SINGLE-SHELL TANK TECHNOLOGY

DEMONSTRATION

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ABSTRACT

Certain radioactive wastes are currently stored in single-shell tanks at Hanford. A "reference" alternative in the Hanford Defense Waste - Environmental Impact Statement (HDW-EIS) recommends in-place stabilization and disposal of these waste tanks. A demonstration of the technology required for implementation of this alternative is planned pending selection of this alternative after completion of the National Environmental Policy Act (NEPA) process. Evaluation of this alternative and others is currently being done in the HDW-EIS. The demonstration consists of filling the remaining space in a six-tank farm with a relatively inert material and placement of protective barriers and a warning marker system. The action will demonstrate the operational safety and cost-effectiveness of the "reference" alternative for final disposal of all such tank waste at Hanford.

INTRODUCTION

A "reference" case for final disposal of Hanford Defense Wastes is set forth in the Hanford Waste Management Plan and is one of four alternatives being evaluated in the Hanford Defense Waste - Environmental Impact Statement. This reference case describes in-place stabilization and disposal of the single-shell waste tanks at Hanford. The demonstration is planned pending selection of this alternative after completion of the National Environmental Policy Act (NEPA) process. If the NEPA process concurs in the reference case, the demonstration will assure the Department of Energy's readiness for implementation of routine disposal of single-shell tanks. Should the NEPA process find the reference alternative unacceptable, other alternatives remain viable and the demonstration disposal described here can be reversed; i.e., the waste and fill material in the tanks can be removed. Earlier work developed a mechanical retrieval system for recovery of waste in single-shell tanks as described in the geologic disposal alternative. If the decision is to recover the waste, the emptied tanks would remain in place. Their final disposal also would require filling which could be accomplished by the method being demonstrated, therefore, the development of dome-filling technology remains justified.

DEMONSTRATION PLAN

In early Fiscal Year 1983, the Department of Energy directed Rockwell Hanford Operations (Rockwell) to prepare a plan for conducting a demonstration of the disposal methods of Hanford single-shell tanks. The demonstration would permit an evaluation of the in-place stabilization and disposal alternative, which is the reference case for single-shell tank disposal. The plan was prepared and calls for the space within the tanks to be filled (referred to as "dome filling"), for all openings to be sealed, and for a system of protective barriers and markers to be constructed over the entire farm. Filling of the existing void space in the tanks provides for the integrity of the protective barrier as follows. Although the tanks are structurally sound and may remain so for hundreds of years, eventually the concrete will deteriorate. By filling the tanks with a stable material, ultimate subsidence, which would be deleterious to the protective barrier, is minimized.

The technology demonstration consists of the following elements, which will be described:

- Selection of the site
- Waste sampling and analysis
- Optimization of technology
- Tank dome filling
- Protective barrier/marker placement
- Short-term monitoring program.

DEMONSTRATION SITE

Single-shell tanks were originally constructed for the storage of radioactive liquid wastes generated as a result of plutonium production and separations operations at Hanford. Tank capacities range from 55,000 gallons (210 m^3) to 1,000,000 gallons (3800 m^3). The total constructed storage capacity exceeds 90,000,000 gallons (340,000 m^3).

Waste concentration, supernatant removal, and jet pumping operations have resulted in reduction of a large portion of the liquids in the single-shell tanks. Approximately 40,000,000 gallons (150,000 m^3) of wet solids are currently stored in the single-shell tanks. These wet solids consist of salt cake, sludge, supernatant, and interstitial liquids.

Tanks which had minimum TRU radionuclide inventories, minimum decay heat values, and were low in organic complexant concentration and moisture content were preferred for the demonstration. Over 60 single-shell tanks were determined to be acceptable for the demonstration. Since the protective barrier requires construction as a unit, covering all the tanks in a farm, an entire farm was desired for the demonstration. Only one tank farm was comprised entirely of tanks which met the selection criteria. The TY Tank Farm was chosen as the demonstration site for that reason.

The TY Tank Farm consists of six tanks, each with a nominal waste storage capacity of 750,000 gallons (2800 m^3). The tank farm contains only 648,000 gallons (2500 m^3) of waste (see Table I). The remaining tank volume is unfilled. The radionuclide inventory data for the TY Tank Farm (based on waste management records) are shown in Table II. This inventory data will be confirmed by tank sampling activities discussed next in this paper.

