Penetrant Examination Procedure
Liquid Penetrant Examination Final Results
Magnetic Particle Examination Procedure
Magnetic Particle Examination Final Results
Major Defect Repair Records
Material Properties Records
Nonconformance Reports
Packaging, Receiving, Storage Procedures
Performance Test Procedure and Results Record
Pressure Test Procedure
Pressure Test Results
Product Equipment Calibration Procedure
Product Equipment Calibration Records
QA Systems Audit Report

QA Manual, Procedures and Instructions
Radiographic Procedures
Radiographic Review Forms and Radiographs
Ultrasonic Examination Procedures
Ultrasonic Examination final Results
Welding Materials Control Procedures
Welding Personnel Qualification
Welding Personnel Qualification and Data Reports
Welding Procedures
Work Processing and Sequencing Documents

A.1.3.4 Civil

Aggregate Test Reports
Batch Plant Operation Reports
Cement Grab Sample Reports
Concrete Cylinder Test Reports and Charts (1)
Concrete Design Mix Reports
Concrete Placement Records
Material Property Reports on Containment Liner and Accessories
Material Property Reports on Metal Containment Shell and Accessories
Material Property Reports on Reinforcing Steel
Material Property Reports on Reinforcing Steel Splice Sleeve Material
Material Property Reports on Steel Embedments in Concrete
Material Property Reports on Structural Steel
Mix Water Chemical Analysis (2)
Procedure for Containment Vessel Pressure-Proof Test and Leak Rate Tests and Results
Reinforcing Steel Splice Operator Qualification Reports
Slump Test Results
Soil Compaction Test Reports
User's Tensile Test Reports on Reinforcing Steel Splices

Comments:

1. Concrete cylinder test reports are kept by the testing agency of the Administration. Testing agencies employed by subcontractors are not used for the acceptance of concrete.

2. Mix water chemical analysis are periodically done and are on file.

A.1.3.5 Welding

Heat Treatment Procedures
Heat Treatment Records
Liquid Penetrant Test Procedures
Liquid Penetrant Test Final Results
Magnetic Particle Test Procedures
Magnetic Particle Test Final Results
Major Weld Repair Procedures and Results
Radiographic Test Procedures

Radiographic Test Final Results
Weld Location Diagrams
Weld Procedures
Weld Procedures Qualifications and Results
Welding Filler Metal Material Reports
Welding Materials Control Procedures
Welding Personnel Qualifications
Visual Inspection Procedures
Visual Inspection Records

A.1.3.6 Mechanical

Construction Lifting and Handling Equipment Test Procedures, Inspection and Test Data
Data Sheets or Logs on Equipment Installation, Inspection and Alignment
Documentation of Systems Check-off (logs or data sheets)
Erection Procedures for Mechanical Components
Hydro-Test Procedures and Results
Installed Lifting and Handling Equipment Procedures, Inspection and Test Data
Material Property Records
Material Property Test Reports for Thermal Insulation
Pipe and Fittings Material Property Reports
Pipe Hanger and Restraint Data

A.1.3.7 Electrical and I&C

Certified Cable Test Reports
Documentation of Testing Performed After Installation and Prior to Systems Conditional Acceptance
Field Workmanship Checklist or Equivalent Logs
Instrument Calibration Results
Relay Test Procedures and Results
Reports of Pre-Installation Tests

A.1.3.8 General

As-Built Drawings and Records
Calibration of Measuring and Test Equipment and Instruments Procedures and Reports (1)
Certificate of Inspection and Test Personnel Qualification (1)
Field Audit Reports
Field Quality Assurance Manuals (1)
Final Inspection Reports and Releases
Nonconformance Reports
Special Tool Calibration Records (1)
Specifications and Drawings

Comments:

(1) This information is available and on file.

A.2 UTILITIES

The AN and AW Tank Farms obtain power from the AZ radial tap on general purpose area feeder C8-L6. This feeder originates at 251-W substation, as do all of the 13 8 KV area feeders for the 200 Areas. Should there be a fault at a point between the 251-W substation and the AZ tap-point on C8-L6, the line may be sectionalized and service restored to system by backfeeding from one of the remaining three general purpose area feeders in the 200-E Area in a matter of minutes. Should there be a fault on the AZ radial tap, power restoration cannot occur until the fault has been cleared. This can be accomplished in a matter of hours. The Occupational Safety Analysis Report for Double-Shell Waste Storage Tanks (OSAR) addresses the loss of utilities in a scenario.

APPENDIX B

SELECTION OF MATERIALS

APPENDIX B

SELECTION OF MATERIALS

The principal material of concern for waste tank construction is carbon steel, used to fabricate both the primary tank and the secondary tank liner on the surrounding concrete structure. Although concrete is important, it is of lesser concern; the principal problems can be resolved by adequate design. In the following discussion, the nature of the factors influencing the steel structure-related problems are examined and the steps which counteract these are described.

TANK STEELS

The structural material for the primary tanks must provide two main functions: 1) resist the mechanical forces exerted by the contents and 2) resist chemical attack or corrosion by those contents.

Coping with the mechanical forces basically involves general engineering principles, and is primarily a function of design, yield strength of the steel, and section thickness. This aspect of waste tank construction is fairly straightforward and needs no further discussion here.

CORROSION

Corrosion, however, is a critical problem for waste tanks, and warrants further discussion.

Corrosion is considered to be the undesired degradation of materials. The term is generally applied to metals which suffer electrochemical oxidation. Fontana and Green (1967) describe eight types of corrosion:

- uniform corrosion
- galvanic corrosion
- crevice corrosion
- pitting corrosion
- intergranular corrosion
- selective leaching
- erosion corrosion
- stress corrosion cracking

Several of these may be dismissed immediately as being inapplicable or unimportant for the tank situation. As used here, galvanic corrosion is the interaction of two dissimilar metals, such as copper and iron; it is not applicable because the tanks are of one metal. Intergranular corrosion is not pertinent because of the low alloying component concentrations in the steel.

Similarly, the lack of significant alloying constituents prevents selective leaching from being a problem. Finally, erosion corrosion is not expected because there will be no agitation of the solution other than by natural convection.

The remaining four types of corrosion have all been observed or are considered possible in these waste solutions. Uniform corrosion is considered to have occurred when no obvious localized corrosion has occurred. As pointed out by others, such as Gainer (1978), uniform attack is not uniformly distributed over a surface. However, the corrosion sites tend to move around, yielding on the average, "uniform" corrosion.

Crevice corrosion and pitting corrosion are similar, the chief difference being that crevice corrosion starts with a ready made pit (the crevice), whereas in pitting corrosion, the pit must be generated as a result of the particular operating conditions. As a result, crevice corrosion can begin more readily. Pitting on the other hand is extremely localized and can literally bore through a piece of metal. Pitting often requires an incubation period of up to years after which it progresses rapidly.

Stress corrosion cracking is considered to be a very undesirable form of corrosion. Its major feature is the almost non-existence of metal removal. Rather, the crack propagates through the bulk metal causing a consequent loss of strength and integrity. Stress cracking requires both specific chemical conditions and stress levels. Requisite conditions are not clearly defined yet for any metal. Work done to date has shown that of the materials typically present in waste solutions, caustic, nitrate and carbonate are associated with stress corrosion cracking of carbon steel (Reinoehl 1972). In addition to the presence of these chemicals in the proper concentration, it is necessary to stress the metal. Stresses can arise from internal forces, such as thermal and weld stresses, and from external forces, such as hydrostatic pressure. At present the mechanism of stress corrosion cracking is not sufficiently well enough described to define required stress limits. It is believed however, that carbon steel must be stressed to, or beyond, the yield point to stress crack in caustic; stresses in stainless steel do not have to be as high as the yield point, however, to affect cracking (Uhlig 1948).

EXPERIMENTAL CORROSION DATA FOR WASTE SOLUTION COMPOSITIONS

Maness (Appendix F) shows limited test data for carbon steel in simulated double-shell slurry, which predicts a uniform corrosion rate of 0.04 to 0.19 mil/yr at 25°C to 95°C. These data are well below the 1 mil/yr assumed in the structural analyses.

Payer (1975) reports corrosion data for a series of salt cake waste solutions whose chemical contents are somewhat different from double-shell slurry (higher caustic content for some cases, lower nitrate and nitrite content). Uniform corrosion rates predicted in these tests are 0.1 to 1.1 mil/yr. These rates also correspond well with the 1 mil/yr allowance assumed in the structural analyses. Moore (1977) reports uniform corrosion rates of carbon steel in terminal liquor. Composition of this waste agrees well with double-shell slurry, except for minor constituents. The measured corrosion rate for these tests was 0.5 mil/yr.

Available corrosion data for compositions departing significantly from the double-shell slurry are summarized below:

1. Maness (Appendix F) indicates a severe penalty in corrosion if the caustic content of the waste increases above the range specified in Appendix G. For example, with a 12M NaOH solution, the uniform corrosion rate increases up to 8.3 mil/yr depending on temperature. Also, Maness (1974) reports uniform corrosion rates of carbon steel in a variety of simulated solidified Hanford wastes. The OH series tests are somewhat applicable, although they represent a considerably more severe caustic environment. Uniform corrosion rates for these tests were higher in many cases than those of the previous reports, ranging from 0.7 to 2.4 mil/yr for the 22-month specimens. A wider range of rates yet were shown in shorter term specimens, 0.4 mil/yr up to 4.2 mil/yr.

2. Average pitting corrosion rates vary from up to 7 mil/yr, with maximum pitting rates up to 12 mil/yr in solidified Hanford waste (BNWL-1969). Tests in double-shell slurry (Maness, Appendix F) were of too short duration (2 months) to predict pitting rates, although incipient pitting was observed in the higher caustic solution tests. For the purposes of judging the effects of pitting on the primary tank shell, the 3 to 12 mil/yr figures will be used, even though this data involved considerably higher caustic waste than those planned for storage in the tanks.

CATHODIC CORROSION PROTECTION

Use of cathodic protection of metal structures is more frequent with structures exposed to a moist or liquid corrosion environment. It is not effective in dry or gaseous environments because the environment will not conduct electricity effectively. The relationship between surface potential and current density is influenced primarily by solution and metal composition and secondarily by surface corrosion product layers, crevice stress, and temperature. A current-density to surface-potential relationship for an idealized laboratory sample in one typical Hanford waste solution is shown in Figure B.1. The current alters the chemical compounds at the metal-solution interface (i.e., $2H^+ \rightarrow H_2$; $HO_3 \rightarrow NO_2^-$; $NO_2^- \rightarrow NH_3^o$; $4OH^- \rightarrow O_2$; $Fe^{+2} \rightarrow Fe^o$, etc.,) depending on the available electrical potential and reactant concentration. At the low current densities usually required for satisfactory mitigation of corrosion, the effect of the altered chemicals is insignificant, unless the metal is sensitive to the altered environment.

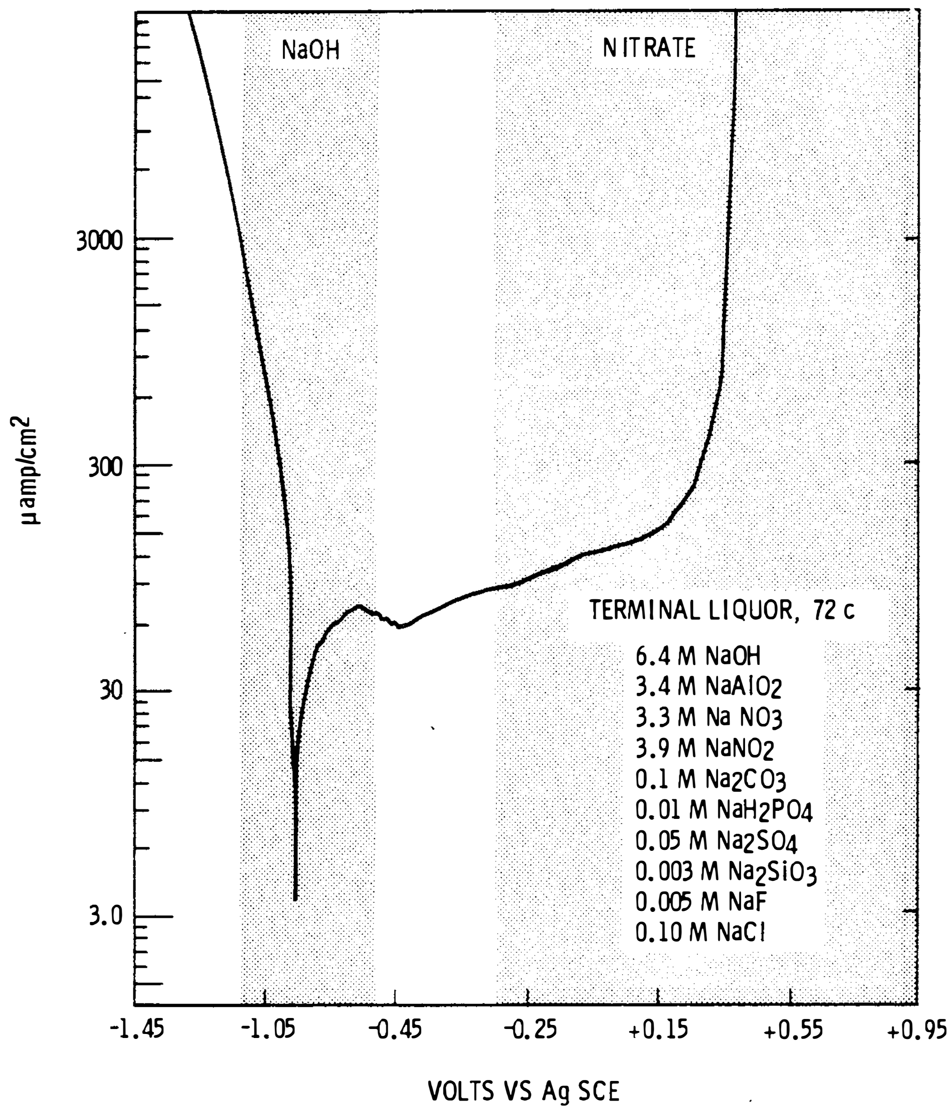

FIGURE B.1. Potentiodynamic Polarization of Mild Steel in Terminal Liquor

SOURCE: Moore 1977, Mazille 1972, Payer 1977b.

