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OAK RIDGE GREATER CONFINEMENT DISPOSAL DEMONSTRATIONS -

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I. Introduction

A number of Low-Level Waste (LLW) disposal demonstrations are being conducted by the Low-Level Waste Disposal Development and Demonstration Program (LLWDDD) for the Department of Energy (DOE). This paper will focus on Greater Confinement Disposal (GCD) demonstrations being conducted in association with the disposal of a high activity low-level waste (LLW) stream to be produced by Oak Ridge National Laboratory (ORNL).

The waste stream in question will result from the cement solidification of decanted liquids from the Melton Valley Storage Tanks (MVST). The solid waste will be produced beginning in mid summer 1988. It is anticipated to have significant concentrations of Cs-137 and Sr-90, with smaller amounts of other radionuclides and <100 nCi/gm of TRU. The solid waste forms are expected to have surface dose rates in the 1-2 r/hr range. The solid waste will also contain several chemical species (nitrates, chlorides, heavy metals, etc.), at concentrations which are below those of concern from a Resource Conservation and Recovery Act (RCRA) viewpoint, but which may present enhanced corrosion potential for the disposal units.

The development of the GCD units is a joint effort among several groups. ORNL Waste Operations is responsible for the placement of the waste in the GCD units. LLWDDD will provide technical support for this effort, including conduct of an extended monitoring program to evaluate the effectiveness of the disposal units. Martin Marietta Energy Systems Engineering Division is responsible for managing project design and construction. An architect-engineer (A-E), Lee Wan and Associates has prepared the Title I and II design. Several fixed price subcontractors will be used to manufacture/construct the disposal units.

II. Disposal Unit Criteria

The GCD units are expected to provide capacity for up to 80 6-ft diameter by 6-ft high concrete waste forms cast in steel containers, each weighing 10-15 tons. The first solidified waste is expected to be produced in June 1988. While the waste forms are expected to meet all DOE and Nuclear Regulatory Commission (NRC) stability criteria, the disposal unit design will include provisions for protecting the disposal units from the potentially corrosive materials contained in the waste.

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The disposal units are required to provide multiple barriers to prevent release of radionuclides to the environment. The disposal unit design life is to be 100-300 years, with a goal of "zero" release to the environment during this control period. The disposal units and associated operation will include provisions for keeping worker exposures as-low-as-reasonably-achievable (ALARA) (the surface dose rate of the waste after emplacement should be <200 mr/hr). The location and design will provide for at least a 2-ft buffer between the disposal unit and the highest recorded groundwater elevation. Disposal unit design will provide protection from natural events such as flood (above 500 yr flood plain), wind, and earthquake (0.12g acceleration). Design, construction, and operations are to be conducted to NQA-1 standards.

III. Disposal Unit Designs

Considering the foregoing criteria, and experience gained over the last year, it was determined that two disposal technologies - an above-grade concrete tumulus and below-grade concrete silos will be engineered to provide greater confinement disposal. These disposal configurations are described later. Recognizing the nature of the solidified liquids, it was determined that corrosion and radiation resistant inner shells and liners would be needed to provide confidence that the 100-300 yr performance goal would be met. The following sections describe the materials evaluation conducted, and the GCD unit designs developed.

Materials Evaluation

An evaluation was carried out to identify materials suitable for use as inner shells and liners that would be capable of protecting the concrete pad and vaults used in the tumulus, and the mild steel and concrete used in the silos from corrosive degradation during the 100-300 yr control time period (Ref. 1). Metalics, metal ceramic composites, and plastics were reviewed. Four materials were determined to provide the desired corrosion/radiation resistance at reasonable cost.

1. Glass-lined steel is expected to provide an effective migration barrier for 300 years based on extrapolated degradation rates. Glass-lined steel provides the greatest radiolytic resistance and ultimate mechanical properties of the candidate materials. The major disadvantages of this material are limited impact resistance, handling difficulties and highest cost among the candidate materials.

2. Filament-wound vinyl ester resins (glass-filled) offer excellent chemical resistance and radiation stability. Cross-linking with novalac and incorporation of a large degree of phenyl structures in the backbone increases radiation stability and reduces oxidative degradation. Outgas rate from radiation-induced scission is very low. This material is the most cost-effective with respect to other candidate materials. Disadvantages are that the mechanical properties are slightly reduced at high dose (10^8 rads) and are less than steel initially.

