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VITRIFICATION PILOT PLANT PROCESS CONFIGURATION UPGRADE EVALUATION

Fernald Environmental
FERMCO
Restoration Management Corporation

July 17, 1996

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Systems Manager: John L. Smets

Task Leader: Brent Johnson

Contributing Authors: Bob Bromm
Rich Lowery
Paul Schroeder
Steve Sharp
Chris Sutton

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1.0 ABSTRACT

This paper presents the results of the second phase of the Vitrification Pilot Plant Upgrade Evaluation. The second phase of the study, Process Configuration Upgrades, provides the basis for pilot plant configuration modifications required to upgrade the pilot plant to a 5 MT/D vitrification plant. While the first phase of the study evaluated which pieces of existing pilot plant equipment can support the production of up to 6 MT/D of glass product, this phase of the study showed what modifications will be required to the pilot plant in terms of new equipment, piping, and basic configuration of the operating systems to support the expanded mission.

2.0 EXECUTIVE SUMMARY

The second phase of the Vitrification Pilot Plant Upgrade Study, Process Configuration Upgrades, was carried out on a systems based approach. Each of the pilot plant process and mechanical systems was evaluated to determine what modifications will be required to support the production of up to 6 MT/D of glass. The modifications considered were equipment replacement or modification, piping replacements, and basic equipment reconfiguration. Modifications to enhance safety, maintainability, and operability were also considered by carrying out Reliability, Availability and Maintainability (RAM) and Failure Modes and Effects Analysis (FMEA) discussed in separate reports. The study also evaluated the optimum interfaces between the individual process and mechanical systems as well as the balance of the Fernald site.

The results of the study are presented in a series of figures and tables included in this report. Figure 1 presents the Vitrification Pilot Plant (VITPP) as it is currently constructed. Equipment which is to be removed from the VITPP or modified and reused is shown on Figure 2 and listed in Table 1. VITPP equipment which can be reused as is in the upgrade is listed in Table 2. The final plant proposed for the upgrade is shown on Figure 3. The key features of the upgrade are listed in Table 3, grouped by systems.

By referring to the tables and figures listed above, it can be seen that the most extensive equipment replacement and reconfiguration occurs in the Off-Gas System. The underlying cause for the inadequacy of the Off-Gas System is hydraulics, i. e., the inability to maintain melter vacuum at increased throughput. While much of the equipment in the Waste Water Treatment System can be reused, the equipment configuration is being modified to meet the requirements of the Advanced Waste Water Treatment (AWWT) plant.

While evaluating each of the process and mechanical systems, it was necessary to develop the functional requirements for each system. In many cases, more than one method of meeting the functional requirements was formulated. The scope of this study did not allow for the detailed evaluation of alternate designs. Therefore, on the basis of judgement, one of the alternatives was selected for the basis of the plant configuration, and alternates are discussed on a qualitative basis in this report.

In order to support the final recommendations, this report will be re-visited when the pilot plant information becomes available. This report represents the recommendations and conclusions based on engineering evaluations while the final recommendations must take into account operating experience from the pilot plant.

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3.0 INTRODUCTION

3.1 BACKGROUND

The overall objectives of the Pilot Plant Upgrade study are: (1) to determine what modifications are required to the existing Vitrification Pilot Plant to upgrade it to an operating 5 MT/D long term vitrification plant and (2) To determine the optimal method of achieving the Fernald ten year clean-up plan by using the upgraded pilot plant and any required additional ancillary facilities.

Phase I of the pilot plant upgrade evaluation was to determine the optimum target upgrade capacity based on the existing equipment in the pilot plant. In order for the upgrade to be economical, it will be necessary to maximize the reuse of the existing equipment and facilities. In order to accomplish this, it is necessary to determine the maximum capacity of each piece of equipment and select an appropriate ultimate capacity that will maximize re-use and therefore minimize cost.

A key assumption to the screening study was that the existing melter can produce at least 5 MT/D of glass based on scale up from a VSL bench scale melter. The Equipment Screening Study did demonstrate that a significant portion of the existing pilot plant equipment can support a 6 MT/D glass production rate (see Table 2). Therefore, the basis for the remaining portions of the Upgrade Study is a glass production rate of up to 6 MT/D.

The second phase of the Upgrade Study, which is the subject of this report, resulted in a recommendation for an upgraded configuration of the VITPP which will facilitate producing up to 6 MT/D of glass with a Total Operating Efficiency (TOE) of at least 70 percent. The proposed configuration must be accepted by FERMCO management and the DOE prior to continuation of the Pilot Plant Upgrade Study.

3.2 PURPOSE, OBJECTIVES, AND SCOPE

The purpose of this Process Configuration Upgrade Study was to evaluate process and mechanical systems to determine what modifications to the VITPP will be required to support the production of up to 6 MT/D of glass. The modifications considered were equipment replacement or modification, piping replacements, and basic equipment reconfiguration. Modifications to enhance safety, maintainability, and operability were also considered by carrying out RAM and FMEA analysis. The study also evaluated the optimum interfaces between the individual process and mechanical systems as well as the balance of the Fernald site.

The objective of the study was to establish a vitrification plant design, incorporating as much of the existing pilot plant equipment and piping as possible, which meets the overall goals for plant capacity, TOE, and compatibility with the Fernald site. The goals for the plant are discussed below under "Assumptions and Criteria" and in Section 4 in terms of functional requirements for each process and mechanical system.

The scope of the Process Configuration Upgrade Study was to establish one vitrification plant design configuration which meets the above stated objectives. Possible alternate design configurations are discussed in this report but are not developed in detail. Alternate configuration studies were not within the scope of this study. Preparation of PFDs and P&IDs, equipment and pipe sizing, facility layout drawings, and cost estimates were not in the scope of this report but are the subject of the remainder of the Pilot Plant Upgrade Study.

It should also be noted that this study does not necessarily cover all of the changes which will be required to upgrade the VITPP to a 5 MT/D production facility. For example the work to be performed in the remainder of the Pilot Plant Upgrade Study may reveal that existing piping is inadequate on the basis of hydraulics or metallurgy. Also, not covered in this report are upgrades which may be required for ancillary, nonprocess systems, i.e., HVAC, DCS, electrical, and facilities.

3.3 METHODOLOGY

The methodology for the Process Configuration Upgrade Study was a systems approach. First, the functional requirements for each of the process and mechanical systems was established in terms of supporting production, interfacing with other systems, meeting regulatory requirements, and integrating with the Fernald site. With the functional requirements established, the need for equipment and piping reconfiguration and the need for new equipment, to supplement existing pilot plant equipment, was established.

3.4 ASSUMPTIONS AND CRITERIA

The key overall criteria and assumptions for the Process Configuration Upgrade Study are:

* The existing pilot plant melter will be capable of producing at least 5 MT/D of glass. This assumption is based on scale up from a bench scale melter at VSL.
* The system supporting the melter must be capable of supporting a glass production rates of 6 MT/D such that they do not bottleneck the melter.
* Only material from silos 1 and 2 will be vitrified. Silo 3 material will be handled by an alternate process. The material balance will be based on "Series A" glass.
* The operating vitrification plant must have a TOE of at least 70 percent.
* Off-spec glass will be stored and recycled to the melter after all silo material has been processed. There will be no preinstallation of recycle equipment.

Additional criteria and assumptions are discussed below in Section 4 for each system and in the calculational backup for each system evaluation.

4.0 TECHNICAL DISCUSSION

The following sections address the functional requirements for each system, the current pilot plant design of each system and its potential problems, the proposed redesign of the systems, and finally, any technical uncertainties and possible alternate designs. For all system discussions, please refer to the overall process flow sketches presented on Figures 1 and 3.

For reference, a listing of the vitrification plant systems and major system components is presented on Table 4.

Except as noted, the following process descriptions of the current VITPP design are based on the PFDs and P&IDs provided in Construction Document Control (CDC)/ /Controlled Copy No. 404 design drawings. Vendor certified performance data and other vendor data are used as available in CDC.

4.1 SILO RETRIEVAL SYSTEM

4.1.1 Required Functions of VITPP Silo Retrieval System

The VITPP Silo 1 and 2 Retrieval System shall be designed to perform the following functions:

- Receive a high-pressure stream of low-solids recycle water and utilize it for hydraulic removal and flushing operations.
- Break-up residue material (K-65) and form a pumpable slurry at a rate to sustain retrieval operations while screening out non-pumpables.
- Remove slurry from silo and transfer sufficient slurry forward to the Thickener Tank to support the VITPP production rate.
- Provide radiological containment to help ensure environmental and worker protection.
- Remove all materials from Silos 1 and 2 to facilitate D&D activities. This includes the removal of: all residue material, all discrete (non-pumpable) articles, and all heel material.
- The Silo 1 and 2 Retrieval System shall provide the capability to decontaminate the interior silo walls and place the silo structure in a safe shut-down condition for ultimate decommissioning.

Additionally, the VITPP Silo Retrieval System shall be designed so that its deployment does not adversely affect removal operations of berm material (e.g., the material standing against the silo's exterior structure). In order to maintain an equal and opposite static load on the silo structure, and thus, maintain silo structural integrity, the standing level of berm material surrounding a silo will be maintained at an equivalent level to the residue material inside a silo.

4.1.2 Description of Existing VITPP Silo Retrieval System

The current baseline for silo residue removal is documented in the Operable Unit 4 Vitrification Pilot Plant Phase II Treatability Study Work Plan, Rev. 1, dated August 1995. The following paragraph summarizes the concept.

A mobile crane will suspend a hydraulic mining device and deploy it through one of five existing manways mounted on the dome of Silo 2. Radon control (from silo headspace) will be via a "bag-in/bag-out" procedure while inserting/removing the hydraulic mining device into the silo. The hydraulic mining device consists of a slurry pump fitted with a sink/spray ring that is compact enough to allow for deployment through the existing silo outer manways. High pressure recycle water from the Recycle Water Tank (5-TK-10) is used to hydraulically mine the silo material. The pump is rated at 50 gpm at 15 to 20 percent solids to supply the VITPP with approximately 30 MT of K-65 residue.

It is intended during Phase 2 VITPP to operate the Silo Retrieval System for up to 6 hours a day rather than continuously. During normal operations, the system receives high pressure, low-solids water pumped from the VITPP Recycle Water Tank (5-TK-10). This stream is carried to the silo via double-walled transfer piping. The recycle water flow rate is adjusted to approximately 40 gpm to balance the rate at which the waste slurry is transferred from the silo by the pump.

Flowing at a pressure of 200 to 250 psig, the water proceeds to the sink ring where it feeds eight separate nozzles. The resulting high velocity jets of water hydraulically mine the solid waste located within the effective excavation diameter. This forms an aqueous slurry that is transferred from the silo at approximately 50 gpm by the submerged, motor driven, pump. At an approximate solids concentration of 20% (correlates to a Specific Gravity of 1.15), the pump can transport approximately 5,748 lb/hr (2,613 kg/hr) of residue material (can pump 30 MT of K-65 residue in approximately 12 hours).

The solids content of the recovered slurry is controlled by raising and lowering the slurry pump and controlling the recycle waste flow. Lowering the pump increases the solids mining rate due to solids settling (slurry density), while raising it has the opposite effect. The actual slurry solids content is expected to vary since the method of its control is crude at best. However, widely varying slurries can be accommodated by the Thickener.

From the top of the silo, the recovered waste slurry is routed to the Thickener Tank (5-TK-01) through double-walled piping. At the conclusion of waste removal operations (daily), the Silo Retrieval pump is turned off and all slurry material is flushed with the low-solids recycle water as necessary to avoid solids settling.

4.1.3 Potential Problems With Existing VITPP Silo Retrieval System

The specific problems anticipated with the Silo Retrieval system design concept at 6 MT/d production are identified and described below.

1. The mobile crane concept is intended for limited, localized retrieval operations. This concept does not appear to be appropriate for a long-term production facility, nor dos it appear appropriate for berm material removal operations.

2. The existing Silo Retrieval design permits retrieval operations from only Silo 2. Currently, no provisions exist for Silo 1 retrieval operations.

3. The present concept requires personnel access on the dome for pump installation and removal (as well as inspection and maintenance of the enclosure seal). Personnel radiological exposure would be at risk of exceeding FEMP and DOE limits which would not meet the intent of ALARA.

4. The present concept does not provide the capability to facilitate D&D activities. Although accessing multiple manways would allow most of the residue to be slurried and pumped out of Silos 1 and 2, no provisions exist for the removal of discrete objects remaining in either silo, or their decontamination.

5. Maintaining glovebag integrity (and thus containment) is difficult during adverse weather conditions (e.g., cold temperatures).

6. Silo structural analysis indicates that berm material around Silos 1 and 2 must be lowered during residue retrieval in order to maintain the silo's structural integrity. Hence, an alternate path for personnel access (in full PPE) to the silo dome structure will have to be provided (currently, silo access is provided by the berm).

7. The current Radon Treatment System does not have the capability to maintain a negative pressure in the silo headspace to ensure directional airflow (ALARA design principle).

4.1.4 Proposed Redesign of VITPP Silo Retrieval System

The proposed redesign of the VITPP Silo Retrieval System to support a VITPP production capacity of 6 MT/d is based on the current concept for FRVP silo residue removal. This concept is documented in the OU4 Conceptual Design Plan for Residue Retrieval System for the Fernald Residues Vitrification Plant Silo Superstructure, Rev. 0, March 1996, and is summarized in the following paragraphs.

A separate and independent retrieval system, one each for Silos 1 and 2, will utilize manway mounted sluicing jets and a centrally deployed submersible slurry pump (with attached spray ring and jet nozzles) to removal silo residues. Access for the retrieval equipment is permitted by a superstructure built over each silo. The superstructure is of modular design and will support an equipment enclosure, vestibule, retrieval equipment (including robotic system), will provide access to platforms for the four outer manways, will support the dome cutting rig and personnel shielding plate, and will provide an operating platform for all retrieval operations. Additionally, the silo superstructure is designed to facilitate berm height reduction activities by permitting access to all points around each silo structure.

Retrieval equipment is staged in an equipment room located in the superstructure (above the center of the silo structure). The equipment (e.g., submersible slurry pump) will be remotely deployed through an enclosed cylindrical sleeve inserted through the silo's dome. At the completion of retrieval operations, equipment (e.g., remotely operated vehicle for solid object removal) can be deployed from the equipment room to perform D&D activities. Together, the equipment room and insert provides containment to prevent the release of contaminants to the environment.

Each retrieval system will use two remotely operated sluicing jets to assist in slurrying the residues for retrieval operations. The sluicing jets will also be used to assist in decontaminating the interior of the silo structure. A submersible pump is used to transport silo residue (using similar basis as discussion above) to the Thickener Tank. The recycle water flow rate will be adjusted to facilitate slurrying operations and balance the rate at which the waste slurry is transferred by a submersible pump. From the reference source above, the submerged pump will transfer aqueous slurry from the silo between 70 and 140 gpm (approximately 20% solids concentration). However, for 6 MT/d production capacity, a lower pumping capacity (approximately 50 gpm) should be explored. This transports approximately 8,000 to 16,000 lb/hr (3,630 to 7257 kg/hr) of residue material from the silo and requires a recycle water flow to the sluicing jets, spray ring and jet nozzles of approximately 57 to 114 gpm (at 200 to 250 psig). A hydraulically powered vehicle, to be deployed through the enclosed cylindrical sleeve inserted through the silo's dome, will be used to supplement retrieval operations and assist in discrete object management and removal of remaining residues following slurrying pumping (heel retrieval).

A new radon treatment system (NRTS) will be connected to the silo to reduce headspace radon concentrations and to provide airflow control to limit personnel exposure during equipment room access.

4.1.5 Areas of Uncertainty/Possible Alternative Configurations

1. VITPP Phase II testing will demonstrate the ability to limit hydraulic loading in the silos to help ensure continued containment of the residues during retrieval operations.

2. VITPP Phase II will demonstrate the effectiveness of a slurry pump without an integral rotating spray nozzle as a less costly slurry pump alternative and lower flow capabilities.

3. Since residue physical properties are expected to vary within a silo (e.g., solids concentration, density), sluicing jet operation is a critical factor in slurrying residues for retrieval. The effectiveness of the sluicing jet system with respect to the residue properties remains to be demonstrated.

4. The ability to control air flow (and thus, equipment room contamination) while limiting NRTS capacity needs to be verified to ensure its feasibility.

4.2 FEED PREPARATION

For purposes of this report, the Feed Preparation System is defined to include all VITPP tanks and appurtenant equipment that handle process slurry upstream of the melter.

4.2.1 Required Functions of VITPP Feed Preparation System

The VITPP Feed Preparation System should be designed and operated to perform the following basic functions:

- Receive daily transfers of slurried waste (K-65 material and bentonite) from Silo 1 or Silo 2 for up to 6 hours/day, at a rate of 50 gpm. The average solids loading of this feed slurry is 7.6 weight percent (2.7 volume percent), while the maximum solids loading is 20 weight percent (7.1 volume percent).

- Partially dewater the plant feed slurry by means of flocculant-assisted gravity settling in the Thickener. The resulting Thickener overflow stream shall contain no

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more than 1 weight percent suspended solids. The Thickener underflow shall be a pumpable slurry, containing between 32 weight percent and 50 weight percent suspended solids.

- Receive solids-laden, aqueous process recycle streams from other systems on either a continuous or an intermittent basis.

- Maintain a sufficient surge volume of settled sludge in the bottom of the Thickener to accommodate both the daily schedule of waste receipt from the Silos and the more frequent schedule of waste delivery to the downstream tanks.

- Perform on-demand transfers of the net forward Thickener underflow stream to one or more downstream process tanks.

- Receive batchwise, measured gravity-flow transfers of dry glass formers from the Additive Filter/Receiver (5-DC-65) to produce a melter-ready process slurry containing 50 to 60 weight percent total solids.

- Provide the continuous delivery of blended feed slurry to the melter at variable, controlled rates corresponding to the specified range of melter throughputs.

- Perform sampling of various process slurry streams as necessary to ensure the proper formulation of the final melter feed stream.

4.2.2 Description of Existing VITPP Feed Preparation System

As the VITPP Feed Preparation System is now designed (see Figure 1), the Thickener Tank (5-TK-01) is capable of receiving daily transfers of slurried waste from Silo 1 or Silo 2 for up to 6 hours per day, at a rate of 50 gpm. The Thickener feed stream receives a controlled addition of flocculant solution to aid in solids settling. Concurrent with these feed transfers, a partially clarified supernatant spills over a weir inside the Thickener and gravity flows to the Recycle Water Tank. Meanwhile, most of the incoming suspended solids undergo gravity settling to form a sludge layer in the bottom cone of the Thickener. The continuous rotation of the Thickener Rake Mechanism (5-TH-02) pushes the sludge to the outlet connection at the bottom of the inverted cone.

The concentrated Thickener underflow is continuously drawn to the suction of one of the two parallel, air-operated Residue Slurry Pumps (5-PM-04A & B). The pump discharge is normally recycled to the Thickener feed well in order to control the solids content of the bottom sludge layer. The underflow stream is also intermittently transferred forward to one of the two parallel-mounted Slurry Tanks (5-TK-29A & B).

The two Slurry Tanks are operated batchwise, on staggered time cycles. A complete operating cycle for either tank consists of a first phase, during which a batch of melter-ready process slurry is prepared, followed by a second phase of equal duration, during which the slurry is continuously fed to the melter by the associated Slurry Tank Pump (5-PM-34A & B). Each time the melter feed function is transferred from one Slurry Tank to another, certain solenoid operated block valves in slurry lines connected to these pumps must change position.

4.2.3 Potential Problems with Existing VITPP Feed Preparation System

The specific problems anticipated with the existing VITPP Feed Preparation System design are identified and described below.

1. At a product glass rate of 6 metric tons/day, the required melter feed rate is estimated to be about 94 gallons/hr. This assumes that the melter feed slurry will contain 50 weight percent solids, and have a specific gravity of 1.47. Based on available tank drawings, the effective working capacity of each Slurry Tank is estimated to be 516 gallons. Therefore, the time required to empty a full Slurry Tank to the melter is calculated to be 5.5 hours. As shown by the attached Time/Motion Diagram, Figure 4, the resulting time availability for a complete Slurry Tank operating cycle is 11 hours. This means that the time available for the first phase of the operating cycle, during which a batch of melter-ready slurry must be formulated, is only 5.5 hours. Therefore, the time that can be allocated to each of the sequential operating steps that make up the first phase will be as follows:

   a. Receive batch transfer of Thickener underflow at 40 gpm, 0.25 hour.

   b. Receive dry glass formers and, if necessary, dilution water, 0.5 hour.

   c. Homogenize tank contents, 0.5 hour.

   d. Draw slurry sample, 0.5 hour.

   e. Analyze slurry sample, 2.75 hours.

   f. Readjust tank contents, as necessary, 0.5 hour.

   g. Idle time/contingency, 0.5 hour.

   The absolute minimum time required for laboratory preparation and analysis of slurry samples is estimated to be 4 - 5 hours. It is therefore concluded that this operating cycle does not allow sufficient time to properly analyze the sample of blended melter feed slurry.

   At a 6 metric ton/day product rate, the melter feed function must be transferred from one Slurry Tank to another once every 5.5 hours. This is simply too high a frequency, given the complex and cumbersome nature of the transfer operation, and the goal of maintaining the uninterrupted flow of melter feed.

