CH2M-36349-FP
Revision 0

Dewatering Treatment Scale-up Testing Results of Hanford Tank Wastes

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

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Dewatering Treatment Scale-up Testing Results of Hanford Tank Wastes – 8259

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ABSTRACT

This report documents CH2M HILL Hanford Group Inc. (CH2M HILL) 2007 dryer testing results in Richland, WA at the AMEC Nuclear Ltd., GeoMelt Division (AMEC) Horn Rapids Test Site. It provides a discussion of scope and results to qualify the dryer system as a viable unit-operation in the continuing evaluation of the bulk vitrification process.

A 10,000 liter (L) dryer/mixer was tested for supplemental treatment of Hanford tank low-activity wastes, drying and mixing a simulated non-radioactive salt solution with glass forming minerals. Testing validated the full scale equipment for producing dried product similar to smaller scale tests, and qualified the dryer system for a subsequent integrated dryer/vitrification test using the same simulant and glass formers. The dryer system is planned for installation at the Hanford tank farms to dry/mix radioactive waste for final treatment evaluation of the supplemental bulk vitrification process.

INTRODUCTION

Dryer testing was performed to support further technology development of the Demonstration Bulk Vitrification System (DBVS) project, proposed for supplemental treatment of Hanford low activity tank wastes. Supplemental treatment is proposed by the Department of Energy – Office of River Protection (DOE-ORP) as a strategic initiative to accelerate Hanford tank waste cleanup, as noted in the 2002 DOE-ORP Performance Management Plan. [1] Bulk vitrification is a technology currently being investigated by CH2M HILL for the DOE-ORP, to supplement current planned Waste Treatment Plant vitrification operations. The DBVS project is evaluating this process, planned for production of up to 50 containers of vitrified radioactive waste at an on-site demonstration facility, verifying the technology and evaluating waste form performance. This technology approach was defined through an investment decision process, evaluating laboratory waste form performance data and proposed facilities. [2] This decision process and results were presented at the Waste Management Symposium in 2004. [3]

Bulk vitrification involves the vitrification of waste within a large engineered disposal container, of approximately 38 m^3. This proprietary In-Containerized Vitrification™ technology was developed by AMEC and uses a dried feed of low-activity waste and glass forming minerals/additives in an incremental bottom-up melt operation. The feed is prepared in a dryer/mixer where water is removed from the retrieved liquid waste stream, and the dried salts and radioactive species are mixed with a silica-based glass former mixture and cellulose.

Testing of DBVS vitrification processes and equipment systems has been occurring since project initiation in 2004. Development off-site (non-radioactive/simulant) testing for the DBVS project in 2006/2007 included laboratory evaluation of a revised glass dry component formulation, additional small scale dryer testing, engineering scale vitrification testing, dryer full scale qualification testing, and integrated full scale dryer and vitrification testing. The DBVS project system installation is planned at the tank farms for 2009/2010 followed by radioactive processing starting in 2011.

Dryer Technology

The dryer is a 10,000L horizontal batch mixer (model # FKM 10000), manufactured by Littleford Day, Inc., (LDI) involving a fixed cylindrical shell, and a rotating center shaft with blade arms and specially designed end ploughs. The dryer operates at near-total vacuum (40 – 90 torr) with a steam-heated shell using low pressure (15 psig) steam. The plough blades on the rotating shaft fluidize dryer contents to maximize wall contact for material drying, and homogenize the bed mixture in an inverse crisscross mixing pattern. The center shaft nominally rotates at 90 rpm producing a tip speed of approximately 24 ft/sec. The entire dryer assembly is mounted on a slide/pontoon arrangement to allow for thermal expansion. The basic dryer unit showing center shaft and blades, with drive gear, and off-gas filter showing sintered metal fiber filter units, is diagramed in Fig. 1.