3. Vinyl ester resin linings on mild steel substrate appear to meet the design criteria of no migration for 300 years. Chemical resistance and radiation stability are expected to be similar to that provided by vinyl ester resin filament-wound vessels. The primary disadvantages of this composite are a limited tendency to spall which may increase with long-term exposure, the lack of standardization in the industry which will require extensive quality assurance, and the labor-intensive application process which elevates cost relative to filament-wound vessels.

4. Vessels of rotationally cast molded cross linked polyethylene (CLPE) are considered a potential material for inner liner application in the GCD silo. CLPE is the current standard in HIC applications, offers low cost and good chemical resistance to the anticipated leachate. The primary disadvantages are a high outgas potential, susceptibility to oxidative degradation and stress crazing, difficulties in the fabrication of large vessels, and the least strength among the candidate materials.

Each of these materials is planned to be used in at least one of the GCD silo units to develop experience with, cost, constructability, and performance. The filament-wound vinyl ester resin material was judged to offer the best cost/performance combination and was selected as the liner material for the casks to be used in the tumulus disposal unit and as the inner shell for six of the silos.

Tumulus Disposal Unit Design

The existing tumulus demonstration disposal unit is planned to receive 60 of the 80 waste forms to be produced in the initial solidification campaign. The tumulus disposal unit is described in more detail in Ref. 2 and consists of a 65-ft X 105-ft, curbed, epoxy coated steel reinforced concrete pad. The pad surface is drained through two lines to a monitoring station. A 30 mil high density polyethylene (HDPE) liner isolates the gravel layer under the pad, and provides additional monitoring capability through a separate drain line.

The tumulus pad will initially be loaded with low activity waste contained in rectangular concrete vaults. The vaults will be placed in a single row, two vaults high, around the perimeter of the pad, creating an open space in the center of the pad, surrounded by a "shield" wall (Fig. 1). The shield wall will provide an access barrier and radiation shielding during the solidified waste loading operations. The solidified waste disposal casks, described in more detail in the following section, will be covered by a layer of low activity vaults following waste loading. Ultimately, the stacked waste will be covered with a layered earthen mound.

The solidified waste disposal cask will consist of steel reinforced (epoxy coated), pre-cast concrete with a filament-wound vinyl ester resin (glass filled) liner (Fig. 2). The cask will have a fixed internal cavity, with varying wall thicknesses (40 units with 8-in., 10 units with 10-in., and 10 units with 12-in. walls) to provide the ability to handle waste form surface dose rates up to 2 r/hr and still achieve <200 mr/hr cask surface dose rates.

The solidified waste is currently planned to be transported to SWSA 6 in a Department of Transportation (DOT) approved shipping cask. The waste will be removed by crane from the shipping cask and placed in the disposal cask, which will have already been placed on the tumulus pad.

The cask will be sealed by two separate covers. An internal vinyl ester resin lid will be placed and sealed to the liner to completely enclose the waste form. This cover will include a pressure relief vent with check valve. A 1-ft thick concrete cover will be placed and sealed with bitumen.

Silo Disposal Unit Design

The remaining 20 waste forms will be placed in below-grade silos which are based on the concept currently being utilized in SWSA 6. The current SWSA 6 concept involves excavation of a trench, placement of two concentric corrugated metal pipes (CMP) in the trench, and filling of the bottom and annulus with concrete to create a concrete silo. As described below, three types of silos are planned to be built as a part of the GCD demonstration/MVST disposal activities. The silos will be constructed in three modules of five units each, with two waste forms to be placed in each silo of two modules. The third module is intended for bulk LLW from routine plant operations. Each silo will include an access pipe to sample the inner silo cavity directly, and an external gravel sump for monitoring and removal of water which may infiltrate around the silos.