4.2.4 Proposed Redesign of VITPP Feed Preparation System

The proposed Feed Preparation System redesign (see Figure 3) is intended to lengthen the time available for the batchwise preparation of melter feed slurry, and to eliminate the need to transfer the melter feed function from one tank to another.

The proposed design changes consist of the addition of a spare transfer pump to each of the two existing Slurry Tanks, and the addition of a new Melter Feed Tank (MFT). The MFT will act as a surge volume, alternately receiving batchwise transfers from Slurry Tank A and Slurry Tank B, while continuously delivering a controlled flow of feed to the melter. In order to improve system reliability, the MFT will be served by two parallel, 100 percent-capacity Melter Feed Pumps and their associated piping loops and instrumentation. This arrangement improves system operability by eliminating the alternating delivery of melter feed by the two Slurry Tanks.

As shown by the attached Time/Motion Diagram, Figure 5, the MFT will be refilled from one or the other Slurry Tank once every 5.5 hours. The time available for a complete Slurry Tank operating cycle remains at 11 hours. However, the elimination of the "controlled melter feed" step from the list of functions alternately assigned to each of the Slurry Tanks essentially doubles the time available for feed preparation activities. Because of this, the time available to analyze a slurry sample rises from 2.75 hours previously to a full 8.0 hours, which is deemed reasonable and more than adequate.

4.2.5 Areas of Uncertainty/Possible Alternative Configurations

1. Neither the existing nor the currently proposed Feed Preparation System designs readily lend themselves to the addition of a radon stripping function. Depending on the cost and difficulty of radon removal from the melter off-gas stream, this limitation may or may not be a problem. If it is determined that the melter off-gas must be processed to remove radon regardless of any radon stripping performed in Feed Preparation, then the benefit of such stripping will be minimal, at best. Conversely, effective radon stripping in Feed Preparation will be of significant value if it eliminates the need for radon recovery from the melter off-gas and thereby reduces the cost and complexity of the MOG System. This course of action could be considered only after determining the acceptability of the unabated MOG System radon emissions, with credit taken for radon stripping upstream of the melter.

   An alternate Feed Preparation System redesign that should more readily accommodate radon stripping is conceptually represented by a process sketch, Figure 6. As with the system redesign discussed in Section 4.2.4, there will be a total of three process tanks located between the Thickener and the melter. In this case, however, all of the tanks will be in series. The Thickener underflow will be maintained at the maximum pumpable solids concentration, which is estimated to be 50 - 60 weight percent. This slurry will be transferred continuously, rather than intermittently, to the immediately downstream Surge Tank. The Surge Tank also receives a continuous addition of radon-free, low solids water that dilutes the slurry down to about 30 weight percent solids.

   The Surge Tank slurry is continuously drawn from the bottom of the tank and recirculated to the top of an overhead stripping column. Grid type packing inside the column breaks up the descending slurry as it falls back into the Surge Tank. A stream of clean air, introduced either through submerged sparge piping or directly to the tank vapor space, rises through the stripping column, counter-current to the slurry. The air volatilizes the dissolved radon, which then leaves the stripping column as part of the overhead vent to the PVV System.

   A portion of the radon-depleted Surge Tank slurry is periodically batch transferred forward to the Feed Preparation Tank (FPT). The FPT then receives a measured, gravity-flow transfer of dry glass formers. The FPT feeds are blended together to form a melter-ready slurry containing about 50 - 60 percent solids.

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The FPT slurry is pumped forward on a batchwise basis to refill the Melter Feed Tank (MFT). The MFT, in turn, continuously delivers feed slurry to the melter at a controlled rate.

This process configuration should limit the inflow of gaseous radon to the MOG System to the sum total of:

(a) Residual radon remaining in the Surge Tank slurry after air stripping, and

(b) Radon generated by the continuous decay of the radium-226 contained within the FPT, the MFT, and the melter.

Further development of this design concept would have to address sampling of the process slurries and proper control of the melter feed composition, and the feasibility of re-using the two existing Slurry Tanks (5-TK-29A & B).

2. Both the existing and the proposed Feed Preparation System designs call for the use of air-operated diaphragm pumps to transfer concentrated process slurries. During the VITPP cold start-up activities conducted to date, the repair and maintenance required by these pumps have been much higher than originally anticipated. If it is ultimately concluded that diaphragm pumps are not suitable for the VITPP slurry, then it will be necessary to select an alternate pump for this service. This raises the possibility that such an alternate might not be able to handle the highly viscous, high solids thickener underflow and melter feed slurries called for by the current material balance. The resulting need to dilute these slurries to permit their pumped transfer would increase both their volumetric and mass flow rates. This, in turn, would reduce the time available for each Slurry Tank operating cycle, and increase the energy consumption by the melter at any given glass production rate.

   In this study, a spare diaphragm pump is added to each Feed Preparation Tank as recognition of the uncertainties regarding the reliability of the pump.

3. Based on a 6 metric ton/day product glass rate and a 70 percent plant TOE, it is calculated that the VITPP will have to operate for 7-8 years to work off all of the Silo 1 and Silo 2 waste. It is also anticipated that this operating life will be divided into 3-year melter campaigns. At the end of each campaign, a 2-month plant shutdown will be needed to replace or rebrick the melter.

The following components of the Feed Preparation System are expected to be particularly vulnerable to long-term wear, and may fail prematurely.

- Slurry Tank Agitators (5-AG-05 A & B)
- Slurry Tanks (5-TK-29 A & B)
- All carbon steel piping carrying thickener underflow or melter feed slurries.

The following paragraphs address the problems anticipated with each specific component and suggest possible remedies.

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Slurry Tank Agitators

Each Slurry Tank is fitted with a 10-inch diameter top nozzle that supports a Slurry Tank Agitator. The agitator shaft extends down through the top nozzle into the center of the tank. A hub is slipped over the end of the shaft, and stainless steel agitator blades are manually bolted to the hub by personnel reaching through the side-mounted tank manway. The outside diameter of the fully assembled agitator blade is 30 inches. Therefore, it will not be possible to remove the agitator from the tank in one piece if and when any of the wetted parts wear out or fail. Recent discussions with the agitator manufacturer indicate that the existing blade assembly may last one year, or less, in highly abrasive service. This is much less than the scheduled plant life or even a melter campaign. Because of this situation, the following three options for plant design and/or operation are now apparent.

(a) Retain Existing Slurry Tanks and Agitator

This option will require that the agitator blade and its appurtenances be replaced at least twice during a 3-year melter campaign. Each occasion will result in a plant outage of several days, if not longer. It will involve the removal of all radioactive process slurry from both of the Slurry Tanks. Next, the Slurry Tanks and associated piping will have to be thoroughly rinsed with clean water to remove the last traces of contamination. After determining that the radioactive field in and around the Slurry Tanks has been sufficiently reduced, it will be necessary for maintenance personnel to open the tank manways to gain access to the agitator blade. Finally, the actual repair or replacement of the agitator blade and its appurtenances will be performed in a contact manner.

(b) Replace Slurry Tanks

This option will involve the purchase of new Slurry Tanks having agitator mounting nozzles large enough to permit the removal of the agitator in one piece by a vertical lift. Also involved will be the relocation of any overhead equipment or structures that would interfere with the vertical removal of a failed agitator. Additional features might include provisions to spray the agitator with clean water as it is being lifted from the tank, the capability to bag out the agitator, and either temporary or permanent radiation shielding to protect the personnel performing the agitator changeout. If radiation shielding were not provided, then it might be necessary to empty and internally rinse the Slurry Tanks before opening the top to remove the agitator.

(c) Coat or Harden the Agitator Blade

This option might be the most attractive if it could lengthen the blade life from one year to at least three years at a reasonable cost. It would require replacement of the agitator blades on a routine basis every three years during the extended plant outages to refit the melter. Consequently, agitator maintenance should have no impact on plant availability.

A hard, abrasion resistant rubber coating could be applied to the individual agitator blades at the factory. After the installation of the agitator blade assembly in the tank, a patch kit could be used to apply a rubber covering to other metal surfaces, such as nuts, bolts and the blade mounting hub, considered vulnerable to erosive wear.

The alternate metal hardening approach would require that individual metal parts be sent to a special facility for treatment. One potential hardening process called boronizing uses high temperature boron gas diffusion to transform the top layer of parent metal into a very hard alloy. The parts undergoing treatment are first individually packed with powdered boron and then placed in a furnace that is slowly heated to 1800°F. Under these conditions, atoms of boron slowly diffuse into the surface of the heat-softened metal. After about 20 hours of treatment, the furnace is slowly cooled to ambient temperature. The hardened parts can then be removed and shipped to the field for installation.

A west coast company in the business of boronizing indicates that this process is more effective with carbon steel than with stainless steel. They also state that extra care must be taken in treating close tolerance, machined parts to be sure that they don't deform excessively at high temperature. For this reason, detailed drawings of the agitator blade assembly would have to be reviewed to determine the suitability of boronizing.

Slurry Tanks

The existing Slurry Tanks are made of uncoated carbon steel. The combination of air, water and various chemical species present inside the tanks will cause some internal corrosion. Thinning of the tank walls may be further accelerated by the synergistic erosive effect of the agitated slurry. It is therefore possible that the existing tanks will not last the entire plant operating life.

The relative importance of corrosion and erosion will determine the feasibility of retaining the existing tanks. A mildly corrosive environment might permit the existing tanks to be treated internally with a flame spray carbide coating. This coating can be applied in the field, and hardens the surface of the metal to resist abrasion. If properly applied, the coating can last for up to 10 years.

This process also improves the corrosion resistance of the treated metal. In highly corrosive service, however, the parent metal may experience unacceptable attack due to the porosity of the coating. If this applies to the VITPP process slurry, then it will be necessary to replace the existing Slurry Tanks with new tanks made of stainless steel. A flame spray carbide coating could then be applied to the stainless steel to improve its erosion resistance.

Carbon Steel Slurry Piping

High linear velocities will be needed to prevent the deposition of solids in the slurry transfer lines. Because of the abrasive nature of the waste solids, these velocities will accelerate internal piping wear. This problem will be particularly acute at the many short radius elbows contained in the existing slurry piping.

The proposed Feed Preparation System redesign will require the replacement of some, but not all, of the existing slurry piping. It is recommended that all of the new slurry pipe use only long radius bends rather than short radius elbows, and be free draining wherever possible. It is also recommended that the new pipe be schedule 80, and that the internal surfaces be hardened to enhance their abrasion resistance. One potential hardening technique would be the high temperature boron gas diffusion process discussed above. Because of the limited size of the boronizing furnace, the pipe would have to be pre-fabricated in flanged spools no more than about 15 feet in length.

It is also very likely that any existing slurry piping retained after the VITPP upgrade will fail in service before the scheduled completion of plant operations. Therefore, serious consideration should be given to the replacement of all slurry piping in the Feed Preparation System as part of the VITPP upgrade.

Conclusion

Later stages of the VITPP Upgrade design will have to identify specific, cost effective methods of improving the durability and service lives of the Slurry Tanks, Slurry Tank Agitators, and process slurry piping. This effort can be greatly facilitated by appropriate materials testing and data acquisition during Phases 1 and 2 of the VITPP Test Program. For example, the correct selection of metallurgy will require that both the corrosiveness and the erosiveness of the process slurry be quantified. If the dominant mechanism of attack is erosion, then a surface-hardened carbon steel may be adequate. On the other hand, an environment that is both highly corrosive and erosive may require surface-hardened stainless steel.

4.3 WASTE WATER TREATMENT

4.3.1 Required Functions of VITPP Waste Water Treatment System

The VITPP Waste Water Treatment System should be designed and operated to perform the following functions:

- Receive miscellaneous aqueous waste streams generated by other process systems.
- Supply recycle water at the required flow rate and pressure to the hydraulic waste removal equipment located in Silos 1 and 2.
- Purge excess water from the VITPP process recycle loop.
- Purge certain dissolved chemical species having limited solubility in the product glass, such as sulfates, from the VITPP process recycle loop.
- Decontaminate the VITPP aqueous waste streams to the extent required by the downstream FEMP Advanced Waste Water Treatment System (AWWT).
- Recycle the contaminants recovered from the aqueous waste streams to a suitable point upstream of the melter.

4.3.2 Description of Existing VITPP Waste Water Treatment System

As the VITPP Waste Water System is now designed (see Figure 1), the partially clarified Thickener overflow stream drains through a sloping line to the Recycle Water Tank (RWT). In addition to a suspended bentonite loading of approximately 1 percent, this liquid is also expected to contain dissolved process solids (such as nitrates, carbonates, sulfates, and various metals) and dissolved radon. From the RWT, the Thickener overflow liquid is routinely pumped to the following destinations where it is used as indicated.

- Silos 1 and 2, where it is used to hydraulically mine solid waste and then transport it to the Thickener.

- MOG System Quench Tower, where it is used on a once-through basis to contact the hot melter off-gas before itself being cooled and returned to the Thickener.

- Waste Water Filter, where particles 5-10 microns and larger are removed and periodically backflushed to the Thickener, and from which the filtrate proceeds to the Sparge Tank.

In addition to filtered Thickener overflow liquid, the Sparge Tank also receives the purge of alkaline solution from the MOG Quench Tower and Scrubber (5-SB-07/22) and the waste desiccant solution from the MOG Desiccant Tower. These combined liquids are warmed to 140°F by a submerged electric heater. Clean compressed plant air is introduced near the bottom of the tank through submerged sparge piping. As it bubbles upward through the liquid, the air strips out dissolved radon and carries it overhead, back to the MOG System. Meanwhile, the radon-depleted process liquid is pumped from the bottom of the Sparge Tank to the Building Sump Tank (BST). The BST also routinely receives:

- Low-solids liquids from Thickener Containment

- Unfiltered building sink drains

- Cooling tower blowdown

- Lab sink drains

- Low-solids liquids from Spill Containment.

The laboratory will segregate spent samples of process slurry for eventual recycle to the Thickener so that the sink drain effluent should be normally free of radionuclides.

The liquid accumulation in the Building Sump Tank represents the entire VITPP process liquid waste. This liquid is periodically pumped from the BST to the existing FEMP High Nitrate Storage Tank, which is located outside the VITPP battery limits. There, it mixes with various other FEMP aqueous wastes before being discharged to the AWWT.

The AWWT decontaminates the incoming waste waters before their discharge to the Great Miami River. The AWWT effluent must be sufficiently decontaminated to satisfy the requirement of the Fernald site NPDES permit. At the present time, the AWWT is designed to perform the following operations on the incoming waters:

- pH adjustment
- Precipitation of dissolved species (uranium)
- Particulate filtration down to 50 microns
- Organics removal using activated carbon
- Ion exchange (uranium removal)

Finally, the Spare Storage Tank (5-TK-56) can be thought of as being a functional adjunct to the Waste Water Treatment System. The Spare Storage Tank will be used only on non-routine occasions, to receive leakage from the process tanks or excessive accumulations of rainwater runoff. The contents of the Spare Storage Tank will be recycled to the Thickener Tank (5-TK-01) as permitted by the status of the Feed Preparation System and the Waste Water Treatment System. In this way, excessive rainwater runoff pumped from the Spare Storage Tank will mix with waste retrieval water in the Thickener, and then become part of the Thickener overflow stream sent to the RWT. This rainwater runoff will subsequently become part of the process water purge stream drawn from the RWT and ultimately discharged from the VITPP as liquid waste.

4.3.3 Potential Problems with Existing VITPP Waste Water Treatment System

The specific problems anticipated with the existing VITPP Waste Water Treatment System design are identified and described below.

1. The dissolved solids loading in the Thickener overflow may require that clean dilution water be added to the Recycle Water Tank to avoid solids precipitation or scale formation in the MOG Quench Tower. This clean water addition will directly increase the volume of the VITPP waste water purge to the AWWT.

2. The fine bentonite clay carried by the Thickener overflow into the Recycle Water Tank may lead to scale formation inside the MOG Quench Tower or fouling inside the downstream Heat Exchanger (5-HE-27) that is used to cool the spent quench liquid.

3. The Thickener overflow will contain dissolved radon that will be subsequently stripped from the liquid phase to the hot gas phase in the MOG Quench Tower. This will add significantly to the total amount of gaseous radon sent to the downstream Carbon Beds (5-RN-19A & B). Other things being equal, this increase in volatilized radon fed to the adsorbent beds will increase the final discharge of radon to the plant stack.

4. The waste water purge drawn from the Recycle Water Tank will contain about 1 weight percent low-density bentonite fines and possibly a fraction of radioactive K-65 waste material in particle sizes smaller than 5 microns. One of the following problems may be encountered when this liquid is passed through the existing deep

bed, multi-media Waste Water Filter, which is expected to remove particles 5 microns and larger at a 10 gpm feed rate.

a. The bentonite clay may prematurely blind the filter by forming a slime layer on the media. The volumes of clean backflush liquid required to dislodge such a layer are not known.

b. The fine bentonite and K-65 particles smaller than 5 microns will not be retained by the media, resulting in their escape to the filtrate stream. These suspended solids will then be discharged from the VITPP as part of the waste water purge. After blending with other FEMP waste waters, these fugitive solids will become part of the much larger AWWT feed stream. As a general rule, it is preferable to filter a solids-bearing stream before dilution rather than after. In any event, it is known that these fine solids will not be captured by the existing, 50-micron AWWT filters, and so will be discharged to the Great Miami River. Based on preliminary discussions with AWWT personnel, and on order of magnitude estimates of the relative amounts of inert bentonite and radioactive K-65 material potentially present in the Thickener overflow, it has been determined that this discharge will not be acceptable.

5. In addition to the filtered drawoff from the Recycle Water Tank, the final VITPP aqueous discharge will also be made up of the following unfiltered process effluents.

- Spent alkaline absorbent liquid from the MOG Scrubber
- Waste desiccant solution from the Off-Gas Desiccant Tower (5-DH-21)
- Building sink drains
- Lab sink drains
- Low-solids rainwater runoff from Thickener Containment
- Low-solids rainwater runoff from Spill Containment.

All of these additional streams have at least the potential to carry radionuclide particulates of some indeterminate size, and so increase the contamination level of the VITPP aqueous discharge.

The Thickener overflow will contain some concentration of dissolved metallic and/or toxic species leached from the K-65 waste. As it is currently designed, the Waste Water Treatment System will not remove these dissolved species from the incoming aqueous wastes. Consequently, these species will leave the VITPP as part of the Waste Water purge. Since these species cannot be removed by the downstream AWWT either, they will ultimately be discharged to the Great Miami River. Based on preliminary discussions with AWWT personnel, and on limited test data defining the water solubilities of K-65 waste constituents, it is believed that such a discharge would violate the site NPDES permit.

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4.3.4 Proposed Redesign of VITPP Waste Water Treatment System

The proposed Waste Water Treatment System redesign described below is based on the future conversion of the VITPP to a 6 ton/day, long-term production facility, as well as on the possible limitations of the downstream AWWT. These changes are intended to eliminate the potential operating problems described above, and to minimize the radionuclide and particulate contamination of the final VITPP waste water discharge. Achieving these goals is deemed necessary to ensure long-term reliable operation of the AWWT and compliance with the Fernald site NPDES permit.

As shown by the attached process flow sketch, Figure 3, it is proposed to eliminate the routine purge of liquid from the Recycle Water Tank. It is also proposed to minimize the need for clean water make-up to this tank. The new design provides for the confinement of Silo waste retrieval water to an essentially closed recirculation loop, consisting of the Silos, Thickener, Recycle Water Tank, and interconnecting piping. Water would be lost from this loop only by way of the Thickener underflow stream and vaporization to overhead vents. Because of this, most of the radon leached from the solid waste would remain confined to the aqueous phase, and eventually decay into a non-volatile element. The introduction of radon to the Melter Off-gas System would be limited to minor losses from tank vents, plus radon dissolved in the melter feed slurry, plus radon generated by radium decay inside the melter itself.

In the Melter Off-Gas System, the hot incoming gas is first quenched by a recirculating, aqueous scrub solution containing an alkaline reagent. This operation removes most of the larger entrained particles and a significant portion of the acid gases (SO_2 and CO_2), and causes partial condensation of the water vapor. In order to purge recaptured sulfur compounds from the VITPP process recycle loop, the blowdown from the recirculating scrub solution must be sent to the new Filter Feed Tank described below.

The existing VITPP design includes a 635-gallon working capacity, carbon steel Sparge Tank (5-AE-39). This tank was originally intended to remove dissolved radon from incoming aqueous waste streams by a combination of heat and air stripping. It is proposed to use this tank as a Filter Feed Tank (FFT) (A more efficient radon stripping operation will be added, as described in subsequent paragraphs). This conversion will probably require the following mechanical changes.

- Add liquid sparging and agitation capabilities to the inside of the tank.
- De-activate and remove the existing electric heaters and air-sparge piping from the inside of the tank.
- Replace the existing Sparge Tank Pump (5-PM-42) with a new filter feed pump.
- Add corrosion-resistant epoxy coating to the inside of the tank. Alternately, add continuous pH monitoring and caustic addition capabilities to the tank.

In addition to aqueous effluents from the MOG System, the Filter Feed Tank will also receive the following potentially contaminated process wastes.

- Building sink drains from PPE Changing Room.

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- Laboratory sink drains.

- Low-solids rainwater runoff recovered from the Thickener Containment (non-routine).

- Low-solids rainwater runoff recovered from the Spill Containment (non-routine).

