SCALE DRYER VERIFICATION TEST RESULTS USED TO SELECT A PROCESSING APPROACH SUPPORTING HANFORD SITE BULK VITRIFICATION SYSTEM LOW-ACTIVITY WASTE SUPPLEMENTAL TREATMENT

C. Nigl, K. Wiemers
DMJM H+N

M. Denton
RWE NUKEM CORPORATION

ABSTRACT

The U.S. Department of Energy (DOE), Office of River Protection (ORP) is responsible for the remediation of the Hanford Site tank farms, including 53 million gallons of radioactive mixed waste contained in the 149 single-shell tanks (SST) and 28 double-shell tanks (DST). The Bulk Vitrification process, also called In-Container Vitrification™ (ICV™) will be used to treat and package a fraction of the low-activity tank waste for on-site disposal. AMEC Earth and Environmental, Inc. under contract to CH2M HILL Hanford Group, Inc. is designing, testing, and fabricating a full-scale demonstration bulk vitrification system (DBVS) for processing low-activity waste from Tank 241-S-109. A key component of the processing unit is a vacuum mixer/dryer. This component will dewater the liquid waste and blend the waste with soil and glassformers [zirconium oxide (ZrO_2) and boron oxide (B_2O_3)] before the vitrification step. The selected dryer technology has been deployed for a wide diversity of both commercial and nuclear applications, and is currently being evaluated for several Hanford Site waste treatment options.

Scale dryer tests with S-109 simulant were completed in fiscal year (FY) 2004 to support the DBVS process and design verification, procurement specifications, operational strategy, and integrated testing. A viable dryer process was selected for producing an acceptable feed for vitrification. Two approaches to dryer processing were investigated, dry batch and wet batch. The wet batch blends the soil with increments of waste; partially drying the blend between incremental waste additions. After the final waste addition, the material is dried to less than 1 wt% water before the glassformers (ZrO_2 and B_2O_3) are added. The dry-batch method begins with a charge of soil in the dryer. The waste is added in small increments, maintaining approximately 1 wt% water throughout the batch process. Glassformers are added after completion of the incremental waste additions. A number of factors were evaluated in selection of the baseline dryer process, including processability (e.g., foaming, caking, peak power demands), final product handling and aging properties, dryer configuration and potential design impacts, safety, as low as reasonably achievable (ALARA), overall facility throughput, maintenance and recovery from upset conditions, and process controls. The scale dryer test results and their application to the engineering design and operations of the DBVS will be presented.

INTRODUCTION

The DOE ORP is responsible for the remediation of the Hanford Site tank farms, including 53 million gallons of radioactive mixed waste contained in the 149 SSTs and 28 DSTs. The Bulk Vitrification process, also called ICV™ will be used to treat and package a portion of the low-activity tank waste for on-site disposal. AMEC Earth and Environmental, Inc. under contract to CH2M HILL Hanford Group, Inc. is designing, testing, and fabricating a full-scale DBVS for processing low-activity waste from Tank 241-S-109.

This paper describes the results of scale component verification testing completed for a key unit operation in the DBVS, the dryer system. These test results provided design inputs for the process flowsheet, equipment selection, operating procedure, and process control strategy, and will be used to develop operation procedures for the integrated and startup testing.

DBVS Process

The DBVS is a full-scale demonstration of low-activity waste treatment. Approximately 600,000 gallons of low-activity waste will be retrieved from Tank 241-S-109 in the Hanford Site tank farms and transferred to the DBVS. The DBVS will dry liquid waste, combine it with soil and glassformers, and transfer the dried material to the ICV™ box (internal dimensions: 7.5 ft by 7.5 ft by 24 ft and volume: 38.22 m^3). Once in the ICV™ box, the waste will be vitrified by joule heating with electrodes that are located in the ICV™ box. The demonstration will produce a maximum of fifty boxes, which will be stored at the DBVS site until a Hanford near-surface disposal site is ready to receive the boxes.

A key component of the processing unit is a vacuum mixer/dryer. This component will dewater the liquid waste and blend the waste with soil and glassformers before the vitrification step. The selected dryer technology has been deployed for a wide variety of both commercial and nuclear applications, and is currently being evaluated for several Hanford Site waste treatment options (1).

The baseline process for the dryer operation is a batch method. The dryer is charged with sufficient soil to make up a single, nominal dryer-capacity batch. The waste feed is then added in small increments, maintaining approximately 1 wt% water throughout the batch process. This continues until the correct proportion of waste to soil is achieved. After the final waste addition, the material is dried to less than 1 wt% water before the glassformers (ZrO_2 and B_2O_3) are added. The dryer contents are then discharged to the ICV™ box and the dryer process repeats as described above.

Dryer Testing Background

Two levels of verification and validation testing are planned for the DBVS: the bench/pilot-scale process verification testing and the full-scale system integration tests. Previous bench-scale dryer test results from April 2003 results were reported in "Drying of Mixtures of Hanford Tank Waste Simulant and Hanford Soil Testing at Littleford Day" (2) and from April 2004 in the "Demonstration Bulk Vitrification System: Interim Dryer Test Report April 2004" (3). These tests were conducted using a "wet batch" approach in which the waste, soil, and glassformers

were blended wet and then dried. This approach resulted in potential problems with foaming, scaling, and product hardening. These results, in addition to an alternative dryer process method developed for the Hanford Contact-Handled Transuranic Mixed Waste Packaging Unit (CH-TRUM WPU) Project (1), provided insight into variations in process parameters that could have a favorable impact on the drying process.

The bench/pilot-scale dryer tests with Tank 241-S-109 simulant, which are discussed in this paper, were completed in August 2004 to support the DBVS dryer design. The tests were performed in collaboration with RWE NUKEM Corporation at the dryer manufacturer's, Littleford Day, Inc., facility in Florence, Kentucky.