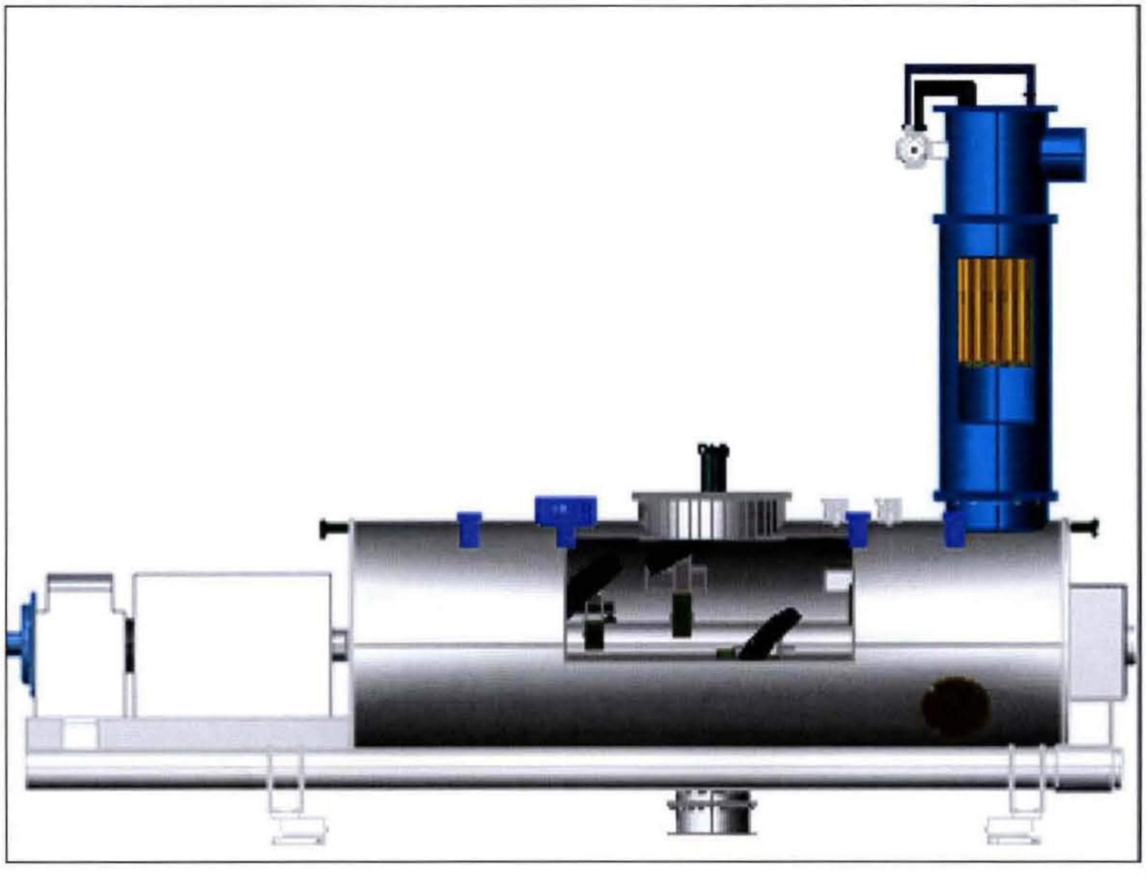

Fig. 1. LDI FKM 10000 Dryer and Filter Cut-away

This hardware has been used extensively around the world to dry a variety of chemical materials, from foodstuffs to plastics. Nuclear industry application for this LDI technology is exclusively marketed by NUKEM Corporation (NUKEM), which has been successful in drying radioactive waste sludges with smaller scale units (e.g., 600L) at commercial nuclear power plants.

Scale Testing

This dryer system was originally proposed in 2003 by the team of NUKEM, LDI, and AMEC as a Hanford tank waste supplemental treatment technology, from initial scale simulant testing at LDI. After selection of the AMEC bulk vitrification technology for further study, design began using this dryer as the treatment application. Project scale testing was then performed at LDI's test shop on both 5L and 130L scale dryer units, using non-radioactive simulated tank waste and glass formers, to qualify final design parameters and operational strategy. This work was performed per AMEC's design/architect firm, DMJM Technology, in coordination with NUKEM/LDI. Additional testing with a scale 22L LDI dryer was performed by Pacific Northwest National Laboratories to test new glass former mineral formulations and prepare feed for engineering scale vitrification testing. Additional testing was performed at LDI by CH2M HILL/NUKEM in 2006 and 2007 to obtain additional 130L process experience and test new formulations. Design and operating solutions from scale testing are noted in Table I.

Table I. Scale Testing Specification Results

DESIGN	
Capacity	10,000 L
Drive Power	Equivalent 500 hp direct electric drive
Drive Application	Hydraulic
Plough Blade Type	"Becker"
Plough Blade Hardening	Yes – LDI proprietary welded coating
Shaft Steam Supply	Yes but not used
Supplemental Side Choppers/Motors	None
Feed Ports	3
Filter Type	Sintered metal fiber filter (SMF)
OPERATION	
Drying Mode	"Dry Batch" (See below)
Dry Mass Loading	2 phases - to handle low bulk density
Bed Moisture Control Target Range	3-6 wt%
Batch Discharge	Incremental ("Bleed and feed")
Expected Pellet Concentration	> 90% larger than 20 mesh screen
Feed Supply	Continuous (metered)

The 10,000L capacity sizing was established prior to scale testing to maximize complete batch load-out into an In-Containerized Vitrification™ box. This criterion was eliminated as vitrification operation strategy changed from a top-down melt to a bottom-up melt with semi-continuous incremental box feed. The 10,000L unit was being constructed during this strategy change and still viewed as an optimum design for further testing and the DBVS project. Basic scale-up results for mass usage and shaft rotation are linear; for example the scale-up factor from 130L to 10,000L is 76.92. The layout of the 130L scale testing equipment at the LDI manufacturing/test facility in Florence, Kentucky is shown in Fig. 2.

