WEST VALLEY'S COMPONENT TEST STAND: THE STRATEGY AND DESIGN BASES FOR THE HIGH-LEVEL WASTE VITRIFICATION FACILITY

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ABSTRACT

The primary objective of the West Valley Demonstration Project is to "...solidify, in a form suitable for transportation and disposal, the high-level radioactive waste at the Center [West Valley] by vitrification...".(1) In July 1983, the Department of Energy formally selected borosilicate glass as the waste form. The purpose of this paper is to describe the strategy that is currently being used to achieve this objective. The sections below outline the general approach and bases for proceeding.

SUMMARY DESCRIPTION OF STRATEGY

The general strategy that is currently being followed is:

1. Produce a detailed design of a remotely operated integrated vitrification process based upon the Slurry-Fed Ceramic Melter (SFCM). The equipment design of the primary components is being performed by Battelle - Pacific Northwest Laboratories (PNL) with close interaction and direction from WVNS(2,3).
2. Construct the foundation and floor of the final vitrification hot cell whose size, shape, etc. are dictated by the design in 1.
3. Enclose the foundation in a "sheet metal" building which will serve as a Component Test Stand (CTS) during a first phase of nonradioactive testing, and after final upgrade (to include the addition of shield walls and roof) will house the vitrification hot cell.
4. Fabricate and install the fully remotized key vitrification components in the CTS.
5. Verify the integrated vitrification process, and then the remote operating techniques in the nonradioactive "pilot plant".
6. Upgrade the facility to a radioactively operable plant.
7. Checkout the performance of the upgraded system in "cold" operations.
8. Vitrify the high-level wastes.

The early stages of this strategy have been initiated. The bases for proceeding with the building and equipment design are discussed in greater detail in the following sections.

BASES FOR BUILDING DESIGN

Location of the vitrification building at the West Valley site was constrained by the campaign duration, the need to use as much of the existing facilities as practical, the process equipment layout and the need for access to the existing facilities at West Valley by other Project activities.

A key assumption in locating the building was access to the large Chemical Process Cell (CPC) in the existing building. This large cell (6.7 m wide, 28.3 m long and 13.1 m to the crane hook) is to serve as the storage area for the glass filled canisters during and after the vitrificaton campaign. This cell is also sufficiently large to accommodate some equipment that might fail during the vitrification campaign. In addition, this cell is attractive because it has rail tracks that allow transfer of large equipment into and out of the cell. These tracks would also provide a means for transfer of glass filled canisters into and out of the cell. Using the CPC as the canister and failed equipment storage area, required that the vitrification building be located on an extension of the CPC rail track.

Because truck access to the Equipment Decontamination Room (EDR), the Scrap Removal Room (SRR), and Master-Slave Manipulator Repair Shop (MSM) is required for decontaminating the existing facility, the proximity of the vitrification building to these areas was constrained. To remove the large dissolvers and other equipment from the CPC, a 50 foot distance is needed in front of the EDR for truck access. Similarly, truck access to the SRR necessitated that a minimum passageway of 15 feet be provided between the CTS and the MSM.

In summary, the location of the CTS building was based on the following constraints.

Anticipated conversion of the CTS to the vitrification facility:

place building on extension of CPC rail track center line;

provide for reliable transfer of waste to the CTS from the underground storage tanks (8D-1, 2, 3, and 4).

Minimum adverse impact on decontamination and decommissioning of the existing building:

allow truck access to the EDR (15.2+ m north of EDR shielding door) until large equipment is removed from CPC.

permit truck access to the SRR (4.6+ m aisle west of MSM repair shop).

These site specific constraints needed to be accommodated but the operability of the vitrification process was the priority consideration. The process scheme, equipment sizing and cell arrangement defined for the building design are described below.

SUMMARY OF VITRIFICATION PROCESS OPERATIONS

The process steps for vitrifying the high-level wastes at West Valley can be summarized as follows:

1. Transfer less than 18,900 litres of 8D-2 slurry to one of the two Concentrator-Feed Makeup Tanks (CFMT).
2. Acidify the slurry to a 2 molar nitric acid solution/slurry.
3. Add the tank 8D-4 acid THOREX waste and eluate from the salt decontamination process.
4. Concentrate the waste, followed by the addition of glass former slurry to achieve the required final glass slurry feed.
5. Batch the melter feed to the melter feed tank after the other CFMT is empty. (The batch cycle time to prepare the waste for melter feeding is about 100 hours.)
6. Meter the waste continously by airlift to the melter at a rate of 100 to 150 litres per hour (depends on the ability to concentrate the feed slurry).
7. Vitrify the waste slurry in the reference Slurry-Fed Ceramic Melter at a glass production rate of 45 kg/h.
8. Cool slowly the glass filled canisters in a canister turntable for 90 to 120 hours and then replace with empty canisters.
9. Move a filled canister to the weld station to affix a lid to it. (Subsequently the canister is loaded into the transfer cart.)
10. Complete the transfer of the canisters to the CPC after five canisters are filled.
11. Fill the cart, on the return trip to the CTS, with empty canisters in the tunnel between the CTS and EDR (canister transfer to the CPC takes place about every 220 hours).

The melter off-gas is quenched, scrubbed and batch recycled to the operating Concentrator-Feed Makeup Tank. Noncondensible off-gasses are scrubbed of NO_x and filtered to below allowable emission standards before release from the stack.

The major equipment pieces in the vitrification process are:

Two, 18,900 litre Concentrator Feed Makeup Tanks
Melter Feed Tank and Feed Delivery System
Slurry-Fed Ceramic Melter
Canister Turntable
Canister Weld Station
Canister Transfer Cart
First Stage of Melter Off-Gas Scrubbing
Secondary and Tertiary Off-Gas Cleaning Components (condenser, aerosol filter, HEPA's, NO_x scrubbing, etc.)

The two large Concentrator-Feed Makeup Tanks are required because mobilization of the 8D-2 slurry will require several days of down time to adjust the locations of the sluicing/transfer pumps and for homogenizing the slurry that is mobilized.

EQUIPMENT ARRANGEMENT

From a knowledge of the required process equipment, of potentially high maintenance items and of remote operating requirements, desirable equipment arrangements would have the following characteristics:

Melter Located on the CPC Track Centerline

The Slurry-Fed Ceramic Melter with a capacity of 150 litres per hour processing rate requires a relatively large unit. Because the assembled melter will weigh about 45.5 tonne and a large overhead capacity crane could not be justified for the short campaign, removal from the building could only be accomplished by using the tracks which are already required for transferring canisters into the CPC.

Melter "Plugs" into one of the Cell Walls

Since the current flow to the melter is relatively high (2,000 to 3,000 amperes) and remote canyon connectors for this purpose are not readily available, the power electrodes were required to be fed through the wall where the electrical connections can be fit-up nonradioactively. This approach has the further advantage of reducing the required in-cell "floor space" because remote connectors are not required inside the cell. Access to these electrode extensions also permits connections for the electrode cooling air and thermocouples to be assembled outside the cell, again reducing the need for valuable in-cell space and eliminating the need for canyon remote connectors for these services.

Feed Delivery System Adjacent to the Melter

The waste slurry exhibits the potential for plugging lines, particularly at the relatively low flow rates to the melter. To minimize the potential, the lines should have a high slope (~45 degrees) and be as short as practical.

First Off-Gas Scrubber Adjacent to the Melter

Although techniques for avoiding off-gas line plugging have been demonstrated by Savannah River, the off-gas line to the first scrubber does exhibit the potential for plugging. Because this could be a high maintenance item, it should be made as short as practical.

Avoid Canister Handling Over Process Equipment

If at all possible, the routine operation of replacing a full canister by an empty one should not require moving over other process components. This would then minimize the potential for damage of process equipment by accidental dropping or dragging the canister onto process tanks and/or jumpers.

The remotization philosophy that was to be used included:

- canyon remote technology;
- potential for visual observation of equipment and jumpers through lead shielding windows;
- potential for Master-Slave Manipulators at potentiallly high maintenance areas;
- capability of removing all equipment from the building by remote operation; no contact maintenance in vitrification cell should be planned.

This approach has a major influence on equipment arrangement and placement. For example, distances from cell walls, space for jumpers, etc., dictate the cell arrangement.

Knowing all the process equipment required and its size, over 60 different building and equipment arrangments were considered. The building arrangment and size that was selected is shown graphically in Fig. 1. The orientation of this building relative to the existing facilities is presented in Fig. 2 A and B. Note that the majority of the process equipment is located in a pit 4.3 m below grade. This approach was required by the elevation of the CPC tracks on which the melter must roll into and out of the facility. The need for the pit is a consequence of the requirement that filling canisters are beneath the melter. Because the mechanical agitators require a crane hook height of about twice the height of the tank, the pit arrangement provides an area for efficient use of required cell volume. Figure 3 presents an elevation cutaway view of the CTS pit.