TABLE I

Waste Volume Status for the TY Tank Farm

Tank	Total Waste Volume (m^3)	Drainable Liquid Volume (m^3)	Solids Volume (m^3) Sludge	Solids Volume (m^3) Saltcake
101TY	466	4	466	0
102TY	235	49	0	235
103TY	640	19	640	0
104TY	174	11	163	0
105TY	874	0	874	0
106TY	64	0	64	0
	2453	83	2207	235

TANK SAMPLING AND ANALYSIS

Waste characterization is required for several reasons: for compliance with regulatory direction, for risk and performance assessments, and for disposal engineering. To obtain samples, Rockwell has adapted a commercially available core drilling rig. The design is intended to permit samples to be retrieved throughout the entire waste depth [to within 0.5 inch (1.3 cm) of the bottom of the tank], maintain the waste strata regardless of phase, and provide shielding throughout sampling, transport, and preparation for analysis.

TABLE II

Estimated Radionuclide Inventory for the TY Tank Farm

Radionuclide	Tank Farm Inventory Curies	Tank Farm Inventory Bequerels
Am-241	7E+1	2.6E+12
Ba-137m	4E+5	1.5E+16
C-14	1E+2	3.7E+12
Cs-135	2E+0	7.4E+10
Cs-137	4E+5	1.5E+16
Nb-93m	7E+0	2.6E+10
Ni-63	2E+3	7.4E+13
Pa-234m	3E+0	1.1E+11
Pu-238	2E+0	7.4E+10
Pu-239	4E+2	1.5E+13
Pu-240	6E+1	2.2E+12
Pu-241	4E+2	1.5E+13
Se-79	8E+0	3.0E+11
Sm-151	1E+3	3.7E+13
Tc-99	3E+2	1.1E+13
Th-234	3E+0	1.1E+11
U-238	3E+0	1.1E+11
Y-90	6E+4	2.2E+15
Zr-93	3E+0	1.1E+11

Samples will be taken from each of the tanks and prepared for radionuclide and chemical analysis in a hot cell or hood, depending upon activity. Plans are to conduct twelve radioassays, to analyze for twenty-seven stable chemicals (using seven analytical methods), and to perform eight physical tests.

TANK DOME FILLING

A variety of materials were considered for use as tank dome fill: sand, native soils, gravels, clays, and grouts. These potential dome fill materials were