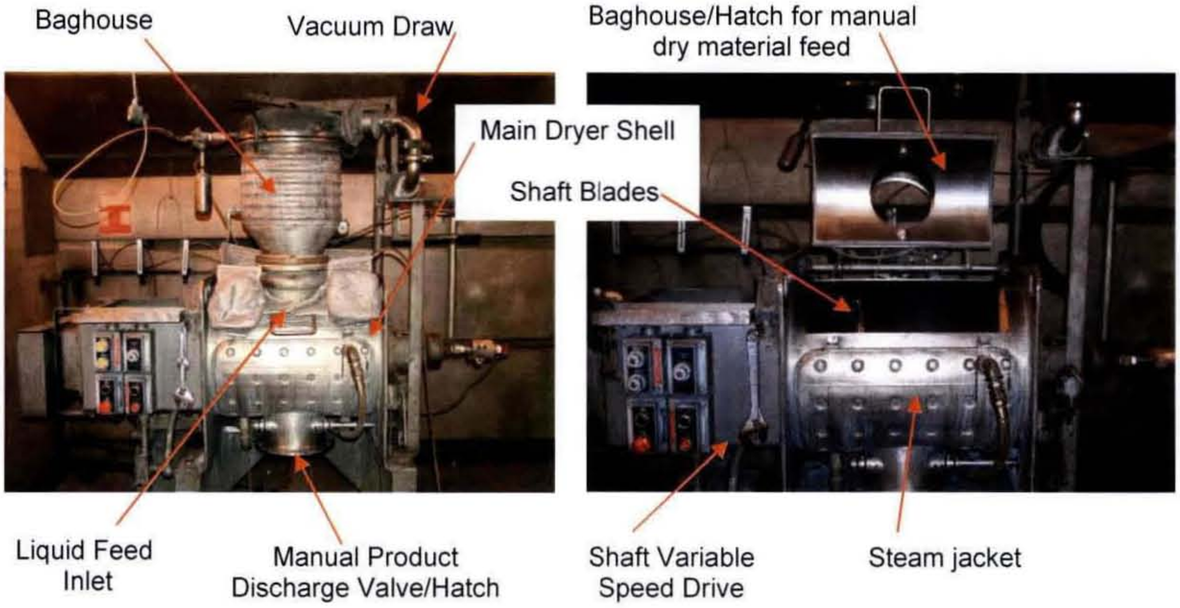

Fig. 2. LDI 130 Scale Testing Dryer.

The 130L scale unit has a direct electric drive for shaft rotation with variable speed controller. Blade style was "Becker" type rather than the standard "V" plough. The steam jacket was supplied with 15 psig steam, and vacuum/condensate was managed by a central system pulling 25 – 26 in. Hg vacuum. The filter system in the baghouse was a set of 4 porous fiber filters.

Drying Modes

Extensive scale testing in both 5L and 130L units identified a high risk of agglomeration as the simulant mixture dries in standard batch drying. This standard methodology or "wet batch" mode adds the complete wet mass into the dryer and dries it to a product moisture endpoint. A different "dry batch" methodology was selected as the operating solution to minimize this risk agglomeration. In "dry batch" mode a small of amount of liquid is injected onto the dry bed keeping the product within a narrow moisture range. Scale testing identified that 9-15 wt% moisture with DBVS chemicals resulted in a sticky mass and excessive dryer buildup, so the bed is maintained in "dry batch" mode below 7 wt% moisture. "Dry batch" methodology also more efficiently supports incremental bed discharge by allowing bed regeneration from addition of more dry and liquid material ("bleed and feed" operation).

SYSTEM DESCRIPTION

The DBVS project is comprised of three major unit operations: dried feed production, vitrification, and off-gas treatment. Dried feed production can be further divided into the following equipment/unit operations: dryer, hydraulic power supply, steam supply, liquid feed, dry mixture feed, dryer discharge, vacuum/condensate handling, coolant chiller, control system, and utilities (air, water, power). The dryer, sintered metal fiber filter, and vacuum/condensate system are housed within a modified dual ISO container system to allow portability for off-site assembly and testing, and relocation at the Hanford site. The ISO container will also provide a confinement barrier for radioactive material. Photographs of the ISO container at the AMEC test site and cutaway diagram showing dryer systems are shown in Fig. 3.