The Hanford tanks are to be used to store alkaline forms of processed Hanford waste. The nominal list of components and the expected range of their concentrations in the waste solutions are given in Appendix F. Because of the specialized source of these wastes, very little information on their corrosion characteristics exists in the open literature; available information is limited to a few summary statements. Therefore, emphasis has been placed on studies conducted specifically on these and similar solutions, the results of which have not all been published.

A summary of corrosion data on waste tanks by Lini (1975) showed that the high (6-8M) nitrate solutions produce stress corrosion cracking (SCC) of the as-welded carbon steel tanks adjacent to the welds. This cracking could be prevented by stress relieving the steel after erection. Also cathodic protection of at least 10 A/cm^2 prevents stress corrosion cracking in a laboratory test in a simulated Purex alkaline waste without added nitrite ion.

Two studies have been conducted to determine the feasibility of cathodic protection for the Hanford waste tanks. One by Norton Corrosion Limited and Pacific Northwest Laboratory (Moore 1977), analyzed the feasibility of applying cathodic protection to the interior of the tanks. A second study was conducted by Battelle Columbus Laboratories to determine the effects of solution composition on stress corrosion cracking (Payer 1977b). Preliminary results from the first study indicated that cathodic protection was feasible. This study was terminated however, when results from the Battelle Columbus study showed that cathodic protection, if not carefully controlled and maintained, could accelerate stress corrosion cracking. Further, the Battelle Columbus study showed that the simulated double-shell slurry waste solutions generally passivated the steel surface and would not promote stress corrosion cracking at their freely corroding potential. The Pacific Northwest Laboratory study showed that the freely corroding potential tended to shift positively with time and thus further reduce the potential for stress corrosion cracking, (see Table B.1).

The surface potential of a metal is affected in a complex manner by the solution composition. Payer (1977b, 1975) studied the effect of the various major constitutents of simulated double-shell waste on the potentiodynamic polarization of carbon steel. In addition, the severity of stress corrosion cracking (SCC) at various surface potentials was tested. He confirmed that steel immersed in solutions of sodium hydroxide would experience SCC over a range of potentials from about -0.77 to -1.05 V (SCE*). Additions of aluminate compressed the range of severe SCC to -0.95 to -1.05 V (SCE) while nitrite and nitrate raised the freely corroding potential of the steel above the SCC range. Payer concluded that solutions with compositions similar to double-shell slurry would not promote stress corrosion cracking of carbon steel if the surface potential remained slightly above -0.7 V (SCE). Maness (Moore 1977) found that steel samples placed in simulated Hanford waste concentrate assumed potentials of about -0.55 V (SCE) after they were corroded which places them comfortably above the SCC range (compare Table B.1 and Figure B.1).

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* Saturated Calomel Electrode is a standard reference electrode used in electrochemical work.

TABLE B.1. Potential of Mild Steel in Terminal Solution (60°C)

Surface Condition of Mild Steel	Potential, mv (versus Ag:AgCl)				
	5 min.	1 hr	72 hr	96 hr	120 hr
1) Polished	-802	-791	-600	-600	-609
2) Freshly polished	-1014	-973	-705	-595	-550
3) Corroded (3-yr contact with simulated Hanford high level wastes)	-520	-597	-593	-590	-587
4) Corroded (2-mo contact with simulated Hanford high level wastes)	-480	-630	-608	-590	-613
5) As hot-rolled	-403	-420	-579	-582	-596

SOURCE: Moore (1977)

Ranges in surface potential of carbon steel that are conducive to SCC in sodium hydroxide and nitrate solutions (Payer 1977b, Mazille 1972) are shown in Figure B.1 as shaded areas. Thus, if all other requirements (i.e., tensile stress, temperature, absence of inhibiting ions) are conducive to SCC, it will probably occur if a sample has a surface potential in one of the shaded areas.

Aluminate ions added to NaOH solution compress the left area to the range -0.95 to -1.05 (SCE) (Payer 1977b). The addition of other major waste ions in double-shell slurry produced slight stress corrosion cracking all the way up to -0.7 V (SEC). Thus, if the areas about -1.05 to -0.7 V and anything more positive than -0.3 V (SCE) are avoided, stress corrosion cracking becomes improbable with the double-shell slurry solution compositions.

The varieties of carbon steel used in various tests have included A201 gr B, A285 gr B, A106 gr B, A283 gr C, A516 gr 65, and A537. Chemically these materials are all quite similar and their test results have been used more or less interchangeably. Actually only A537 and A516 gr 65 have been experimentally compared to establish interchangeability of SCC results (Payer 1977a). Considering the normal variability of experimental data, there is no reason to believe that any of the test materials was unique. However, Uhlig (1974) found that some minor heat treatment and composition differences produced measurable results.

Limited corrosion data are available for the double-shell slurry at temperatures below 95°C, but at temperatures higher than 95°C no quantitative data were located. Predicting the corrosion of the tanks in these solutions at temperatures greater than 95°C, requires substantial extrapolations of existing data. Payer (1977b) examined the polarization behavior of steel in simulated double-shell slurry solution at 121°C and 148°C, and found no significant effect of temperature. He also found no effect of many minor ions in the alkaline nitrate, nitrite, aluminate solutions on polarization data for steel. In general, the uniform and pitting corrosion rates of steel in alkaline solutions ranging from 1 to 8 M NaOH, but with substantial quantities of $NaNO_3$, $NaNO_2$, and $NaAlO_2$ has been less than 0.5 mil/yr (Moore 1977, Maness 1975). However, if the sodium hydroxide is increased in concentration to about 15 M, the measured corrosion rate was as high as 4.2 mils/yr with pitting to 10 mils/yr (Maness 1974). Pre-cracked stress corrosion specimens in the same tests showed no crack propagation. This agrees with Payer (1977b) that the alkaline nitrate, nitrite, aluminate solutions spontaneously passivate steel to a potential that does not promote stress corrosion.

GENERAL CHARACTERISTICS OF CARBON STEELS

Conventional wisdom regarding high-strength low-alloy structural steel plate is outlined by reference to a standard test; Metals Handbook, Vol. 1, 8th Edition, 1961, American Society for Metals.

> "Caustic and Boiler Embrittlement. Embrittlement in conjunction with steam boilers (sometimes called caustic embrittlement) may give rise to cracks at riveted joints or other areas where contact between metal surfaces permits the accumulation of concentrated solution and where the stresses are high. Such embrittlement has been found also in rolled tube ends, tube ligaments, headers and threaded pipe connections. There is scant likelihood of embrittlement in mild steel in boilers unless it has been stressed beyond the yield point; the stress created by steam pressure or uniformly distributed structural loads has slight effect; on the other hand, stresses left from the roll forming of plate into a shell or drum, distortion during riveting, or any cold work that causes permanent deformation can provide the stress condition necessary for cracking. There are no data definitely showing any grade of mild steel to be more or less susceptible to this type of cracking than another grade."

Weldability is a relative term which must be carefully related to the welding method used and the skill of the technicians involved. Weldability may be carefully defined in terms of properties and soundness obtainable with different welding processes. In general, however, it is the ease with which a material can be welded with sound welds possessing good mechanical properties. The chief influential factors are composition, heat input, and rate of cooling. These factors produce various effects such as grain growth, phase changes, expansion, and contraction, which in turn determine weldability.

All comments about the effect of carbon and manganese on weldability must be qualified in terms of section size because of its relation to heat input and cooling rate. In welding heavier sections, the relatively cold base metal serves to accelerate greatly the cooling rate after welding, with the result that section size is a very important consideration.

Six principal types of cracking can occur during or after welding:

- solidification cracking (weld metal hot tearing)
- liquation cracking (heating-affected zone hot tearing)
- cold cracking (heat-affected zone)
- lamellar tearing (base metal)
- hydrogen-assisted cracking (heat-affected zone and weld)
- restraint cracking (weld and heat-affected zone).

Short-range stress systems due to solidification and thermal shrinkage activate many of these cracking modes. Longer range stress systems due to restraint may then act to extend the cracks by the same or other modes.

Sensitivity to cracking may be inherent in the composition of the metal or may develop as the result of welding. High sensitivity develops if metallurgical and welding factors combine adversely.

In general, serious cracking problems arise when one of the additive causes becomes excessively dominant. Thus, the usual solution is to identify the critical factors and establish procedures for minimizing them. For example, hydrogen-assisted cracking problems are generally solved by lowering hydrogen content. Additional controls (stress, hardness of the heat-affected zone, etc.) are important but not decisive if the hydrogen content is high.

Each cracking mode has its own metallurgical features. These are described by Pellini (1976).

PRIMARY STEEL TANK

The concept of containing high-level liquid waste in a sealed, stress-relieved vessel, including all penetrations, is a good engineering practice. Construction principles for achieving design goals are reasonable and well-devised. There appears no reason why the tanks cannot be fabricated with negligible construction stresses, barring the normally expected, unobserved "ding" from a dropped or mishandled tool following stress relief treatment. Such local marks can cause situations of residual stress where cracking may occur; but since the stress is local, the event stress is self-equilibrating and cracking will not proceed unless the general stress field is high. High stresses can occur in the tank walls and lower knuckle regions under some loadings; however, necessarily severe dings to initiate such cracking are much more likely in the tank bottom than in the sides. Nonetheless, the possibility for tank failure from this cause is real, though perhaps slight, and the design with secondary containment is well-advised.

Residual Stresses and Stress-Relief Treatment. Occurrence of residual stresses from welding or cold-work forming or other plastic deformations of the tank material may be expected as part of the ordinary circumstances of construction. Welding stresses are described above and may be understood by considering the locally violent processes of melting and solidification and cooling that occur during this joining method. As a first approximation, the residual stresses from welding, or other sources, may be taken as approximately yield strength value for the material involved. These stresses from welding can be very annoying during construction because they tend to cause warping and broad distortions. Care is necessary in the fabrication techniques to avoid such distortions so that the completed structure meets specifications.

In the primary tank, residual stresses are relieved by subjecting the entire vessel, including all penetrations, to a suitably high thermal exposure, called the stress-relief treatment. During this exposure, the stresses contained within the affected regions cause local creep on a microscopic scale and are thereby substantially reduced. The treatment is considered efficacious in dramatically reducing the incidence of stress-corrosion cracking of welded constructions.

The stress-relieved primary tank is therefore much less likely to leak from stress-corrosion cracking than the secondary tank, which is not stress-relieved.

SECONDARY STEEL LINER

The secondary steel liner and the reinforced concrete vault work together as a system. The steel of the secondary tank is not stress-relieved.

Should wastes leak into the annulus of the double-shell tanks, temporary containment is provided by the secondary tank (liner). Experiences with single-shell tanks indicate likely safe containment by the secondary tank for periods as least as long as several months.

Should the leak be substantial, with a typical slurry, pumpout from the annulus will likely require sluicing (addition of liquid to provide pumpability) and this action will add substantially to the total waste volume to be handled and transferred elsewhere. It is apparent the provision for such storage would be prudent, and one spare tank should always be available.

CORROSION RESISTANCE AND WASTE COMPOSITION

It is a common engineering situation for a structure or system to be designed for one use and, sooner or later, be used in a different way than intended. The waste storage tanks are of this genre. Their design specifications were broadened beyond what might be called a minimum design package, to include several likely possibilities, yet undefined. The temperature requirement of 350°F is an example; this situation is an upper bound of possible conditions in the typical tank, e.g. if certain film evaporation methods of waste concentration are used at some future time.

Thus, detailed information on waste composition is uncertain, since possibilities always exist for alteration or adjustment of the composition. Consequently, some corrosion studies have been conducted with so-called generic wastes; looking for some unusually deleterious set of conditions. In the case of studies bearing on possible cathodic protection systems, substantially greater efforts were applied until a clear resolution seemed in hand. It might be expected, then, that as more details about actual waste compositions which will be placed into the waste tanks becomes firm, more efforts will be expended in determining if any unusually aggressive corrosion of simulated tank structure might be generated within any likely excursions of chemical variation.

CONCRETE TANK

A brief explanation of why reinforced concrete is selected as the construction medium for underground storage systems may be useful. Underground storage is a good choice for reasons of security and accident, however, the choice requires substantial design skills to provide successful resistance to the soil pressures on such large vessels. The dome shape of the tank is vital to successful performance of the structure. By properly sizing and shaping the dome and the haunch region where the dome and walls join, stability of the system against normally conceived loading possibilities is assured, even though the relative proportions of the dome span and dome thickness might make it appear thin and flimsy like an egg-shell.

Structural stability of the tank results from balancing the dome shape and its thickness to suit the desired span dimensions, then providing analogous stability of the walls by suitable sizing. This sizing procedure has developed out of studies on such (relatively) thin structures, where it has been learned that maintaining relative thickness of the components above some critical value is necessary to suppress general instabilities and subsequent collapse. Consequently, the actual, computed stresses in the dome components - concrete and rebar - do not reach particularly large values, because of the necessity to keep the thickness well above critical buckling range.

Reinforced concrete construction utilizes the steel rebar quite efficiently, considering that the amount of rebar is just a fraction of the amount of sectional area at any given location. Interestingly enough, even under relatively modest loads, concrete, itself, creeps measurably. Thus, the rebar, in reinforced construction, tends to pick up loads shed by the concrete.