The contents of the Filter Feed Tank will be maintained under continuous agitation using an internal liquid sparge to prevent the settling of suspended solids. An aqueous slurry of diatomaceous earth may be added to the tank as necessary to act as a filter aid. The blended FFT liquids will be pumped forward at a controlled rate of about 500 gpm to a new, horizontally-mounted, crossflow-type Waste Water Filter.

In its construction, the filter resembles a single-pass, shell-and-tube heat exchanger measuring about 10 feet in length by about 18 - 24 inches in diameter. The filter media consists of porous, sintered metal tubes. Most of the crossflow filter feed slurry moves at high velocity through the insides of the tubular elements before leaving the housing and returning to the FFT, where it acts as an agitation sparge. These high linear velocities scour the inside surfaces of the elements and prevent the deposition of a thick filter cake. The modest buildup of solids that does occur is periodically dislodged by a quick pneumatic pulse applied to the shellside of the housing. This operation does not interrupt the continuous flow of feed to the filter.

For every 20 gpm of feed slurry, about 1 gpm of liquid will actually flow radially outward through the walls of the filter elements and leave the shellside of the housing as clean filtrate. The inertia created by high longitudinal velocities inside the elements prevents all but the very smallest particles from changing direction and escaping to the filtrate stream. Indeed, it is reported that properly operated crossflow filters can achieve 98 - 99 percent removal of particles 0.1 micron and larger. While the size distribution of particles carried by the FFT feed streams has not been defined, it is known from a hydrometer analysis that about 13 weight percent of the K-65 waste is finer than 1.1 microns (see process data sheet for 5-PM-04A and B). Assuming that the filter feed solids are no finer than the K-65 waste, it is estimated that the filtrate stream will contain essentially negligible levels of radioactive particulates.

As the crossflow filter continues to operate, its recirculating feed slurry becomes progressively more concentrated with suspended solids. These solids can be recycled by periodically sending a portion of the FFT slurry back to the Thickener or some other tank upstream of the melter.

The 500 gpm filter feed rate cited above was selected to produce 25 gpm of forward flowing filtrate. This design effluent rate, which far exceeds the normal FFT feed rate, was selected to accommodate the worst case pumpout of rainwater runoff from the Thickener Containment and Spill Containment. It is anticipated that these areas will accumulate a total of 9500 gallons of water after a 2-inch rainfall. Removing this liquid over a period of about 6 hours will require a continuous 25 gpm transfer to the FFT, which has only very limited surge capacity. It should also be noted that the active decontamination of rainwater runoff from process areas is deemed conservative and appropriate for a long-term production facility. The current VITPP design, which anticipated only short-term operation in a test mode, allowed this liquid to be discharged from the plant without treatment.

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The clean filtrate from the Waste Water Filter, containing various dissolved species, passes successively through a Feed/Bottoms Heat Exchanger and a Heater before entering the new Radon Stripper. The hot liquid falls through a packed bed, counter-current to a rising stream of air introduced at the bottom of the column. The combination of high temperatures and the stripping action of the air volatilizes any dissolved radon from the descending liquid. Non-volatile species, such as sodium sulfate, remain in the liquid phase.

Rising from the packed bed, the warm, moist air contacts cooling coils mounted in the top of the Stripper. The resulting gas cooling causes most of the water vapor to condense and fall back into the packed section. The cooled effluent gas carrying desorbed radon leaves the top of the Stripper and is routed to the Process Vessel Vent System. Meanwhile, thermally hot, decontaminated process liquid waste is pumped from the bottom of the column. This liquid is first cooled to near ambient temperature in the Feed/Bottoms Exchanger before emptying into the existing Building Sump Tank (5-SU-74). The contents of this tank, which may also include cooling tower blowdown, are periodically pumped to the High Nitrate Storage Tank, which is located outside the VITPP battery limits.

It should be noted that the packed, counter-current Radon Stripper will achieve higher mass transfer efficiencies than the in-tank, air sparging operation shown in the existing VITPP design. Consequently, the packed column should be able to use a smaller volume of stripping air for any given level of radon removal. This is significant, since it should reduce the cost of gaseous radon adsorption performed downstream in the Melter Off-Gas System.

Finally, new piping will be added to permit the alternate transfer of liquids from the Spare Storage Tank to the Filter Feed Tank. This alternate flow path will allow any rainwater runoff accumulated in the Spare Storage Tank to be sent directly to the Waste Water Treatment System, rather than to the Thickener where it would mix with contaminated waste retrieval water.

4.3.5 Areas of Uncertainty/Possible Alternative Configurations

The Areas of Uncertainty and/or Possible Alternative Configurations that may require future study are discussed below.

1. The analysis of waters drained from Silos 1 and 2 and subsequently collected in the Decant Sump Tank (DST) indicated the presence of various dissolved species presumably leached from the K-65 waste, including radium-226, cyanide, copper, lead, and silver. Unfortunately, the currently available analytical data are quite limited and may be subject to error due to the presence of other waste waters in the DST. Final resolution of this issue will probably have to await process sampling and analysis during Phase 2 of VITPP operation. It is also known, however, that the AWWT would not be able to remove significant amounts of the contaminants identified above if they were to be dissolved in the VITPP waste water purge. In addition, the Fernald site NPDES permit imposes limits on the discharge of these species to the Great Miami River.

   It is likely that the liquid phase of the melter feed slurry will become saturated with chemical species leached from the K-65 waste, including the contaminants identified

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above. It is also reasonable to assume that these contaminants will, to some degree, be carried into the melter off-gas stream and then be recaptured by the recirculating MOG quench solution. If the quench solution bleed could be recycled to the Thickener, then the potential presence of dissolved contaminants would have no effect on the quality of the VITPP waste water purge. This change, however, would require the elimination of alkaline reagents from the MOG quench solution. Conversely, sending the quench solution bleed to the Filter Feed Tank will add some undetermined amount of dissolved contaminants to this purge stream. This at least raises the possibility that some new operation, such as ion exchange, might be needed to selectively remove certain dissolved species from the "clean" Filter effluent.

2. The potential loading of dissolved contaminants in the identified Waste Water Treatment System feed streams, and the discharges of these contaminants allowed by the site NPDES permit, should both be quantified. If the currently proposed system design cannot comply with the discharge limits, then it may be necessary to add a heated tank to drive off excess process water by evaporation. The concentrated bottoms from such a tank, containing both dissolved and suspended solids, would be periodically pumped back to the Thickener. This approach will not be suitable, however, if any of the incoming aqueous waste streams also contain dissolved sulfur compounds that must be purged from the plant recycle loop. This situation would require the addition of a dissolved contaminant removal step to some point downstream of the Filter.

3. The feasibility of converting the existing, uncoated carbon steel Sparge Tank (5-AE-39) into an internally agitated Filter Feed Tank having sufficient durability for 10 years of service should be studied in more detail. If this conversion is not really possible, then a new process tank will be needed.

4. At the start of each day's Silo waste retrieval operation, water will be drawn from the RWT to re-establish the flow of waste slurry from the Silos to the Thickener. There will be some delay between the commencement of RWT pumpout and the resumption of Thickener-to-RWT liquid overflow. The RWT should therefore have sufficient surge capacity to accommodate this delay without the need for clean water makeup. Based on available tank drawings, the effective working capacity of the existing RWT is estimated to be about 4100 gallons. The adequacy of this capacity should be checked by performing a time/motion analysis of the liquid flows to and from the Silos, Thickener, and the RWT itself.

5. The potential need to design the new, crossflow-type Waste Water Filter for an approximate 25 gpm filtrate rate would be based on:

   a. the limited surge capacity available in the existing Sparge Tank, assuming its conversion to a Filter Feed Tank, and

   b. the intermittent pumpout of rainwater runoff from the Thickener Containment and Spill Containment over a period of six hours at a time average rate of 25 gpm.

   Another approach would be to abandon the existing Sparge Tank and replace it with a new Filter Feed Tank having sufficient surge capacity to accommodate the maximum anticipated volume of rainwater runoff. This would lengthen the time available to work off batches of rainwater, and also make it easier to take downstream equipment briefly out of service for periodic maintenance. Consequently, the Waste Water Filter effluent rate could be reduced from 25 gpm to perhaps 5 gpm. The design capacities of the Filter Feed Pump and the downstream Radon Stripper and its appurtenances could also be reduced by the same magnitude.

Because of its potential for significant cost savings, further investigation of this alternate design is recommended.

6. The need to operate the Radon Stripper at an elevated temperature should be re-checked during a later stage of design. It may be possible to achieve high-efficiency radon removal using only air as a stripping agent at ambient temperature. In that case, it would be possible to eliminate the Feed/Bottoms Heat Exchanger, Radon Stripper Feed Preheater and Radon Stripper Bottoms Pumps. Then the Radon Stripper could be elevated--either adjacent to or on top of the Building Sump Tank--so that the decontaminated bottoms liquid would gravity drain into the BST.

4.4 MELTER OFF-GAS

4.4.1 Required Functions of VITPP Melter Off-Gas System

The primary functions of the VITPP Melter Off-Gas System are to maintain the melter plenum within a defined range of negative gauge pressures and to decontaminate the melter off-gases to permit their release to the atmosphere. Achieving these two primary objectives will require that the MOG System perform the following functions:

- Receive overhead gases from the melter plenum at an assumed temperature of 800°C and, in a specially designed Film Cooler, mix in cool injection air or recycle gas to achieve a 350°C effluent temperature. This cooling should solidify any molten droplets entrained in the melter overhead, and thereby prevent their deposition on downstream piping or equipment. The targeted 350°C Film Cooler outlet is consistent with the MOG System design at the Defense Waste Processing Facility (DWPF). Air inleakage to the melter plenum is assumed to be 80 SCFM at normal operating pressures.

- Maintain a minimum gas velocity of 50 ft/second in the MOG line from the Film Cooler to the first quench device. This minimum velocity was recommended by Pacific Northwest Laboratory (PNL) to minimize solids deposition.

- Quench the hot Film Cooler effluent gas by means of direct contact with an aqueous solution. This operation should remove most of the larger entrained particulates, cool the gas to slightly above ambient temperature, and condense most of the water vapor.

- Perform additional particulate and acid gas removal with an alkaline scrub solution downstream of the off-gas quench. The degree of acid gas removal shall be determined by plant emissions limits or by constraints imposed by downstream radon adsorption equipment, whichever is more limiting.

- Remove or destroy gaseous NOx to the extent required by plant emissions limits or by constraints imposed by downstream radon adsorption equipment, whichever is more limiting.

- Chill the off-gas and separate the resulting condensate to improve the efficiency of radon adsorption.

- Dry the off-gas down to a relative humidity of 15% or less before proceeding on to radon adsorption.

- Remove gaseous radon using a suitable adsorbent. The required radon removal efficiency is at present TBD.

- Remove entrained particulates using a HEPA or some other type of filter of equal or greater efficiency.

- Maintain the melter and those portions of the MOG System containing radionuclide particulates at a controlled, negative gauge pressure during both normal operation and a design case melter surge. The targeted melter operating pressure is -2" W.C. normally, and -0.5" W.C. during a design case surge of TBD magnitude.

- Provide sufficient redundancy within the MOG System design and/or an emergency gas flow path to permit a safe transition to a melter idle or shutdown following an equipment failure or other system upset. Maintain the melter at a negative gauge pressure during and after this transition.

- Provide a means of safely venting the melter off-gas directly to the atmosphere in the event that the melter plenum rises to a TBD positive value.

4.4.2 Description of Existing VITPP Melter Off-Gas System

Figure 1 is a process flow sketch of the existing VITPP. The Melter Off-Gas System treats the gases leaving the melter plenum prior to their release to the atmosphere. This treatment includes quench cooling and moisture condensation, solids scrubbing, acid gas removal, dehumidification, radon adsorption, and high efficiency final filtration. The MOG System also maintains the melter at a slight partial vacuum, thereby creating a secondary confinement to prevent the release of contaminants to the atmosphere. Except as otherwise noted, the flow rates and stream conditions provided below are consistent with the existing VITPP PFDs. However, these data are not necessarily consistent with the above stated Functional Requirements, or with assumptions and calculations supporting the VITPP Upgrade Study.

The gases leaving the melter plenum at 1472°F consist of water vapor boiled off from the feed slurry (about 30 SCFM), thermal decomposition or reaction gases (such as CO_2, SO_2, NOx), volatiles (such as radon), inleakage air and air admitted to internal bubblers and an air lift (totalling about 70 SCFM), and particulates. These gases rise from the melter directly into the top-mounted Film Cooler, where approximately 50 SCFM of cool compressed air is blended in to produce a 600°F effluent. This cooling should solidify any molten droplets entrained in the gas and thereby reduce their tendency to deposit on downstream piping and equipment.

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The Film Cooler effluent proceeds directly to the bottom entrance of the Quench Tower. The hot gas rises inside the Quench Tower, counter-current to 40 gpm of process water (from the Recycle Water Tank) introduced at the top through two spray nozzles. The resulting vapor/liquid contact cools the gas to about 115°F and condenses most of the water vapor. It also causes some of the radon dissolved in the Quench Tower feed water to be stripped from the liquid phase into the Quench Tower overhead gas. The warm, spent quench water is transferred from the bottom of the tower by one of the Quench Tower Pumps (5-PM-23A or B) on level control. This stream is then cooled to about 100°F in the Heat Exchanger (5-HE-27) before being routed to the Thickener Tank (5-TK-01). Concentrated caustic solution can be metered into the bottom of the Quench Tower by the Caustic Additive Package System (5-PM-60) as needed to minimize corrosion of downstream piping and equipment.

Meanwhile, the cooled off-gas leaves the top of the Quench Tower and proceeds directly to the Scrubber, which consists of an ejector venturi scrubber (EVS) and a packed contacting column mounted in series on a common scrub solution tank. This tank provides the needed storage volume for the alkaline scrub solution that is continuously re-circulated to the EVS and the column by a shared pump. The off-gas first undergoes direct, co-current contact with 30 gpm of pressurized scrub solution in the ejector venturi scrubber. The particulate removal achieved by the EVS has been estimated by the vendor to be 95% at 3-4 microns and larger. The EVS discharge is directly connected to the top of the scrub solution tank, which acts as a vapor/liquid separator. The off-gas phase then passes through the tank vapor space before ascending into the top-mounted packed column.

As it rises through the packing, the gas undergoes counter-current contact with about 8 gpm of alkaline solution recirculated from the tank. This liquid contains reaction products from previous acid gas absorption (carbonates and sulfates) as well as some free NaOH. With each pass through the packed column, the scrub solution absorbs more SO_2 and CO_2 from the gas phase, thereby depleting the free NaOH and increasing the concentrations of reaction products. The consumed NaOH is replaced by metered transfers of concentrated caustic from the Caustic Additive Package System (5-PM-60) to the scrub solution tank. Reaction products are purged from the scrub solution loop by sending a bleed from the Scrubber Recirculating Pump discharge to the Sparge Tank in the Waste Water Treatment System. This procedure also results in the loss of some unreacted NaOH. Clean makeup water can be added to the scrub solution tank as necessary to maintain the desired inventory of solution. An SO_2 removal efficiency of 99% has been claimed by the supplier of the packaged Quench Tower and Scrubber (5-SB-07/22).

The packed column overhead gas is blended first with the combined vents from the contaminated process tanks and then with the warm overhead gas from the Sparge Tank (5-AE-39). The resulting water-saturated, melter off-gas/process vessel vent mixture proceeds to the Off-Gas Desiccant Tower (5-DH-21). Inside the Tower, the gas rises through beds of proprietary Dry-o-Lite ($CaCl_2$) and 10BF (LiCl) solid desiccant tablets supported by activated alumina spheres. As they absorb water vapor from the gas phase, the two desiccants dissolve to form a saline brine that drains from the Tower to an adjacent condensate tank. This tank is periodically pumped out to the Sparge Tank. Fresh Dry-o-Lite and 10BF desiccant must be periodically added to the Tower to replace losses, and to maintain the Tower overhead gas at 15% relative humidity.

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Leaving the Desiccant Tower, the partially dried process gas continues on to the two parallel and uninsulated Carbon Bed Vessels (5-RN-19A & B). It is anticipated that these two vessels will alternate between "operating" and "standby" status. As the gas flows through the beds, some portion of the gaseous radon is adsorbed onto the surface of the activated carbon granules. This adsorbed radon eventually decays into a solid, non-volatile daughter product that continuously accumulates on the carbon. At some time after initial carbon bed startup, a steady-state equilibrium is reached between the inventory of adsorbed radon on the carbon and the concentration of gaseous radon remaining in the treated overhead stream. This equilibrium is determined by a number of factors, including the process gas temperature, pressure and flow rate, the inlet concentration of radon, the size of the carbon bed, and possible long-term de-activation of the carbon.

The treated effluent from the Carbon Bed Vessels undergoes a final decontamination as it passes through one of the two parallel HEPA Filters (5-FL-48A & B). The filtered gas then passes through a flow control valve (FCV-250) before entering the suction of the Exhaust Fan (5-FA-25). The continuous operation of the Exhaust Fan produces the required motive force to maintain the melter and the tanks connected to the vessel vent header at a negative gauge pressure. The Exhaust Fan discharge is routed to the Exhaust Stack (5-XS-20) from which it is released to the atmosphere.

A number of operating upsets, such as failure of the Exhaust Fan or an inadvertent valve closure, could prevent the primary MOG System from properly controlling melter pressure. For this reason, the melter plenum is also connected to an Emergency Off-Gas System (EOS) that is intended to accept diverted melter off-gas during such upsets, to maintain a minimal pressure confinement of the melter plenum, and to perform partial decontamination of the diverted gases prior to their discharge to the plant stack. The EOS also provides overpressure relief to protect the structural integrity of the melter.

Whenever the melter plenum rises from its normal pressure of -2" W.C. to -0.5 W.C., the EOS instrumentation causes automatic block value FV-370 to open, thereby admitting melter off-gas into the EOS, which is maintained at a negative gauge pressure by the continuous operation of the EOS Exhaust Fan (5-FA-38). Cooling of the incoming off-gas to 250°F is achieved by the automatic opening of FV-360, which admits 407.5 SCFM of cool ambient air from the melter room to mix with the off-gas.

Immediately downstream of FV-370, the cooled off-gas enters a Knock Out Pot (5-KO-36), which is designed as a cyclone separator. The swirling flow pattern induced by the Knock Out Pot creates centrifugal forces that separate entrained droplets and particulates from the gas phase. This material must be flushed out of the Knock Out Pot under manual control after normal plant operation has been restored.

The overhead gas from the Knock Out Pot passes successively through a roughing filter and a HEPA filter housed inside 5-FL-37. The filtered gas then proceeds to the suction of the EOS Exhaust Fan (5-FA-38) which creates the motive force to pull the gas through the upstream piping and equipment and to maintain a slight negative pressure on the melter. The Exhaust Fan discharge is sent to the VITPP stack.

The EOS also contains features to protect the structural integrity of melter against overpressure. A bypass line containing a rupture disk (5-RD-35) is provided around the EOS inlet value (FV-370). The rupture disk will open if, for any reason, the upstream melter pressure rises to 3 psig. The relieved off-gas will then pass successively through the Knock Out Pot (5-KO-36) and a chevron mist eliminator in the overhead line before reaching a pressure safety valve (PSV-360), which is also set at 3 psig. The PSV-360 discharge is routed to a safe location for direct release to the atmosphere.

4.4.3 Potential Problems with Existing VITPP Melter Off-Gas System

The specific problems anticipated with the VITPP Melter Off-Gas System design are identified and described below.

1. Increasing the product glass rate from 1 to 6 metric tons/day will raise the required melter feed rate from about 16 gal/hr to 94 gal/hr. This will cause a commensurate increase in the water vapor content of the melter off-gas, and therefore, a significant increase in its total enthalpy. Maintaining a 350°C Film Cooler exit temperature will require significantly higher additions of cooling air. Consequently, the total flow of non-condensibles downstream of the Film Cooler will be much higher than the volumetric design capacity of the existing MOG System. This will prevent the existing system from adequately performing its two primary functions.

2. Like most of the other major components of the MOG System, the existing Film Cooler is too small to accommodate a 6 metric ton/day melter. Also, its design appears to be much less sophisticated than that developed by PNL after extensive film cooler testing. Because of this, the existing design is expected to be more susceptible to solids deposition and less effective at rapid gas cooling than the PNL design. The existing Film Cooler also lacks the installed capability to periodically scrape away internal deposits, which is particularly important for long term plant operation.

3. The VITPP equipment layout is such that the off-gas line from the Film Cooler to the Quench Tower is very long and contains a number of short radius elbows. This will increase piping friction losses (particularly during melter surges) as well as internal fouling and solids deposition.

4. As discussed in the Waste Water Treatment section, the use of Thickener overflow water drawn from the RWT to cool hot off-gas in the Quench Tower may create a number of problems. These include the possible precipitation of dissolved salts to form scale, fouling of heat transfer surfaces by bentonite entrained in the quench water, and an increase in the radon loading of the quenched gas due to stripping from the liquid phase.

5. The off-gas line from the Scrubber (5-SB-07/22) to the Desiccant Tower is made of carbon steel. Over the long term, this pipe may experience serious internal corrosion because the gas is essentially water-saturated air, with small concentrations of acidic SO_2 and CO_2. Also, rust from the inner surfaces of the pipe may be entrained by the off-gas and then prematurely plug the downstream roughing filter.