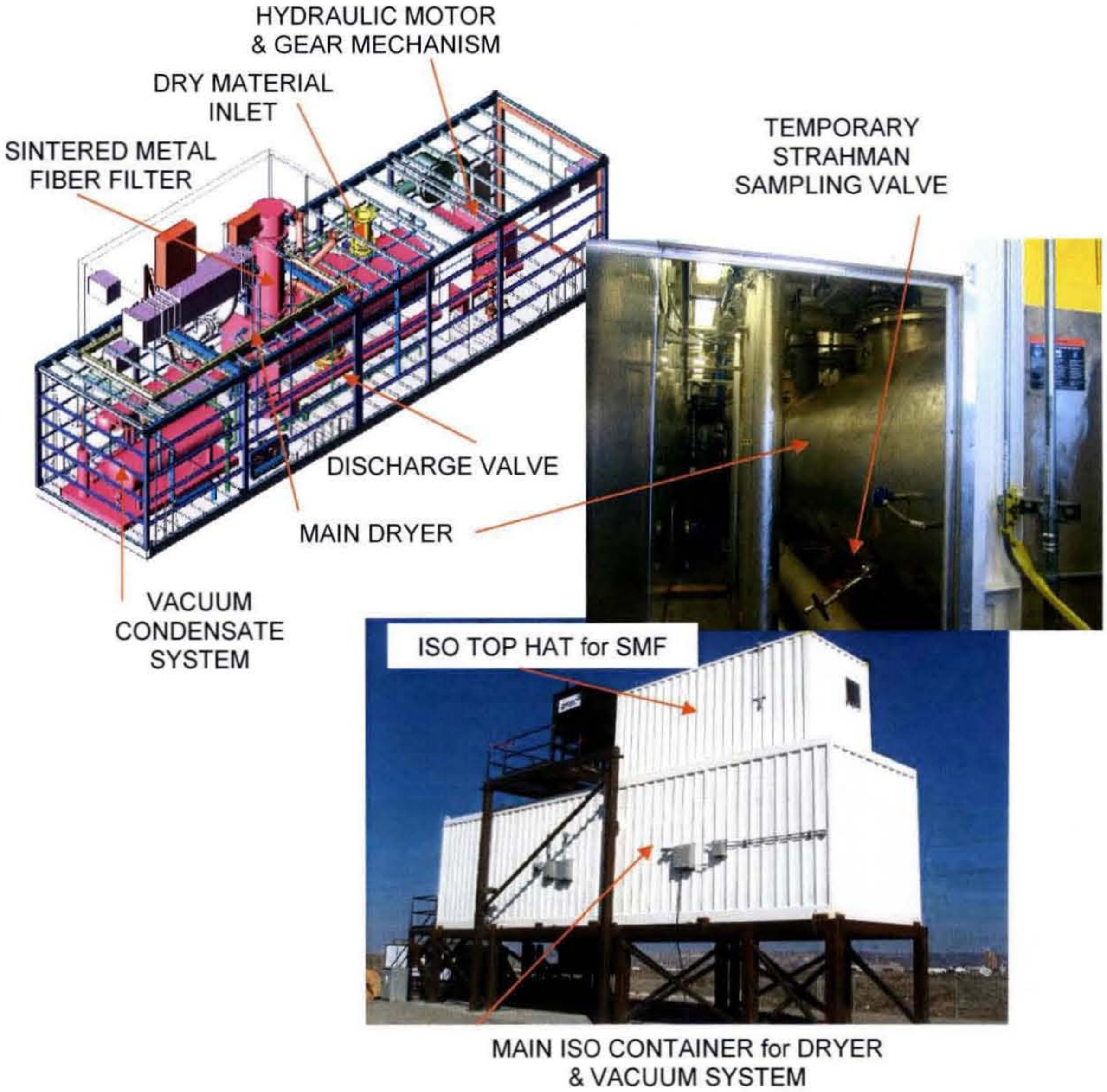

Fig. 3. Dryer System Layout.

Technical Specifications

Table 2. Dryer System Major Design Details

Equipment	*Engineering Details*
Dryer	LDI - 10,000 liter volume, 304 SS wetted parts, Becker blades, hollowed center shaft for potential steam supply, steam jacketed wall body, chopper ports for potential future chopper blades, rated at full vacuum and 5 psig pressure, center product discharge
Sintered Metal Fiber Filter	Microfiltrex - 21 candle, 304 SS sintered metal fiber filter, with air pulse back and candle inside/outside water flush, nominal 0.5 micron opening
Load Cells	Mettler-Toledo - Flexmount®, 4-point monitoring
Discharge Valve	GEMCO – Model T, 12" spherical disc valve
Hydraulic Motor	Kawasaki – 500 hp, max 1200 rpm
Hydraulic Power Unit	Sun Source – two 300 hp motor/pumps, 133 gpm ea, vegetable-based hydraulic fluid
Gear Reducer	Falk – Type A, HS 1170 rpm, LS 96 rpm
Vacuum/Condensate	Wintek - condenser = shell and tube 3300 lbs/hr water, vacuum pump = DVT 10 hp 150 cfm
Steam	Cole Industries – boiler 2.1 MBTU/hr; 15 psig delivery
Chiller	Carrier – 210.5 ton cooling
Control System	Allen Bradley® ControlLogix™ programmable logic controller, Ethernet interface, operator workstation Dell 360 minitower with Rockwell RSView software

SUMMARY OF RESULTS

Test Start – May 21, 2007
Test Completion – July 30, 2007
Testing days – 54.