Rebar stresses thereby increase almost inversely to their percentage of content in a particular section; in effect, they become more heavily worked and hence the system is quite efficient. The concrete carries some of the principal loading, but its more important structural function is to continuously support the rebar so it doesn't buckle and collapse, which would occur if the concrete were absent or removed.

If the structural vault were made entirely of steel, it would still need to be almost as thick as the reinforced concrete because of the basic requirement to maintain thickness above critical dimensions. Cost and fabrication difficulties associated with such massive steelwork are not reasonable or cost-effective compared with concrete design. The actual reinforced concrete vault construction is therefore prudent engineering.

APPENDIX C

WASTE RETRIEVAL TECHNOLOGY

APPENDIX C

WASTE RETRIEVAL TECHNOLOGY

Projections on waste types and volumes requiring interim storage in the 13 double-shell tanks have been made through the next decade. These projections indicate that the high-level radioactive waste requiring such storage will consist of approximately four million gallons of liquid waste awaiting conversion to double-shell slurry; eight million gallons of double-shell slurry (a gelatinous, cream of wheat-like water-soluble semi-solid); and, depending on future programs, approximately one million gallons of sludge (a water-insoluble semi-solid).

Removal of these radioactive wastes from the one-million gallon capacity double-shell tanks may be required at some future date. This removal may be for reasons of: a) a leaking tank, in which case the waste would probably have to be removed with minimal increase in volume by dilution to facilitate placing it in a spare tank of equal volume, b) interim processing, in which case the waste could sustain minimal to moderate dilution but would ultimately be reduced in volume by evaporation of its water content and then replaced in the tanks, or c) final processing, in which case the wastes could sustain moderate to full dilution depending on the type of processing and time available to both carry it out and to vacate the tanks.

The technology for handling and moving liquids, slurries, and sludges by pump and pipeline predates the construction of radioactive materials processing facilities at Hanford. It has been an evolving technology, with existing equipment being modified and adapted to meet specific requirements and applications both here at Hanford and also at other nuclear waste facilities around the world. The specific application of this technology to the removal of radioactive wastes from underground tanks, however, has and is being done most notably at Hanford and Savannah River. A discussion of the methods of retrieving wastes from double-shell tanks should perhaps be divided into two categories, namely, extended-term and near-term retrieval methods. Extended-term can be described as scheduled retrieval to be done in conjunction with interim or final processing of the in-tank wastes. Of necessity, such a retrieval system would be a fully-engineered system taking into account Hanford parameters and would be the result of an engineering development and testing program. Near-term, on the other hand, can be described as unscheduled retrieval to be done in conjunction with situations such as where a primary tank has developed a leak and the waste contained in it must be moved to another tank.

A hydraulic system of sluicing and slurry pumping is proposed for retrieving double-shell slurry and sludge wastes from in-tank.

The first task in this operation is deploying the necessary equipment over the tanks and into the waste to be retrieved. Referring to Figure C.1, the pumping equipment would be inserted through a 42 in. dia riser located in the top of the tank some 7 to 10 ft below grade and then lowered, first through a 16 ft air space above the waste surface, and then an additional 30 ft through the waste to the bottom of the tank, approximately, 56 ft overall below grade. Connections to existing underground piping would be made within the 8 x 12 ft concrete pump pit situated on top of the concrete tank dome and extending some 7 ft below grade. In the past, pumping equipment has been simply suspended and lowered into the tanks by manually operated cranes. However, because the 30 ft depth of waste that the equipment must penetrate may become quite consolidated, and because the equipment may have to "work" its way down to the bottom of the tank at a controlled rate over a lengthy time period, a conceptual system along the lines of that shown in Figure C.2 is being considered. The sketch shows a mobile operations control room which can be placed by crane or driven over the tank pump pit. A tower containing the sluicing/pumping equipment would then be erected (by crane or other means) and attached to the top of the Operations Control Room. The tower could be stabilized by guy wires extending from the top of the tower to earth anchors. The tower would also house the equipment for lowering the sluicing/pumping equipment into the tank. It is fully

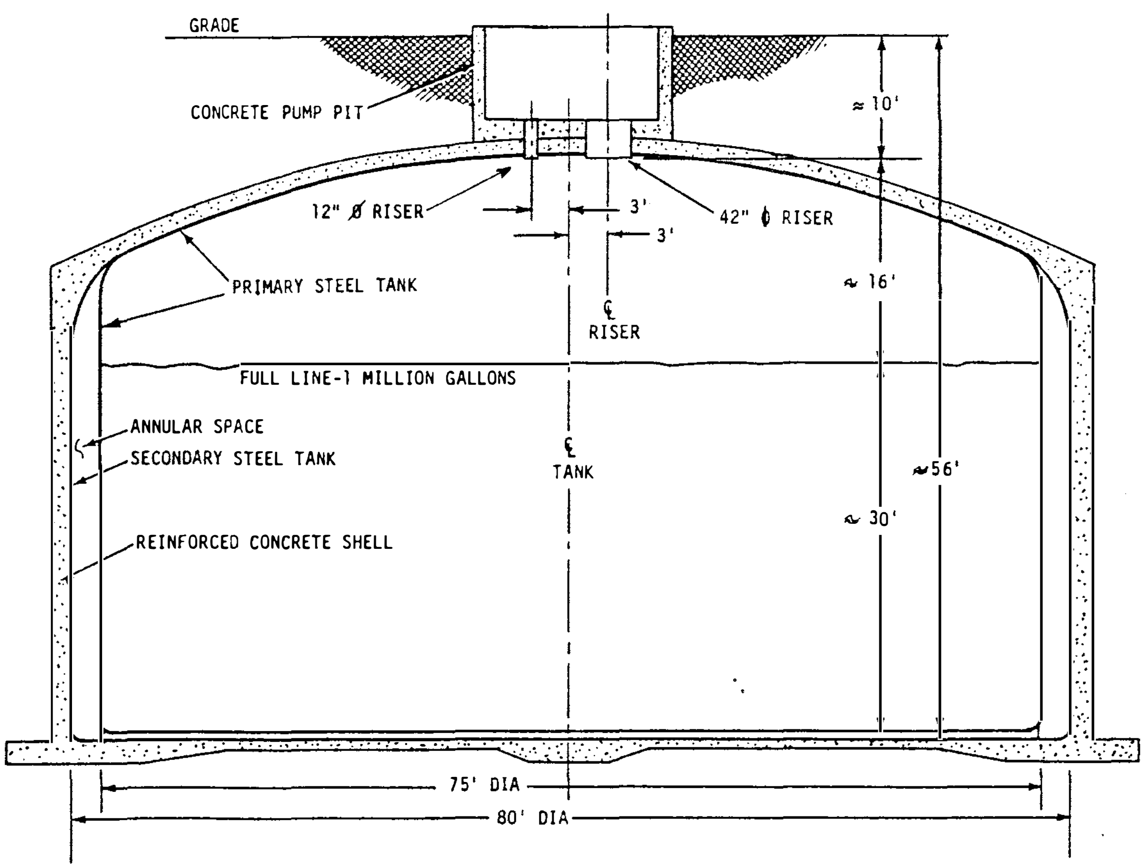

FIGURE C.1. Typical Double-Shell Tank Section

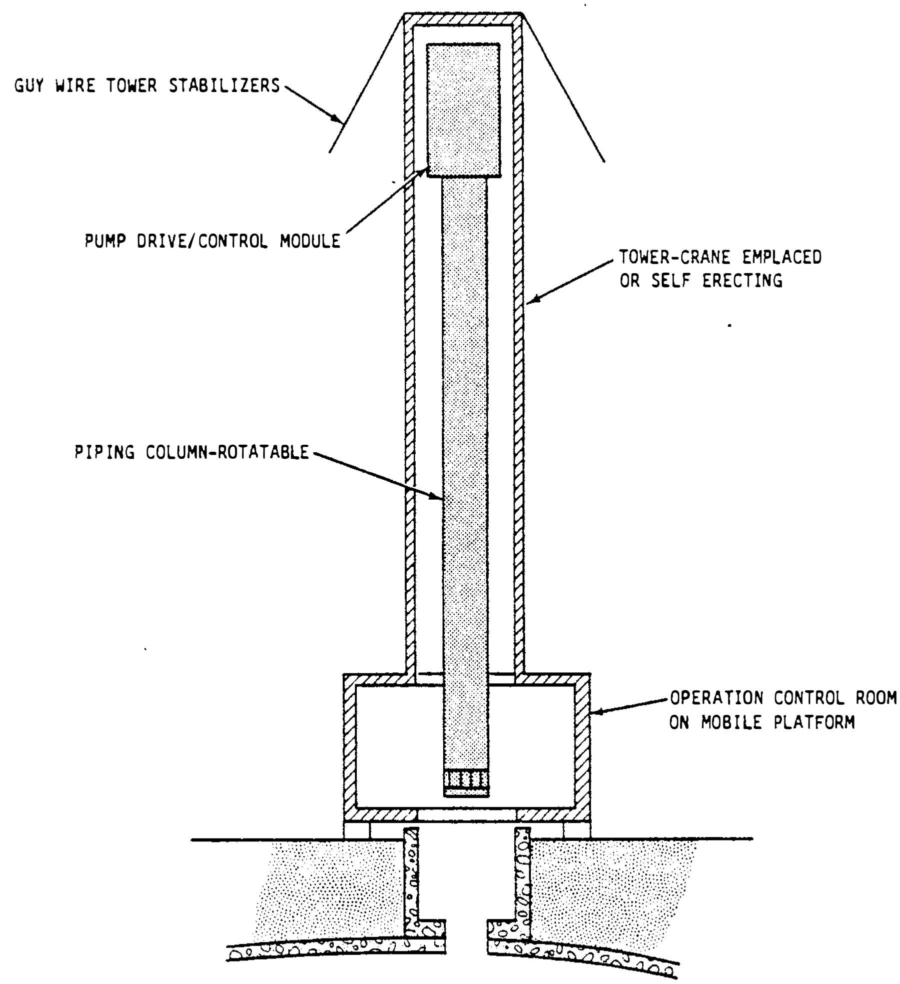

FIGURE C.2. Retrieval System - Equipment Set-up

expected that the Operations Control Room would not only serve to "plumb" and operate the sluicing/pumping equipment but would also have full functional capability for limiting personnel exposure, contamination control, and utilization of auxiliary systems such as electrical power, steam, water, air handling, and monitoring of in-tank conditions.

All pumps, piping, shafting, valving, controls, etc., would be contained in a piping column which would be a cylindrical casing of a diameter able to pass through the 42 in. dia riser on the top of the tank. All portals for fluid intake or discharge would be internally connected to and slightly recessed in the cylindrical casing wall. This would allow the entire piping column to be rotated (by a proper drive system) around its vertical axis with minimal impedance from the waste in which it is submerged. This may also allow premature emplacement or leaving the sluicing/pumping submerged for lengthy periods in a nonoperational state with minimal likelihood of its being "frozen in" by salt caking. Furthermore, the cylindrical shape and contained "plumbing" make the unit amenable to flushing and cleansing and thereby relocatable and reusable in another location. Figure C.3 shows the piping column being lowered into the waste. This would be done with high pressure jets of steam heated hot water from an outside source. Once it can be ascertained that a sufficient pool of liquid exists, the lower sluicers could be activated in conjunction with the slurry pump to circulate this liquid pool, agitating the waste, and assisting in submerging the piping column. The upper sluicers could be activated once they become submerged. Figure C.4 shows the piping column totally submerged and the submergence jets deactivated. Once this condition is reached the system can be plumbed to external piping and pump down of the tank can commence. It is anticipated that the sluicers can be individually activated and deactivated and that they are capable of using externally supplied liquid, recirculated in-tank liquid, or a combination of these. This would allow high dilution and pump out of the tank heel. For final cleansing and scouring, the tanks would be flooded with a series of wash solutions