6. It is anticipated that all of the nitrogen-bearing species in the melter feed will be converted to gaseous NO inside the melter. A small fraction of the NO may be subsequently oxidized to NO_2, and then be removed from the gas phase by alkaline scrub solution. There are, at present, no provisions to remove or destroy NO,

which will remain in the off-gas as it passes through the Carbon Bed Vessels (5-RN-19A & B). This raises a serious safety concern since it is known that under certain conditions, gaseous NO can undergo a highly exothermic reaction with activated carbon. It is further noted that the Carbon Bed Vessels do not have fire suppression capabilities.

7. The existing design relies exclusively on the Off-Gas Desiccant Tower (5-DH-21) to dry a warm, low-pressure, water-saturated gas stream down to 15% relative humidity. As already shown during cold startup activities, this arrangement leads to a prohibitively high consumption of the non-regenerable solid desiccant. This is clearly unacceptable for long term plant operation.

8. The single, continuously-operating Exhaust Fan (5-FA-25) serves both the Melter Off-Gas and the Vessel Vent Systems. Therefore, both of these systems will lose ventilation if the fan becomes unavailable for any reason.

9. Diversion of the melter off-gas to the Emergency Off-Gas System during a pressure excursion requires the quick opening of a pneumatically operated block value (FV-370). However, the reliability of this may not be as great as desired because of its continuous exposure to hot, particulate-laden gases from the melter plenum. A delayed opening of FV-370 will allow the melter plenum to reach a positive gauge pressure.

10. The ability of the Emergency Off-Gas System piping and equipment to accommodate a 500°F design temperature should be evaluated.

11. Operation of the Melter at a negative gauge pressure creates the potential for air inleakage, either from the surrounding room or from the Gem Machine that is direct-connected to the Melter discharge chamber. This inleakage will readily migrate from the Melter discharge chamber to the main chamber where it will become part of the off-gas stream drawn into the MOG System. The off-gas mass flow that ultimately passes through the radon removal beds before discharge to the atmosphere will equal the total of air inleakage, air supplied to the melter bubblers and air lift, and melter reaction gases not removed by the MOG System. The inleakage air present in this stream acts as a diluent that reduces the efficiency of radon absorption, NOx destruction and acid gas removal. It also increases the required volumetric capacity of the MOG System and its constituent piping and equipment. It is therefore vital that the total inleakage to the Melter/Gem Machine package not exceed some reasonable upper limit.

    During recent startup operation of the Melter, the vacuum drawn by the MOG System on the main chamber was limited to -0.5 to -1.0 inches W.C., rather than the targeted -2.0" W.C. A possible cause of this deficiency is higher than anticipated--and perhaps even uncontrolled--air inleakage to the Melter/Gem Machine package. If so, this situation must be corrected at its source in order for the MOG System to properly perform its assigned functions, i.e. control of the melter vacuum and decontamination of melter off-gas. No realistic redesign of the MOG System alone can compensate for excessive air inleakage into upstream equipment.

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4.4.4 Proposed Redesign of VITPP Melter Off-Gas System

Figure 3 shows the proposed MOG System redesign. Significant changes from the present design include the use of recycled off-gas rather than compressed plant air for injection into the Film Cooler, the use of zeolite rather than a non-regenerable desiccant for gas drying, and the addition of NOx removal capabilities. Except for the Carbon Bed Vessels (5-RN-19A & B) and the HEPA Filters (5-FL-48A & B), all of the gas handling equipment must be replaced with larger units to accommodate the increased plant capacity.

As in the existing design, hot gases leave the melter plenum at 1472°F. These gases consist of about 200 SCFM of water vapor (vs. 30-35 SCFM previously), non-condensibles totalling 85 SCFM (vs. 70 SCFM), and particulates. These gases enter the top-mounted, 8-inch diameter Film Cooler, where they mix with about 500 SCFM of cool, partially decontaminated off-gas recycled from a downstream point. The elimination of plant air injection at the Film Cooler minimizes the net forward flow of off-gas that will ultimately pass through the Carbon Bed Vessels, thereby improving radon recovery. The design configuration of the Film Cooler itself will be essentially the same as that already developed by PNL, and will include features to facilitate internal cleaning.

The 350°C Film Cooler effluent first passes through a new, increased diameter outlet line, where it is sprayed with 100°F water enroute to the Quench Tower. To the extent possible, this line will incorporate long radius bends and its total length will be minimized. This new line discharges into the bottom inlet of the new Quench Tower, which measures 5 feet in diameter to accommodate the increased volume of gas. As it rises through the Tower, the off-gas is cooled to about 115°F by direct, counter-current contact with 40 gpm of 100°F water sprayed from the top. The absorption of both sensible and latent heat from the off-gas warms the quench water to 155°F by the time it reaches the bottom of the Tower. From there, the water is drawn to the existing Quench Tower Pumps (5-PM-23A & B) from which it is discharged to the tube side of the existing Heat Exchanger (5-HE-27). The quench water leaves the Heat Exchanger at 100°F and is recycled to the top of the Quench Tower. Because of the condensation of water from the off-gas, excess quench solution must be purged to the Waste Water Treatment System (see Section 4.2). The adoption of this water recirculation loop in place of the one-through use of Thickener overflow for off-gas quenching should eliminate the previously identified operating problems.

Leaving the top of the Quench Tower, the cooled melter off-gas first passes through a throttling valve that is used to control the melter pressure. The gas then enters the new and enlarged Ejector Venturi Scrubber (EVS). The two phase EVS discharge enters the top of the new scrub solution tank. The heavy liquid phase falls to the bottom while the gas rises into the new, top-mounted packed contacting column. The required diameter of this column is estimated to be 24". As in the existing MOG System design, alkaline liquid recirculated from the scrub solution tank enters the top of the packed column and absorbs acidic components from the rising gas stream.

Because of the increased off-gas flow, the total circulation of scrub solution to the EVS and the packed contacting column must also increase significantly. Thus, the existing Scrubber Recirculating Pumps must be replaced with new, larger units.

As it rises from the packed bed, the off-gas passes through mist eliminators designed to prevent overhead entrainment before leaving the top of the column. It then continues on through stainless steel piping to the suction of the new, increased capacity MOG Exhaust Fan. An installed spare unit is also provided to allow for periodic fan maintenance. The continuous operation of the fan provides the motive force required to draw down the melter below atmospheric pressure and to overcome piping and equipment friction losses. Because the net forward flow of off-gas must pass through additional equipment before its release to the atmosphere, the fan discharge must be at a modest, positive gauge pressure.

The MOG Exhaust Fan discharge is split into two unequal streams. The larger stream is recycled to the Film Cooler where it is used to cool hot gases from the melter plenum. The flow rate of this stream, which is typically 500 SCFM, is regulated to control the Film Cooler outlet temperature. The smaller stream represents the net excess of gas that must be purged forward and undergo further decontamination before release to the atmosphere. Its 85 SCFM flow rate is equal to the total of uncontrolled air inleakage to the melter, miscellaneous additions of pressurized air to the melter, and melter reaction gases not absorbed by upstream wet scrubbing.

From the MOG Exhaust Fan, the net forward MOG purge is joined by the discharge from the new Vessel Vent Exhaust Fan. This latter stream consists of the combined vents from all contaminated equipment in the VITPP, except the melter, the gem machine, and the MOG System. The mixed MOG/Vessel Vent stream then proceeds through stainless steel pipe to the new Off-Gas Chiller/Condenser which cools the mixed stream to 50°F to condense most of the remaining water before entering the Desiccant/NOx Removal Beds. These beds are intended to perform both gas dehydration and NOx removal using a granular molecular sieve or zeolite. This pre-conditioning of the gas is necessary to achieve effective radon adsorption in the downstream Carbon Bed Vessels. Bench scale testing will be required to identify which, if any, grade of solid adsorbent can acceptably perform this dual function. A total of two parallel beds will be provided. At any given time, one of the beds will be handling the flowing off-gas while the other will be going through a regeneration cycle. During bed regeneration, ambient air discharged from the Regeneration Blower is first heated and then admitted to the bottom of the appropriate vessel. As it rises through the internal beds, the hot regeneration air strips water and NOx molecules from the surfaces of the adsorbent granules. Leaving the top of the vessel, the regeneration air passes through a HEPA filter before discharge to the VITPP stack.

Meanwhile conditioned off-gas leaves the bottom of the adjacent Desiccant/NOx Removal Bed. The process of water vapor adsorption onto a solid releases a substantial amount of latent heat, which warms the treated gas exiting the bed. In order to improve the efficiency of downstream radon adsorption, this off-gas must be cooled to 50°F in a new Chiller. From the Chiller, the off-gas passes through a Guard Bed which contains the same adsorbent as the upstream Desiccant/NOx Removal Beds. The purpose of the Guard Bed is to prevent excessive concentrations of NOx from entering the downstream Carbon Bed Vessels, which could result in an uncontrolled exothermic reaction.

The aforementioned injection of partially decontaminated recycle gas rather than clean plant air to the melter Film Cooler maintains the net forward off-gas purge essentially unchanged from the original VITPP design. Therefore, the existing Carbon Bed Vessels can be re-used to adsorb radon from the off-gas stream exiting the Guard Vessel. In fact, the gas pre-chilling feature added to the new design is expected to improve radon removal efficiencies. Based on adsorption coefficients measured by Rust Geotech, the radon removal efficiency is expected to exceed 95%. As an added safeguard against a runaway reaction caused by NOx in the feed gas, the Carbon Bed Vessels are now served by a new fire suppression system. The effluent from the Carbon Bed Vessels passes through the existing HEPA Filters (5-FL-48A & B) and then on to the VITPP stack.

The Emergency Off-Gas System (EOS) in the redesigned plant continues to perform two primary functions. First, it serves as a backup source of vacuum ventilation and off-gas filtration, and second, it performs overpressure relief for the melter plenum. The flow of air from the melter plenum to the EOS is estimated to be 40 SCFM during a diversion episode. This is based on the expected air inleakage to a melter operating at -0.5" WC. Consequently, the design capacity of the EOS should not change significantly as a result of the plant upgrade.

The proposed EOS redesign relocates automatic block valve FV-370 from the Knock Out Pot (5-KO-36) inlet line to the HEPA Filter (5-FL-37) outlet line. This change is intended to protect FV-370 (which must open quickly to provide a backup source of vacuum to the melter) from routine contact with any droplets of molten glass carried by the hot gases that can migrate from the plenum to the upstream EOS piping.

The proposed EOS redesign also simplifies the flow path taken by the diverted MOG during an overpressure relief. A new off-gas relief line now branches off from the main EOS line just upstream of the Knock Out Pot. This relief line runs a short distance to the top of the new Seal Pot, which contains an internal diptube to receive incoming off-gas. The downward pointing diptube terminates below the surface of a pool of water maintained inside the Seal Pot. The diptube submergence is set to prevent the forward flow of off-gas except when the melter rises to a positive gauge pressure. During such as excursion, melter off-gas flows first through the new relief line and then down into the Seal Pot diptube. After blowing through the water seal, the off-gas leaves the top of the Seal Pot through an overhead vent line. It is then released directly to the atmosphere at a safe location.

The items eliminated by the EOS redesign include the rupture disk (5-RD-35), the mist eliminator (5-MS-53), and the pressure safety valve (PSV-360).

4.4.5 Areas of Uncertainty/Possible Alternative Configurations

1. The proposed redesign uses partially decontaminated off-gas rather than compressed plant air for injection into the Film Cooler. This requires that the partially decontaminated off-gas first be raised to a slightly positive gauge pressure upstream of the recycle take off to the Film Cooler. Since all of the piping and equipment connections are contact maintained, leak tight makeup should be easy to achieve and verify. In any case, the safety and acceptability of this arrangement should be double checked during a later stage of design.

2. Preliminary data from Rust Geotech indicates that the adsorption coefficient for radon on activated carbon will rise significantly as the system temperature falls from 75°F to 50°F. These data should be confirmed and finalized prior to the final stage of design to permit an accurate forecast of radon emissions.

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3. The extent to which water vapor, SO_2 and CO_2 must be removed from the off-gas before the radon adsorption step has not been clearly defined. The allowable residual concentrations of these gaseous impurities are needed to provide the design bases for the acid gas removal and dehydration operations.

4. It is known that under certain conditions, gaseous NOx will undergo a highly exothermic and uncontrollable reaction with activated carbon. However, the specific conditions under which this occurs, and the upper allowable concentration limit for NOx in the flowing process gas, have not yet been defined. These data are needed to provide a design basis for the NOx removal operation, and to give some advance assurance that activated carbon can be safely used to adsorb radon from the VITPP off-gas.

   The currently proposed redesign calls for the removal of both water vapor and NOx from the off-gas by a single stage of zeolite contacting upstream of the carbon beds. In order to identify a specific grade of zeolite that is actually capable of this dual function, laboratory tests are now being performed at the University of Cincinnati using three prospective materials (type 5A, ZSM-5 and NaY). It is possible that the test results may require the use of one type of zeolite for dehydration and another for NOx removal, thereby creating the need for two separate contacting stages mounted in series. Another possibility is that some of the zeolites may co-adsorb appreciable amounts of radon from the gas phase. Such behavior would probably make the identified zeolite unsuitable for dehydration and/or NOx removal, since it would lead to the atmospheric release of radon as part of the hot gas stream used to periodically regenerate the zeolite. And finally, it is also possible that none of the identified zeolites will effectively remove NOx from the gas phase. In that case, some alternate NOx abatement technique, such as selective catalytic reduction (SCR) or the proprietary Tri-NOx wet scrubbing process will be needed.

5. The proposed redesign allows hot, untreated gases from the melter plenum to migrate up into much of the Emergency Off-Gas System piping and equipment, including the quick opening valve that is used to admit cooling air during a relief episode. An alternate approach would be to prevent the out-migration of melter gases by adding a Back-Up Film Cooler to the top of the melter. Like the Primary Film Cooler, the Back-up Film Cooler would routinely receive partially decontaminated off-gases recycled from the MOG System. These incoming gases would pass through the Back-Up Film Cooler and then flow down into the melter plenum, thereby creating a barrier to out-migration. Once inside the melter plenum, these gases would mix with air inleakage and melter reaction gases before entering the Primary Film Cooler. In this way, there would be an increase in the flow of non-condensibles through the MOG System, upstream of the recycle gas take off point. This change, however, would not affect the volume or mass of the net forward MOG purge that is ultimately discharged to the atmosphere.

6. The need for a separate Emergency Off-Gas System is created by the possibility that a critical function of the Primary MOG System, such as gas quenching or a flow path to the atmosphere, may be lost without warning. The functions of the EOS are limited to the maintenance of a very slight melter vacuum and the removal of entrained particulates from the diverted gas. The EOS is not designed to remove SO_2, NOx or radon.

An alternative approach would be to design sufficient redundancy into the Primary MOG System to obviate the need for a separate EOS.

7. In both the existing and proposed MOG System designs, an ejector venturi scrubber (EVS) is essentially the only particulate removal device provided upstream of the disposable roughing filter elements inside 5-FL-48A & B. While a properly designed EVS can very effectively remove larger particulates, its efficiency falls dramatically for particles below about 3-4 microns. The preliminary results from VITPP Phase 1 startup activities indicate a substantial accumulation of solids, apparently below this size range, on the roughing filter elements. Because of the cost, difficulty and potential radiation exposure associated with spent element disposal, element consumption should be kept to a minimum.

   There are a number of ways to achieve this goal. One method would be to incorporate a high-energy EVS or similar wet scrubbing device into the MOG System. Depending on the desired particulate removal efficiency, such a device would produce a gas phase pressure drop of 20" W.C. or more. Another approach would be to replace the disposable roughing filter and HEPA elements with washable filters designed to last the life of the plant. These new filter elements would be made of sintered metal fibers or, in the case of roughing service, possibly a polymeric material. Because of their greater mechanical strength, these metallic or polymeric elements would eliminate the danger of catastrophic, in-service failure that now exists with conventional, glass fiber HEPAs. The spent wash water from the new filters could be sent to either the Thickener or the Waste Water Treatment System. In either case, the recovered solids would eventually be recycled to the melter.

4.5 PROCESS VESSEL VENT

4.5.1 Required Functions of VITPP Vessel Vent System

The primary functions of the VITPP Process Vessel Vent System are to:

- Draw suction on all contaminated process tanks and vessels (except those in the MOG System and the melter) in order to pull a continuous, manually controlled air sweep through the vapor space of each tank. The resulting in-rush of outside air to the affected tanks is intended to prevent the outleakage of contamination.
- Collect the overhead vent streams from all of the aforementioned tanks and vessels.
- Discharge the combined process vessel vents to an appropriate point in the MOG System to permit their decontamination prior to release to the atmosphere.

4.5.2 Description of Existing VITPP Process Vessel Vent System

Figure 1 is a process flow sketch of the existing VITPP. The specific tanks served by the Process Vessel Vent System are as follows:

Thickener Tank	(5-TK-01)

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Slurry Tanks	(5-TK-29A & B)
Recycle Water Tank	(5-TK-10)
Spare Storage Tank	(5-TK-56)
Building Sump Tank	(5-SU-74)
Silo 3 Surge Bin	(4-BN-29)
Sparge Tank	(5-AE-39)

These tanks are designed for only a very modest internal vacuum of -4" WC. Each tank is provided with an overhead breather line fitted with a conservation vent valve that performs both vacuum relief and pressure relief. The overhead vent gases from the process tanks are drawn by suction to a point in the MOG System where the internal vacuum is likely to be greater than -4" WC. Consequently, the conservation vents will be at least partly open during normal plant operation to protect the process tanks from excessive vacuum. The overhead vent line from each tank contains a manual throttling valve that can be used to adjust the vent gas rate.

With the exception of the Sparge Tank vent, the individual tank vents combine into a single stream that its merged into the MOG System downstream of the Quench Tower and Scrubber (5-SB-07/22). The separate Sparge Tank vent then ties into the same MOG line a short distance further downstream. It is anticipated that the PVV gases may contain mists, particulates and radon volatilized from the process slurry in the tanks.

The combined melter off-gas/process vessel vent stream successively undergoes dehydration, radon removal and particulate filtration before entering the suction of the Exhaust Fan (5-FA-25). Thus, the design relies on a single operating fan to maintain a partial vacuum in both the melter and the contaminated process tanks.

4.5.3 <u>Potential Problems with Existing VITPP Process Vessel Vent System</u>

The specific problems anticipated with the VITPP Process Vessel Vent System design are identified and described below.

1. The motive force required to make the PVV System operate is provided by the single, continuously-operating Exhaust Fan (5-FA-25), which is actually part of the MOG System. The PVV System will therefore be nonfunctional during Exhaust Fan outages.

2. The existing design does not permit precise control of the pressure in the PVV collection header. Consequently, the conservation vents on the contaminated process tanks are expected to be routinely open to protect the tanks from excessive vacuum. Thus, the total PVV flow will be much higher than would be the case if reliable control of the PVV header pressure allowed the conservation vents to remain closed. This is significant, since all of the PVV gases must be dehydrated and filtered, and undergo radon removal. For a given size activated carbon adsorption bed, higher gas flow rates will reduce radon removal efficiency.

   A related concern arises from the fact that conservation vents are designed to perform intermittent vacuum or pressure relief at some worst case gas flow rate.

rather than continuous flow control. Because of this, the conservation vents may operate in an alternating on/off mode rather than a stable and continuous throttling mode. The resulting fluctuations in total PVV gas flow to the MOG System would handicap efforts to properly control the melter pressure.

4.5.4 Proposed Redesign of VITPP Process Vessel Vent System

Figure 3 shows the proposed PVV System redesign. The overhead vent lines from all contaminated process tanks and vessels tie into a single PVV collection header. The operating pressure of the collection header is continuously and precisely controlled at -1" WC to -2" WC. The connected process tanks ride on the header vacuum and are thereby protected against outleakage. Proper selection of the collection header operating pressure should also prevent the routine opening of the tank conservation vents and the resulting in-rush of outside air. This should minimize the overhead flow of vent gas from each tank, and so reduce the final PVV discharge stream that is sent to the MOG System.

The collection header carries the combined vent gases to the suction side of the new PVV Exhaust Fan. An installed spare unit is also provided to improve system reliability. The PVV Exhaust Fan discharge stream is routed to the MOG Exhaust Fan discharge line. The blended MOG/PVV gases then successively undergo dehydration/NOx removal, radon removal and particulate filtration before being sent to the VITPP stack.

4.5.5 Areas of Uncertainty/Possible Alternative Configurations

1. The current need to remove gaseous radon from the melter off-gas might be eliminated by the future addition of radon stripping capabilities to the Feed Preparation System. If this were to occur, then the MOG and PVV Systems should be modified in such a way that only the PVV gases would pass through the activated carbon beds used to adsorb radon.

4.6 MELTER SYSTEM

4.6.1 Required Functions of VITPP Melter

The VITPP melter shall be designed to perform the following functions:

- Receive slurry from the Melter Feed Preparation System and maintain glass level.
- Provide joule heating to process molten glass at rated capacity.
- Provide an acceptable vitrified glass product.
- Monitor and control melter operations and provide appropriate interlocks with all interfacing systems.
- Maintain melter outer surface temperature at approximately 100 °C (212 °F).
- Provide capability for draining molten glass.

- Provide capability for removing salt layer.

- Provide melter restart capability.