The primary purpose of dryer qualification testing was to validate scale drying experience providing confidence of continuous operation in the ensuing dryer operation and melt test. This objective was successfully met after 54 days of system testing resulting in 100% dryer on-stream time providing quality material during the subsequent dryer/vitrification test in August 2007. Testing results are also being applied to final radioactive facility design, plans for further optimization testing, and refinement of the operational control strategy. Specific testing criteria and detailed test procedures were defined in the CH2M HILL dryer qualification test plan and test instructions, respectively. [4,5]

Dry batch methodology was successfully repeated at full scale, producing a flowable dried product at less than 5 weight % moisture. Minimum pellet concentration criteria of 50% > 20 mesh (0.841 mm opening) was realized. Additional testing was implemented to attempt increased pellet formation. This effort produced valuable parametric data for the drying process but unfortunately did not significantly increase the pellet concentration.

Three full scale dryer batches of S-109 simulant/glass former mineral product were produced; two for ensuing dryer/melt testing and one for contingency. Stable incremental discharge and bed regeneration was demonstrated. Stable operation of the sintered metal fiber filter was also documented - an untested design application where scale testing had used a fabric baghouse with larger pore sizes.

Major hardware improvements during testing included installation of new type of dryer shaft seals, addition of dryer liquid feed filtration, increase of dryer liquid feed ports from a single connection to four, and installation of additional steam blowdown lines/valving.

SYSTEM PERFORMANCE

The major dryer systems are noted below in Fig. 4, followed by system performance summaries.

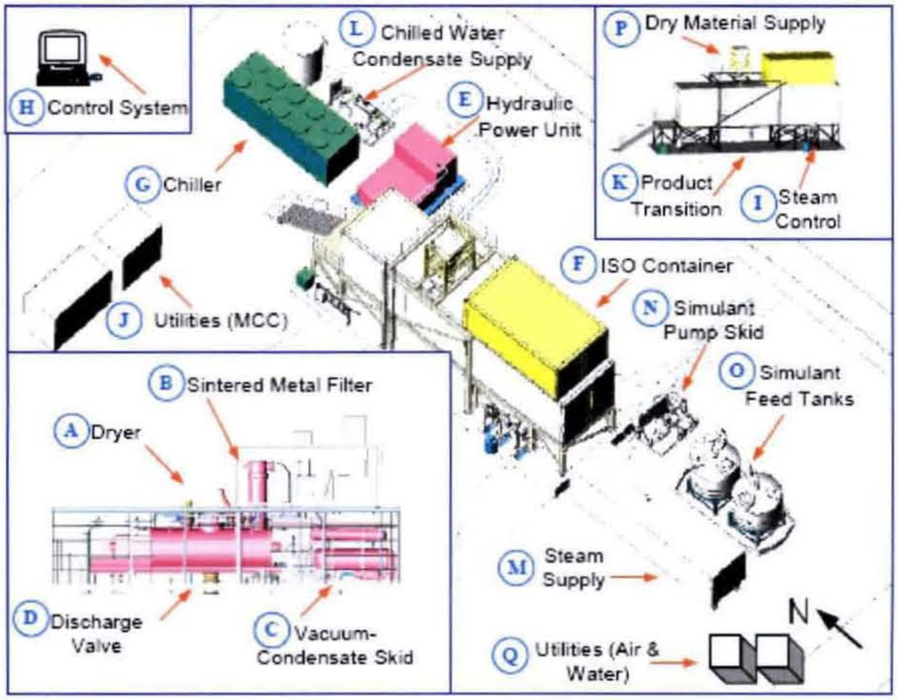

Fig. 4. Dryer System Result Pictorial.

Actual Project Equipment (equipment planned for radioactive waste processing)

A - Dryer

- Dry batch methodology was successfully repeated from scale testing to produce a quality dried product with 3 - 5 wt % moisture.
- Feed rate was controlled to maintain bed moisture. Bed temperature and moisture level were not able to be directly correlated as noted similarly in scale testing.
- Dried product met pelletization concentration ranged from 50% to 75% > 20 mesh, but was not able to repeat maximum pellet formation of +95% exhibited in 22L and 130L scale testing.
- Shaft vacuum shaft seal design was inadequate; plastic lip seals were replaced with split graphite packing resulting in excellent dryer vacuum of less than 80 torr prior to drying.
- Thermal expansion was without incident. Expansion joints cycled without damage or vacuum loss.
- The load cells were extremely accurate at initial material load-in but were inadequate for detailed material balance after engaging vacuum, heat, or shaft rotation.
- Shaft rotation was demonstrated at maximum full speed of 90 rpm, but normally operated at 80-85 rpm to minimize dryer/ISO container vibration harmonics with a loaded dryer.
- Drying a small mass in wet batch mode to reduce volume of sluiced build-up material resulted in significant wall and shaft coating.
- The temporary Strahman valve successfully obtained samples under vacuum.

B - Sintered Metal Fiber Filter (SMF)

- The SMF was successful in removing particulate suspended in the water vapor exiting the dryer based upon visual observations of condensate.
- Air pulse-back operation was directly affected by powder concentration in dryer air space; blowback frequency/volume to maintain minimal filter differential pressure and vacuum loss was higher then expected.