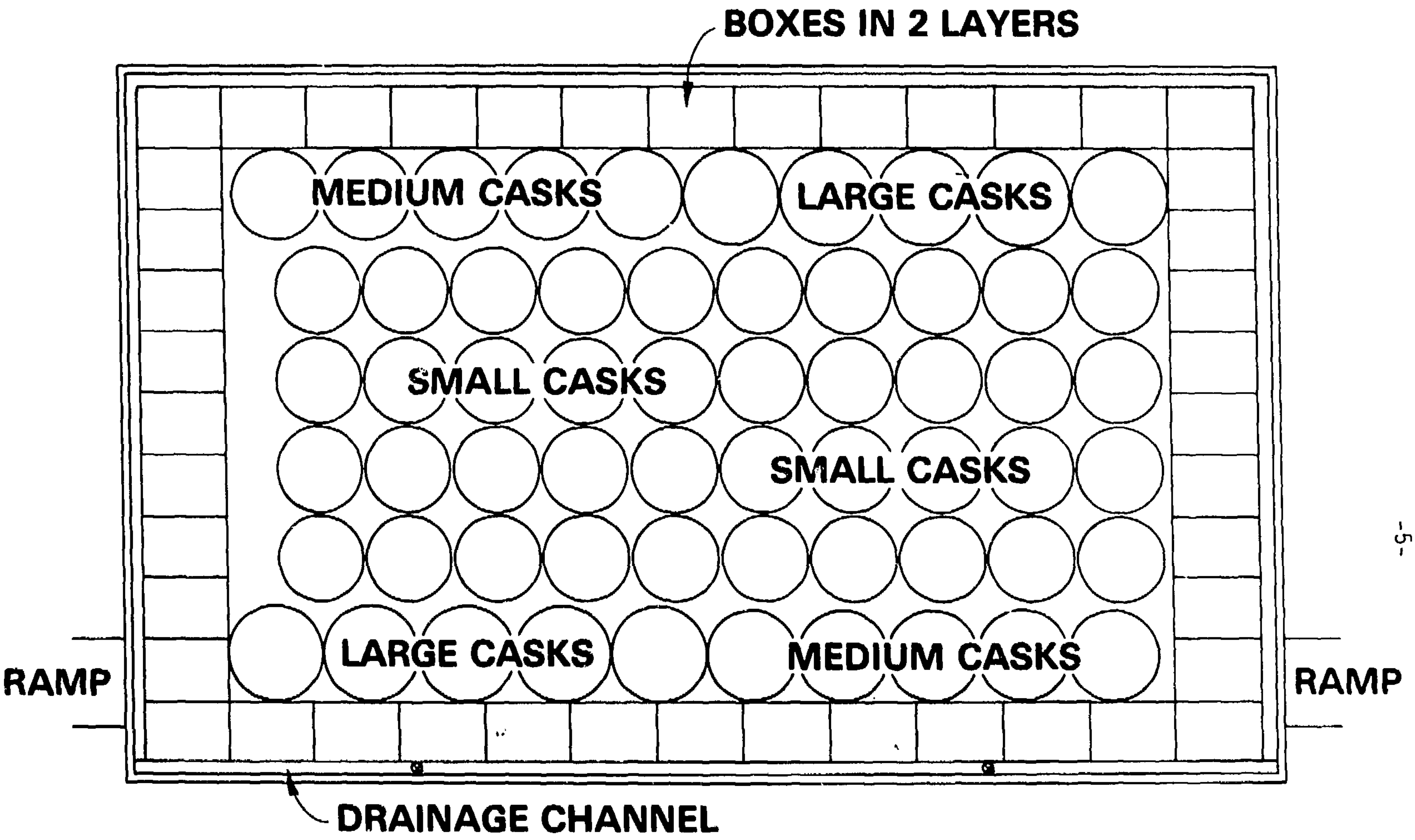

FIG. 1. TUMULUS LOADING PLAN

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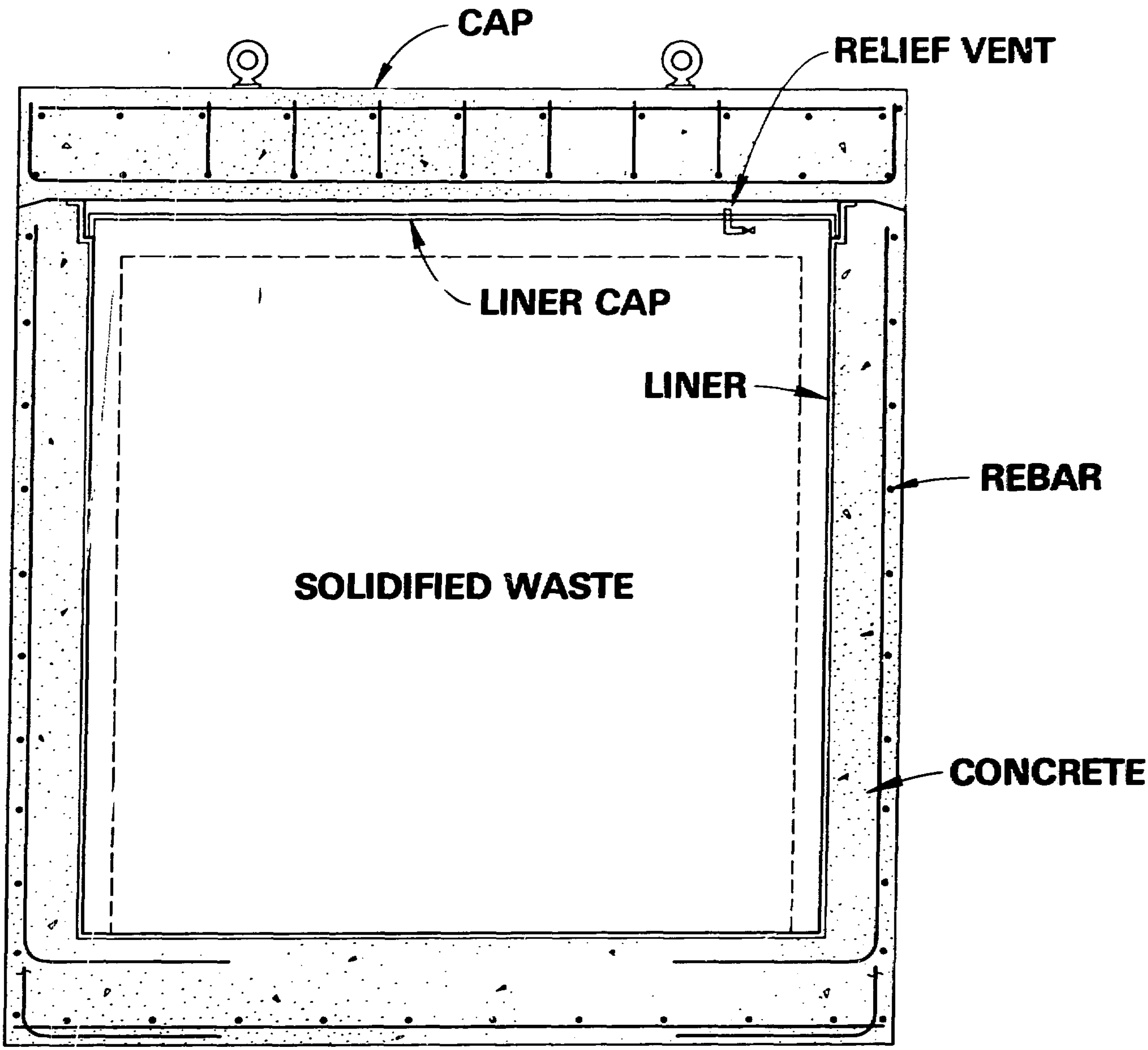

FIG. 2. DISPOSAL CASK

Type I Silo

The Type I silo is aimed at providing a retrieval capability to allow for long-term monitoring and examination of the waste form to be produced in the MVST solidification efforts. Two non-radioactive, surrogate waste forms will be produced during initial checkout and testing of the MVST solidification system and placed in the Type I silo.