Based on the previous requirements, the selected equipment arrangement and location of the building were defined. A detailed design for the vitrification building foundation and floor has been completed. The design was based on contemporary and anticipated requirements so it will be appropriate for conversion to the vitrification building. The codes and standards adopted for the CTS foundation are tabulated below:

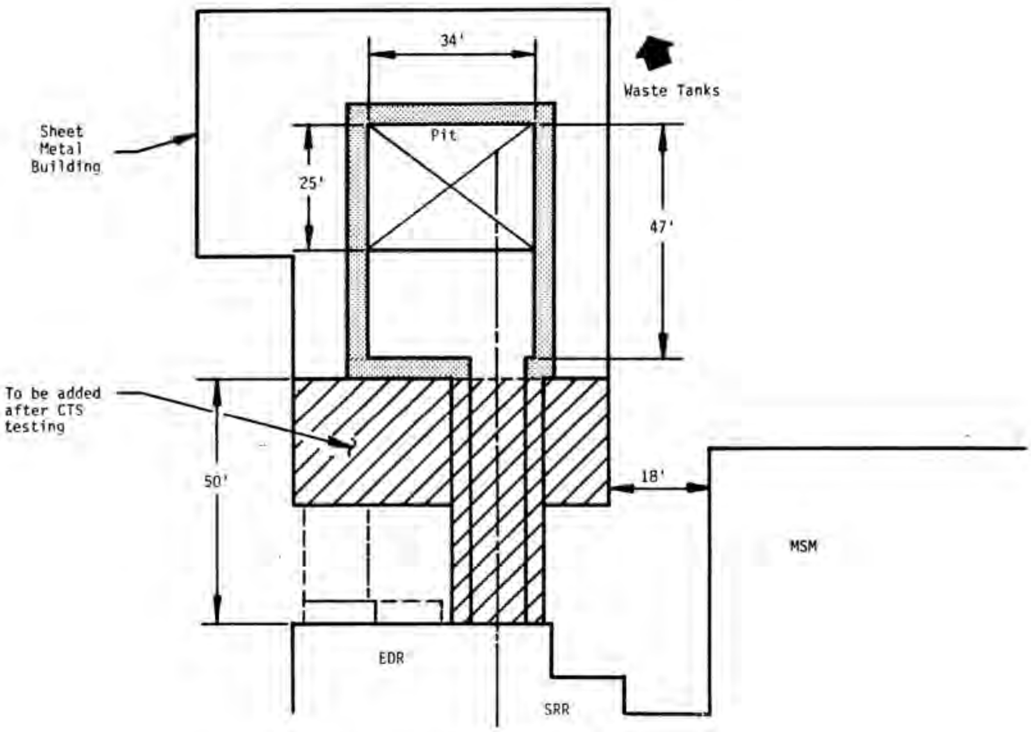


Fig. 1. CTS Building arrangement and size.