4.6.2 Description of Existing VITPP Melter

The VITPP melter is designed specifically to address waste material processing problems identified in the early development of the FERMCO vitrification program (e.g., high processing temperatures). The melter is joule-heated and uses 5 sets of water-cooled, molybdenum electrodes to provide power for joule-heating (joule-heating is achieved by passing a current through the glass pool by electrodes placed inside the melter). The electrodes are not in contact with corrosive waste materials, but instead, are submerged in a benign glass formulation in two isolated side-chambers. Isolation walls provide a physical barrier that serve to minimize the transport of corrosive waste materials into the side-chambers. The isolation walls are electrically conductive and permit current to travel between the electrodes and molten glass in the main-chamber (vitrification of silo residues occur in the main-chamber). Glass levels in each chamber (two side, one main) are maintained by independent feed systems.

The melter design temperature is 1400°C with a maximum operating temperature of 1350°C (expected operating temperature is estimated at 1250 °C). Waste slurry is introduced into the melter by the melter feed pump. At design capacity, the melter will operate with partial cold cap coverage. An air bridge is used for agitation in the VITPP melter to increase the waste processing rate. The air bridge is located in the center of the melter (the air bridge bubbles air through the molten bath). Air flow is regulated to control the utilization of air for: (1) increased dissolution of the feed materials and cold cap, (2) distribution of heat in the bath, and (3) reduce the potential of elemental metals and debris settling in the glass melt (melter bottom).

Molten glass is discharged from discharge chamber by using an air lift feature located in the bottom of the melter (or lift tube area). Injected air effectively reduces the specific gravity of molten glass in the lift tube, which permits the more dense molten glass in the main chamber to "lift and push" the molten glass in the lift tube over the edge of the discharge trough. The rate of melter glass discharge can be controlled by the rate of air flow applied to the air lift, and gives flexibility in the control of glass flow through the melter and to the gem making machine.

At design capacity, glass level is manually maintained in the main chamber of the melter by observation of the cold cap. As the cold cap is consumed, melter feed operations are permitted. If the cold cap is observed to accumulate, melter feed operations are interrupted. Steady state melter feed operations is defined as the condition when the rate of cold cap consumption and the rate of cold cap accumulation are equivalent.

The melter control system measures and responds to changes in the vitrification process in order to maintain steady-state conditions. The following are "real-time" parameters measured and controlled by the melter control system to maintain the "condition" of the vitrification process.

Melter Chamber

- Temperature - bath (multiple points)
- Amperage - plenum resistance heaters (startup)
- Voltage - plenum resistance heaters (startup)
- Air flow rate - air bridge
- Percent cold cap and appearance
- Liquid salt (sulfate) or "talc like" solids layer formation on surface
- Foaming
- Appearance and thickness of glass in the melt
- Response time to changed conditions

Side Chamber(s)

- Amperage - each electrode
- Voltage - each electrode
- Temperature - optical infrared glass surface measurement
- Cooling water temperature - each electrode
- Water flow rate - each electrode
- Electrode glass level - molybdenum disilicide electrical contacts
- Periodic sampling of electrode chamber glass for analysis to determine leakage

Glass Discharge Chamber

- Temperature
- Amperage - discharge resistance heaters
- Voltage - discharge resistance heaters
- Air flow rate - air lift
- Air pressure - air lift
- Appearance of glass discharged

Ground and Melter Skin Temperature

- Amperage and voltage to ground (increasing number may be an indication of glass leakage through refractory or failure in the melter)
- Skin temperature profile around melter (needed to complete energy balance around melter. Also, local increased temperatures may be an indication of glass leakage in the melter).

The basic control philosophy for the melter focuses on maintaining the temperature of the bath to a desired set point. When the temperature of the bath drops, more power (and, thus, heat) is placed into the bath until the set point temperature is again reached. The larger temperature difference between the bath and the set point temperature, the more power is imparted to the bath. Power is delivered in oscillating pulses while the voltage is maintained constant. The amount of power delivered is directly proportional to the duration and frequency of the pulse that is electronically regulated by a Silicon Controlled Rectifier (SCR) circuit. If the pulses become excessively long (leaving little range for control), the voltage to the melter can be manually increased. The increased voltage will allow more power to be imparted to the melter with shorter duration pulses, and as such, permit better control.

4.6.3 Potential Problems With Existing VITPP Melter System

The melter discharge chamber interfaces with the Gem Machine through the 3 inch diameter discharge port. It also interfaces with the main chamber through the leaky refractory brick wall separating the two chambers. The main chamber is held at a vacuum of 2 inches of water by the Melter Off-Gas System. Air leakage through the refractory brick wall maintains the discharge chamber at or near the main chamber vacuum.

The Gem Machine is cooled in part by room air that is brought in through a control valve and discharged to the HVAC system. A pressure controller modulates this inlet valve to maintain a vacuum of around ½ inch of water in the Gem Maker.

Since the glass stream flowing through the discharge port will be only ½ to ¼ inch in diameter, there will be significant open area between the melter discharge chamber and the Gem Maker. The theoretical design of the two systems ensures zero air flow through this pour spout by maintaining a zero differential pressure across the pour spout. In reality this may be difficult to control.

Melter vacuum will fluctuate with varying feed rates and melter off-gas system maintenance activities. Gem Maker vacuum will be sensitive to opening and closing of the roll-up door into the Furnace Room and other HVAC system variations. Since these two control systems are independent of each other, the chances of this differential pressure being zero are low. The net result is that sometimes melter off-gas will flow into the HVAC system potentially releasing radon to the atmosphere, and sometimes room air will flow into the melter off-gas system potentially choking the system.

4.6.4 Proposed Redesign of VITPP Melter System

The melter pour spout will be replaced with one that is more closely matched to the glass pour stream diameter in order to minimize air flow either into or out of the melter discharge chamber.

4.6.5 Areas of Uncertainty/Possible Alternative Configurations

No areas of uncertainty or possible alternative configurations are investigated/ proposed for this system.

4.7 GEM MAKING SYSTEM

4.7.1 Required Functions of VITPP Gem Making System

The VITPP Gem Making System shall be designed to perform the following functions:

- Receive molten glass from the Melter System (discharge chamber) and produce waste forms (gems) from minimum to design rated capacity.

- Provide heat removal for critical components (e.g., gob cutter) and waste forms (gems) at rated design capacity.

- Provide failsafe diversion and containment of molten glass stream in the event of system upset/failure.

- Transport and cool waste forms (gems) to a Gem Transfer Container (GTC) at rated production capacity.

- Monitor and control the waste form production process.

- Provide confinement to minimize dispersion of radioactive materials to the vitrification facility.

4.7.2 Description of Existing VITPP Gem Making System

The Gem Making System will receive continuous molten glass from the Melter System via the melter discharge chamber at an approximate temperature of 1,200 ^{o}C (2,192 ^{o}F) and is rated from 1 to 3 MT per day gem production. The gob making mechanism is composed of two counter rotating cylinders. The gob cutter (made of stainless steel) has machined flutes that fill with molten glass as it rotates. The crest of each flute rotates against the gob roller, a smooth cylinder made of graphite. This "pinch point" cuts the stream of molten glass and produces a discrete waste form called a gob. As the gob cutter rotates, molten gobs fall onto a conveyor and flatten. Due to the surface tension of the viscous glass, however, the gob quickly "pulls" itself together to form a gem. The gems are quickly cooled and solidified by a combination of radiant, conductive (cooling plates are located under the metal gem conveyor belt), and convective (air flow provided by the exhaust system) heat transfer. Cooled gems are transferred to a discharge chute where they are routed into a GTC (surface temperature is approximately 600 ^{o}C). When a GTC fills, the discharge chute is closed and the GTC is removed and replaced by the Glass Packaging System.

Off-gas from the Gem Maker system will be vented to the building HVAC exhaust system for treatment to remove any particulates prior to release to the environment. The Gem Maker vapor space includes the void volumes that define the melter discharge chamber and the gem maker (including any container attached to the gem maker during filling operations). The building HVAC system will maintain the Gem Maker system at a negative pressure relative to the facility/atmosphere.

The Gem Making System's control system measures and responds to changes in the glass forming process in order to maintain steady-state conditions. The following are "real-time" parameters measured by the Gem Making System's control system to maintain the "condition" of the glass forming process.

- Temperature - molten glass (from melter discharge chamber)
- Temperature - gem conveyor belt (multiple points)
- Temperature - glass (at GTC, emergency/startup containers)
- Temperature - main box atmosphere
- Pressure - main box atmosphere
- Motor speed - gob cutter, roller, conveyor
- Air flow rate - compressed air system cooling (gob cutter)
- Cooling water temperature - cooling plates
- Cooling water flow - cooling plates

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4.7.3 Potential Problems With Existing VITPP Gem Making System

The specific problems anticipated with the Gem Making system design concept at 6 MT/d production are identified and described below.

1. Exhaust from the Gem Making system is controlled around a pressure differential set point with the VIT building. As the vitrification building pressure changes (from opening the roll-up metal door for GTC removal), this will cause the differential pressure to drift from its set point. The Gem Making exhaust pressure control system is expected to "struggle" (i.e., work at capacity) during these periods to achieve its set point.

2. A potential in-leakage pathway exits in the physical boundary separating the Melter Off-gas system and Gem Maker exhaust system. This boundary is constructed of Monofrax E* refractory material (GTS Duratek drawing CRU4-M-M-001, Rev. 3) and serves to isolate/separate the main chamber from the discharge chamber. If melter pressure becomes positive with resect to the Gem Maker system pressure, potential for in-leakage of radon bearing gas to the VITPP building exhaust system exists.

3. Many of the instrumented Gem Making components/parameters are on local and control room panels. However, no alarms for upset conditions are identified in reference drawings (FERMCO drawing 94X-5500-N-00962, Rev. 0, 2//96). Lack of alarms in the control panel may allow upset conditions to continue until an operator observes these conditions on indicator screens.

4. Preliminary calculations indicate a maximum gem production capability of approximately 8.5 MT/d. Capacity calculations for the gem conveyor indicate a maximum gem transfer rate of approximately 3.5 MT/d. Hence, the current gem maker configuration is not capable of supporting increased production of 6 MT/d.

5. During GTC change out on the Gem Maker, the south discharge chute (at the end of the gem conveyor) is used to accumulate gems (has a fixed volume of approximately 0.06 m^3). At a production capacity of 1 MT/d, the rate in which the hopper is filling is approximately 3.6E-4 m^3 per minute (takes almost 3 hours to fill). At an increased production capacity of 6 MT/d, the hopper fills 6 times this rate (takes approximately 30 minutes to fill). Although it is estimated to take less than 30 minutes to changeout a GTC (without incident), unanticipated (or unaccounted for) events may cause GTC changeout to approach/exceed 30 minutes.

4.7.4 Proposed Redesign of VITPP Gem Making System

The proposed Gem Making System redesign described below is based on the future conversion of the VITPP to a 6 MT/d production facility. These changes are intended to eliminate the potential operating problems described above, as well as handle the increased production capacity. Achieving these goals is deemed necessary to ensure long-term reliable operations of the VITPP Gem Making System.

1. Operating pressure of the Gem Maker system should be maintained positive with respect to the Melter system under all operating conditions (i.e., activation of the Emergency Off-gas system). This serves minimize/eliminate in-leakage from the

Melter system and prohibit the transfer of radon-bearing gases into the Gem Maker/VITPP building exhaust system.

2. Modifications to the current Gem Maker system to achieve increased capacity of 6 MT/d may include:

   - modify gem conveyor to provide increased capacity (gem cooling requirements must be considered).

   - modify the melter discharge chamber to provide multiple discharge ports to feed the gob cutter.

3. Provide the appropriate alarm features required to alert control room operators of system upsets (see Section 4.7.5 below).

4. The current heat removal capacity in the Gem Maker cooling plates is determined not to be adequate for 6 MT/d production (see discussion in Section 4.9.1 of the VITPP Closed-Loop Cooling Water System). The flow rate (assumed at 4 gpm) must be increased for adequate heat removal associated with higher glass production rates.

4.7.5 Areas of Uncertainty/Possible Alternative Configurations

The areas of uncertainty and/or possible alternative configurations that may require future study are discussed below.

1. Currently, no detailed heat transfer calculations are available from the vendor (GTS Duratek) for the gem making system to determine the design limit heat removal capacity (e.g., gob cutter, main box).

2. A complete FMEA and RAM analysis are required for the Gem Maker System at the increased production rates.

4.8 GLASS PACKAGING SYSTEM

4.8.1 Required Functions of VITPP Glass Packaging System

The VITPP Glass Packaging System shall be designed to perform the following functions:

- Management of glass container system for the following melter glass pouring modes: start-up, emergency (bypass), and normal operations (to include staging, transporting, placement, inspection and maintenance of containers).

- Packaging filled glass containers prior to container removal outside of the vitrification building (e.g., lid placement).

- Permitting appropriate cooling period for glass gem forms prior to removal from Gem Transfer Container (GTC).

- Transferring glass gem forms into DOT Specification 7A Type A container (includes packaging of this container).

- Loading of DOT Specification 7A Type A container onto trailer for removal.

4.8.2 Description of Existing VITPP Glass Packaging System

The current Glass Packaging concept utilizes the following components: forklift truck (shielded), emergency fill containers (monolith), start-up containers (for benign glass), Gem Transfer Containers (GTCs), a covered concrete pad (48ft x 24ft), and DOT Specification 7A Type A containers. When a GTC is full, an operator closes the discharge chute at the south end of the gem conveyor to permit gems to accumulate during GTC change-over (local control). A forklift truck enters the vitrification building through a roll up metal door. In a minimal amount of maneuvers, the forklift operator performs the following functions (assumes gem production):

- Brings an empty GTC into the facility (for GTC replacement) and places it in a dedicated staging area.

- Removes the full GTC from the roller conveyor load platform (Gem Machine) and places it on the floor of the facility (operations personnel may take glass sample, then place temporary enclosure lid on the GTC).

- Picks up the empty GTC and places it onto the load platform of the roller conveyor (operations personnel to transport GTC to discharge chute and verify position).

- Picks up filled GTC (with lid in place) from floor and transfers it to a covered concrete pad for cooling (roll up metal door to close after exiting facility). Filled GTCs are placed on a covered, concrete pad for approximately 70 hours (for gem annealing and cooling). After the cooling period, GTCs are lifted by the forklift, positioned over a DOT Specification 7A Type A container, and emptied (GTCs are emptied by a bottom slide gate). Each DOT Specification 7A Type A container can hold approximately 7 GTCs (a lid is maintained over the DOT container between fills). A forklift truck is used to load filled DOT containers onto a trailer for off-site transfer.

4.8.3 Potential Problems With Existing VITPP Glass Packaging System

The specific problems anticipated with the Glass Packaging system design concept at 6 MT/d production are identified and described below.

1. Placement and removal of GTCs to/from the vitrification building requires a large, roll-up, metal door to remain open while a forklift performs these operations (one GTC is filled approximately every 12 hours at 1 MT/d, every 2 hours at 6 MT/d production). In addition to causing the building HVAC and gem maker exhaust system to operate at design capacity in order to maintain a negative pressure (which will not be achieved), this presents an open pathway for contaminate release to the environment.

2. Forklift operations for replacement and removal of GTCs in the vitrification building should be independent of weather conditions. During adverse weather conditions

(e.g., rain), in addition to sediment introduced into the facility, an open pathway will exist (roll-up door) for elements to enter the facility. Hence, this requires the capability to "clean up" after forklift operations. No such clean up facilities (e.g., wash station and a contaminated water collection system) exist at the VITPP.

3. For increased operations (6 MT/d), it is estimated that 35 filled GTCs will require staging during the 70 hour cool-down requirement (compared to 6 GTCs cooling for 1 MT/d operations). Preliminary Microshield calculations estimate the maximum GTC dose rate for the series A glass formulation to be 45 mrem/hr at 1 foot. The calculated dose rate between similar columns of GTCs (staged for cooling) spaced 3 feet apart is 80 mrem/hr. For continuous occupancy around a dedicated staging area (for GTCs cooling), preliminary calculations indicate an 18" concrete shield wall is required.

4. Filling operations (the activities associated with loading cooled GTCs into the DOT Specification 7A Type A containers) are performed on a covered concrete pad and requires the assistance of operators. This concept, developed specifically for the VITPP demonstration work scope (i.e., Phase 1 and 2), is based on the ALARA premise that insignificant amounts of air borne contaminates are released during these procedures, and operator exposure is limited. However, for increased operations (6 MT/d), the loading frequency is approximately 6 times greater, and therefore requires re-evaluation of the ALARA process (site manual RM-0015, <u>FEMP ALARA Requirements Manual</u>). Additionally, during adverse weather conditions (e.g., rain), it is expected that certain areas on the concrete pad will get "washed-down". Similar to the discussion in item 2 above, contingencies for the collection of contaminated "run-off" do not exist.

5. It is expected that during plant operations, GTC inspection and maintenance (and/or replacement) will be required. Currently, no provisions exist for the inspection and maintenance of GTCs.

6. Glass quality testing (TCLP) requires a turnover period of approximately 7 days. Over this duration, approximately 14 GTCs have been processed at 1 MT/d plant capacity (6 cooling, 8 unloaded into DOT Specification 7A Type A containers). At 6 MT/d production capacity, approximately 84 GTCs have been processed (approximately 35 cooling, with the other 49 GTCs unloaded into the equivalent of 7 DOT Specification 7A Type A containers). Currently, no provisions exist for staging of DOT Specification 7A Type A containers containing glass awaiting glass quality test results (i.e., glass containing natural metals and awaiting/not passing TCLP requirements are subject to the substantive requirements of RCRA). Additionally, no provisions exist in the current glass packaging concept to stage, recover and process glass not passing glass quality testing.

4.8.4 <u>Proposed Redesign of VITPP Glass Packaging System</u>

The proposed Glass Packaging System redesign described below is based on the future conversion of the VITPP to a 6 MT/d production facility. The current glass packaging concept is based on a limited production duration (30 MT glass production) for demonstration of the vitrification concept. All methods of material handling as well as the design of the GTC are based on a short-term campaign. At 1 MT/d, a GTC is filled approximately every 12 hours. The 6 MT/d facility fills a GTC approximately every 2 hours. The changes noted below are intended to eliminate potential operating problems as described above, as well as address the changes in production capacity and operational durations. Achieving these goals is deemed necessary to ensure long-term reliable operations of the VITPP Glass Packaging System.

1. Build a GTC transfer system (e.g., mechanized roller conveyor) into the existing VITPP facility. The transfer system shall be designed to:

   - receive filled GTCs from the Gem Machine (with operator assistance) and transfer it at a controlled speed (minimal operator assistance).

   - utilize a double-door transfer system to permit: (1) controlled transfer of a GTC from the vitrification facility, and (2) transfer of empty GTCs into facility for reuse. The double-door transfer system will be designed to maintain facility confinement during container transfer activities. This system shall serve to maintain negative building pressure (with respect to atmosphere), eliminate the release pathway to the environment (roll-up metal door), and eliminate the need for wash-down capacity.

   - permit use of hand truck(s) inside VITPP facility to manage empty containers (includes positioning containers at the load platform on the Gem Machine, staging empty containers, and managing filled containers as necessary). Utilization of hand trucks should minimize movement of containers, permit flexible container management, and maintain a clean VITPP facility.

2. Replace the covered concrete pad concept with a facility designed to interface with the GTC transfer system discussed in item 1 above. This facility should be designed to provide the required administrative support (i.e., inventory control, HP), stage the equivalent of 70 hours of filled GTCs (as defined by the cooling duration), achieve maximum radiation and contamination control, provide confined area for handling and filling the DOT Specification 7A Type A containers, provide ventilation and air filtration for contamination control, provide ease of personnel access, material handling, manage/inventory waste form containers, and facilitate decontamination. Other features of this facility should include optimum space utilization, low installation and maintenance costs, sufficient space provided for operations, lay down and repair without compromising safety and health physics requirements. Additionally, a covered staging area for filled DOT Specification 7A Type A containers awaiting glass quality test results should be provided.

3. Provide a dedicated concrete staging area for packaged DOT Specification 7A Type A containers containing glass product awaiting off-site transfer. This staging area should be in located in the contaminated area (i.e., VITPP proper is considered as contaminated area during its operational phase), however, should be sited to facilitate truck-loading for off-site transfer (loading activities should be performed in a buffer area once DOT Specification 7A Type A container has passed radiological survey).

4. Provide a dedicated concrete staging area for packaged DOT Specification 7A Type A containers containing glass for recycle (e.g., glass failing TCLP). Due to the hazard associated with the toxicity of natural metals (e.g., lead), the substantive requirements of RCRA will be considered relevant and appropriate to the design of the concrete staging area to ensure adequate protection of human health and the

environment. In addition, all regulatory requirements for radon release during interim storage, and all applicable Health and Safety plans, will be met.

4.8.5 Areas of Uncertainty/Possible Alternative Configurations

The areas of uncertainty and/or possible alternative configurations that may require future study are discussed below.