C - Vacuum Condensate Skid

- Successfully/consistently established initial vacuum in dryer below 80 torr.
- Condensate tank pump had difficulty priming at lower vacuum values.

D - Discharge valve

- Successful operation through 100+ open/close cycles without seal degradation – able to normally maintain vacuum after valve cycling.
- Normal buildup above the valve was minimal even during wet batch processing.

E - Hydraulic Power Unit (HPU)

- The Cosmolubric® vegetable-based hydraulic fluid performed successfully with the power unit in flow, temperature management, and pressure performance.
- The hydraulic fluid supply system was incapable of rotating a dryer mass above ~12,000 pounds, not meeting the complete batch size per process flowsheet; workaround of using initial 60% dryer batch mass successfully resolved the issue.

F - ISO Container

- High vibration/noise was noted from direct welded hydraulic piping to the ISO container floor; no weld damage was seen.

G - Chiller

- Chiller capacity was sufficient.

H - Control System

- The programmable logic controller operation and network were stable.

I - Steam Control

- Automatic steam control valve and manual valving were adequate for steam supply; however, revision to operating strategy to maximize steam flow to the dryer SMF required significant unplanned operation of the manual block valves.

J - Utilities (Electrical)

- System power was sufficient and stable.

Prototypical Hardware

K - Product Discharge

- The initial product discharge timing through the discharge cone and rotary valve into a Super Sack® was 62 lbs per minute, but increased to an average 149 lbs/minute after addition of pneumatic vibrator and purge air supply at the cone.

L - Chilled Water Condensate System

- Chilling and pumping capacity was adequate.

M - Steam Supply

- Steam quality and supply (15 psig), and trap system were adequate except during wet batch processing.
- Additional steam blowdown valving and lines were added including safer routing to condensate collection vessels.

N - Simulant Pump Skid

- The dual coriolis flow meter and the magnetic flow meter tracked consistently in reporting similar simulant flows in recirculation mode.
- Continuous liquid feed to the dryer from the vane, positive displacement, metering pump was more stable than intermittent incremental feed using the slip-stream valving, thus enhancing bed temperature stability.
- Undissolved solids in the liquid feed eroded the plastic metering pump vane and seal which degraded pump performance; a new vane seal kit was installed to repair the damage, and a dual parallel strainer set was added to the piping upstream of the pump.

Non-prototypical Hardware

O - Simulant Feed Tanks
- Simulant flow back into the tank through the simulant recirculation pump was adequate by itself to maintain a well-mixed volume after the agitator was shut down from low level.

P - Dry Material Supply
- Continual cycling of the horizontal discharge hopper knife-gate valve resulted in material buildup in the valve guide rail, causing vacuum loss upon system restart until cleaned.

Q - Utilities (Instrument Air and Water)
- There were no significant issues with instrument air quality or supply, or water supply.

Testing was conducted in three phases. The first phase tested the integration of the dryer with its hardware support systems: steam, vacuum, chiller, filtration, condensate, hydraulic power, programmable control computers, and feed/product delivery. The second phase tested drying operations using water feed onto Hanford soil (the soil is similar in properties to the glass forming minerals). The third phase tested drying of a non-radioactive, simulated Hanford tank salt solution (with non-radioactive tracer materials) onto actual glass formers. This phased approach was very successful in allowing resolution of issues without the costly impacts of simulant or glass former waste.

ISSUES AND RESOLUTION

There were two major issues that were resolved during testing.

Dryer Lip Seal Failure

The dryer shaft seals failed early in Phase 1 shaft rotation testing, prior to addition of any material into the dryer. The dryer shaft seals function to maintain dryer vacuum and confinement of dryer contents. The drive motor end of the shaft utilizes 11-in diameter seals, while the free end of the shaft is equipped with 9-inch diameter seals. The installed design included dual (side-by-side) single-piece lip seals fabricated from TIVAR® H.O.T.; an ultra high molecular weight polyethylene plastic having a 275 °F maximum operating temperature, along with installed spares (since the seals are a one piece unit requiring shaft removal for replacement).

The 11-inch lip seals experienced two separate catastrophic failures and the 9-inch lip seals experienced one. The first 11-inch seal failure was attributed to an out-of tolerance spacer ring which both scored the plastic seal and caused it to overheat. The remaining failures with pre-installed spares were attributed to the lip seal design and close temperature tolerances with operating conditions. The "lips" of each seal extended outward beyond the seal body. When forced together in the installed configuration, the extended "lips" of adjacent seals bear on each other resulting in deformation and seal failure.

The dual lip seal design was a custom, "first-of-a-kind" dryer seal arrangement for this larger LDI dryer, selected for its superior vacuum sealing capability, and to eliminate any radioactive degradation issue with Teflon® in standard packing.