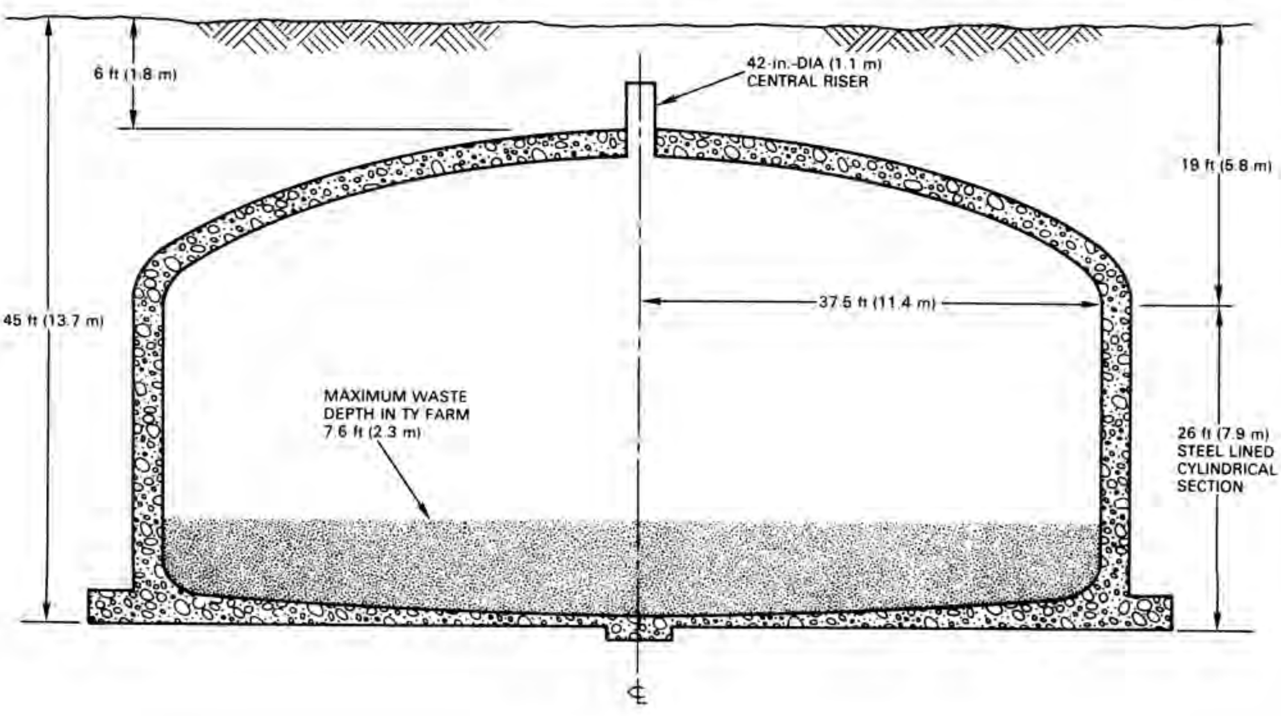

Fig. 1. TY Tank Construction.

evaluated based on several factors, including availability, cost, means of placement, and expected performance in the disposal system.

A crushed basalt gravel was selected as the fill material for the TY Tank Farm. The basalt fill material has several advantages over the other materials examined. Basalt is readily available on the Hanford Site; numerous basalt outcrops exist which can be quarried for material. Tests are being conducted to determine the chemical stability of basalt gravel in the tank environment. Radical changes in its form or properties as a result of interactions with the caustic wastes are not expected. Screened, washed basalt gravel will result in minimal dusting during tank dome filling; this is an important concern with the high efficiency particulate air (HEPA) filtered tank ventilation system which will be used during the filling operation. It is expected that basalt gravel will form a structurally stable base for supporting overburden loads and will resist post-placement compaction. The basalt gravel also has a significant void fraction which can accommodate displaced waste materials. The gravel will sink in plastic or fluid waste forms, allowing the waste to occupy the interstitial spaces.

Access to the TY Tanks is provided by a variety of risers in the tank dome. The largest of these, the central 42-inch (1.1 m) diameter riser, provides the best access for tank filling operations. Since the basalt gravel fill is not a flowable material, means of distributing the gravel to the farthest reaches of the 38-foot (11.4 m) tank radius had to be devised (Fig. 1).

A commercially available materials handling system was chosen for the tank filling operation. The "Swivel Piler" centrifugal throwing system is commonly used for material distribution in both the wood products industry (wood chips) and in agriculture (grains). The device uses a motor-driven belt to redirect a falling stream of material into a horizontal trajectory (Fig. 2).

As currently envisioned, conveyor belts would be used to introduce the initial 30-40% of the required fill material into the tanks through the risers. The centrifugal thrower would then be inserted into the central riser and used to project material into the haunch areas along the tank perimeter, filling the remaining void space "from the outside in." The tank risers would then be filled and sealed.

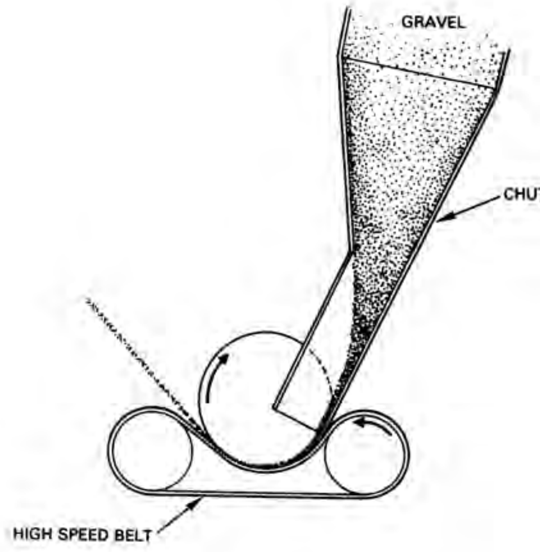

Fig. 2. Schematic of Swivel Piler

Extensive "cold" testing of the centrifugal thrower system is under way. A mockup facility has been constructed which simulates the central 42-inch (1.1 m) riser and a section of the tank dome (Fig. 3). A series of development tasks will be performed in this facility in a nonradioactive "hands on" environment.