1. Glass product recycle is currently not defined. Glass product recycle requires quantification and definition.

4.9 CLOSED-LOOP COOLING WATER SYSTEM

4.9.1 Required Functions of VITPP Closed-Loop Cooling Water System

The VITPP Closed-Loop Cooling Water System (CLCW) System shall be designed to perform the following functions:

- Supply water at the required flow rate and temperature to the following melter and gem maker system components for heat removal: electrode holders, bottom drains, surface drain, feed tubes, IR detectors, gem diverters, and gem cooling plates.
- Provide nominal and design capacity heat rejection to the atmosphere for the CLCW system.
- During loss of power event(s), provide means of heat removal and rejection capability.
- Provide capacity for volume fluctuations (thermal expansion) in the CLCW system.
- Provide de-ionized water supply system for electrode operation and maintenance.
- Provide a means to reinitiate CLCW flow to the electrode holders after electrode maintenance requirements (e.g., insertion).
- Monitor and control the CLCW system.

4.9.2 Description of Existing VITPP Closed-Loop Cooling Water System

The Closed-Loop Cooling Water (CLCW) system provides a closed loop method of removing heat from melter and gem maker system components during normal process operations and is illustrated on Figure 3. These components include: 10-electrode holders, 4-bottom drains, 1-surface drain, 4-feed tubes, 2-IR detectors, 2-gem diverters, and 2-gem cooling plates. The CLCW system includes a forced-air radiator system for heat rejection, redundant circulation pumps, distribution piping, filter, an expansion/ surge tank, a chemical addition system, and a de-ionized water supply tank with associated piping.

Redundant CLCW pumps are provided to increase the availability of this system. The surge tank provides the CLCW system the capability to respond to volumetric changes (i.e., temperature changes) and is designed with a 15 psi rated relief system. Make-up water is provided manually at the surge tank. In the event of loss of heat rejection capability, the potable water system, in conjunction associated instrumentation and control, provides emergency "once-through" heat removal capability for the CLCW system.

A de-ionized water system is provided to assist in reestablishing water flow to the electrode holders during routine maintenance activities. Prior to electrode insertion, CLCW flow is stopped to the electrode holder which permits the frozen glass (a protective glass seal around the electrode that prevents molten glass from seeping into the refractory walls) to "soften". After insertion, the de-ionized water system is connected to the electrode holder and used to reestablish flow (the use of de-ionized water minimizes solid material deposited on the interior surface of the electrode holder as the water vaporizes). Once flow is established to the electrode holder, the de-ionized water system is disconnected and the electrode holder is reconnected to the CLCW system for normal operations.

4.9.3 Potential Problems With Existing VITPP Closed-Loop Cooling Water System

The specific problems anticipated with the Closed-Loop Cooling Water system design concept at increased production (6 MT/d) are identified and described below.

1. The current method of electrode insertion requires the CLCW system to be disconnected from the electrode holders. Upon reestablishing flow with the CLCW system, entrained air is introduced into the system. Currently, the CLCW system does not have an effective vent system for air removal.

2. A review of drawing 94X-5500-N-00962 (dated 2/3/96) shows no control room alarms for CLCW System upsets.

3. Review of system control logic diagrams indicate continued operation of the radiator cooler pump during operation of the emergency "once-through" cooling water system.

4. For 6 MT/d production capacity, preliminary heat transfer calculations indicate a potential problem with the current CLCW flow rate to the cooling plates. Based on a flow rate of 4 gpm, cooling plate outlet temperature may approach (or exceed) saturation temperature.

4.9.4 Proposed Redesign of VITPP Closed-Loop Cooling Water System

The proposed CLCW System redesign described below is based on the future conversion of the VITPP to a 6 MT/d production facility. These changes are intended to eliminate the potential operating problems described above, as well as handle the increased production capacity. Achieving these goals is deemed necessary to ensure long-term reliable operations of the VITPP CLCW System.

1. Modify the electrode holder cooling system to facilitate electrode maintenance procedures. Modifications would include isolation from the CLCW system, self-priming and venting of entrained air (de-ionized water) prior to reestablishing flow

with the CLCW system. This system would require the use of the de-ionized water tank, a vent tank (enclosed), and associated piping.

2. Increase the CLCW flow to the cooling plates, as required for increased production capacity.

3. Modify the CLCW surge tank to include automated water make-up addition, a pressure relief valve on the cooling-loop side of manual valve V-513, and a surge tank level indicator/alarm.

4. Provide the appropriate alarms in the CLCW (identified in the preliminary FMEA). These include: high temperature alarm after discharge from the CLCW radiator, low-flow alarm after radiator cooler pump (5-PM-51A/B discharge, and low-flow alarm to monitor emergency "once-through" cooling water system (modify signal from FS-002).

5. Provide interlock that will shut down the radiator cooler pump if the emergency "once-through" cooling water system is activated.

4.9.5 Areas of Uncertainty/Possible Alternative Configurations

The areas of uncertainty and/or possible alternative configurations that may require future study are discussed below.

4.10 BULK GLASS FORMER HANDLING SYSTEM

4.10.1 Required Functions of VITPP Bulk Glass Former Handling System

The VITPP Bulk Glass Former Handling System shall be designed to perform the following functions:

- Receive, stage and transport bulk glass former additives.
- Provide facilities for bulk additive sampling and measurement.
- Provide facilities to transfer measured quantities of bulk glass formers to the Melter Feed Preparation system.
- Prevent dispersion of dust to the environment during transfer of bulk glass former additives.

4.10.2 Description of Existing VITPP Bulk Glass Former Handling System

Figure 1 illustrates the current configuration of the Bulk Glass Former Handling system. Bulk glass former materials are received, staged and sampled as required by VITPP operations. The glass former additives considered for this system include: aluminum oxide (Al_2O_3), boric acid ($H_3 BO_3$), calcium carbonate ($CaCO_3$), lithium carbonate (Li_2CO_3), and sodium borate decahydrate ($Na_2B_4O_7$). Glass sampling analysis determines the quantities of glass former additives required per batch of melter feed (the glass formulation assumed for this section is S12G-01). Bulk glass formers are measured (e.g., weighed) prior to pneumatic transfer to the Additive Filter/Receiver tank (5-DC-65) via a Bag Dump Station (5-BG-64).

Two glass former loading periods per batch of slurry are assumed in this section. These loading periods include bulk glass former addition and readjustment. Bulk glass former addition is the first (and primary) addition of glass formers to the slurry has been transferred from the Thickener to the Slurry Tank. The appropriate combination/blend of glass formers per batch is determined by sample analysis of the Thickener underflow prior to transfer into the Slurry Tank. After glass former addition and homogenization (inside the Slurry Tank), the mixture is sampled and glass former readjustments are determined. Glass former readjustment is the final step to obtain a properly formulated melter slurry.

An operator (wearing full Personnel Protective Equipment, or PPEs) is required to manually weigh and feed bulk glass formers into the vented Bag Dump Station. The glass formers are pneumatically transferred to the Filter/ Receiver Tank where they are accumulated until the batch additive materials are ready for transfer to one of two Slurry Tanks (5-TK-29A,B). A diverter valve (5-VL-18) directs constant volume feed operations of glass former to a Slurry Tank. The VITPP Bulk Glass Former Handling System has a design rated capacity of 3,000 to 6,000 lbs/hr.

4.10.3 <u>Potential Problems With Existing VITPP Bulk Glass Former Handling System</u>

The specific problems anticipated with the Bulk Glass Former Handling system design concept at increased production (6 MT/d) are identified and described below.

1. The Bulk Glass Former Handling configuration is located in a small, partially enclosed area. The concerns that exist for increased production capacity (in the proximity of the Bag Dump Station) include: staging bulk glass formers in a non-controlled environment, required handling/addition of glass formers at the increased production rate, and worker health safety concerns.

2. No provisions exist for breaking agglomerations (caused by moisture or other binding constituents) in the bulk glass formers prior to transfer.

3. No dumping, bypass, or specific removal capability exists for removing the contents from the Additive Filter/Receiver Tank. If a condition exists that requires content removal of the Additive Filter/Receiver Tank (i.e., improper mixing the glass formers), non-routine maintenance would be required to remove contents of the tank and would create a non-availability condition of this system.

4. Personnel are required to wear full PPEs while handling bulk glass former materials (reference appropriate Material Safety Data Sheets). This creates safety concerns over handling methods and procedures (applicable for both 1MT/d and 6MT/d production).

5. A time motion study for a 6 MT/d production rate assumed a 1.5 hour duration between the readjustment of one Slurry Tank and the bulk addition to the other (only a single Filter/Receiver Tank is dedicated to glass former use). Within the 1.5 hour, approximately 1,100 lbs of glass former must be pneumatically transferred to the Additive Filter/Receiver Tank for the increased plant production. The internal

volume of the Additive Filter/Receiver Tank is 7.5 ft^3. The calculated volume for 1,100 lbs of glass former is approximately 10 ft^3. Hence, for bulk glass former addition, the existing Additive Filter/Receiver Tank must be filled and emptied twice. Considering the maximum capacity of this system (6,000 lbs/hr), 11 minutes are required to discharge 1,100 lbs of glass former from the Additive Filter/Receiver Tank by the constant volume feeder (5-RV-71) to the Slurry Tank. This permits 79 minutes for an operator dressed in full PPEs to load 1,100 lbs of glass former into the Bag Dump Station. Assuming an operator is limited to 35 lbs per lift, the operator is required to lift 32 bags over the 79 minute duration and empty them into the Bag Dump Station for pneumatic transfer (gives the operator approximately 2.5 minutes per bag). Hence, the time motion study suggests that for the 6 MT/d production rate, the current method of handling bulk glass formers is not adequate.

4.10.4 Proposed Redesign of VITPP Bulk Glass Former Handling System

The proposed Bulk Material System redesign is illustrated on Figure 3 and is described below. These modifications are based on the future conversion of the VITPP to a 6 MT/d production facility. For increased production, glass former addition is approximately 2.4 MT/d, or 500 kg/batch (1,100 lbs/batch). The changes discussed below are intended to eliminate the potential operating problems described in the previous section in order to handle the increased production capacity. Achieving these goals is deemed necessary to ensure long-term reliable operations of the VITPP Bulk Glass Former System.

1. The method of staging glass former materials in a separate facility and transferring them to the Bag Dump Station as required is not considered adequate (some materials require special handling and storage). Modifications to the current Bag Dump Station include a dedicated glass former staging area in the vicinity of the Bag Dump Station to manage bulk glass former materials. This area should include:

   - One day bin per additive, sized appropriately for several days (TBD) production requirements. Day bins will include all associated piping/venting for pneumatic transfer to maintain inventory.
   - Constant volume rotary feeders (one per bin) to permit operators to "dial-in" the appropriate glass former additives as required by slurry sampling methods (total capacity of the constant volume feeders to be rated at the existing system capacity of 3,000 to 6,000 lbs/hr).
   - The associated piping for transfer of the glass former additives from the constant volume feeders to the Bag Dump Station for pneumatic transfer to the Additive Filter/Receiver Tank.
   - The associated instrumentation and controls to permit control room management of the glass former addition process.

2. The Silo 3 Surge Bin (4-BN-29) should be removed. The facility housing the surge bin should be modified to provide an enclosure for the equipment required to stage glass former materials, as discussed in item 1 above.

3. The Silo 3 Filter/Receiver Tank (5-DC-27) should be connected and dedicated to the glass former addition system. The addition of this tank will provide increased capacity and availability to the glass former addition system required for increased plant production.

4.10.5 Areas of Uncertainty/Possible Alternative Configurations

The areas of uncertainty and/or possible alternative configurations that may require future study are discussed below.

1. Optimization is required for the modifications to the Bulk Glass Former Handling System as noted above.

4.11 UTILITY SYSTEMS

4.11.1 PLANT AND INSTRUMENT AIR

4.11.1.1 Required Functions of the VITPP Plant and Instrument Air System

- The Plant and Instrument Air System will provide:

  Plant Air. High pressure air (5 micron, 100 psig) for operation of Diaphragm Pumps, the Gem Machine, and miscellaneous other uses

  Instrument Air. Dry compressed air (-40°F dew point, < 1 ppm oil, 100 psig) for pneumatically operated and controlled valves

4.11.1.2 Description of the Existing VITPP Plant and Instrument Air System

The existing system is comprised of one air compressor with a capacity of 483 SCFM @100 psig and a 400 SCFM dryer, and one air compressor with a capacity of 320 SCFM @125 psig and a 200 SCFM dryer. Both of these trains go to a single air receiver and then to a single distribution system for both plant and instrument air.

4.11.1.3 Potential Problems with the Existing VITPP Plant and Instrument Air System

Based on **Instrument Air System Issues and Proposed Resolution** (Parsons), the total required compressed air flow is 445 SCFM for the One Metric Ton Pilot Plant. The present installed capacity is limited by the dryers (one 400 SCFM and one 200 SCFM) to 600 SCFM. The compressors themselves (one 483 SCFM and one 320 SCFM) have a combined capacity of 803 SCFM. Thus, 25 percent of their capacity is unutilized. Apparently, they **do** provide the required amount of air for the One Metric Ton Pilot Plant.

The required compressed air capacity for the Six Metric Ton Pilot Plant is estimated to be **less** than the installed capacity for the One Metric Ton Pilot Plant - 365 Versus 600 SCFM (see **Table 5 - PLANT AND INSTRUMENT AIR**, following). This very significant reduction is made possible by the change in the source of Film Cooler air (the largest previous user) from compressed air to air which is recycled from the Off-Gas System.

It should be noted that less than 15 percent of the demand is for instrument air. For the remainder of the users, drying is desirable, but not required. Plant Air capacity could be increased by providing a separate receiver and distribution system for Instrument Air and allowing the air that the dryers cannot handle to bypass the dryers. However, this change is not necessary and will not be implemented in the Upgrade Study.

The existing system makes no provision for critical air users to have priority use of the air that is available during an emergency shutdown. This situation needs to be corrected for the Six Metric Ton Pilot Plant.

4.11.1.4 Proposed Redesign of the VITPP Plant and Instrument Air System

The air header system will be modified to divide the system into two isolated branches, one for critical air users and one for non-critical air users. If the pressure in the critical air header should fall below a predetermined level for any reason (such as the compressors becoming inoperative) the valve in the line that supplies the non-critical users would close.

4.11.1.5 Areas of Uncertainty

The existing air system was put together in a piecemeal fashion. This may be continuing. A review of the current status of the system will be required, prior to committing funds for system modifications.

4.11.2 UTILITY STEAM

4.11.2.1 Required Functions of the VITPP Utility Steam System

- The Utility Steam System will provide low pressure (50 psig) steam:

  To the Utility Stations for general purpose use (Clean-up, thawing, et cetera)

  As a source of process heat for once-thru users

4.11.2.2 Description of the Existing VITPP Utility Steam System

There is no steam production capability in the One Metric Ton Pilot Plant.

4.11.2.3 Potential Problems with the Existing VITPP Utility Steam System

The VITPP has no provision for steam production. Steam is needed for utility stations. There is an existing boiler in the Fernald facility, but it is so far from the VITPP that it would be impractical to supply steam from that source, even if plenty of excess capacity were available.

4.11.2.4 Proposed Design of the VITPP Utility Steam System

The proposed system is based on the assumption that there will be a total of six Utility Stations and that they will be the only users of Utility Steam. The capacity of each station will be 200 #/Hr for a peak demand of 1,200 #/Hr. It is unlikely that more than two of these stations would be operating simultaneously; hence, 500 #/Hr would supply the need with 25 percent contingency. Please see the following **Table 6 - UTILITY STEAM** for further details.

4.11.2.5 Areas of Uncertainty

Thus far, there is no established requirement for steam as a source of heat for once-thru users. There are a couple of places in the process where heat is required, but the duty is so small that it could probably best be served by electric heat (the current plan).

4.11.3 COOLING WATER

4.11.3.1 Required Functions of the VITPP Cooling Water System

- The Cooling Water System removes heat from normal processing operations, and rejects that heat via evaporative cooling.
- The system maintains chemistry control of the tower water by a combination of tower water blowdown and the use of treated water as make-up.

4.11.3.2 Description of the Existing VITPP Cooling Water System

The existing system is comprised of a Cooling Tower and a Cooling Tower Pump. The cooling tower serves the heat exchanger in the Off-Gas System.

4.11.3.3 Potential Problems with the Existing VITPP Cooling Water System

The existing system is designed to cool 200 gpm from 115°F to 85°F[1]. Cooling water for both the Melter and the Gem Machine were included in the heat loads for that design. Since then, both of these duties have been transferred to an air cooled closed loop cooling system. Hence, the existing system has a lot of excess capacity for the One Metric Ton Pilot Plant. It also has plenty of capacity for the Six Metric Ton Pilot Plant. The heat exchanger in the Off-Gas System is the only currently planned user for cooling water in the Six Metric Ton Pilot Plant. The following **Table 7 - COOLING WATER** shows that 100 gpm would supply this need with 25 percent excess capacity.

However, the Cooling Tower Pump is not spared. Failure of this pump would shutdown the entire operation - an untenable situation for a continuously operating plant. The addition of a spare has been recommended by a Failure Mode Effects Analysis.

4.11.3.4 Proposed Redesign of the VITPP Cooling Water System

No change in the existing system capacity is required. However the Cooling Tower Pump will be spared, thereby significantly increasing the total operating efficiency.

[1] DATA SHEET A PROCESS REQUIREMENTS, CRU4 ENGR 14/1994

4.11.3.5 Areas of Uncertainty

Relying solely on the combination of tower water blowdown and the use of treated water as make-up to control fouling, scaling, and corrosion is unproven. The current operation should be monitored periodically for signs of problems in any of these areas.

4.11.4 PROCESS WATER

4.11.4.1 Required Functions of the VITPP Process Water System

- The Process Water System delivers (treated) water of adequate quality and pressure to the process equipment which requires make-up water for operation. These users include:

  Flocculant Make-up Tank
  Thickener Tank
  Recycle Water Tank
  Scrubber
  Cooling Tower

4.11.4.2 Description of the Existing VITPP Process Water System

The existing system is comprised of piping and controls.

4.11.4.3 Potential Problems with the Existing VITPP Process Water System

Although the larger plant will require more flow than the existing one, the existing system should be adequate.

4.11.4.4 Proposed Redesign of the VITPP Process Water System

No change in the existing system is required.

4.11.4.5 Areas of Uncertainty

There are no apparent areas of uncertainty.

4.11.5 PROCESS CHILLED WATER

4.11.5.1 Required Functions of the VITPP Process Chilled Water System

- The Process Chilled Water System delivers chilled (40°F) water to the process equipment which requires chilled water for operation. These users include:

  Scrub Water Chiller
  Off-Gas Chiller
  Radon Stripper Chiller

4.11.5.2 Description of the Existing VITPP Process Chilled Water System

There is no existing Process Chilled Water System in the One Metric Ton Pilot Plant.

4.11.5.3 Potential Problems with the Existing VITPP Process Chilled Water System

There is no existing Process Chilled Water System in the VITPP. Chilled water is required for the equipment listed above.

4.11.5.4 Proposed Design of the VITPP Process Chilled Water System

A chiller package, which includes an air-cooled refrigeration unit, a chilled water pump, a compression tank, and piping and controls, will be provided.

4.11.5.5 Areas of Uncertainty

The chilled water requirement for the equipment listed above is undefined at this time, but is believed to be small (These requirements will be established in upcoming phases of the Pilot Plant Upgrade Study). Should this prove to be incorrect, a water cooled refrigeration unit may be required. If so, cooling water requirements would also be impacted.

4.12 COLD CHEMICALS

4.12.1.1 Required Functions of the VITPP Cold Chemicals System

The Cold Chemicals System will:

- Receive liquid and dry chemicals in bulk quantities
- Provide safe storage of these chemicals in order to ensure inventory requirements
- Prepare the chemicals for use in the process
- Feed these chemicals to the process

4.12.1.2 Description of the Existing VITPP Cold Chemicals System

The existing system is comprised of two main parts:

Flocculant Addition
Caustic Additives Package System (Melter Off-Gas Treatment)

Flocculant addition consists of a flocculant transfer pump, a flocculant make-up tank, and a flocculant make-up tank pump.

The caustic additives package system consists of a caustic metering pump.

4.12.1.3 Potential Problems with the Existing VITPP Cold Chemicals System

The estimated flow rate of flocculant (See following Table 8 -COLD CHEMICAL REQUIREMENTS) is 0.110 #/Hr. The flocculant transfer pump has a capacity of 0.1 GPM; the flocculant make-up tank pump, 2.4 GPM - both more than ample.

Although the new system will require about two and one-half times as much caustic as the existing system, it is still not a large amount (49 #/Hr - See following Table 8 -COLD CHEMICAL REQUIREMENTS). The existing system should be adequate.

4.12.1.4 Proposed Redesign of the VITPP Cold Chemicals System

No change in the existing system is required.

4.12.1.5 Areas of Uncertainty

Even if no other caustic users develop, it will be necessary to change feed drums about once each shift - a potential labor problem.

4.13 SAMPLING AND ANALYTICAL FACILITIES

4.13.1 Required Functions of VITPP Sampling and Analytical System

The Sampling and Analytical System should provide the following basic functions:

- Receive melter feed slurry samples from vessels in the Feed Preparation System. These samples are for process control.
- Provide analysis of slurry samples from Feed Preparation vessels within an eight hour turn-around time.
- Receive and provide continuous analysis of gas samples from the Melter Off-Gas System.
- Receive routine samples and provide analysis of plant waste water streams. Number and turn-around time on samples is TBD.
- Receive routine samples and provide analysis of product glass. Number and turn-around time is TBD.

4.13.2 Description of Existing VITPP Sampling and Analytical System

The VITPP does not have a dedicated analytical facility. The Fernald site analytical facility is scheduled for D&D in 2001.