The silo will be constructed by placing a 10-ft diameter X approximately 20-ft long CMP in the prepared trench (Fig. 3). An 8-ft diameter painted mild steel shell with attached sampling and vent tubes, and associated steel reinforcing will be suspended inside the CMP by a hold down structure. Concrete will be placed in the annular space creating an integral concrete silo. A 7-ft diameter X 14-ft long filament wound, vinyl ester resin tank will be placed in the silo and the void space between the silo and the tank will be backfilled with sand. A layer of sand will be placed in the bottom of the tank, a waste form placed, and backfilled and covered with a layer of sand, then the second waste form will be placed and backfilled with sand. The waste forms will be equipped with handling fixtures designed to provide capability for long-term retrieval. The tank will also be designed with handling capability to allow it to be "retrieved" from the silo to provide back-up capability for long-term waste form examination. Prior to closure a vinyl ester resin cover, with sampling/vent relief capability will then be temporarily sealed to the tank. An interim concrete cover with penetrations for the sampling lines will then be placed.

Type II Silo

The Type II silos will be designed for disposal of solidified radioactive MVST waste. The basic approach will be similar to the Type I silo, except that the free standing, inner tank be eliminated. Instead, the inner mild steel shell will be replaced with a shell made of corrosion resistant materials. One Type II silo will be constructed using each of the four materials described previously - glass lined steel, filament-wound vinyl ester resin (glass filled), vinyl ester resin lined steel, and CLFE - for the inner shell. These four Type II silos plus the one Type I silo will be placed in a single module (5 silo unit). In addition, one module (5 silos) using the filament wound vinyl ester resin (glass filled) inner shell will also be constructed.

The Type II silos will be 9-ft outside diameter, 7-ft inside diameter, by approximately 20-ft long (Fig. 4). Sampling and vent relief capabilities similar to the Type I silo will be provided. Waste loading will also involve the use of sand backfill. Inner corrosion resistant lids sealed to the inner shell, and interim concrete covers will be used. The Type II silo will include a rebar dowell insert in the top edge of the silo wall which will allow for construction of an integrally reinforced, permanent concrete cover in the future.

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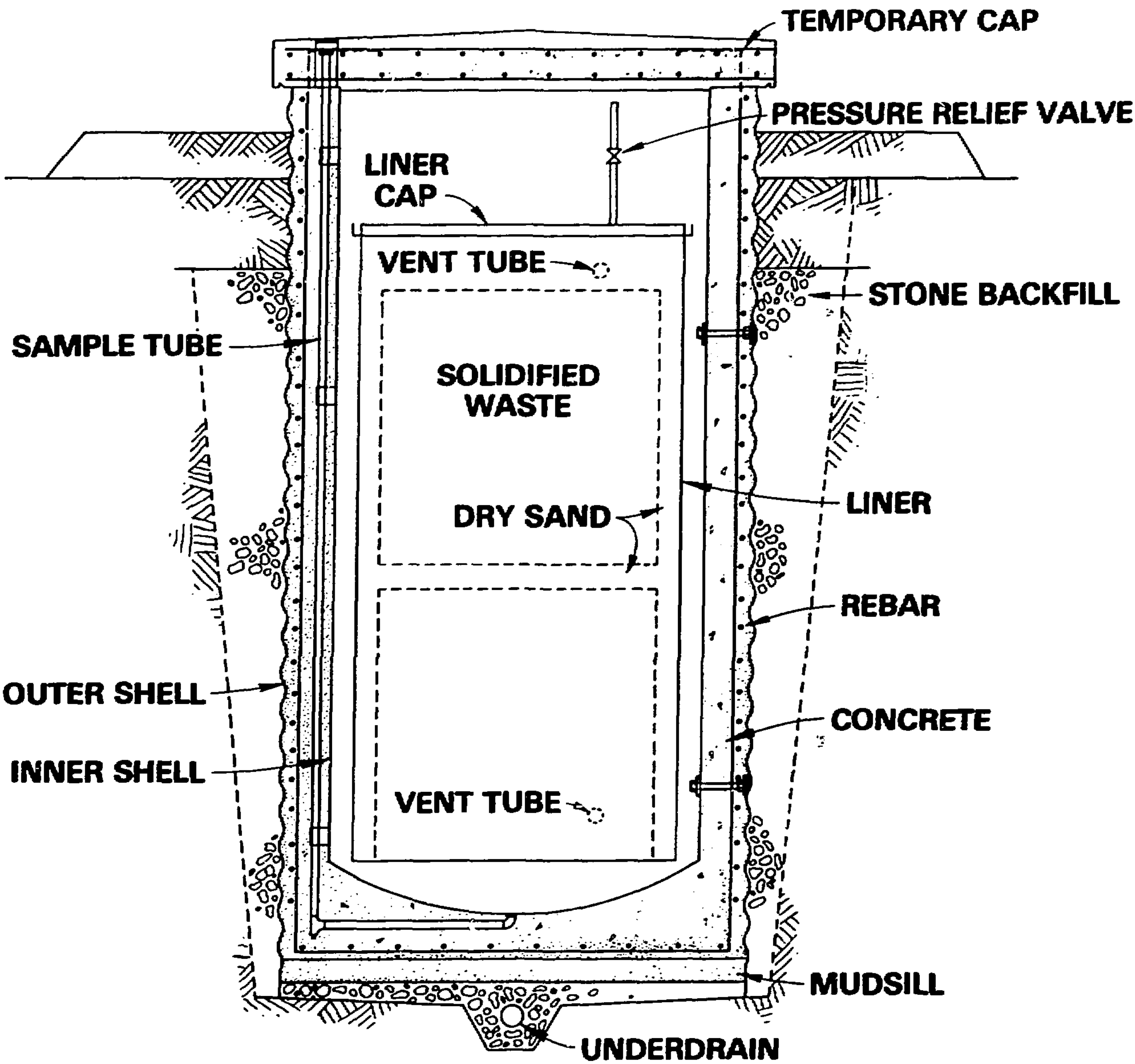