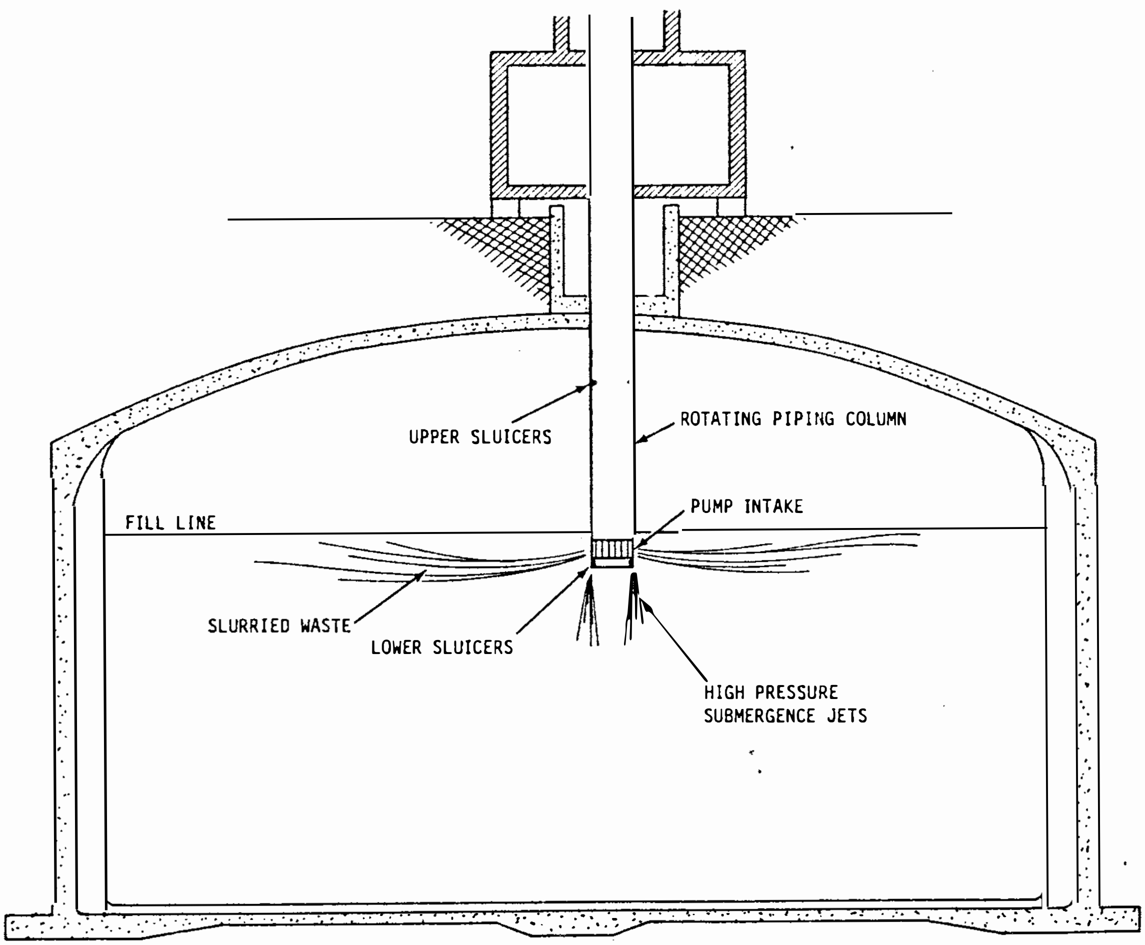

FIGURE C.3. Retrieval System - Equipment Emplacement

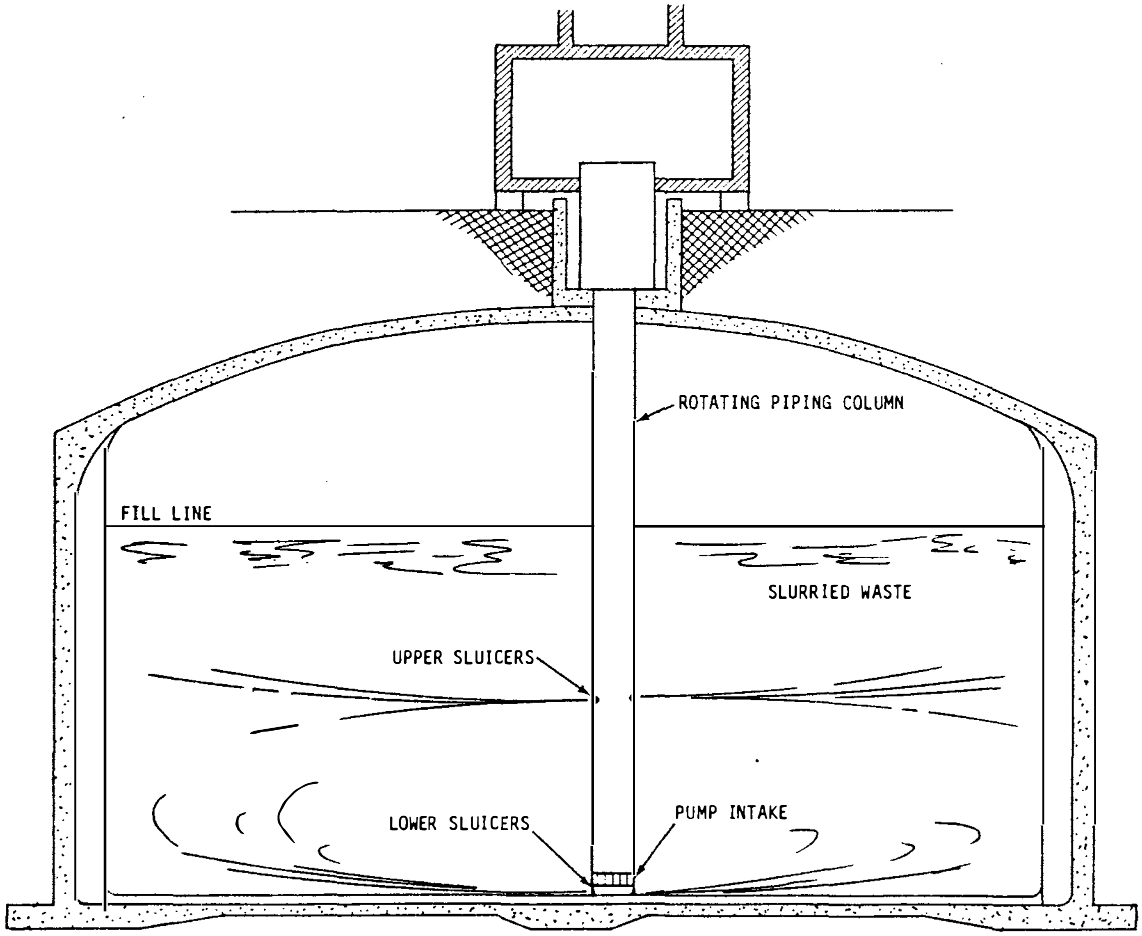

FIGURE C.4. Retrieval System - Equipment Operational

through the piping column, as envisioned in Figure C.5. The slurry pump, run at reduced speed, would be used to keep a reservoir within the piping column filled with the wash solution. This reservoir of wash solution would be drawn upon by an onboard high pressure pumping system supplying the wash jets. These jets could be manually or automatically deactivated either individually or in groups. By slight pressure variations and rotation of the piping column it is conceivable that the entire interior surface of the tank could be scoured, washed, and rinsed. The slurry pump would be used to pump out the bulk of this wash solution and then vacuum and other pumping means within the piping column could be used to reduce the liquid level to within a fraction of an inch of the bottom. Final drying of the tank interior (and the entire piping internal to the piping column if desired) could be accomplished by warm air circulation.

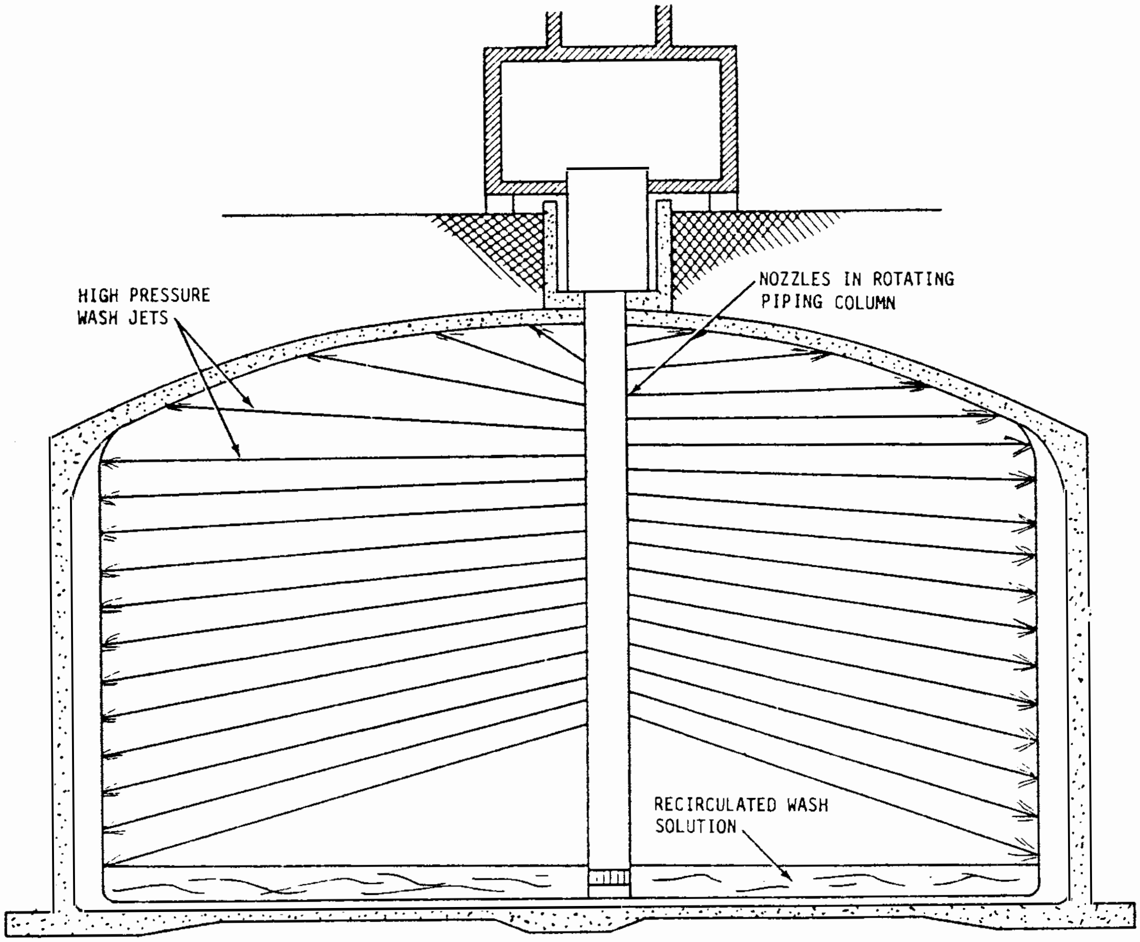

FIGURE C.5. Retrieval System - Tank Cleansing Operation

The retrieval system just described is still in the conceptual stage and may undergo modification. The concept, however, is a valid one and has as its basis similar equipment both commercially available and under development at Savannah River.

Commercially available equipment can be obtained from Marconaflo of Oakland, California. They manufacture two standard lines of sluicing/slurry pumping units with slurry pumping capacities ranging from 200 to 5000 gpm. The unit considered most adaptable to Hanford double-shell tanks is their Caisson line shown in Figure C.6. The intermediate piping and shafting between pump and motor can be modified as required to match the depth of double-shell tanks. The pump in this unit remains fixed and sluicing is accomplished by oscillating marconajet nozzles. Two jet nozzles can accomplish nearly 360° arc coverage and are capable of sluicing out to 50 to 100 ft radial distance. The pumps normally used by Marconaflo in their units are Hazleton pumps manufactured by Barrett, Haentjens and Co. of Hazleton, Pennsylvania. These pumps have been used before at Hanford in radioactive waste sludge transfers.

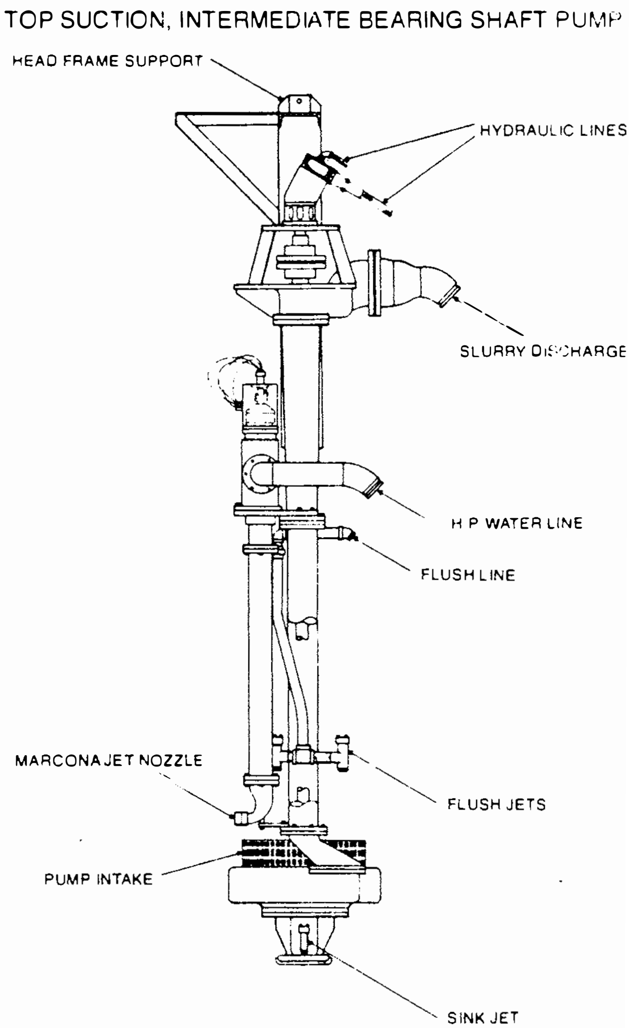

FIGURE C.6. Marconaflo Caisson Type Sluicing/Slurry Pump Unit

Equipment under development at Savannah River is shown in Figures C.7, C.8, and C.9. It consists of a centrifugal pump mounted in a piping column. The pump in the column itself does not discharge material from the tank. Its sole purpose is to slurry the contents of the tank by recirculation. The discharge from the pump exits through two nozzles 180° apart located at the base of the piping column. The pump, piping column, and pump motor can be made to rotate on a turntable mounting so that the entire tank contents can be sluiced and slurried. This system relies on a secondary slurry pump in another tank riser to discharge the slurried waste from the tank. Cleaning of the tank can be accomplished with a series of wash solutions introduced by rotary spray nozzles located in the upper portion of the tank and agitated by the recirculation slurry jets.