Liquid and slurry sampling at the VITPP is done manually at sample valve stations. The samples are carried to remote analytical facilities. During Phase 2 of VITPP operations there will be continuous on-line sampling and analysis of melter off-gas streams.

4.13.3 Potential Problems with Existing VITPP Sampling and Analytical Facility

The full production, 6 MT/D vitrification facility will require a dedicated analytical facility to carry out the required analytical functions (8 hour turn-around of samples from all Feed Preparation tanks, etc.)

Manual gathering of liquid and slurry samples, especially radioactive samples, is not practical in a full production facility.

4.13.4 Proposed Redesign of VITPP Sampling and Analytical System

The design of a Sampling and Analytical System for the 6 MT/D vitrification facility will be carried out in upcoming phases of the Vitrification Pilot Plant Upgrade Study. The following assumptions will serve as the basis for the design:

- The number and type of samples will be taken from the Remediation Analytical Schedule "Benchmark" Report, Oct. 95. The information from this report may be updated by personnel at the Fernald Analytical Facility during the course of the study.
- The laboratory for the vitrification plant will be standalone and dedicated to the vitrification plant. It will be located in close proximity to the vitrification plant.
- The analytical facility shall be housed in temporary/modularized buildings.
- For this study, only the facilities required to support the 6 MT/D upgraded pilot plant will be considered. It will be assumed that analytical facilities for the additional vitrification capacity requirements (TBD) will be added in modules.
- The sampling of liquid and slurry streams will be automated. The method will be determined during the remainder of the Upgrade Study and will likely include the use of pumps and sampling devises.

4.13.5 Areas of Uncertainty/Possible Alternative Configurations

The design of the Sampling and Analytical System has not been started at this time. Areas of uncertainty and alternate designs will be determined as the Upgrade Study proceeds.

TABLE 1

VITPP EQUIPMENT TO BE REMOVED OR MODIFIED FOR UPGRADE

Equipment to be Removed/Replaced:

* Film Cooler
* Melter Off-Gas Line
* Quench Tower
* Venturi Scrubber/Packed Scrubber
* Piping from Scrubber through Exhauster
* Desiccant Tower
* Off-Gas Exhauster
* Waste Water Filters

Equipment to be Modified:

* Gem Cooling Area
* EOS (Addition to UPS and other Modifications)
* Carbon Beds (Fire Suppression)
* Closed Loop Cooling Water System
* Melter Pour Spout

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TABLE 2

VITPP EQUIPMENT TO BE REUSED IN UPGRADE

* Slurry Tanks
* Platform Scales (Retained as Backup)
* Bag Dump Station (Retained as Backup)
* Additive and Silo 3 Filter/Receivers
* Silo 3 Surge Bin
* Rotary Air Locks
* Diverter Valves
* Thickener
* Recycle Water Tank
* Recycle Water Pump
* Spare Water Tank
* Sparge Tank
* Sparge Tank Pump
* Building Sump Tank and Pump
* Gem Machine
* Quench Tower Circ Pumps
* Heat Exchanger
* Cooling Tower/Pump
* Caustic Pump
* Carbon Beds
* HEPA Filters

TABLE 3

SYSTEMS UPGRADES

A. Feed Preparation

- Add a third slurry tank (Melter Feed Tank with pumps & agitator)
- Automate additive weighing and loading
- Melter feed loop modifications with parallel prep tanks and one melter feed tank

B. Melter

- Upgrades and/or replacement of closed loop cooling water system
- Replace melter pour spout

C. Waste Water Processing

- "Decouple" silo recycle water from quench tower water (Quench tower water and silo water to be closed loop)
- Collect Off-Gas System purge and miscellaneous drains and spills in a new tank
- Install a crossflow filter to remove particulate matter before discharging waste water to the AWWT via the existing radon sparge tank

D. Melter Off-Gas

- Replace inadequately sized equipment and piping
- Make provisions to recycle off-gas for use in the film cooler (to replace plant air)
- Replace Desiccant Bed with Chiller Unit and Mol Sieve Bed drying
- Install a scrubber/KO drum upstream of the exhausters
- Install Zeolite Beds for NOx removal (carbon bed protection)
- Install fire suppression in carbon beds
- Revise EOS as required
- Add a separate Process Vessel Vent Exhauster

E. Utility Systems

- Provide Standby Power for air compressors
- Provide plant steam for utility services
- Provide a chilled water system

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TABLE 3, CONT.

SYSTEMS UPGRADES, CONT.

F. Support Facilities

* Install dedicated laboratory
* Install dedicated maintenance facility
* Install dedicated spare parts warehouse

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TABLE 4

PROCESS AND UTILITY SYSTEMS IN A 6 MT/D VITRIFICATION PLANT

Silo Residue Retrieval System

Silo Superstructure
NRTS
Equipment Room
Retrieval Equipment

Feed Preparation System

Thickener
Slurry Tanks (2)
Melter Feed Tank

Melter System

Melter
Discharge Heater
Plenum/Main Chamber Heaters
Electrodes
Bubblers
Air Lift
Drains (5, 4-bottom, 1-side)

Waste Water Treatment System

Recycle Water Tank
Filter Feed Tank
Waste Water Filter
Radon Stripper
Building Sump Tank

Melter Off-Gas System

Film Cooler
Quench Tower
Scrubber
Exhaust Fans (2)
Desiccant/NOx Removal Beds (2)
Carbon Beds
HEPA Filters (2)
EOS Equipment

Vessel Vent System

Exhausters (2)

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TABLE 4, CONT.

PROCESS AND UTILITY SYSTEMS IN A 6 MT/D VITRIFICATION PLANT, CONT.

Gem Maker System

Gob Maker (cutter, roller)
Diverter Valve
Gem Conveyer
Discharge Chute
Cooling Plates
Gem Exhaust System

Glass Packaging System

Washdown Rack
Contaminated Water Collection System
Air Hood

Bulk Glass Former Handling System

Scales
Bag Dump Station
Bag/Barrel Handler
Filter/Receiver Tank

Cold Chemical System

Liquid Chemical Tanks
Flocculant Make-up Tank

Melter Cooling Water System

Melter Cooling Water Pumps (2)
Radiator
Surge Tank
De-ionized Water Tank

Plant & Instrument Air System

Air Compressors (2)
Dryer
Air Receiver

Steam System

Boiler Package

Cooling Water System

Cooling Tower
Cooling Water Pumps (2)

TABLE 4, CONT.

PROCESS AND UTILITY SYSTEMS IN A 6 MT/D VITRIFICATION PLANT, CONT.

Process Water System

Distribution Piping

Process Chilled Water System

Chiller Package

Sampling & Analytical System

TBD

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TABLE 5

VITRIFICATION PILOT PLANT UPGRADE

SIX METRIC TONS
UTILITY REQUIREMENTS
PLANT AND INSTRUMENT AIR

SUMMARY	Air Flow SCFM
Controls and Instruments	40
Diaphragm Pumps	212
Other Users	40
Total	292
Design @ 25% Excess Capacity =	365

CONTROLS AND INSTRUMENTS

Item	No. Required	Unit Usage SCFH	Total Usage SCFM	Air Flow (Say) SCFM
Control Valves	30	10.6	5.3	40

DIAPHRAGM PUMPS

Equip No.	Description	Capacity GPM	Air Flow SCFM
5-PM-04A&B	Residue Slurry Pump	40	50
5-PM-70	Thickener Containment Sump Pump	90	60
5-PM-57	Spare Storage Tank Pump	90	52
5-PM-34A&B	Slurry Tank Pump	40	50
TBD A&B	Melter Feed Pump	40	50
Total for Diaphragm Pumps			262

However, it is unlikely that all pumps would run concurrently. If it is assumed that the Slurry Tank Pump and the Thickener Containment Sump Pump would not run concurrently:

Design Air Flow for Diaphragm Pumps would be (262 − 50) SCFM = 212 SCFM

OTHER USERS	Air Flow SCFM
Gem Machine	10
Miscellaneous Other Uses, say	30
Total for Other Users	40

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TABLE 6

VITRIFICATION PILOT PLANT UPGRADE

SIX METRIC TONS
UTILITY REQUIREMENTS
UTILITY STEAM

Basis
The only users of Utility Steam will be the Utility Stations.

Number of Stations = 6

Nominal Pipe Size = 1

Steam Flow Rate, #/Hr = 200

Steam Pressure, psig = 50

Referenced Data
Steam Temperature, °F = 298

Steam Density, #/ft³ = 0.150

Pressure Drop
$deltaP_{100} = C_1C_2/rho$.
where
C_1 is a flow rate capacity factor = $W^2 \times 10^{-9}$
C_2 is a pipe capacity factor = 336 000 f / d^5
rho is the density (#/ft³)

For One Utility Station

Stream	Description	Flow #/Hr	C_1	Pipe Size	C_2	$deltaP_{100}$
TBD	Utility Station	200	0.000040	1	5.950	1.591

For Six Utility Stations

Flow Rate for 6 Stations = 6 x 200 #/Hr = 1,200 #/Hr

However, it is likely that only two would be operating, most of the time. This would require:

2 x 200 #/Hr = 400 #/Hr, allow 500 #/Hr

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TABLE 7

VITRIFICATION PILOT PLANT UPGRADE

SIX METRIC TONS
UTILITY REQUIREMENTS
COOLING WATER

COOLING WATER USERS	Flow – GPM
Heat Exchanger	76
Design @ 25% Excess Capacity	100

Heat Exchanger

Duty =	1.140 mmBtu/Hr
Cooling Water Inlet Temperature =	85 °F
Cooling Water Outlet Temperature =	115 °F
$w = 1.140 \times 10^6$ Btu/Hr x #°F/Btu / (115 – 85)°F =	38,000 #/Hr. or
	76 GPM

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TABLE 8

VITRIFICATION PILOT PLANT UPGRADE

SIX METRIC TONS
UTILITY REQUIREMENTS
COLD CHEMICALS
FLOCCULANT

BASIS

The total flow of solids to the Thickener and the weight percent solids in the feed are from the current material balance for the Six Metric Ton Pilot Plant.

Solid Feed Rate to Thickener =	5.3 Short Tons/Day, or
	0.22 Short Tons/Hr
Weight Percent Solids in Feed =	20%
Specific Gravity of solids =	3
Flocculant feed rate to the Thickener =	50 ppm (by weight – slurry)

ANNUAL CONSUMPTION

Total Slurry Flow = 0.22 Tons Solids/Hr / 0.20 Tons Solids/Ton Slurry =	1.10 Tons/Hr
Water flow = (1.10 – 0.22) Tons/Hr =	0.88 "
Volume Flow of Solids = (0.22 Tons/Hr x 2,000 #/Ton) / (3 x 62.4 #/ft^3) =	2.35 ft^3/Hr
Volume Flow of Water = (0.88 Tons/Hr x 2,000 #/Ton) / 62.4 #/ft^3 =	28.21 "
Total Volume	30.56 ft^3/Hr
rho = (1.10 Tons/Hr x 2,000 #/Ton) / 30.56 ft^3/Hr =	72.0 #/ft^3
Flow = (1.10 Tons/Hr x 2,000 #/Ton x 7.48 Gal/ft^3) / (72.0 #/ft^3 x60 Min/Hr =	3.81 GPM
Floculant Flow = (1.10 Tons/Hr x 2,000 #/Ton) x 50/1,000,000 =	0.110 #/Hr
Annual Consumption = 0.110 #/Hr x 6 Hr/Day x 275 Days/Yr =	182 #/Yr

CAUSTIC – MELTER OFF-GAS

BASIS

The glass production rate is from the current material balance for the Six Metric Ton Pilot Plant.

Glass Production Rate =	549.4 #/Hr
Weight of CO_2 Released/Unit Weight of Product Glass =	0.0218
Weight of SO_3 Released/Unit Weight of Product Glass =	0.0414
Molecular Weight CO_2 =	44 #/Mol
Molecular Weight SO_3 =	80 "
Molecular Weight SO_2 =	64 "

ANNUAL CONSUMPTION

For CO_2 Removal

Release Rate of CO_2 = 549.4 # Glass/Hr x 0.0218 # CO_2/# Glass =	11.98 # CO_2/Hr, or
11.98 #/Hr / 44 #/Mol =	0.272 Mol/Hr

For SO_2 Removal

It is assumed that all of the sulfur fed to the Melter leaves as SO_2.

Weight of SO_2 Released/Unit Weight of Glass Product = 0.0414 x 64/80 =	0.0331
Release Rate of SO_2 = 549.4 # Glass/Hr x 0.0331 # SO_2/# Glass =	18.19 # SO_2/Hr, or
18.19 #/Hr / 64 #/Mol =	0.284 Mol/Hr

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TABLE 8 (CONTINUED)

VITRIFICATION PILOT PLANT UPGRADE

CRU4 – SIX METRIC TONS
UTILITY REQUIREMENTS
COLD CHEMICALS
CAUSTIC – MELTER OFF–GAS (CONTINUED)

Stoichiometry

$2 NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$
$2 NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O$

Mols NaOH Required/Mol CO_2 =	2	
Mols NaOH Required/Mol SO_2 =	2	
Moles NaOH Required for CO_2 and SO_2 = 2 x 0.272 + 2 x 0.284 =	1.112	Mol/Hr

Assume that 10 percent of the Caustic fed leaves with the spent absorbent solution:

Total Moles of NaOH Required = 1.1 x 1.112 =	1.223	Mol/Hr. or
1.223 Mol/Hr x 40 #/Mol =	48.9	#/Hr
Annual Consumption = 48.9 #/Hr x 24 Hr/Day x 275 Days/Yr x Ton/2,000 # =	161	Short Tons/Yr

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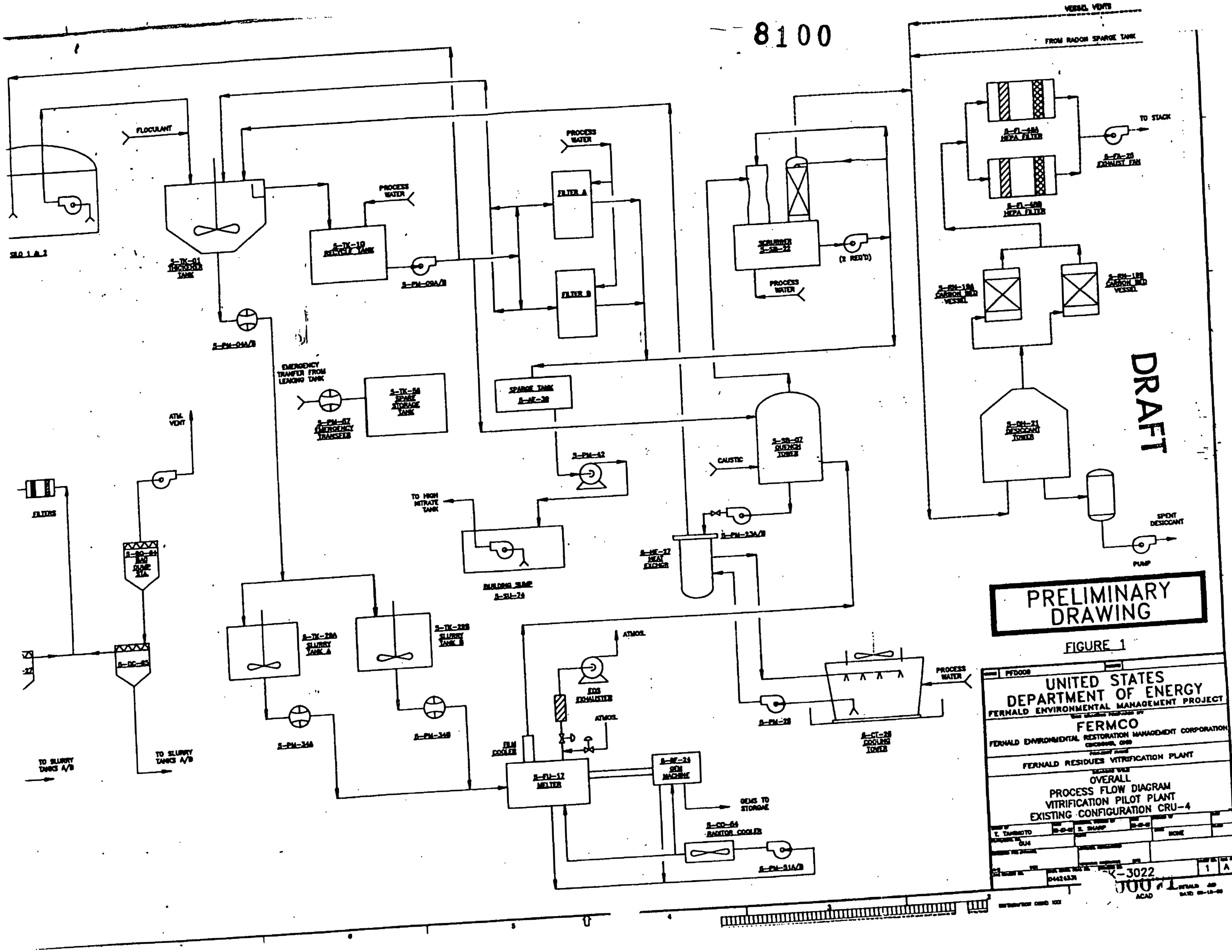
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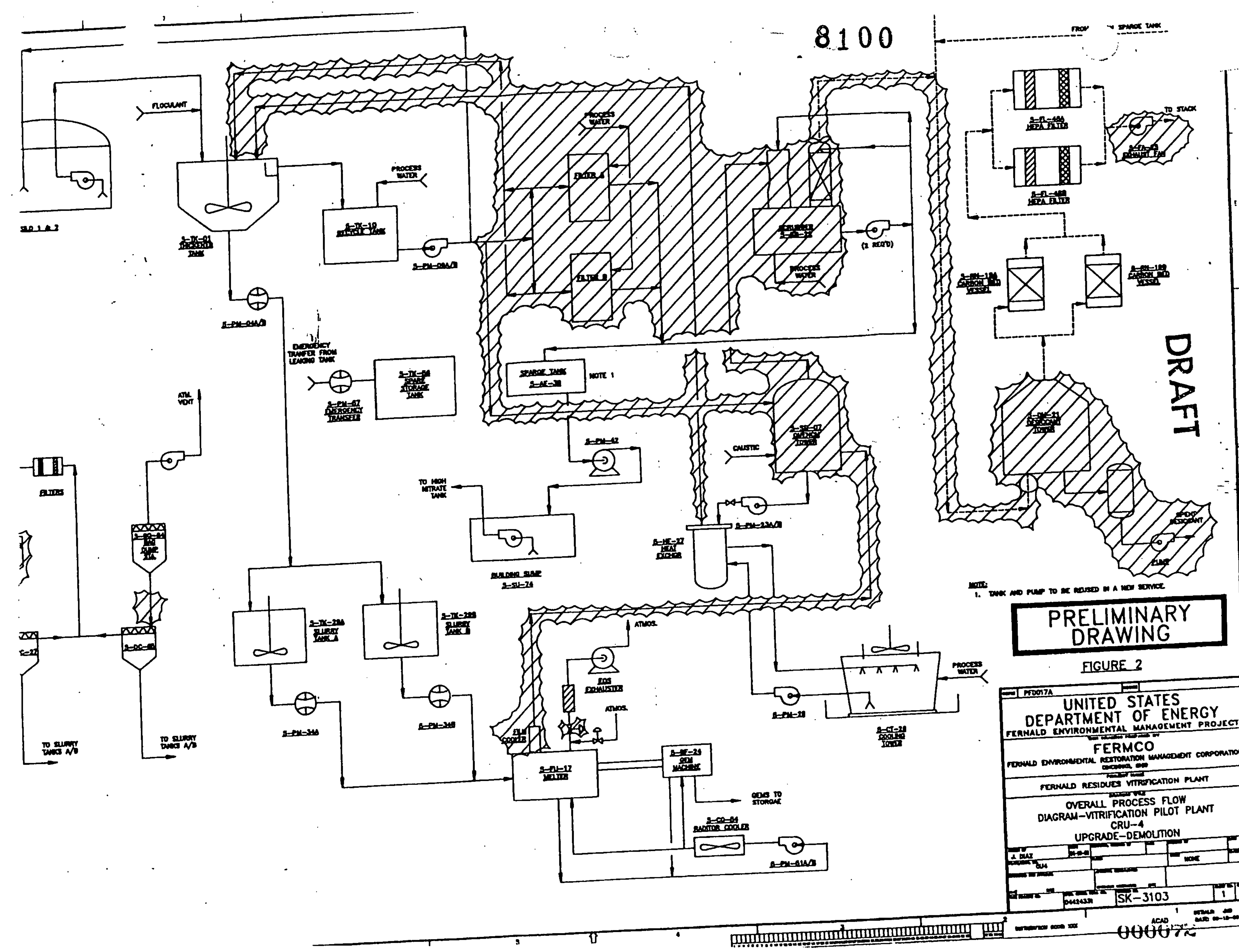
PRELIMINARY DRAWING
FIGURE 1
VESSEL VENTS
FROM RADON SPARGE TANK
TO STACK
HEPA FILTER
EXHAUST FAN
CARBON BED VESSEL
DESICCANT TOWER
SPENT DESICCANT
PUMP
FLOCULANT
PROCESS WATER
RECYCLE TANK
FILTER A
FILTER B
SCRUBBER
(2 REQ'D)
SPARGE TANK
QUENCH TOWER
CAUSTIC
EMERGENCY TRANSFER FROM LEACHING TANK
SPARE STORAGE TANK
EMERGENCY TRANSFER
ATM. VENT
TO HIGH NITRATE TANK
BUILDING SUMP
HEAT EXCHGR
FILTERS
SLURRY TANK A
SLURRY TANK B
ATMOS.
EDS EXHAUSTER
FILM COOLER
MELTER
GEM MACHINE
GEMS TO STORAGE
RADITOR COOLER
COOLING TOWER
TO SLURRY TANKS A/B
UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERMCO
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION
FERNALD RESIDUES VITRIFICATION PLANT
OVERALL PROCESS FLOW DIAGRAM VITRIFICATION PILOT PLANT EXISTING CONFIGURATION CRU-4
PFD008
NONE
ACAD