The lip seals on both shaft ends were replaced with standard LDI seal material: polytetrafluoroethylene-impregnated graphite rope, that can be installed (unlike the lip seals) without dismantling the dryer shaft. This material is a simple square braid and can withstand temperatures way in excess of steam pressure conditions. LDI has logged many thousands of hours of successful packing seal operation on dryers of different sizes, including larger units such as the 10,000 liter DBVS system. NUKEM has also successfully used the graphite seals in LDI dryers in their commercial reactor cleanup operations, and has had no apparent degrading from exposure to radiation. The inside of the seal packing gland was also knurled by a local machine shop to minimize seal movement during run-in.

There was a probability of degraded vacuum capability with this packing, however, subsequent testing showed excellent vacuum seal; a minimum of 90 torr in the dryer prior to start of drying was achieved for the remainder of dryer testing. The graphite seals performed very reliably and produced excellent vacuum process conditions.

Inadequate Scale up of Hydraulic Power Unit Capacity

During the addition of soil for dryer load testing in Phase 2 the Hydraulic Power Unit (HPU) was unable to turn the dryer shaft when the dryer contained some final loading of dry soil - 14,448 pounds. A complete dried batch mass of simulant and glass forming material was specified at 16,653 pounds. Subsequent troubleshooting identified that the HPU was undersized to rotate the process flowsheet dried batch size.

A causal analysis of this design inadequacy identified inadequate conservatisms and review of scale load data during changing design and operating strategy. Proper power calculations were performed from load data in early scale testing resulting in a 500 hp direct electric drive specification, however, change to a hydraulic flow technology for greater flexibility, implementation of dry batch methodology, and major revision of the dry mass formulation during scale development testing was not adequately reviewed for impacts to the initial drive specification. Initial conversion early in the design phase to two 300 hp hydraulic power unit motors for turning a single hydraulic motor was never challenged from marginal power data results in later scale testing.

The resolution of this issue during testing was accept as-is since the vitrification operating strategy had significantly changed. Bottom up melting required a continual feed addition to the In-Containerized Vitrification™ box in smaller increments than a complete dryer batch size. Also, smaller incremental batches were proposed as a method for maintaining a thin cold cap above the melt surface, thus minimizing the formation of a highly mobile, molten ionic salt layer. The dryer batch size was thus reduced to 60% of its process flowsheet basis, allowing sufficient margin for shaft rotation. Overall process throughput was never a problem since material melting is the current critical time constraint of the DBVS design, and was validated during subsequent integrated dryer operation/melt testing in August 2007.

ADDITIONAL TESTING to MAXIMIZE PELLET FORMATION

The testing focus changed during Phase 3 simulant/glass former drying to maximize product pellet concentration. The new formulation of glass forming minerals and cellulose, proposed in late 2006 to replace Hanford site soil/sand and minimize molten ionic salt formation at the glass surface, had produced a very high concentration (80 – 100%)of pellets greater than a 20 mesh screen in scale testing. This was unexpected but greatly desired in order to simplify dry material feed into the In-Containerized Vitrification™ box and promote minimal mounding in the box during melt operations. Full scale dryer testing could not reproduce this result; pellet concentration during initial simulant drying only could only realize concentrations normally around 50% > 20 mesh, with occasional samples up to 75%.

The following modifications to process conditions and equipment were made during subsequent simulant/glass former drying.

- Increased metering pump simulant feed ports from one to two then four.
- Added industrial nozzles and then flattened tubing ends on feed lines.
- Started with smaller batch sizes (40% of design baseline size)
- Increased moisture target band from 3-5 wt% to 4-6 wt% to 5-7 wt%.
- Reintroduced dried product into dryer and then dried additional water stream

None of these changes appreciably increased pellet concentration. There are a large number of parameters that could have been tested, but effort was limited by available raw materials and schedule need to complete ensuing dryer operation/melt test.

CONCLUSIONS

Process Control

1.) Dry batch methodology is the best protocol to successfully dry Hanford tank simulant, and thus radioactive tank waste, with a minimal risk of material agglomeration and equipment coating. Dry batch methodology is best controlled through establishment of a flat bed temperature profile in the drying mass using a stable simulant/waste feed flow. Stable and slightly increasing shaft power draw trending can be successfully used to identify normal material drying and uniform pellet formation. Sudden power increases on trending will also provide early notification of waste agglomeration and buildup on dryer surfaces, and high bed moisture content.

2.) The dryer can produce quality dried product in a semi-continuous batch mode, where dried product in incrementally discharged (not a complete load-out), and the dried mass is regenerated from addition of dry mixture and liquid. No significant impacts to product quality were evidenced from this "bleed and feed" operating strategy.

3.) Control at the baseline target temperature range of 140 °F - 150 °F is recommended, however the actual temperature value is not that significant for drying stability; stable temperatures were maintained within 130 °F to 160 °F. Further testing may determine the best temperature for maximizing pellet formation. The baseline liquid feed flow of 3.0 gpm should be maintained as an initial starting condition and target, unless further pelletization testing qualifies a different value.

4.) Bed moisture content should be maintained in the range of 4 wt% to 5 wt%. This is a slight increase of the original target range of 3 wt% - 5 wt% to ensure maximum pellet formation. Again, further testing may redefine this range.