FIG. 3. SILO - TYPE I

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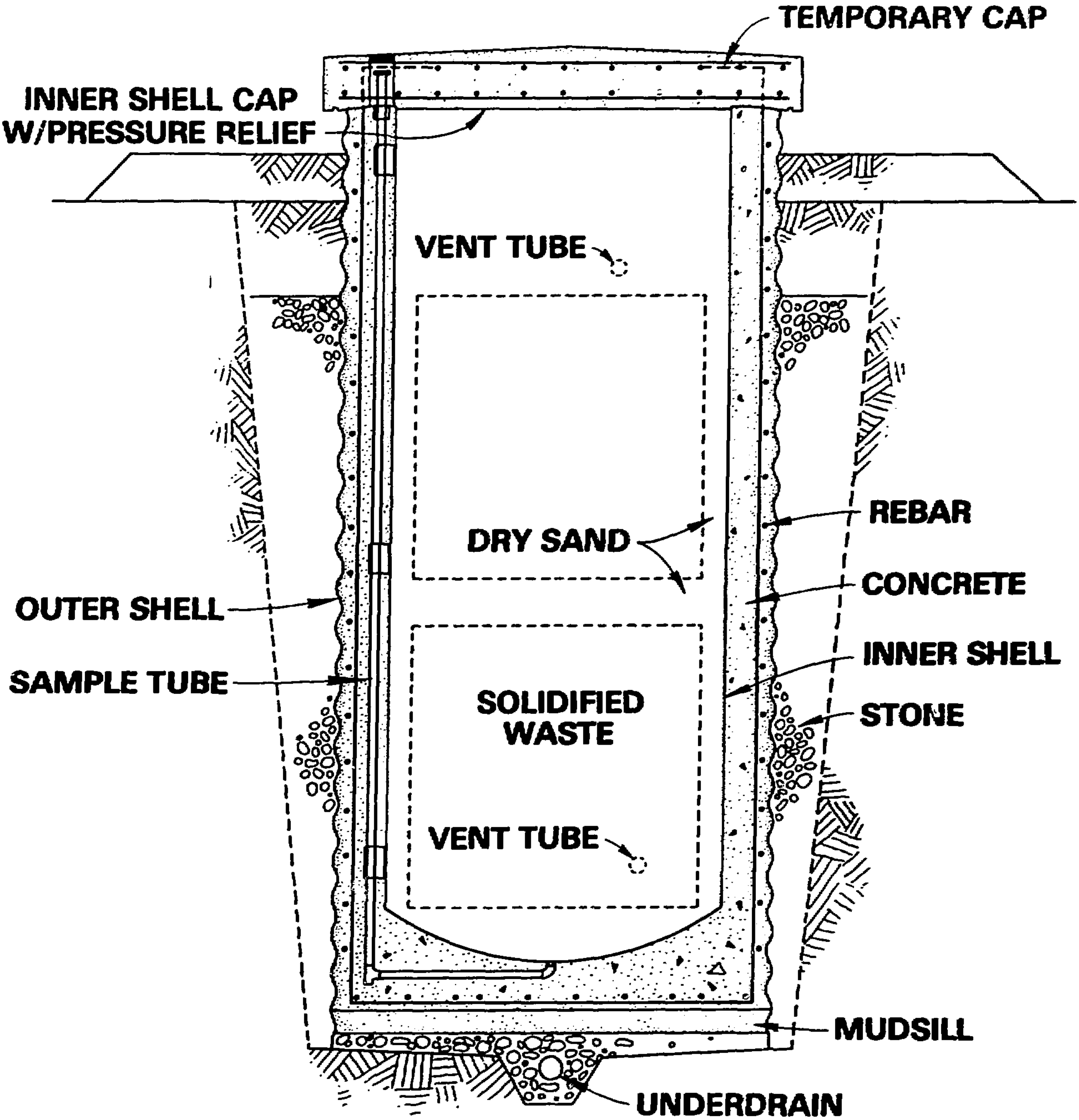