8100
DRAFT
FLOCULANT
SILO 1 & 2
S-TK-01 THICKENER TANK
S-TK-10 RECYCLE TANK
PROCESS WATER
S-PM-09A/B
S-PM-04A/B
EMERGENCY TRANSFER FROM LEAKING TANK
S-PM-67 EMERGENCY TRANSFER
S-TK-56 SPARE STORAGE TANK
FILTER A
FILTER B
SPARGE TANK S-AE-38
NOTE 1
SCRUBBER
(2 REQ'D)
S-FL-48A HEPA FILTER
S-FL-48B HEPA FILTER
TO STACK
S-BN-19A CARBON BED VESSEL
S-BN-19B CARBON BED VESSEL
DESICCANT TOWER
SPENT DESICCANT
PUMP
FROM SPARGE TANK
ATM. VENT
FILTERS
TO HIGH NITRATE TANK
S-PM-42
BUILDING SUMP S-SU-74
CAUSTIC
QUENCH TOWER
S-PM-23A/B
S-HE-27 HEAT EXCHGR
S-TK-28A SLURRY TANK A
S-TK-28B SLURRY TANK B
S-PM-34A
S-PM-34B
TO SLURRY TANKS A/B
TO SLURRY TANKS A/B
ATMOS.
EOS EXHAUSTER
ATMOS.
FILM COOLER
S-FU-17 MELTER
S-BF-24 GEM MACHINE
GEMS TO STORAGE
S-CO-64 RADITOR COOLER
S-PM-61A/B
S-PM-28
PROCESS WATER
S-CT-28 COOLING TOWER
NOTE:
1. TANK AND PUMP TO BE REUSED IN A NEW SERVICE.
PRELIMINARY DRAWING
FIGURE 2
PFD017A
UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
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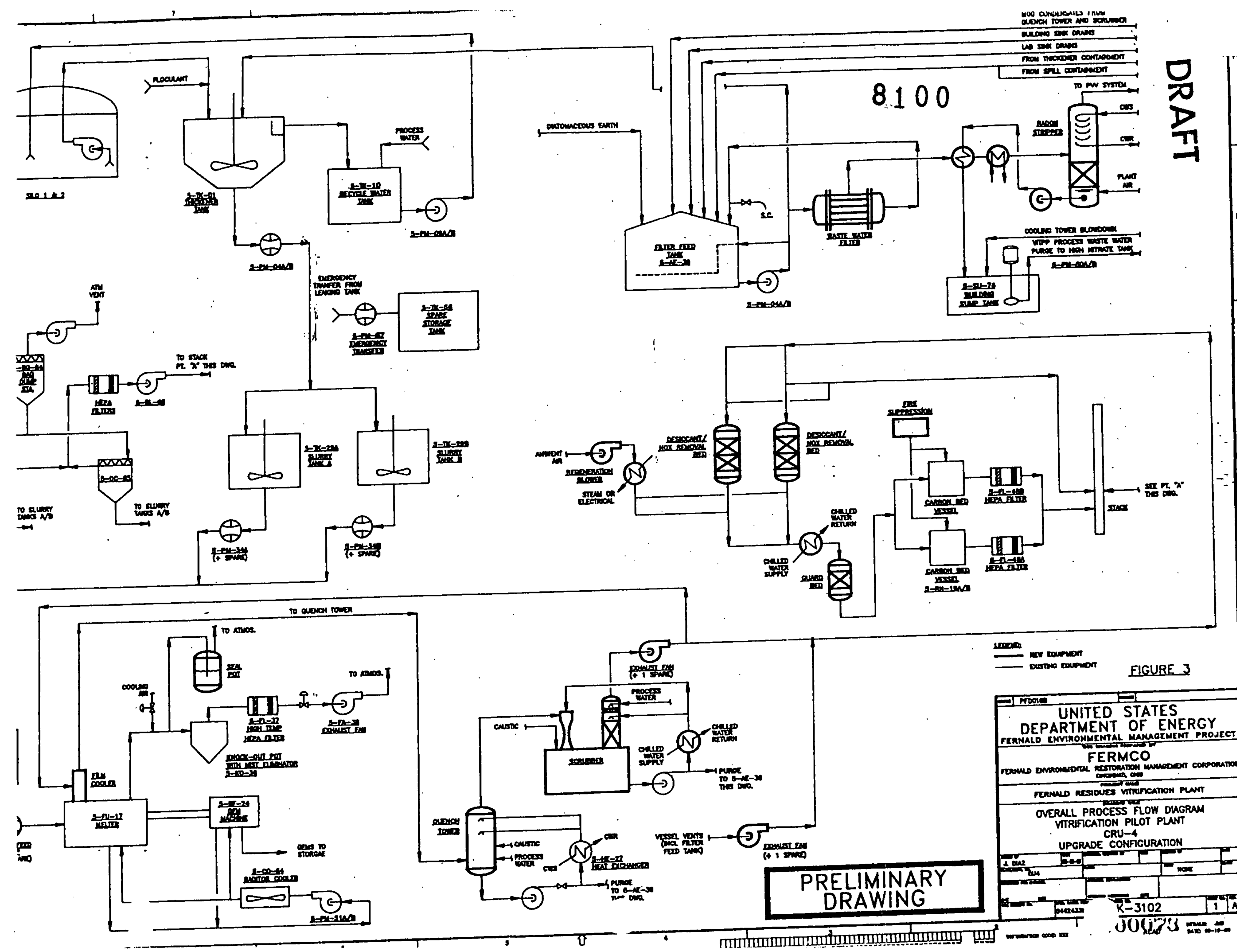
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION
FERNALD RESIDUES VITRIFICATION PLANT
OVERALL PROCESS FLOW DIAGRAM-VITRIFICATION PILOT PLANT CRU-4 UPGRADE-DEMOLITION
J. DIAZ
NONE
SK-3103
ACAD
000072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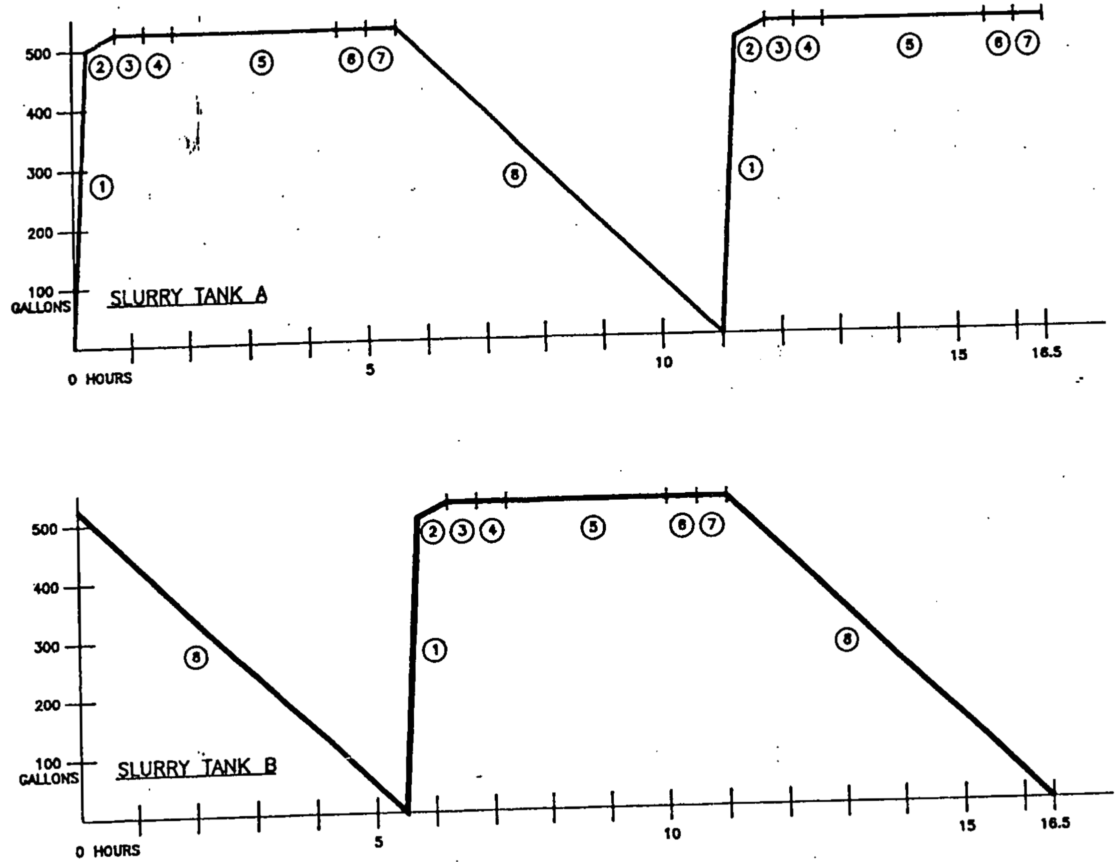
MOD CONDENSATE FROM QUENCH TOWER AND SCRUBBER
BUILDING SINK DRAINS
LAB SINK DRAINS
FROM THICKENER CONTAINMENT
FROM SPILL CONTAINMENT
TO PW SYSTEM
CWS
CWR
PLANT AIR
RADON STRIPPER
COOLING TOWER BLOWDOWN
VITPP PROCESS WASTE WATER
PURGE TO HIGH NITRATE TANK
DIATOMACEOUS EARTH
FILTER FEED TANK
WASTE WATER FILTER
BUILDING SUMP TANK
S.C.
FLOCULANT
SILO 1 & 2
THICKENER TANK
PROCESS WATER
RECYCLE WATER TANK
EMERGENCY TRANSFER FROM LEAKING TANK
SPARE STORAGE TANK
EMERGENCY TRANSFER
ATM VENT
TO STACK PT. "A" THIS DWG.
HEPA FILTERS
TO SLURRY TANKS A/B
SLURRY TANK A
SLURRY TANK B
(+ SPARE)
AMBIENT AIR
REGENERATION BLOWER
STEAM OR ELECTRICAL
DESICCANT/ NOX REMOVAL BED
CHILLED WATER RETURN
CHILLED WATER SUPPLY
GUARD BED
FIRE SUPPRESSION
CARBON BED VESSEL
HEPA FILTER
STACK
SEE PT. "A" THIS DWG.
TO QUENCH TOWER
TO ATMOS.
SEAL POT
COOLING AIR
HIGH TEMP HEPA FILTER
EXHAUST FAN
KNOCK-OUT POT WITH MIST ELIMINATOR
FILM COOLER
MELTER
GEM MACHINE
GEMS TO STORAGE
RADIATOR COOLER
FEED
QUENCH TOWER
CAUSTIC
PROCESS WATER
CWS
CWR
HEAT EXCHANGER
PURGE TO 8-AE-38 THIS DWG.
SCRUBBER
EXHAUST FAN (+ 1 SPARE)
VESSEL VENTS (INCL FILTER FEED TANK)
LEGEND:
NEW EQUIPMENT
EXISTING EQUIPMENT
FIGURE 3
PRELIMINARY DRAWING
UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERMCO
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION
CINCINNATI, OHIO
FERNALD RESIDUES VITRIFICATION PLANT
OVERALL PROCESS FLOW DIAGRAM
VITRIFICATION PILOT PLANT
CRU-4
UPGRADE CONFIGURATION
NONE
K-3102

8100 DRAFT



OPERATING STEPS

1. RECEIVE APPROXIMATELY 500 GALLON TRANSFER OF THICKENER UNDERFLOW AT 40 GPM
2. RECEIVE DRY GLASS FORMERS AND DILUTION WATER
3. HOMOGENIZE TANK
4. DRAW SLURRY SAMPLE
5. TIME AVAILABLE TO ANALYZE SLURRY SAMPLE, 2.75 HOURS
6. RE-ADJUST SLURRY TANK, AS NECESSARY
7. IDLE TIME/CONTINGENCY
8. DELIVER FEED SLURRY TO THE MELTER AT THER RATE OF 94 GAL/HR

FIGURE 4

TMEMOT4

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

FERMCO
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION
CINCINNATI, OHIO

FERNALD RESIDUES VITRIFICATION PLANT

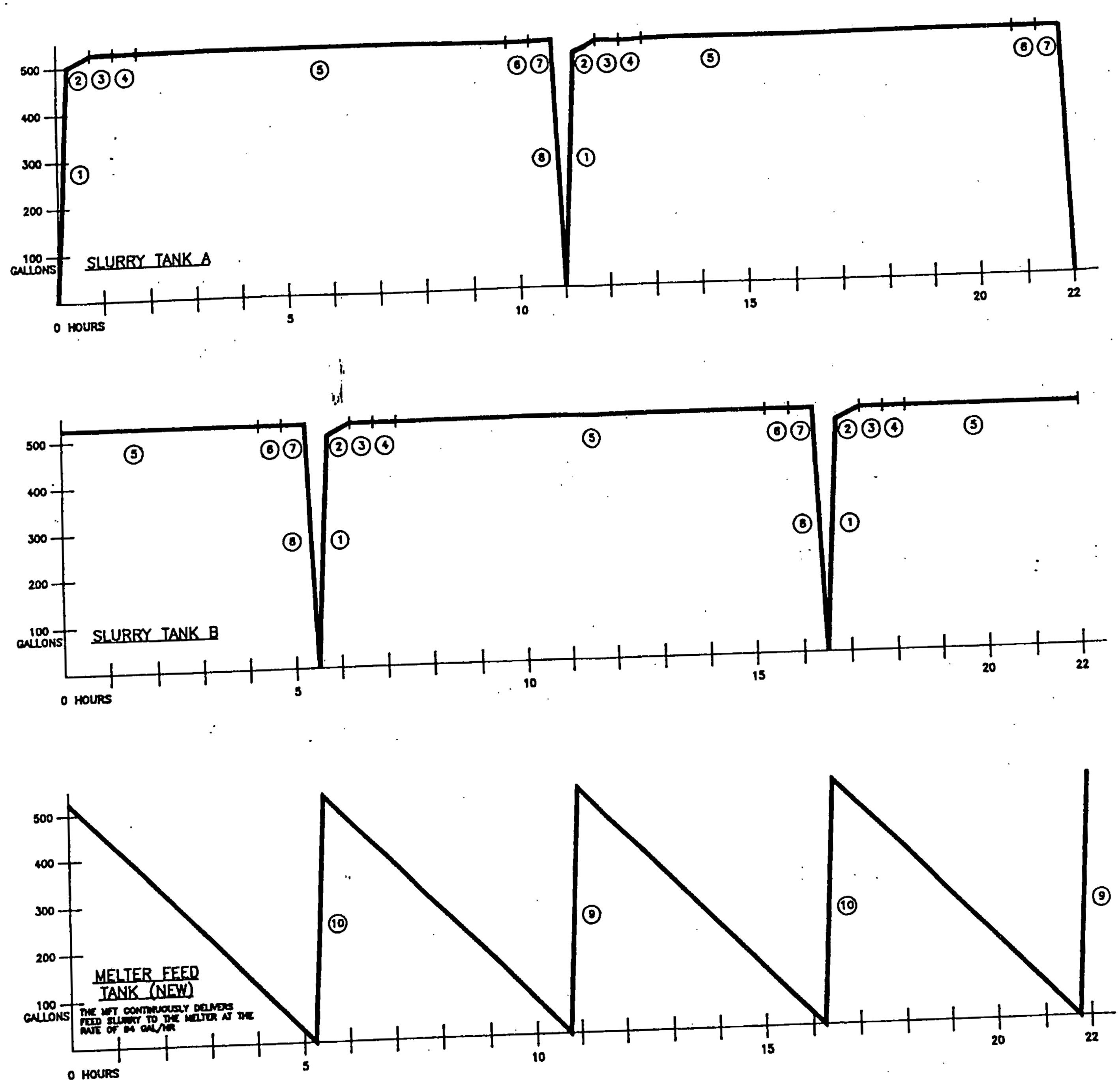
TIME/MOTION ANALYSIS
EXISTING VITPP FEED PREP
SYSTEM OPERATING TO SUPPORT
6 MT/D GLASS PRODUCTION

J. SCHILLING | S. SHARP | NONE

04424331 | SK-1005 | 1 | A

000074

8100 DRAFT



OPERATING STEPS

1. RECEIVE APPROXIMATELY 500 GALLON TRANSFER OF THICKENER UNDERFLOW AT 40 GPM.
2. RECEIVE DRY GLASS FORMERS AND DILUTION WATER
3. HOMOGENIZE TANK
4. DRAW SLURRY SAMPLE
5. ANALYZE SLURRY SAMPLE, 6 HOURS
6. RE-ADJUST SLURRY TANK, AS NECESARY
7. AVAILABLE IDLE TIME
8. BATCH TRANSFER 518 GALLONS MELTER – READY SLURRY TO MFT AT 40 GPM
9. RECEIVE 518 GALLONS BATCH TRANSFER FROM SLURRY TANK A
10. RECEIVE 518 GALLONS BATCH TRANSFER FROM SLURRY TANK B

FIGURE 5

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERMCO
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION
FERNALD RESIDUES VITRIFICATION PLANT
TIME/MOTION ANALYSIS UPGRADED VITPP FEED PREP SYSTEM OPERATING TO SUPPORT 6 MT/D GLASS PRODUCTION
TIMEMOT5
J. SCHILLING
S. SHARP
NONE
OU4
X-1006
1 A
ACAD

8100 DRAFT

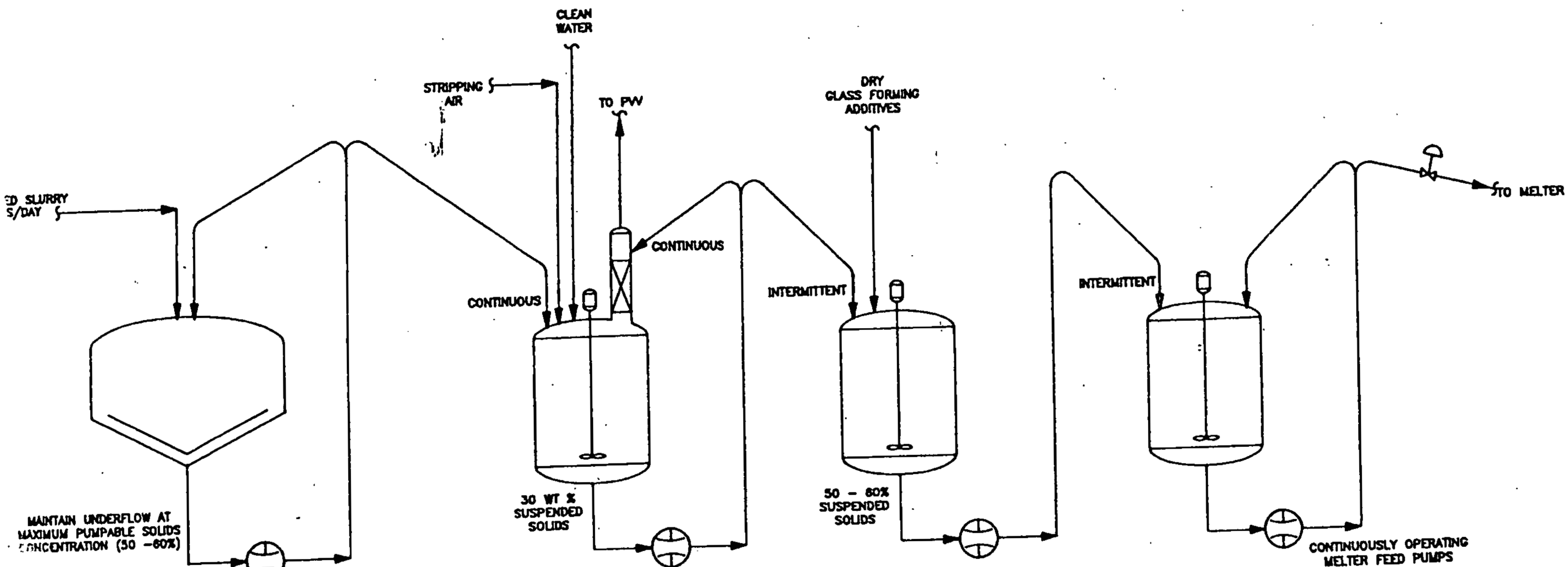


FIGURE 6

PFD020

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

FERMCO
FERNALD ENVIRONMENTAL RESTORATION MANAGEMENT CORPORATION

FERNALD RESIDUES VITRIFICATION PLANT

PFD – POSSIBLE ADDITION OF RADON STRIPPING CAPABILITY TO VITPP FEED PREP SYSTEM

J. SCHILLING | S. SHARP | NONE

SK-

ACAD