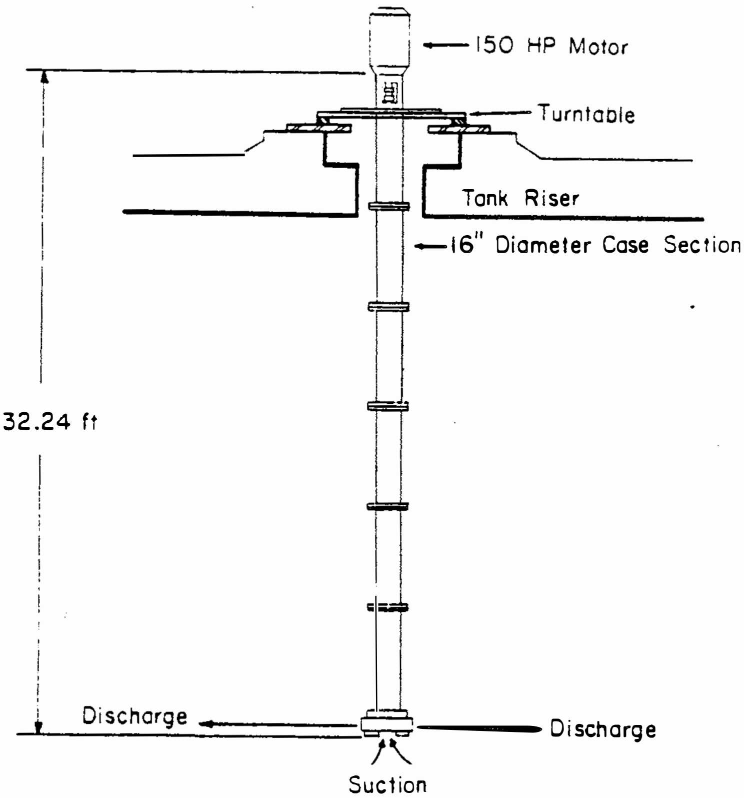

FIGURE C.7. Proposed Mounting of Slurrying Pump in Waste Tank Riser at Savannah River

As mentioned in Section 3.1.4.2, a mechanical retrieval system is another conceptual alernative; but the concept has not yet been reduced to practice for the retrieval of radioactive wastes from tanks. A conceptual system designed for mechnical retrieval of wastes from storage tanks at Hanford is shown in Figure C.10. Such systems are highly sensitive to the size, shape and location of the openings. The system shown is designed for a 42-in. opening.

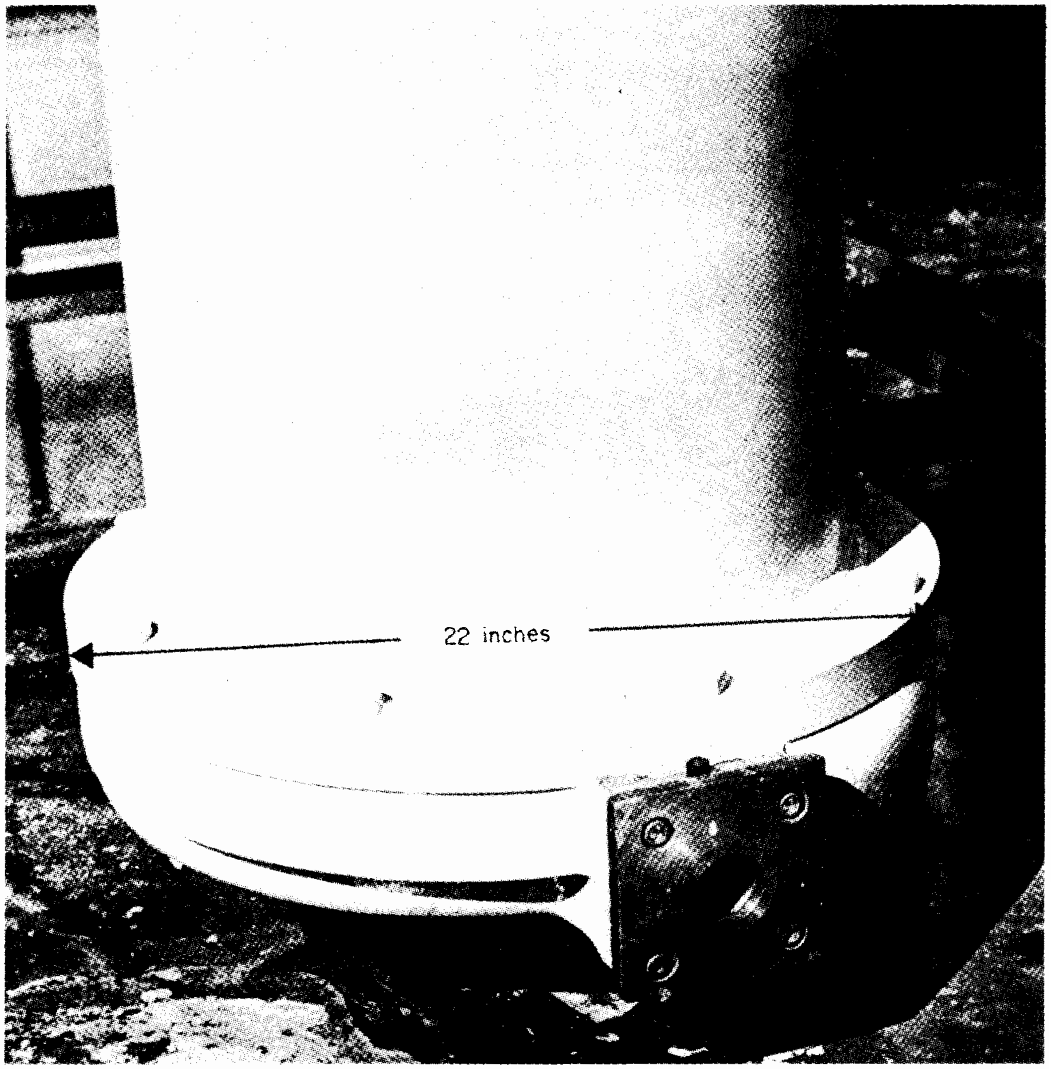

FIGURE C.8. Discharge Nozzle of Slurrying Pump

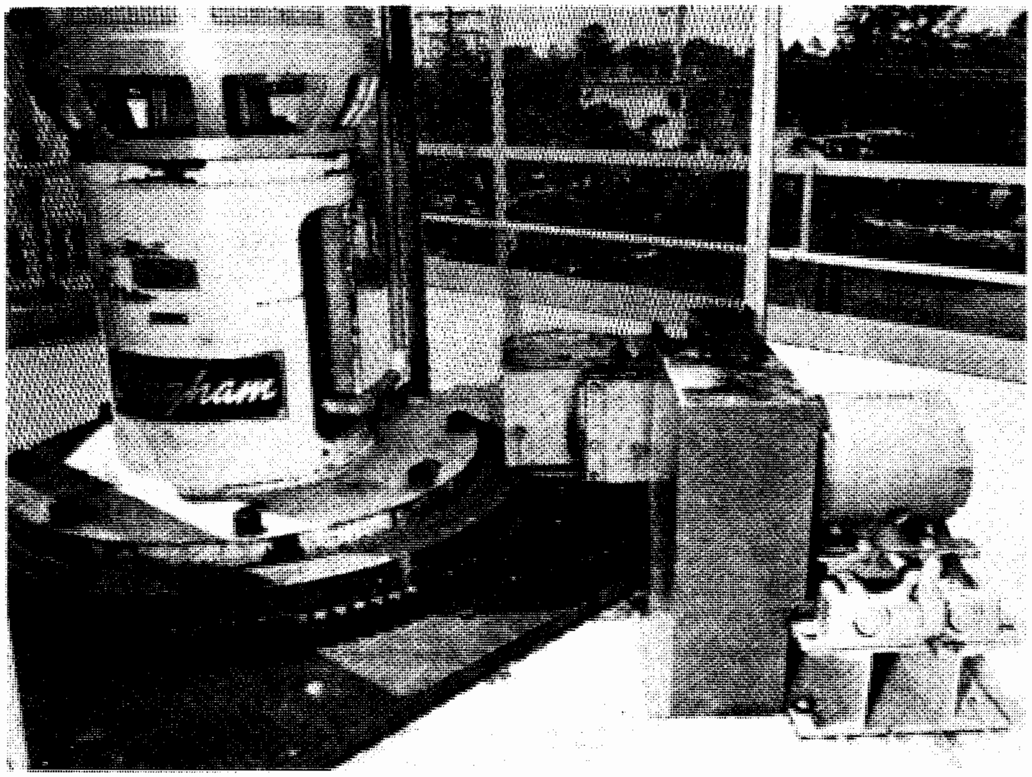

FIGURE C.9. Turntable and Pinion Drive for Slurrying Pump

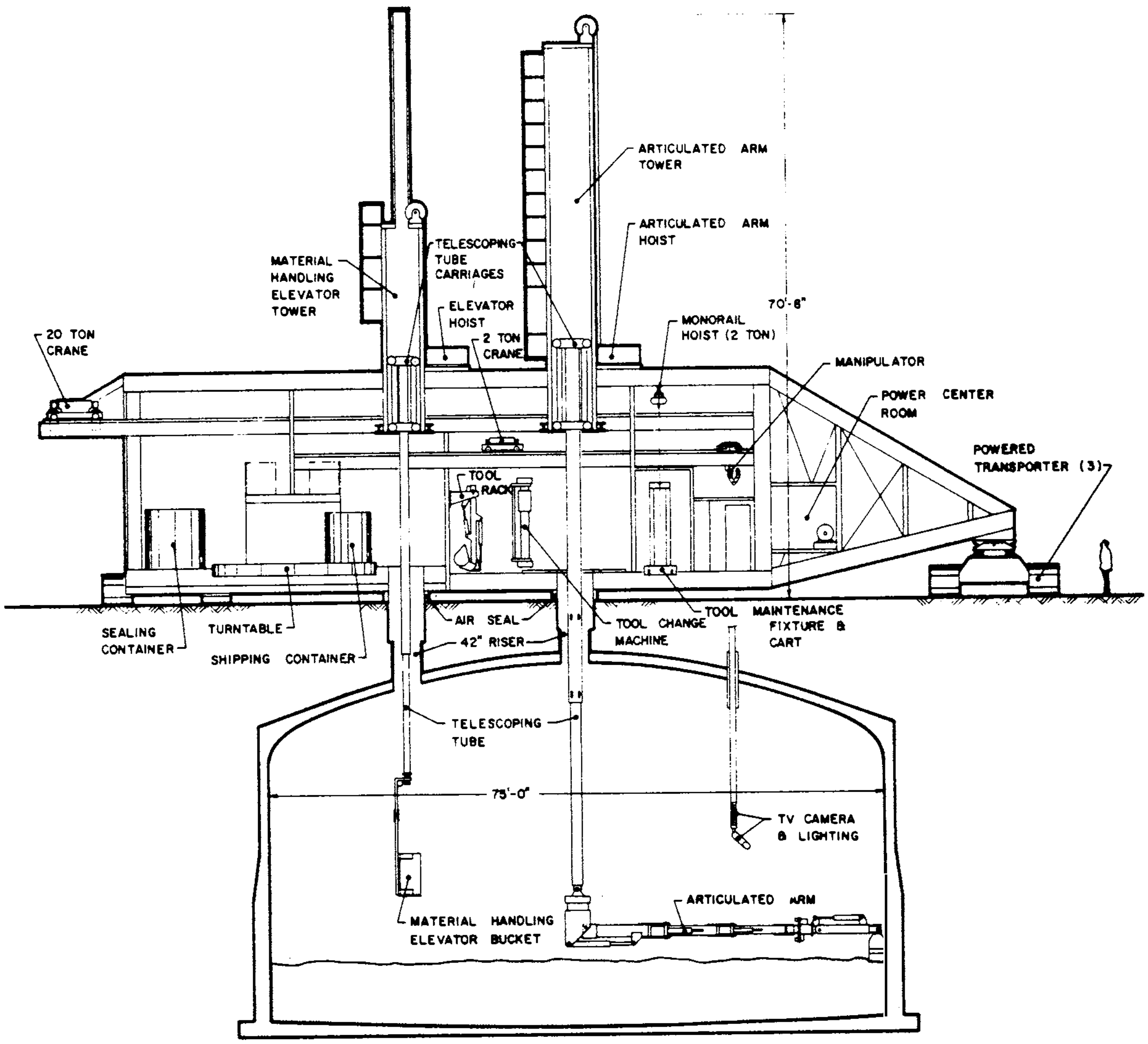

FIGURE C.10. A Conceptual Mechnical Waste Retrieval System Schematic (Elevation View)