Investigations into equipment performance are being conducted. The material handling equipment will be operated for extended periods to determine material flow rates, optimum belt speeds and angles of throw, equipment durability and reliability, and remote operation and maintenance requirements. Fill material behavior during placement will also be investigated. The ability to adequately fill behind obstructions (existing in-tank structures) will be examined. The

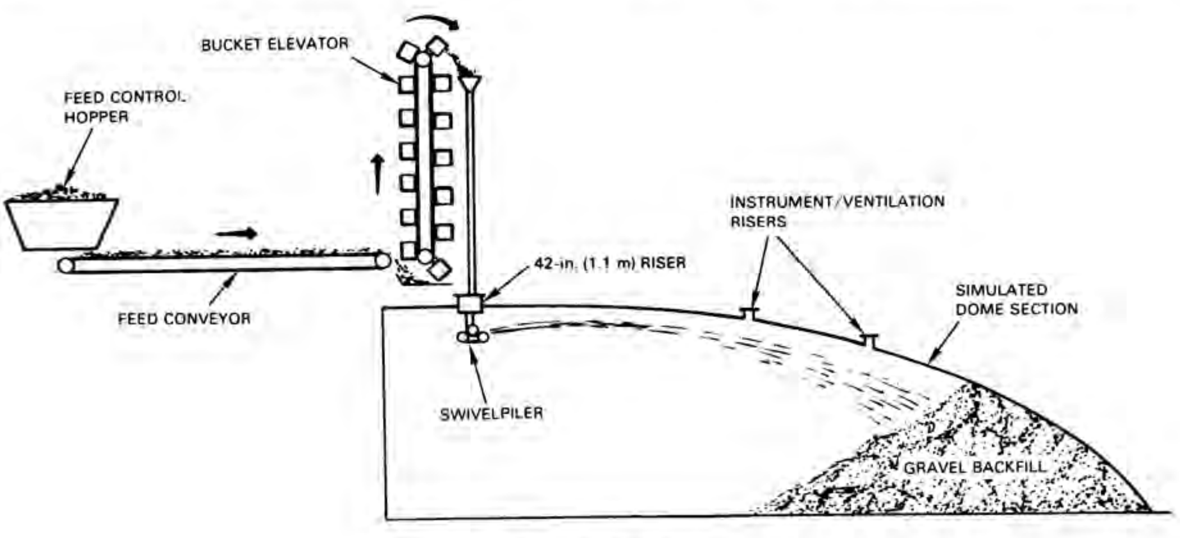

Fig. 3. Tank Mockup Facility.

impact of tank filling operations on ventilation system performance will be assessed. Ventilation flow rates, prefilter requirements, and riser sealing requirements will be determined. Tank dome fill performance and waste/fill interactions are to be examined through the use of in-tank instrumentation systems. Methods to adequately place instrument packages within the tanks and to protect them from damage during dome filling operations will be developed. The mockup facility will also serve as a training site for operators prior to actual dome filling operations and will aid the development of operating procedures.

Final equipment design, procurement, and fabrication will be completed after the mockup facility testing phase. Following completion of dome filling operations, the tank risers will be temporarily sealed and fill equipment removed from the farm. A period of dome fill observation will then begin. Upon completion, risers will be reopened and make-up fill (or alternative fills such as a grout cap) will be added if necessary. The tanks will then be permanently sealed and preparations made for protective barrier placement.

PROTECTIVE BARRIER/MARKER PLACEMENT

Barriers

Following dome filling and fill observation, a protective barrier/marker system will be constructed over the tank farm to deter biological intrusion, water infiltration, water and wind erosion, and human intrusion (Fig. 4). The barrier design selected consists of a revegetated, fine-textured soil layer 4.9 feet (1.5 m) thick overlying a coarse basalt rock (riprap) layer 11 feet (3.5 m) thick. The purpose of the revegetated soil is to hold water near the surface of the barrier where it can evapotranspirate. The purpose of the coarse rock is to provide a clean, dry matrix that is difficult for plant roots or animals to penetrate. A rock/gravel filter layer 1.0 foot (0.3 m) thick lies between the soil and coarse rock layers. The purpose of the rock/gravel filter is to prevent infiltration of the fine-textured soil downward into the coarse rock. A porous plastic construction fabric also serves to separate the fine-textured soil from the coarse rock layer during construction.