5.) Dryer vacuum should be maintained as low as possible to ensure SMF buildup does not impact stable bed temperatures.

6.) Sampling of dryer contents through the temporarily installed Strahman valve (in a non-radioactive environment) was invaluable for moisture monitoring.

7.) Wet batch processing is possible for reducing water content of total wet batch (e.g. during flushing and cleanout) however, this process risks significant agglomeration of the bed and coating of the shaft and side walls, especially since the dryer side walls and shaft are not steam heated. Increased insulation and providing shaft steam supply would minimize buildup during this mode and significantly reduce any buildup during dry batch processing.

8.) A metering pump in the liquid feed system provides the most stable flow for establishing a stable dry bed temperature profile. A recirculation loop has value for maintaining solids in suspension, so the most ideal design would be a metering pump feeding a mass-flow slipstream from a recirculation loop.

9.) Final Phase 3 drying of a 40% baseline batch was completed in 4 hours and 53 minutes (4.88 hours) at simulant flow rates from 2.75 to 3.05 gpm. This equates in a straight linear ratio to 12.2 hours, similar to projected rates from the original 2004 development testing, supporting initial throughput conclusions that critical DBVS process timing is material melting.

10.) Pellet formation is complex, potentially affected by many parameters. Pellet formation was witnessed at the middle or end of simulant processing, consistent with smaller scale testing. Logically, higher bed moisture values tend to produce more agglomeration, but whether these moisture values will produce a greater uniform pellet concentration was not confirmed. Other changes made during full scale testing did not appreciably increase pelletization: multiple liquid feed ports, variation of feed rate, use of spray nozzles, water spray upon dried product, and smaller batch sizes.

The one significant change from scale testing parameters was the reduction of the baseline mass to 60%. Pellet formation is inherently mass-related (solids or simulant mass, and/or raw material ratios) so this reduction may have limited their production; the highest priority for further scale testing should be to demonstrate that similar scale pellet formation results will occur at reduced batch sizes under controlled simulant-to-solids ratios. Other parameters for evaluation include shaft speed, dryer vacuum, bed temperature, and plough type.

11.) The SMF is an effective filter; dryer condensate was clear of solid material from condensate collection grab samples. The value of an SMF over a fabric bag was demonstrated with the ability to water-wash the filter candles. The decreased pore size of the filter as compared to a normal bag did not adversely affect the pressure drop. Air pulsing of the filter candles produced vacuum perturbations of 10 - 25 torr but was recoverable with the vacuum pump capacity. It is essential to maintain the filter candles at the highest temperature during drying to ensure the buildup layer on the candle is not wetted.

RECOMMENDATIONS

- Perform additional simulant testing at 130L scale, with larger dryer units (e.g., 600L), and then full scale to qualify parametric effects on pellet formation, gather additional data on dryer buildup for ALARA (as low as reasonably achievable) analysis, and to optimize SMF candle dust loading and pulse control. Testing for evaluation of increased pelletization should include verification of mass effects, variance of shaft rpm, and modification of heat transfer rate through changes to shaft steam supply and system vacuum. Other options for simulant testing to increase pelletization include waste feed dilution, installation of commercial nozzles, use of pre-pelletized dry components, and addition of other chemical binders.

- Evaluate method for remote sampling/moisture analysis of bed contents.

- Revise design to implement direct metering pump liquid feed, from baseline recirculation loop, into multiple feed ports.

- Evaluate options for integrating dryer water flushing and subsequent liquid handling to allow best recovery from agglomeration.

- Investigate improvements to load cell monitoring during drying conditions.

- Install separate steam control to SMF jacket to maintain highest candle temperature while still maintaining stable dryer bed temperature, investigate application of steam flow in shaft, and improve exposed flange and dryer surface insulation.

REFERENCES

1. "Performance Management Plan for the Accelerated Cleanup of the Hanford Site," DOE/RL-2002-47, Revision D, United States Department of Energy (2002).

2. R.W. POWELL, E.S. AROMI, "Contract Number DE-AC27-99RL14047; CH2M HILL Hanford Group, Inc. Recommendation for Further Testing of Supplemental Technologies," Correspondence # CH2M-0303565 to DOE-ORP, CH2M HILL Hanford Group, Inc. (2003).

3. Waste Management Symposium 2004, Tucson, Arizona, February 29 – March 4 2004, Publication WM-4524, "Initial Selection of Supplemental Treatment Technologies for Hanford Low-Activity Waste" (2004).

4. A.R. TEDESCHI, "Demonstration Bulk Vitrification System Full Scale Dryer Qualification Test Plan," RPP-PLAN-32696, Revision 1, CH2M HILL Hanford Group, Inc. (2007).

5. A.R. TEDESCHI, "Demonstration Bulk Vitrification System Full Scale Dryer Qualification Test Instruction," RPP-33176, Revision 0, CH2M HILL Hanford Group, Inc. (2007).