SOURCE: ERDA 77-44

APPENDIX D

CONSTRUCTION AND PROJECTED UTILIZATION SCHEDULE FOR THIRTEEN TANKS

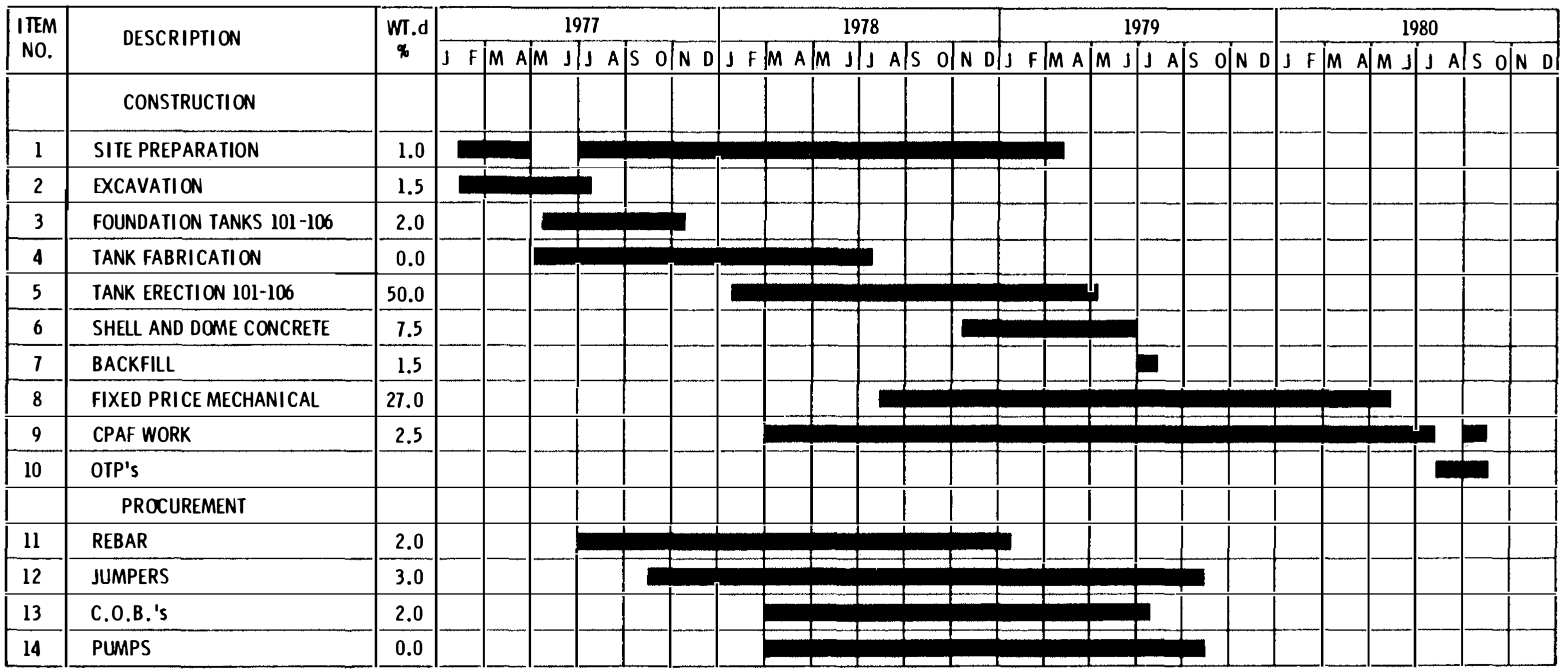

FIGURE D.1. 241-AN Tank Farm Construction Schedule

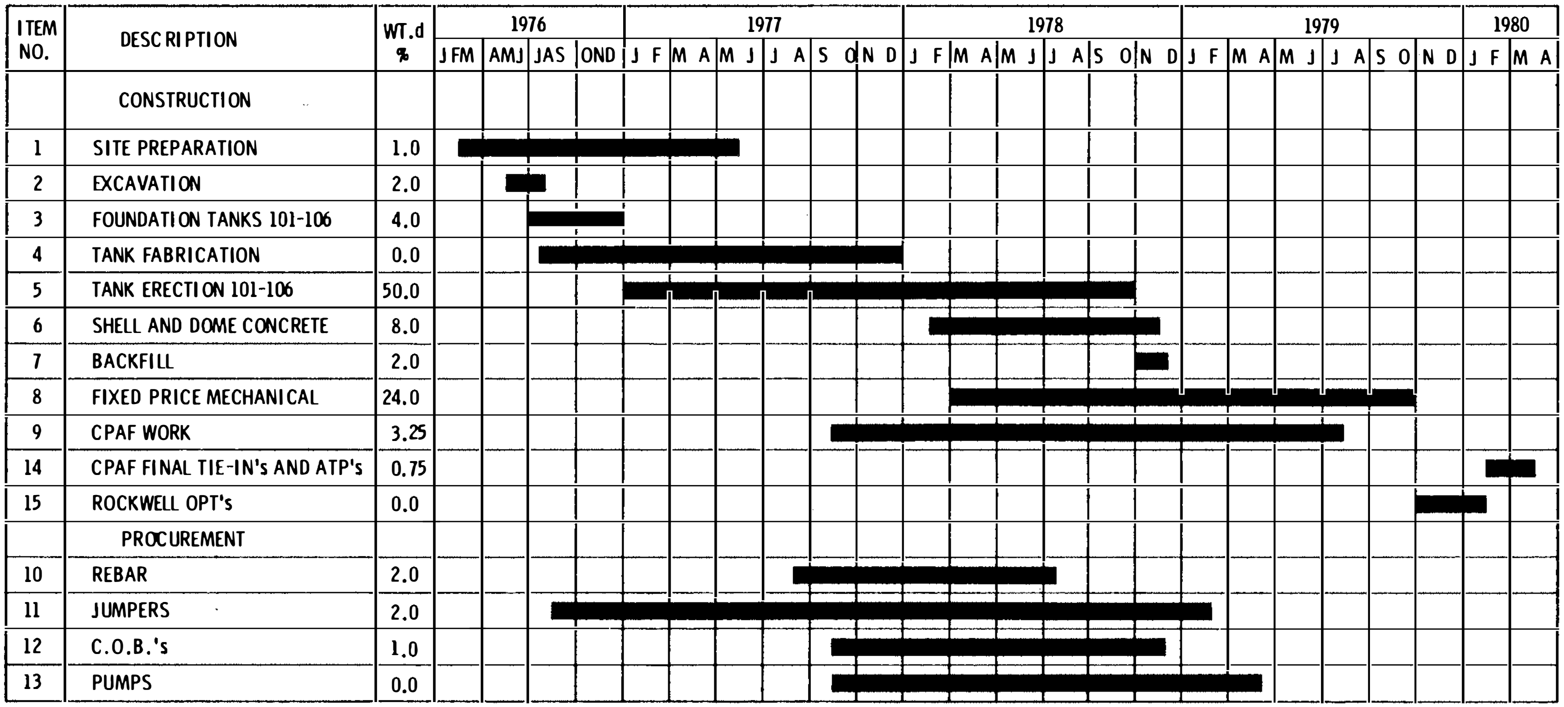

FIGURE D.2. 241-AW Tank Farm Construction Schedule

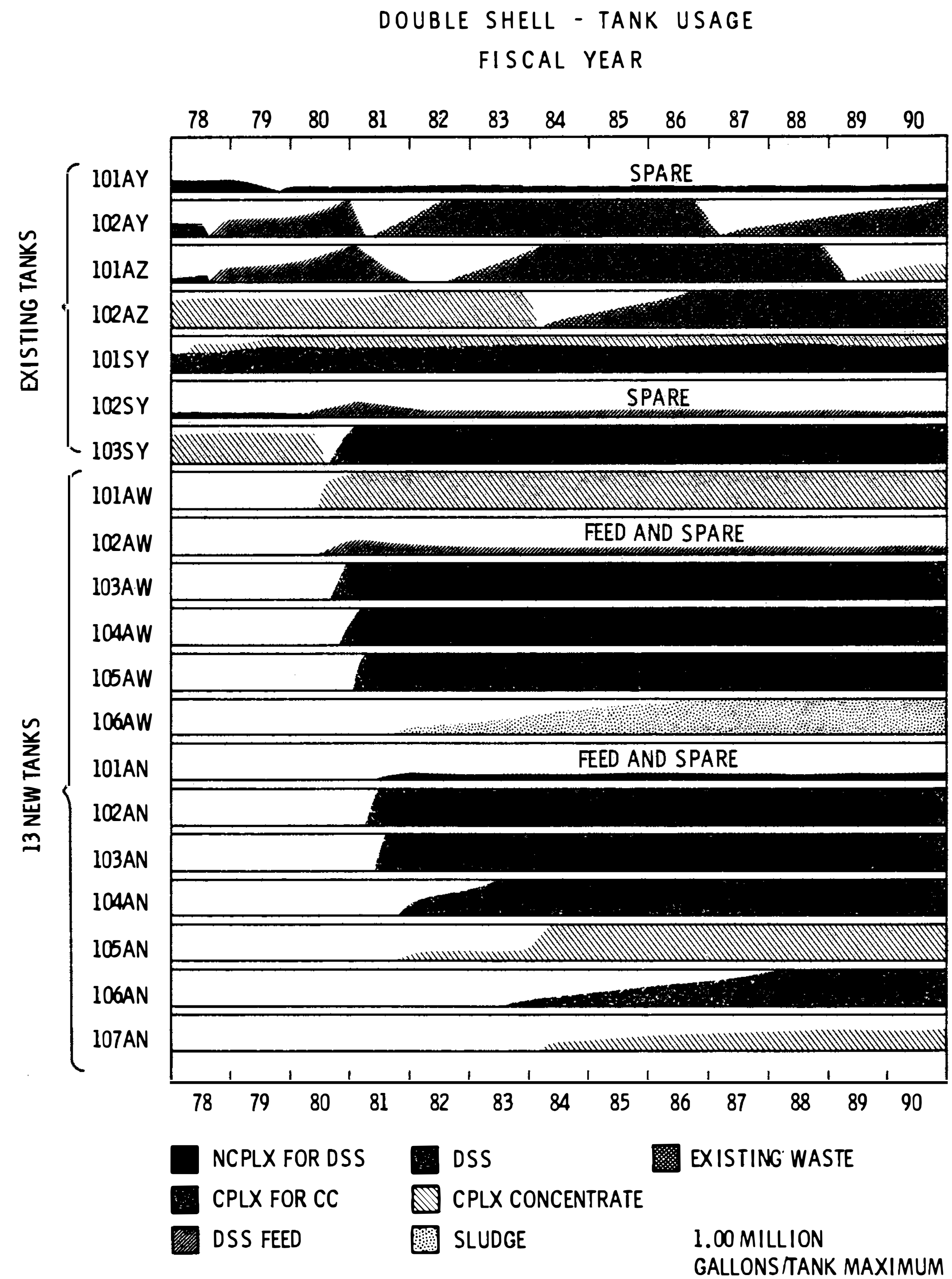

FIGURE D.3. Projected Utilization Schedule

APPENDIX E

MAJOR DIFFERENCES BETWEEN SRP AND HANFORD TANKS

APPENDIX E

MAJOR DIFFERENCES BETWEEN SRP AND HANFORD TANKS

The most recent tank designs at the Savannah River Plant (SRP) and at Hanford are similar in principal. Both designs utilize a double-shell concept to contain, cool, and shield high-level wastes. The waste stored in the SRP tanks exhibits heat generation and radionuclide concentration characteristics that are higher than the Hanford waste by a factor of fifteen (15). The inherent difference in the waste requires different provisions for heat removal. Processing of Savannah River waste does not include a Cesium or Strontium removal step as does Hanford waste intended for storage in the double-shell tanks. These isotopes have contribute significantly to the high heat generation rate. Wastes at both plants are evaporated to achieve a volume reduction.

Differences in the environment between Hanford and SRP Tanks exist but do not contribute to notable differences in design. The SRP Tanks are located in a wet climate with a shallow groundwater level. Hanford tanks are situated in a dry climate with groundwater levels in excess of 150 ft below the tanks.

A summary of the characteristics of each design is included in Table E.1.

E.1 TANK STRUCTURE

The basic tank structures of SRP and Hanford tanks are similar in concept; both tanks include a cylindrical primary tank contained within a secondary liner enclosed in concrete. The SRP Tanks employ a concrete center post to support the flat roof as shown in Figure E.1. The Hanford Tanks utilize a self-supporting dome shaped roof. Both designs employ a gridwork of slots in the insulating concrete and the base concrete to remove leakage from the primary and secondary tanks. Cooling air is routed through the slots in the insulating concrete and up through the annulus to remove heat.

Design of SRP Tanks was based on ASME Sec. VIII, Division I, while Hanford Tanks were designed in accordance with Division II. Both designs included stress relieving the primary tank after fabrication. Nearly identical nondestructive testing procedures were used to verify integrity.

The SRP Tanks do not require earthcover for shielding. A 48-in. thick, flat, concrete roof provides adequate shielding. Hanford tanks utilize less concrete thickness in the dome but are buried beneath a minimum of 6.5 ft of earth cover.

TABLE E.1. Summary of Tank Design Characteristics

Element	Hanford	SRP
Volume (working)	1×10^6 gal	1.3×10^6 gal
Design	ASME Sec. VIII, Div. 2	ASME Sec. VIII, Div. 1
Design Life	50 years	40 to 60 years
Heat generation Rate, maximum design value	50,000 Btu/hr	3,000,000 Btu/hr
Heat removal rate, maximum	100,000 Btu/hr	6,000,000 Btu/hr
Earth Cover	6.5 feet minimum	None
Roof type	Self-supporting dome	Flat with supporting center column
Live Load	40 psf plus 50 tons concentrated	275 psf
Steel Type	ASTM A-537, Class I Carbon Steel	ASTM A-537 Class I Carbon Steel
Yield Strength	50,000 psi	50,000 psi
Specific gravity of Waste, Max.	2.0	1.8
Annulus Air Flow	800 cfm	8,000 cfm
Max Primary Tank Skin temperature	200°F	391°F
Water-cooled coils intake	None	4 to 6 miles pipe per tank

E.2 VENTILATION

The higher heat generation in SRP Tanks requires special provisions for cooling. The SRP Tanks contain cooling coils capable of removing up to 600,000 Btu/hr each. With the ventilation airflow each SRP Tank is designed to remove 6 million Btu/hr. This compares to a heat removal rate of 100,000 Btu/hr for Hanford Tanks. Annulus ventilation flow rates are 8,000 cfm for SRP Tanks and 800 cfm for Hanford Tanks. The difference in cooling capacity reflect the different heat generation rates of the wastes stored in the tanks. Water routed through the cooling coils of the SRP Tanks poses an extra potential for contamination spread via leakage through piping in the tanks.