The barrier also features a riprap perimeter berm at the foot of which is a riprap-filled perimeter trench 3.3 feet (1.0 m) wide by 3.3 feet (1.0 m) deep. The riprap berm is 16.0 feet (5.0 m) wide with a 1:1 sideslope. The purpose of the perimeter trench is to deter lateral intrusion by burrowing animals. The perimeter berm makes the revegetated surface of the barrier difficult to access by vehicles and provides protection against wind and water erosion along the barrier perimeter. The revegetated surface of the barrier will also feature a rock mulch either admixed into the upper surface of the soil or spread thinly on the surface. The gravel mulch will provide "armoring" in the event of failure of the grasses by prolonged drought or range fire. The mulch is designed to allow natural reestablishment of grasses following a drought or fire. The gravel mulch will probably consist of pea gravel, although the size of gravel and method of application is the subject of study and field testing at the present time.

Key to the success of the barrier is the maintenance of a distinct interface between the top fine-textured soil layer of the barrier and the lower coarse rock layer. The multilayer concept is based on the outflow law for soil water which dictates that the soil at or near the interface must approach saturation before water will flow downward into the coarse rock layer. To achieve this, a great textural difference between the fine upper layer and the coarse lower layer is desired. Soil water storage is particularly enhanced when the soil is moderately fine textured. The stored water in the upper soil layer of the multilayered barrier will be removed by evaporation and by transpiration of plants growing on the soil layer. The plant roots will remain in the upper soil layer and tend not to penetrate into the coarse rock layer which lacks water and nutrients. Burrowing animals such as badgers will also not penetrate the coarse rock layer because their prey (mice and other small rodents) reside in the vegetated soil zone and because the rock provides a physical barrier.

In order to optimize barrier design, particularly as to soil layer thickness and texture, three development approaches are being pursued. In the first, barrier field plots are being studied at Hanford. Five