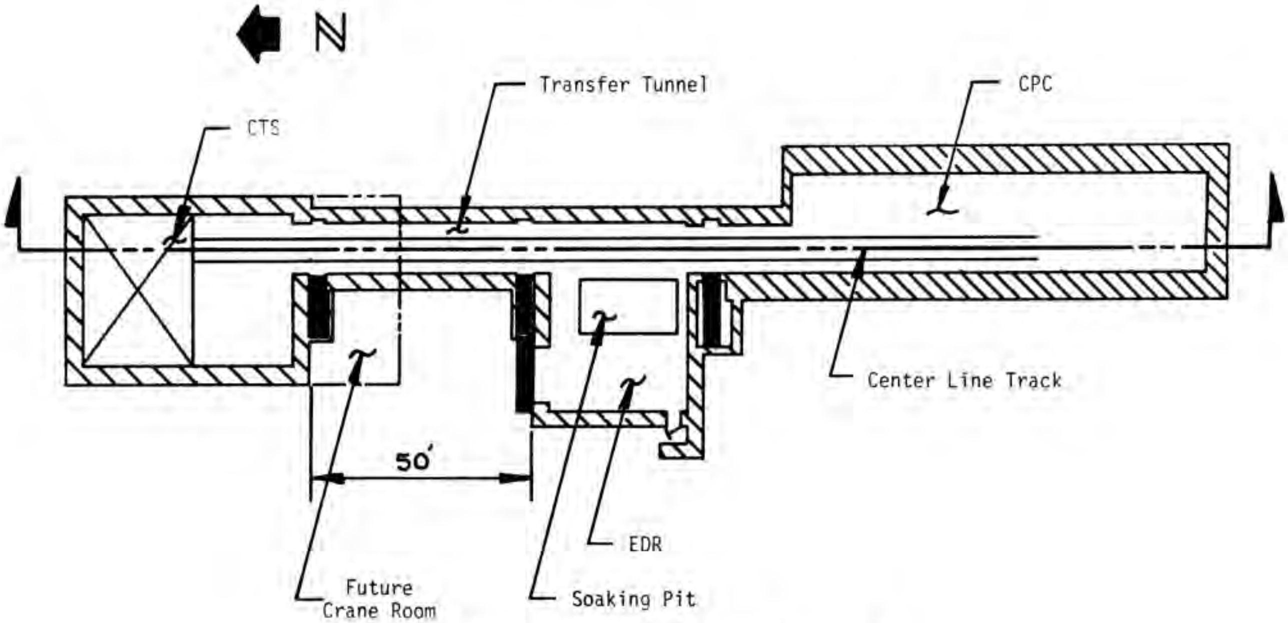
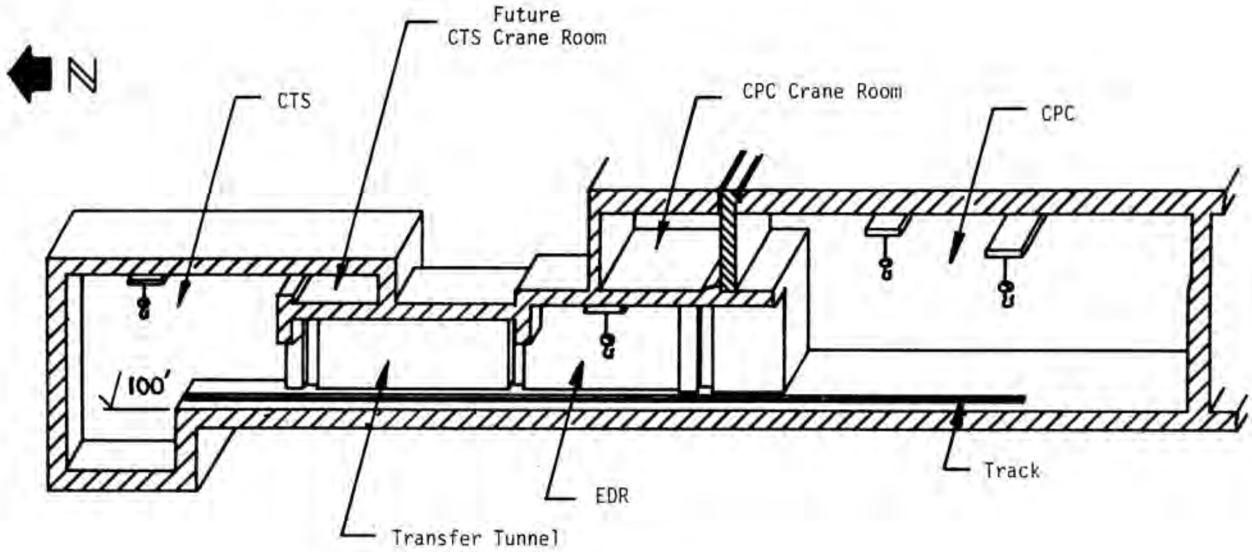


Fig. 2A. Plan section of CTS, EDR, and CPC Cells.



Section A-A

Fig. 2B. Vertical section of CTS, EDR, and CPC Cells.

Codes and Standards for the CTS Foundation

ACI 318, with Supplemental Loads as Specified;
AISC
AWS D1.1
UBC, Zone III, I = 1.5 with a Vertical Acceler- tion Component Equal to Two-Thirds of the Horizontal
ANSI A58.1

The completed concrete pad design is currently under construction at the West Valley site and barring extended inclement weather conditions, the CTS foundation will be completed by the spring of 1984.