FIG. 4. SILO - TYPE II

Type III Silo

The Type III silo design is based on the existing SWSA 6 silo concept. These silos are intended for use for the disposal of non-corrosive bulk solid LLW. An 8-ft diameter by 20-ft long CMP will be placed in the trench, and the drainage system installed (Fig. 5). A 7-ft diameter CMP with centering devices will be placed inside the larger CMP with its bottom edge above the mudsill. Reinforcing steel will be placed to tie the silo bottom and sides together. Concrete will be poured for the silo base and allowed to harden. The silo walls will then be poured with a construction joint at the wall-base interface. Rebar will be placed in the upper portion of the wall to provide a connection point for the cap rebar. A temporary rain cover (and possibly radiation shielding) will be provided during waste loading operations. Upon completion of waste loading, the cap rebar will be tied to the wall rebar, and the permanent concrete cap constructed.

IV. Demonstration Performance Monitoring

A program to monitor the occupational exposures, waste form/disposal unit performance, and environmental performance of the GCD units is planned. The program is currently being developed and will likely be revised as additional information and experience becomes available.

Due to the elevated radiation fields associated with the solidified waste form (1-2 r/hr estimated), occupational exposure evaluations will be a prime focus of the monitoring plan. Preliminary analysis of doses resulting from waste form handling operations have been performed to provide information for use in identifying equipment (e.g., remote disconnect rigging, shields, etc.) and operations modifications needed to keep doses ALARA. A worker exposure monitoring program will be conducted which is aimed at providing information to validate the predictive models used initially, and to ensure that workers are protected.

Several provisions have been included in the silo units to allow monitoring of the performance of the waste forms and disposal unit materials. Each silo will include an inner cavity sump and monitoring line to allow collection and analysis of any liquids and corrosion products that may accumulate in the disposal units. Two vent tubes are also provided which are intended to provide the means to monitor for any gas generation that may result from radiation damage to the waste form or silo materials. One Type I silo will be constructed which will include provisions for direct retrieval of the non-radioactive surrogate waste forms which will be placed in that unit.