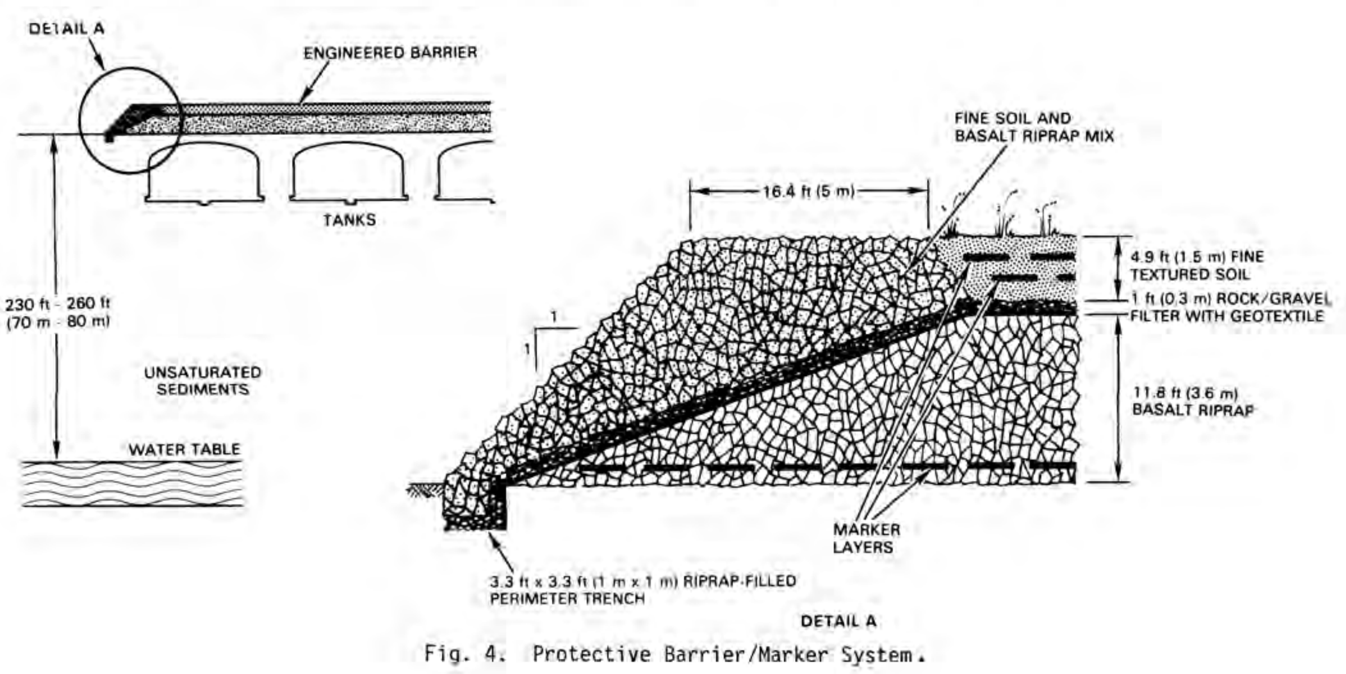

Fig. 4. Protective Barrier/Marker System.

circular barrier test plots of various design (including two multilayered barrier designs) have been constructed and instrumented to monitor water infiltration, biotic intrusion, wind erosion, and particulate infiltration. The test plots are full scale in the vertical dimension.

In a second approach, field study of geologic deposits similar in dimension and layering to barrier designs are being investigated as "natural analogs" to the barriers. The natural analogs, which have been in place from 10,000 to 100,000 years, are useful in determining the extent of water infiltration and biotic intrusion. Natural rock armored surfaces in the desert environment are also being examined to determine wind erosion rates and processes.

Third, optimization studies using existing simulation models are being conducted. Cases for various soil texture, soil thickness, plant cover, and precipitation distribution are being simulated. To date, the preliminary modeling effort supports the ability of the multilayer design concept to effectively recycle moisture even under conditions of extreme precipitation. [The 100-year maximum of 12 inches (30 cm) is considered a reasonable estimate for the mean value of precipitation in a future wet climate scenario.]

Markers

While the barrier itself would discourage human excavation or farming, a determined intruder with heavy machinery could penetrate or even destroy the barrier. A system of onsite markers and offsite records will be used in conjunction with the barriers as a means of warning human intruders. The marker system will include large surface and small subsurface components. Subsurface markers will be placed at three levels within the barrier during its construction. The subsurface markers will be placed approximately 20 feet (6.0 m) apart (center to center) at each of the three levels. The uppermost level of markers will be about 2.0 feet (0.6 m) below the soil surface. Markers will also be placed near the soil/rock interface (4.9 feet or 1.5 m) below the barrier top and near the bottom of the barrier (16 feet or 5.0 m) below the barrier top. The subsurface markers are porcelain or stoneware disks approximately 5.0 inches (13 cm) in diameter and approximately 0.5 inches (1.3 cm) thick.

Specifications for the subsurface markers were determined after consultation with a professional archaeologist. Stoneware and porcelain markers were selected based on a history of pottery extending over 8,000 years. The marker size was indicated because potsherds in archaeological excavations rarely exceed 5-6 inches across.

Messages and symbols for the subsurface markers have been proposed. One side of the disk would have a radiation symbol with the words "DO NOT DIG HERE - HAZARDOUS WASTE BELOW." The other side of the disk would have a pictogram showing a cross-section of the barrier with a person digging and another person eating food from a plant growing on the barrier (Fig. 5). A slash is drawn across the face of the pictogram to indicate that digging or eating should not be done. The pictogram is prototypical and may vary as a result of ongoing studies.

Prototype subsurface markers of five different compositions are being tested in the field and in accelerated laboratory tests. The tests will determine how well the markers withstand the chemical and physical stresses likely to be encountered in the environment. Tests to be conducted on subsurface marker specimens are thermal stress and crazing (cracking), alkali resistance, chemical resistance, compressive strength, color retention, and construction placement tests.

Fig. 5. Subsurface Marker Design.