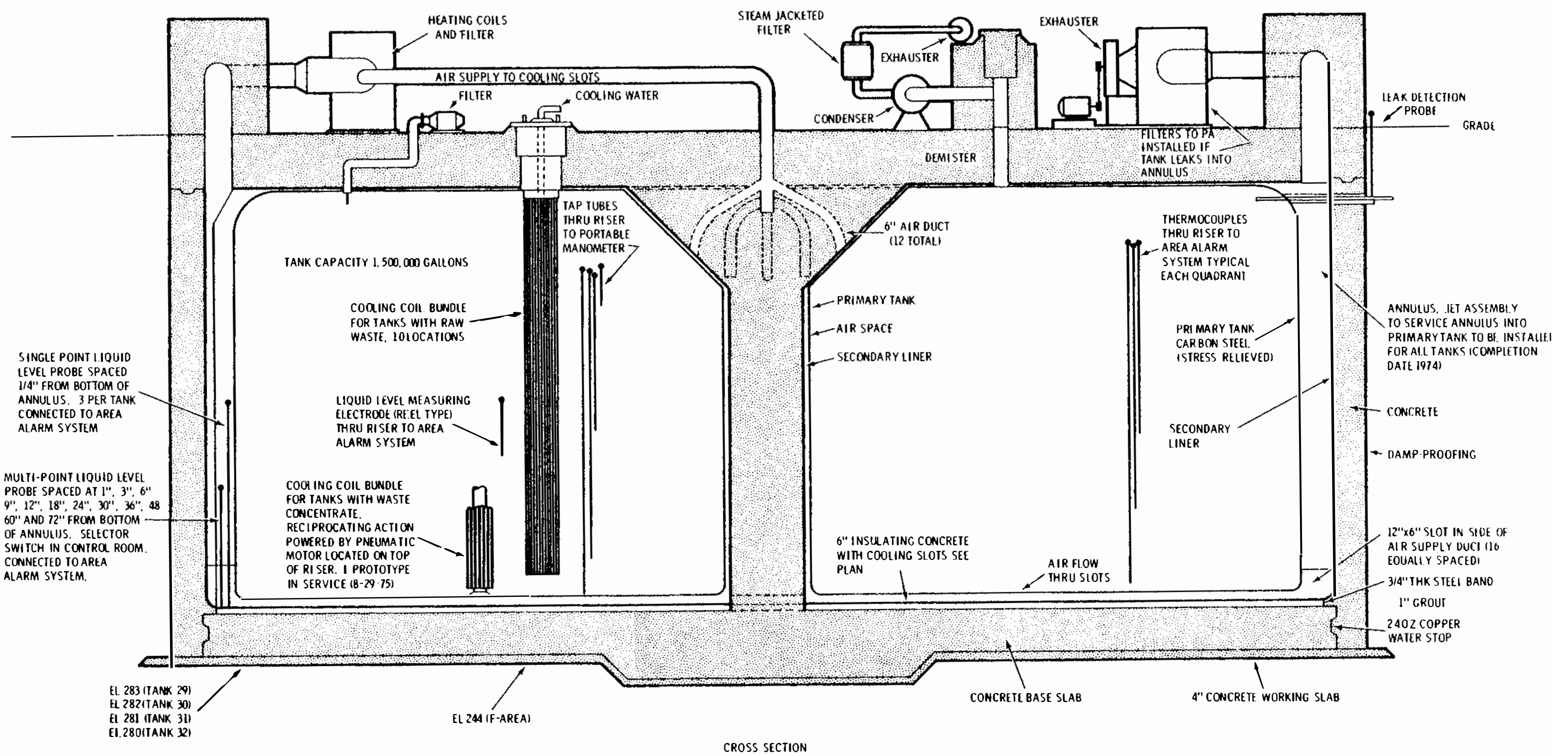

FIGURE E.1. Type III Waste Storage Tanks (Building 241-F: Tanks 33-34, 1969-72; Tanks 25-28, 1975078) (Building 241-H: Tanks 29-32, 1967-70; Tanks 35-37, 1974-77)

E.3 COOLING METHODS

Cooling coils[a] are installed in three types of tanks at Savannah River. These tanks are designated Types I, II, and III. Type I tanks are the original storage tanks constructed during 1951-1953. Each tank holds 720,000 gal, is 75 ft in diameter and 24-1/2 ft high. The primary tank is set in a circular pan of 1/2-in. steel plate, 5 ft deep and 5 ft larger in diameter than the primary tank. A 3-in. layer of grout separates the primary tank and the pan. The tank and pan assembly is surrounded by a cylindrical reinforced concrete enclosure with a flat concrete roof and foundation slab. There are 36 parallel cooling coils in Type I tanks.

Type II tanks at Savannah River were constructed during 1955-1956. Each primary tank holds 1,070,000 gal, is 85 ft in diameter and 27 ft high. The primary tank sits in a circular pan similar to the Type I tank, except that a 1-in. layer of sand replaces the 3 in. of grout. The primary tank and pan are also surrounded by a reinforced concrete enclosure. Cooling is provided by 44 parallel cooling coils.

The tanks constructed most recently (1962 to present) at Savannah River are designated as Type III. Each primary tank holds 1,300,000 gal, is 85 ft in diameter and 33 ft high. The primary tank sits on a 6-in. bed of insulating concrete within a secondary containment vessel. The concrete bed is grooved radially so that ventilating air can flow under the primary tank. The liquid waste and sludge in some Type III tanks is cooled by means of the replaceable cooling coil bundles. The remainder of the Type III tanks have the permanently installed cooling coils similar to those in Type I and Type II tanks. In Type III tanks, the total heat removal capability for either cooling coils design is 6,000,000 Btu/hr (ERDA-1537).

At Hanford, the 241-AW and 241-AN tanks, authorized for construction during 1976 and 1978, have some design similarity with the Type III tanks at Savannah River in that the Hanford tanks contain a primary tank sitting on an 8-in. bed of insulating concrete within a secondary containment vessel. The insulation concrete has slots cut in it to allow for flow of ventilating air under the primary tank. The amount of ventilating air in the annulus is 800 standard cubic feet per minute (SCFM). According to design, this air circulates uniformly around the tank, thereby providing heat removal. The air cooling system (consisting of the annulus cooling and in-tank ventilation) is designed to remove 100,000 Btu/hr, while the typical heat generation is 50,000 Btu/hr, thus providing an acceptable reserve capacity.

(a) These coils are constructed of 2-in. schedule 40 carbon steel pipe. Two types of coils are used: horizontal coils mounted permanently at the bottom of the waste tanks, and vertical coils permanently mounted all across the tank inside. Also, removable vertical coils are employed in some tanks.

The design heat generation rate for the 241-AW and 241-AN tanks is 100,000 Btu/hr with a tank capacity of 1,000,000 gal. Typical heat generation rate for the Hanford double shell slurry is about 0.05 Btu/hr/gal or 50,000 Btu/hr for each full tank.

E.4 LEAK DETECTION

Both SRP and Hanford Tanks have similar leak detection provisions which alarm in a manned facility. In addition, automated liquid level gauges provide supplementary data on the loss of liquid from the primary tank. Both designs include sumps to collect liquid from the slots in the base concrete (secondary liner leakage).

APPENDIX F

SUPPORT LETTERS

Rockwell Hanford Operations
Energy Systems Group
P.O. Box 800
Richland, WA 99352

Rockwell International

December 7, 1979

In Reply, Refer to Ltr. R79-3043-Rev. 1

Mr. K. S. Murthy
Battelle Memorial Institute
Packfic Northwest Laboratory
Richland, Washington 99352

Dear Mr. Murthy:

CHARACTERIZATION OF FUTURE WASTE TO BE STORED IN AW AND AN TANK FARMS

As requested at the meeting held on October 16, 1979, at Pacific Northwest Laboratory (PNL) between Rockwell Hanford Operations and PNL personnel, submitted herewith is the information regarding the characterization of current and future AN and AW waste material. The requested data is presented in eight tables (attached):

Existing Waste

Table 1a - Double-Shell Slurry (DSS) Chemical Composition Inventory After Processing Current Liquid Waste

Table 1b - Complexant Concentrate Chemical Inventory

Future Waste*

Table 2 - Future Purex Inventory After DSS Processing

Future Purex By-Waste Type

Table 3 - Cladding Sludge
Table 4 - High-Level Salt (DSS)
Table 5 - High-Level Sludge
Table 6 - Cladding Waste Salt (DSS)
Table 7 - Complexant Concentrate
Table 8 - Total Activity (Curies) for All Waste Existing plus Future In Double-Shell Tank Wastes (Note: Would include 101-SY, 103-SY)

The physical properties of double-shell slurry (DSS) are not absolutely defined. The characteristics will vary with composition, percent solids, total organic carbon (TOC) and temperature. Only one double-shell slurry run has been performed to date (April 1977). Approximately 274,000 gallons of DSS were produced from 365,000 gallons of Hanford defense residual liquor (HDRL). This material is now stored in Tank 101-SY.

*Approximately 1.2 million gallons of customer waste DSS will be stored. Its molarity range can be assumed to be that as shown in Table 1a.

Double-shell slurry is a thixotropic mixture of fine solids suspended in a viscous liquid medium. The evaporator operation limits the mixture to a specific gravity (SpG) of 1.5 to 1.7, a maximum viscosity of 500 cp and, at most, 30 percent solids by volume. In actuality, the 500 cp viscosity limitation is rarely approached. The solids experience extremely long settling times. The suspended solids are primarily sodium nitrate with minor quantities of sodium carbonate, sodium aluminate, and sodium nitrate. The solids are almost totally soluble upon dissolution.

The DSS feed and complexant concentrate are nearly total liquid. These materials, in most cases, are liquids saturated with salts and range in SpG from 1.40 to 1.50. The viscosity of these liquids is approximately 60 cp or less.

The sludge to be contained in these double-shell tanks is mostly hydrated metal oxides and metal hydroxides. The material is wet precipitated solids that have a SpG of approximately 2.0 or less.

The material to be stored in the 241-AN and 241-AW tank farms is either pumpable or sluiceable. In the foreseeable future, no nonretrievable materials (via pumping, sluicing) will be stored in these tanks. Some solids settling may occur in the DSS material, producing minor quantities of salt cake. This material should be removable by sluicing.

It needs to be impressed that there is some degree of uncertainty in the submitted information. This data is, however, the best available to date.

Very truly yours,

R. C. Roal, Manager
Systems Engineering

RCR/LDV/JFA/eo

Att.(8)

TABLE 1a. Double Shell Slurry Chemical Composition (Existing)

Chemical	Molarity	Lbs.
NaOH	3.3 - 7.3	8.3×10^6 - 1.8×10^7
$NaAlO_2$	2.3 - 4.3	1.2×10^7 - 1.1×10^7
$NaNO_3$	3.6 - 4.0	1.9×10^7 - 2.1×10^7
$NaNO_2$	2.9 - 4.5	1.3×10^7 - 1.9×10^7
Na_2CO_3	0.13 - 0.27	8.4×10^5 - 1.8×10^6
Na_3PO_4	0.13	1.5×10^6
Na_2SO_4	0.05	5.2×10^5
TOC (g/l)	7 - 17	4.4×10^5 - 1.1×10^6

TABLE 1b. Concentrated Complexant (Existing - Not DSS)

Chemical	Molarity	Lbs.
NaOH	0.61 - 1.83	4.5×10^5 - 1.4×10^6
$NaAlO_2$	0.07 - 0.21	1.1×10^5 - 3.2×10^5
$NaNO_3$	2.17 - 6.50	3.4×10^6 - 1.0×10^7
$NaNO_2$	0.21 - 0.63	2.6×10^5 - 7.9×10^5
Na_2CO_3	0.38 - 0.14	7.4×10^5 - 2.2×10^6
Na_3PO_4	0.005 - 0.14	1.5×10^4 - 4.5×10^4
TOC (g/l)	87 - 120	1.6×10^6 - 2.2×10^6

TABLE 2. Chemical Composition of Future Purex Waste

Chemical	Total Waste (Lbs.)	Chemical	Total Waste (Lbs.)
Process Additives		Fission Products and Actinides	
$NaNO_3$	8.48 E+6	Rb	4.50 E+2
$NaNO_2$	6.00 E+4	Y	6.00 E+2
NaF	2.98 E+6	Zr	4.30 E+3
NaOH	1.15 E+6	Mo	3.60 E+3
$NaAlO_2$	6.6 E+5	Tc	9.30 E+2
Na_2O_3	1.14 E+6	Ru	1.90 E+3
Na_2SO_4	1.10 E+6	Rh	5.60 E+2
Na_3PO_4	1.00 E+4	Pd	6.00 E+2
KF	4.50 E+5	Te	4.00 E+2
KOH	7.50 E+5	I	1.80 E+2
$Fe(OH)_3$	1.00 E+5	Cs	1.10 E+2
$ZrO_2 \cdot 2\ H_2O$	1.61 E+6	Ba	1.80 E+3
Organic Carbon	5.50 E+5	La	1.40 E+3
H_2O	2.30 E+7	Ce	2.60 E+3
		Pr	1.20 E+3
		Nd	4.40 E+3
		Sm	8.80 E+3
		U	2.50 E+4
		Pu	1.20 E+2
		The sum of Ge, As, Se, Br, Sr, Nb, Ag, Cd, In, Sn, Sb, Pm, Eu, Gd, Tb, ^{14}C, Co, Am	4.90 E+2
		Total (Lbs.)	4.21 E+7

TABLE 3. Zirconium Cladding Waste Sludge Estimates (Future Purex)

	Volume (10^6 gal)	Mass (10^6 lbs.)
ZCW Sludge	2.04	20.5
Chemical	**Weight %**	**Mass (10^6 lbs.)**
$ZrO_2 \cdot 2H_2O$	7.8	1.61
H_2O	73.7	15.11
NaF	10.0	2.06
$NaNO_3$	0.5	0.11
NaOH	3.3	0.68
KF	1.6	0.32
KOH	2.6	0.53
Na_2CO_3	0.3	0.07
Total	99.8	20.49

TABLE 4. Neutralized High Level Waste Salt Estimates (Future Purex)

	Volume (10^6 gal)	Mass (10^6 lbs.)
NHW Salt	0.88	12
Chemical	**Weight %**	**Mass (10^6 lbs.)**
$NaNO_3$	55.4	6.61
H_2O	30.0	3.58
NaOH	---	Included with $NaNO_3$
$NaAlO_2$	5.0	0.59
Na_2CO_3	5.3	0.63
Na_2SO_4	4.0	0.45
NaF	0.6	0.07
Total	100.3	11.9

TABLE 5. Neutralized High Level Waste Sludge Estimates (Future Purex)

	Volume (10^6 gal)	Mass (10^6 lbs.)
NHW Sludge	0.02	0.3

Chemical	Weight %	Mass (10^6 lbs.)
FeO(OH)	30.6	0.084
H_2O	42.0	0.115
Fission Product Oxides	27.4	0.075
Total	100.0	0.274