CTS COMPONENT DESIGN

The Component Test Stand (CTS) will verify the integrated process of the key components, namely, the Concentrator-Feed Makeup Tank, the Melter Feed Tank, the Feed Delivery System, the Slurry-Fed Ceramic Melter, the Canister Turntable, and the First Off-Gas Scrubber. Additional equipment will be required to operate the integrated system but it will not be remotized or configured for remote operations during the early stages of CTS operation. Battelle Pacific Northwest Laboratories has the task of detailed design of the in-cell components and associated jumpers. A schematic of the components and jumpers is presented in Fig. 4. The

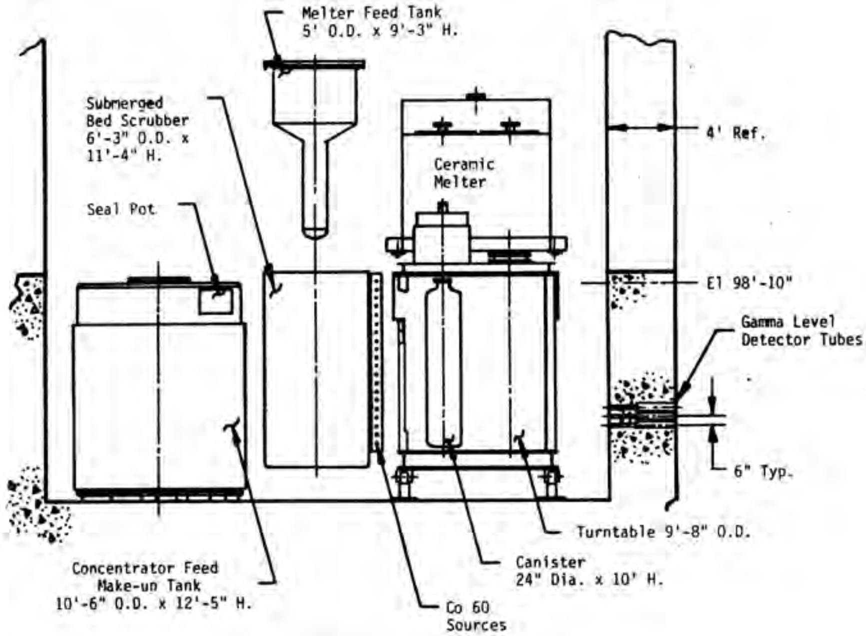


Fig. 3. Elevation view in the CTS pit.

detailed design of the CTS components and jumpers is scheduled to be completed by early summer 1984. Installation of the components is scheduled to begin in late 1984. Initial startup of remotely operable integrated vitrification "pilot plant" is scheduled for June 1985.

CTS VERIFICATION TESTING

The early stage of the CTS testing will focus on verification of the process flowsheet, equipment operation, and then integration. The next stage will be to define technical operating specifications and validation of operating procedures. Important characteristics to be verified include:

Concentrator Performance - evaporation rate, foaming tendency, carryover, homogenization of simulated waste feed and glass formers, sampling capabilities - accuracy and batch cycle time.

Melter Feed Tank - maintenance of feed homogeneity/suspension and the need for feed sampling.

Feed Delivery System - plugging tendency, gas rate for accurate metering, head pot foaming, and carry over.

Slurry-Fed Ceramic Melter - processing rate range and limitations, homogeneity of output glass for inlet feed and response to feed rate and compositional variations.

Canister Turntable - thermal environment provided canister, extent of canister contamination and canister removal and replacement times.

First Off-Gas Scrubber - particulate removal efficiency, solids accumulation tendency and accommodation of off-gas surging.

These and other data will be important to the upgrade design work which will parallel the later CTS testing. When the upgrade design is completed and actual construction of the upgrade is scheduled, the primary focus of the CTS testing will be on remote change out of jumpers with anticipated high maintenance requirements. If the upgrade construction requires removal of the components, as is now anticipated, the components will all be remotely removed to verify this capability.

During the CTS upgrade construction phase, all of the components will be examined to verify that they are suitable for use in the radioactive vitrification campaign. Those requiring replacement or modification will be replaced/modified for radioactive operations.

As upgrade construction permits, the vitrification components will be installed back into the CTS using remote placement techniques. After installation, the equipment will be tested during cold operations to confirm fully integrated operations and operating procedures will be confirmed. At this stage the gamma glass level detection system which uses cobalt 60 sources will be verified.

Finally, hot vitrification will be initiated by late 1988.