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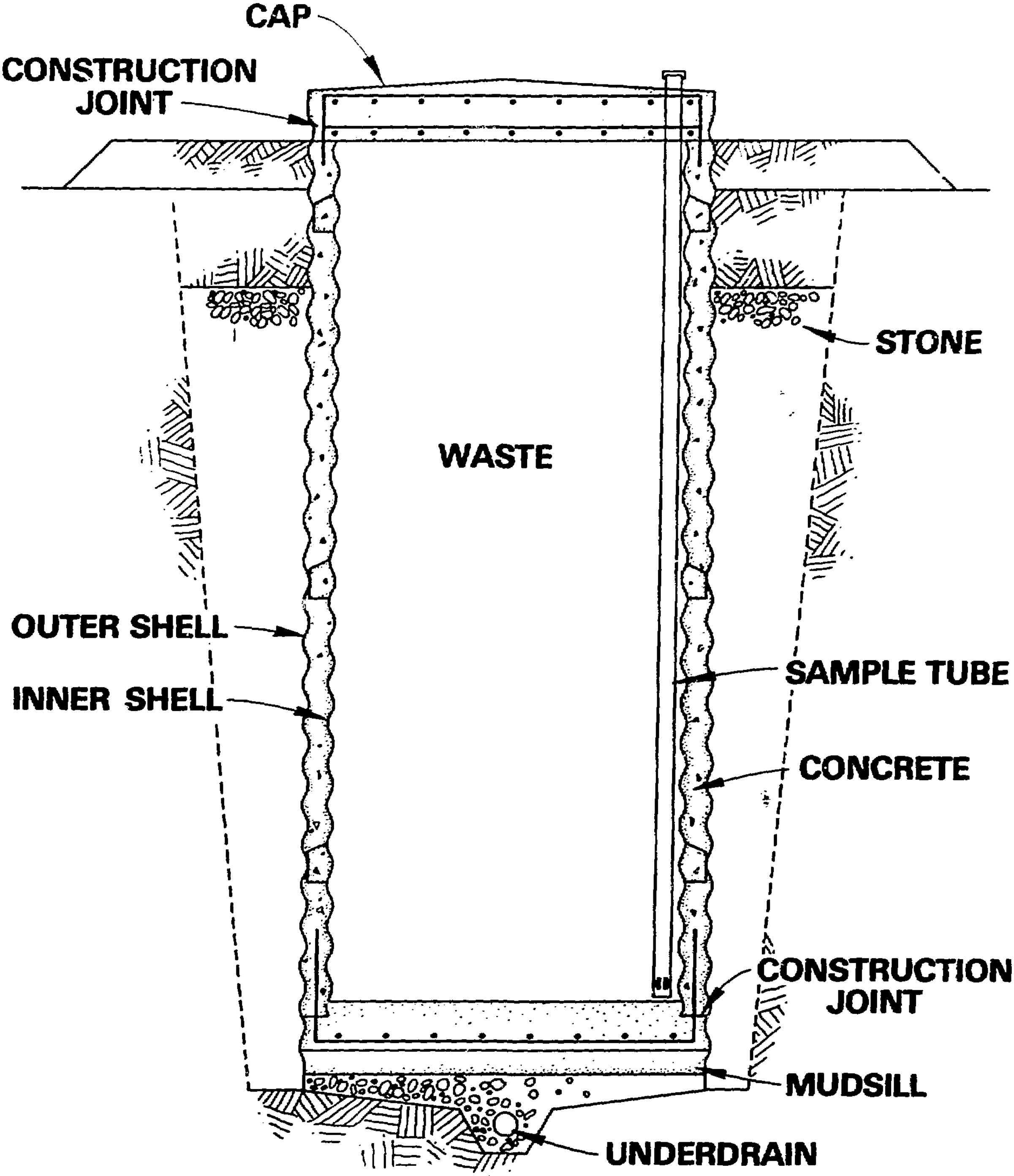

FIG. 5. SILO - TYPE III

Environmental monitoring capabilities have been provided for the silos and the tumulus. The silo's inner cavity sump will provide a means to collect and analyze any leachate which may form in the disposal unit. The external gravel sump in the bottom of each trench will provide a means to detect and monitor any release of radionuclides from the disposal unit. Ground water monitoring wells will also be placed around the disposal unit area. The tumulus unit includes pad surface drainage provisions to allow collection and monitoring of water which may have contacted the waste. In addition, the HDPE liner which encloses the area directly beneath the pad is also monitored to allow detection of any leaks through the pad.

REFERENCES

1. Selection of Materials for the Greater Confinement Disposal Silo Inner Liner, W. P. Teichert, Lee Wan & Associates, Inc., 1987, pg. 1-4.

2. S. D. Van Hoesen and R. B. Clapp, "SWSA 6 Tumulus Disposal Demonstration," Oak Ridge Model Conference, February 3-5, 1987.