To provide further discouragement to human intruders, the two major waste disposal areas at Hanford containing tank farms and other waste sites (200 East and West Areas) are planned to be ringed with a series of surface markers. (This is planned as a final phase in waste disposal at Hanford and is not included in the scope of the TY Tank Farm demonstration.) The marker design of interest is a granite or basalt monolith approximately 17 feet (5.3 m) high, 12 feet (3.7 m) of which would be above grade (Fig. 6). The monolith will have a four-sided, tapered shape and a pyramidal top. Three faces will be polished and have inscribed messages, symbols, and pictograms similar to those on the subsurface markers. The messages will be in the six languages of the United Nations. A raised boss will extend around the polished faces to provide protection against message deterioration by wind and water. Surface markers will be placed so that a person standing at a marker would see another marker on either side, conveying the impression that a perimeter around a boundary of concern is formed.

Surface marker specifications were also defined following consultation with a professional archaeologist. As a rule of thumb, markers at least two times human size are indicated based on evidence from Stonehenge and other sites. Smaller objects tend to be removed and placed in museums or collections. Metals and organic materials were not selected as materials because they tend to be scavenged or deteriorate. Durable, megalithic stones such as granites are recommended because they are known to suffer less deterioration as building and monument materials in polluted industrial and urban areas than do stones such as limestone and marble. Softer stones are also more subject to erosion, abrasion, and defacement.

Good drainage will be provided at the base of the markers. Granular stones tend to "wick" water from the soil by capillary action resulting in damage to inscribed surfaces. This phenomenon, known as efflorescence, can be deterred by use of a well-drained foundation for the stone.

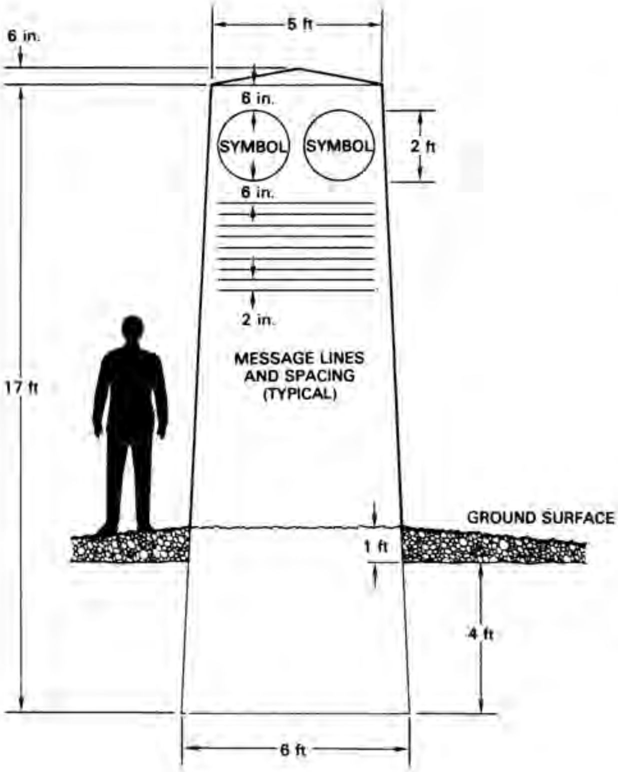

Fig. 6. Surface Marker Configuration and Dimensions.

MONITORING PROGRAM

Studies and laboratory tests have been initiated to examine chemical interaction and compaction behavior of the waste and fill mixture. As currently planned, two of the six tanks will be instrumented and a short-term (five-year) monitoring program will be undertaken. The tanks selected for monitoring represent the waste form extremes, saltcake and sludge, within the TY Farm. The rise of the level of waste in the tank, as it occupies interstitial space in the gravel, will be measured. Temperatures and temperature gradients will be determined so that predictions for temperature regimes in higher heat loaded tanks can be made. Settlement will be measured and observed. The purpose of the monitoring program is to confirm waste/fill behavior; the monitoring program does not represent particular success/failure criteria for long-term performance.

CONCLUSION

In conclusion, the single-shell tank farm disposal demonstration planned for the TY Tank Farm at Hanford is expected, after completion of the NEPA process, to demonstrate safe, cost effective, in-place stabilization and disposal of tanked salt cakes and sludges. The dome fill, protective barrier and marker system is expected to effectively deter water infiltration, biotic intrusion, erosion, and human intrusion until the waste in TY and other tank farms decays to harmless levels. The demonstration will serve to define operational costs and procedures, thus providing a basis for implementation of routine single-shell tank disposal at Hanford.