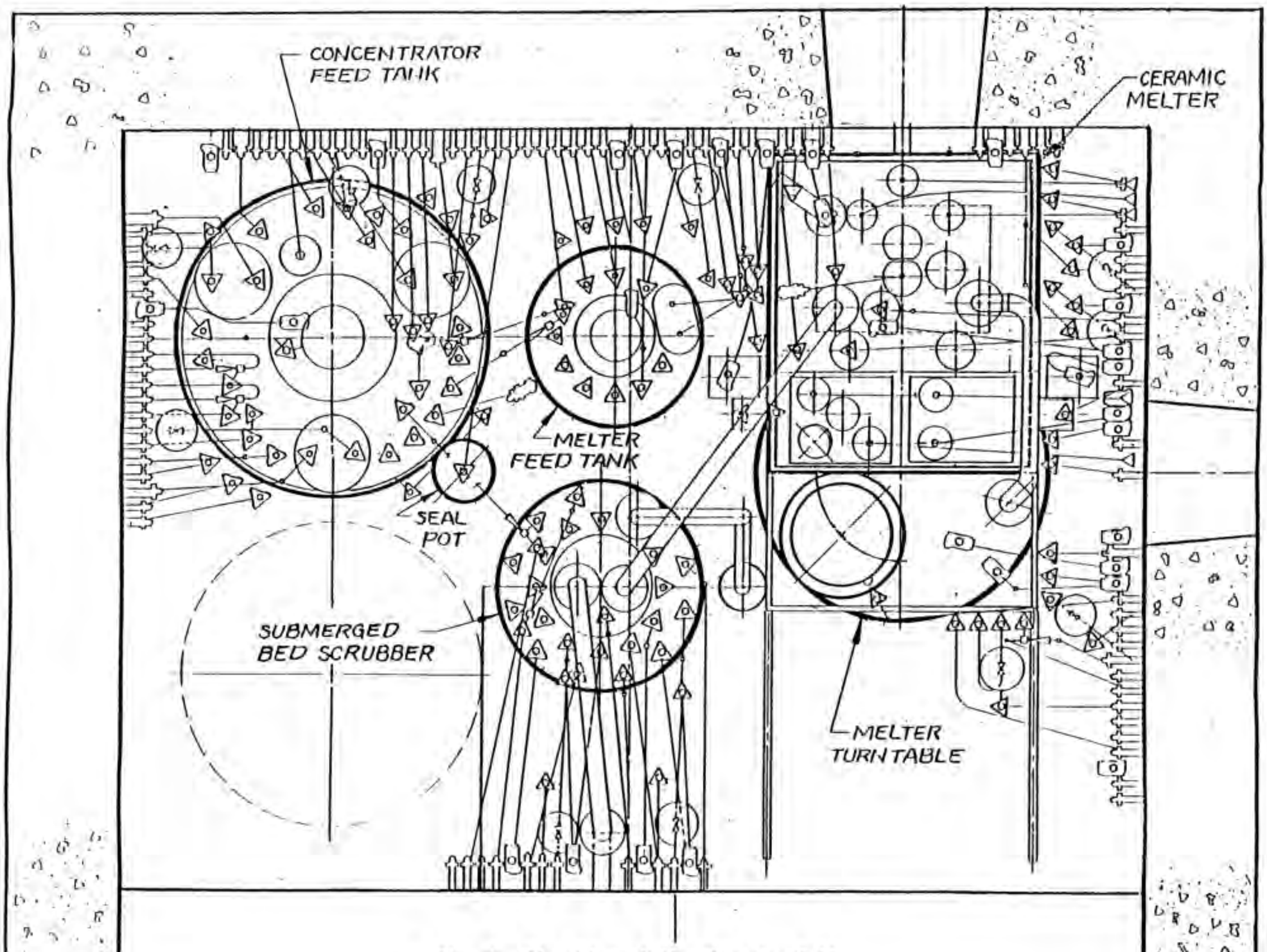


Fig. 4. Plan View of Vitrification Cell Showing Jumpers

REFERENCES

1. Public Law 96-368 - October 1, 1980

2. D. H. SIEMENS and C. C. CHAPMAN, "Remote Design Considerations for the West Valley Slurry-Fed Ceramic Melter System," Presented at the Second International Symposium in Ceramics in Nuclear Waste Management, 85th Annual Meeting of the American Ceramic Society, April 24-27, 1983, Chicago, Illinois

3. C. C. CHAPMAN, "Design Preferences for a Slurry-Fed Ceramic Melter Suitable for Vitrifiying West Valley Wastes," ibid