TABLE 6. Zirconium Cladding Waste/Organic Wash Waste Salts Estimates (Future Purex)

	Volume (10^6 gal)	Mass (10^6 lbs.)
ZCW/OWW Salts	0.2	2.4

Chemical	Weight %	Mass (10^6 lbs.)
NaF	35.3	0.853
$NaNO_3$	2.0	0.047
NaOH	11.8	0.284
KF	5.5	0.133
KOH	9.2	0.221
Na_2CO_3	1.2	0.029
H_2O	35.0	0.846
Total	100.0	2.413

TABLE 7. Concentrated Complexant Estimates (Future Purex)

	Volume (10^6 gal)	Mass (10^6 lbs.)
Concentrated Complexant	0.60	7.0

Composition of concentrated complexant, future Purex waste based on Samples from 102 AZ

Chemical	Weight %	Mass (10^6 lbs.)
Na_2SO_4	8.6	0.60
$NaAlO_2$	.80	0.06
Na_2CO_3	5.7	0.40
$NaNO_2$	2.1	0.15
$NaNO_3$	26.5	1.84
Na_3PO_4	0.1	0.007
T ORG C	7.2	0.50
NaOH	3.5	0.24
H_2O	45.5	3.16
Total	99.9	6.96

TABLE 8. Existing Plus Future Inventories of Major Fission Products, Activation Products, and Actinides in Hanford High-Level Waste Decayed to 1991

CURIES

Double-Shell Tanks

Radionuclide	Sludge[1]	Salt, Concentrated Complexant, Double-Shell Slurry
^{3}H	*	1.8×10^{4}
^{14}C	*	9.6×10^{2}
^{59}Ni	1.3×10^{1}	*
^{60}Co	4.1×10^{4}	*
^{63}Ni	9.1×10^{3}	*
^{79}Se	3.9×10^{1}	7.3×10^{2}
^{89}Sr	2.2×10^{3}	1.1×10^{2}
^{90}Sr	1.3×10^{6}	6.8×10^{5}
^{90}Y	1.3×10^{6}	6.8×10^{5}
^{91}Y	1.7×10^{5}	*
^{93}Zr	1.6×10^{3}	*
^{93m}Nb	8.0×10^{1}	*
^{95}Zr	3.7×10^{5}	*
^{95}Nb	7.8×10^{5}	*
^{95m}Nb	7.8×10^{3}	*
^{99}Tc	*	3.8×10^{4}
^{103}Ru	2.7×10^{3}	2.7×10^{3}
^{103m}Rh	2.7×10^{3}	2.7×10^{3}
^{106}Ru	3.5×10^{6}	3.5×10^{6}
^{106}Rh	3.5×10^{6}	3.5×10^{6}
^{107}Pd	2.2×10^{1}	*
^{110}Ag	3.2×10^{3}	*
^{110m}Ag	2.5×10^{4}	*

TABLE 8. (contd)

Radionuclide	Sludge[1]	Salt, Concentrated Complexant, Double-Shell Slurry
^{113m}Cd	3.1×10^{3}	*
^{115m}Cd	3.2×10^{0}	*
^{119m}Sn	3.4×10^{2}	1.4×10^{3}
^{121m}Sn	1.2×10^{1}	1.2×10^{2}
^{123}Sn	2.8×10^{3}	1.1×10^{4}
^{124}Sb	2.6×10^{-1}	1.0×10^{0}
^{125}Sb	1.2×10^{5}	4.7×10^{6}
^{125m}Te	4.7×10^{4}	1.9×10^{5}
^{126}Sn	3.8×10^{0}	6.3×10^{1}
^{126}Sb	3.7×10^{0}	6.2×10^{1}
^{126m}Sb	3.8×10^{0}	6.3×10^{1}
^{127}Te	4.0×10^{3}	1.6×10^{4}
^{127}Te	4.0×10^{3}	1.6×10^{4}
^{127}Te	4.0×10^{3}	1.6×10^{4}
^{129}I	*	5.9×10^{1}
^{129}Te	7.3×10^{0}	2.9×10^{1}
^{129}Tc	1.1×10^{0}	4.5×10^{1}
^{134}Cs	5.7×10^{3}	2.6×10^{4}
^{135}Cs	1.4 z 10^{0}	1.3×10^{2}
^{137}Cs	2.7×10^{5}	1.5×10^{7}
^{137m}Ba	2.6×10^{5}	1.4×10^{7}
^{141}Ce	9.6×10^{2}	*
^{144}Ce	2.7×10^{7}	*
^{144}Pr	2.7×10^{7}	*
^{147}Pm	2.8×10^{7}	*
^{148}Pm	1.8×10^{1}	*
^{148m}Pm	2.3×10^{2}	*

TABLE 8. (contd)

Radionuclide	Sludge[1]	Salt, Concentrated Complexant, Double-Shell Slurry
^{151}Sm	1.4×10^5	*
^{152}Eu	8.3×10^2	*
^{153}Gd	2.2×10^1	*
^{154}Eu	2.1×10^5	*
^{155}Eu	1.1×10^5	*
^{160}Tb	7.3×10^0	*
^{21}Pb	---------	*
^{212}Bi	---------	*
^{212}Po	---------	*
^{216}Po	---------	*
^{220}Rn	---------	*
^{224}Ra	---------	*
^{228}Th	---------	*
^{231}Th	1.8×10^{-1}	*
^{232}Th	----------	*
^{234}Th	3.8×10^0	*
^{233}Pa	2.8×10^1	*
^{234m}Pa	3.8×10^0	*
^{232}U	---------	*
^{233}U	---------	*
^{234}U	---------	*
^{235}U	---------	*
^{237}U	4.0×10^0	*
^{238}U	3.8×10^0	*
^{237}Np	2.8×10^1	
^{239}Np	6.9×10^2	*
^{238}Pu	4.5×10^2	*

TABLE 8. (contd)

Radionuclide	Sludge[1]	Salt, Concentrated Complexant, Double-Shell Slurry
^{239}Pu	2.8×10^3	*
^{240}Pu	1.4×10^3	*
^{241}Pu	1.6×10^5	*
^{242}Pu	5.0×10^{-1}	*
^{241}Am	1.3×10^5	*
^{242m}Am	1.0×10^3	*
^{242}Am	1.0×10^3	*
^{243}Am	6.9×10^2	*
^{242}Cm	8.4×10^2	*
^{243}Cm	9.0×10^2	*
^{244}Cm	1.4×10^4	*
^{245}Cm	1.2×10^0	*

(1) Derived from future waste only. (Majority of radionuclides expected to be contained in high level sludge, a small volume fraction of future sludge.)

March 19, 1975 COPY

Mr. E. L. Moore
Research Engineering Division
ARHCO
271-T Bldg., 200 West Area

Dear Ernest,

Corrosion of Mild Steel in Terminal Liquor Slurry

Ref: Letter, W.P. Metz to E.L. Moore, "Corrosion Rates for Terminal Liquor "Mush" Products," December 31, 1974

Corrosion tests were made to determine the corrosion rate of mild steel in terminal liquor as a function of temperature and composition. The slurry compositions used are given in Table I.

TABLE I

Composition of Test Terminal Liquor Slurries

Constituent	Slurry No. I	Molarity(1) Slurry No. II	Slurry No. III
NaOH	8	12	12
$NaAlO_2$	3	3	3
$NaNO_3$	4	4	4
$NaNO_2$	3	3	3
Na_2CO_3	-	0.2	-
Na_3PO_4	-	0.2	-

Note:
(1) Moles/l of slurry at 25°C

Test temperatures were 25, 50, and 95°C; Teflon was used as the containment material in all cases. Specimens consisted of coupons for weight loss measurements and for observation of pitting or other localized attack, crevice specimens (Teflon loop around a coupon) to determine the potential for crevice attack and notched C-rings to determine the propensity for stress corrosion cracking. The corrosion coupons were prepared from mild steel plate (ASTM A-201). The plate was heated to 1100°C for 0.5 hr and furnace cooled prior to use. The C-rings were prepared from sections of 1 1/4" Schedule 80 pipe (ASTM A-105) and were in the mill annealed condition. The specimens were evaluated after two months exposure. No crevice attack of stress corrosion cracking was observed in any case. Evidence of incipient pitting was observed on specimens exposed to Slurries No. II and III at

50 and 95°C. A longer exposure will be required to determined the significance of this observation. Corrosion rates as determined by weight loss measurements are given in Table II. Corrosion coupons were exposed at the liquid-vapor interface (about two-thirds of the area in liquid phase) and in the slurry phase.

Table II

Corrosion Rates of Mild Steel in Terminal Liquor Slurry

	Corrosion Rate, mils/year					
	25°C		50°C		95°C	
	I.F.	Slurry	I.F.	Slurry	I.F.	Slurry
Slurry No. I	0.01	0.04	0.01	0.03	0.52	0.19
Slurry No. II	0.62	0.98	5.5	5.8	2.6	0.92
Slurry No. III	0.74	1.4	4.6	8.3	1.5	0.38

Perferential attack at the liquid-vapor interface was not observed in case. The corrosion product coating appears to be more protective at 95°C than at 50°C in the case of Slurries No. II and III. This effect was previously observed in exposures of mild steel to "standard" solidified waste. Although Slurry No. I is appreciably less corrosive than the other two compositions, corrosion was not severe in any case. The exposures are being continued, primarily to evaluate pitting intensity.

Exposures were also made to determine the corrosion which a 304L evaporator operating at atmospheric pressure might experience while producing terminal liquor. Sensitized 304L coupons and notched C-rings were exposed to boiling terminal liquor compositions as used in the tests with mild steel specimens. The results obtained in a two-month exposure are given in Table III.

TABLE III

Corrosion of 304L SS in Boiling Terminal Liquor

	Corrosion Rate, mils/year
Slurry No. I	1.2
Slurry No. II	12.0
Slurry No. III	8.9

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Coupons exposed to Slurries No. II and III were attacked intergranularly and were also subject to high density shallow pitting. Higher corrosion rates (perhaps a factor of 1 to 3) would be expected on heat transfer surfaces. Stress corrosion cracking was not observed in any case. These exposures are continuing.

You will be informed when additional observations are made.

Very truly yours,

(signed)

R. F. Maness
Corrosion Research
and Engineering

APPENDIX G

TANK OPERATION CRITERIA

APPENDIX G

TANK OPERATION CRITERIA

1. The tanks will be used to store double-shell slurry, complexant concentrate, double-shell slurry feed, or sludges. The chemical composition ranges of these wastes are identified in Table G.1. One tank (107-AN) may be used to store hotter Hanford aging waste but external modifications to the tank such as air supply lines and a surface condensor, will be required in this event. Airlift circulators are being installed inside this tank.

2. The tanks will store a maximum mass equivalant to 1,000,000 gallons of waste at a maximum average specific gravity is 2.0. Some waste types may expand up to 8% in the tanks, but the total mass will be unchanged.

3. The maximum heat generation rate of the waste is 0.1 Btu/hr/gallon. The typical heat generation rate of the waste is expected to be more like 0.05 Btu/hr/gallon. The tank wall temperatures in normal operation will not be allowed to exceed 203°F.

4. The waste forms will be in such a physical state that they can be either pumped or slurried.

5. The chemical composition of waste to be stored will be in the range indicated in Table G.1 or may be more dilute than these values if the corrosion properties of the waste do not change into adverse conditions.

TABLE G.1. Chemical Composition of Waste Forms

Chemical Constituent (Molarity)	Double Shell Slurry	Concentrated Complexant
NaOH	3.3 - 7.3	0.6 - 1.8
$NaAlO_2$	2.3 - 4.3	0.07 - 0.21
$NaNO_3$	3.6 - 4.0	2.2 - 6.0
$NaNO_2$	2.9 - 4.5	0.21 - 0.63
Na_2CO_3	0.13 - 0.27	0.38 - 1.1
Na_3PO_4	0.13	0.005 - 0.02

APPENDIX H

COURT ORDER

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

NATURAL RESOURCES DEFENSE COUNCIL, INC., et al., Plaintiffs,	)	
v.	)	Civil No. 76-1691
SECRETARY, DEPARTMENT OF ENERGY, et al., Defendants.	)	

ORDER

Upon consideration of the decision and judgment of the United States Court of Appeals for the District of Columbia Circuit remanding this proceeding for an order requiring the Department of Energy to prepare an environmental impact statement, and upon consideration of plaintiffs' and defendants' joint motion for the entry of such an order and the entire record herein, it is, by the Court, this 29 day of September, 1979,

ORDERED, the defendants will prepare with diligence and with all reasonable speed and file with the Court by no later than April 15, 1980, adequate final supplemental environmental impact statements to ERDA-1537, Final Environmental Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, and ERDA-1538, Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington, discussing the safety and design alternatives for the Fisal Years 1976 and

1977 double-shell radioactive waste storage tanks at Hanford and Savannah River. A minimum of 45 calendar days shall be provided for public comment on the draft statement.

FURTHER ORDERED, that the environmental impact statements shall discuss in detail at least those design and safety feature alternatives identified at note 19, page 13 of the Court of Appeals slip opinion, including the reasonably foreseeable environmental effects of these alternatives, their effect on the durability of the tanks or the ease of waste retrieval from such tanks, and the effect, if any, of these design and safety feature alternatives on the choices of a technology for long-term radioactive waste storage and final disposal, and on the timing of such choices.

FURTHER ORDERED, that this case be, and the same hereby is remanded to the Department of Energy for its compliance with the terms of this Order.

FURTHER ORDERED, that this Court shall retain jurisdiction over this proceeding until this Order is complied with.

(original signed by Charles Richey)

United State District Judge

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Committee on Appropriations, United States Senate
Committee on Armed Services, United States Senate
Committee on Appropriations, House of Representatives
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