Test Objectives

The primary objective of this test activity was to develop and verify a dryer process that would produce an acceptable feed for vitrification and overall facility throughput. The tests were conducted in two phases: Phase I (5-L dryer) scoping tests and Phase II (130-L dryer) verification tests. The objective of the Phase I tests was to down select process conditions for the Phase II 130-L dryer tests. The objective of the Phase II dryer tests was to verify process steps and parameters, and equipment configuration for the production 10,000-L dryer. Results from the 130-L tests were also scaled up to the 10,000-L dryer for throughput evaluation.

Three key parameters were investigated based on earlier tests results:

1. process steps (wet-batch versus dry-batch methods),

2. glassformer addition sequence, and

3. effectiveness of an antifoaming agent.

TESTING METHODS

All tests were conducted with a Tank 241-S-109 simulant prepared in accordance with the formulation provided by CH2M HILL Hanford Group, Inc. (4). The additives consisted of soil from AMEC's Horn Rapids Test Site (HRTS), which is located near the Hanford Site, glassformers (ZrO_2 and B_2O_3), and a Dow Corning® chemical silica-based antifoaming agent (as needed). The required blend of soil, glassformers, and simulant is based on the Demonstration Bulk Vitrification System Process Design Criteria (5) and is shown in

Table I.

Table I. Composition Ratios of Soil, Glassformers and Waste Simulant Used in Testing

Test Material	Ratio of Materials	Mass Added to 130 L
Hanford Soil	30%	127
B_2O_3	2%	9.0
ZrO_2	3%	13
Waste Simulant	65%	272
Antifoam	N/A	0.3

The tests were conducted on two scale versions of the 10,000-L full-scale dryer. The scoping tests (Phase I) were conducted with the 5-L (bench-scale) dryer. The Phase II tests were conducted on the 130-L (pilot-scale) dryer system. The 130-L dryer results are directly scalable to the 10,000-L dryer. Pictures of the 5-L and 130-L scale dryers are shown in Fig. 1.

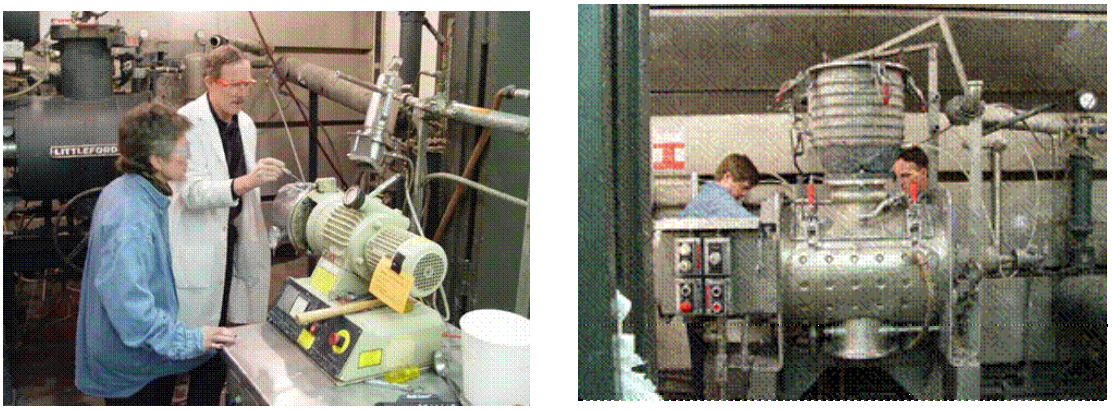

Fig. 1. 5-L Bench-Scale Dryer and 130-L Pilot Scale Dryer.

T

he pilot-scale dryer was configured to be as prototypic of the production dryer as possible including plow type and feed delivery port. The scale dryers were equipped with: steam jackets, access for simulant addition, and sampling collection; motor driven standard Becker plows; bag filter on vapor outlet; vapor condensers; condensate receiver tanks and access to condensate for sample collection; vacuum pumps and gauge (to accommodate -24 to -26-in. Hg); steam supply (jacket temperature to be maintained at 250 °F $\pm$ 5 degrees); chilled water supply system (50 °F $\pm$ 5 degrees); control panel to monitor, at a minimum, product temperature and dryer shaft motor power; manually set or monitored variable speed (rpm) control for dryer shaft speeds (full speed for 130 L is 160 rpm and for full-scale is 90 rpm); and a calibrated thermocouple.

All data was collected and supporting calculations prepared in accordance with the NQA-1 compliant DMJM H+N Quality Assurance Plan (6). The main operational difference in the tests conducted was the drying method: wet batch versus dry batch. The process steps used for the wet batch and dry batch methods are described in the following sections.

Wet Batch

The procedure steps used to perform the successful wet-batch runs are shown in the block flow diagram in Fig. 2. The goal was to maintain a visible liquid fraction during the incremental simulant additions and before proceeding to the extended drying period. Scoping tests confirmed that addition of glassformers with the soil resulted in undesirable scaling and product setup, therefore, glassformers were added after the completion of waste additions and only to a dry ($\leq$ 1 wt% water) intermediate product. The waste simulant required for the wet-batch runs was divided into four equal volume increments. The first simulant increment for each run was used to rinse off the caking that formed on the dryer drum walls during the previous run. After the rinse, the total required amount of soil for the batch and the second waste simulant increment were added to the dryer. This mixture was dried for 20 minutes before the next simulant increment was added. The last simulant increment was added after another 20 minutes of drying. The final extended drying time after the fourth increment addition was approximately 90 minutes and produced the dry flowable product. After verification that the dryer contents were less than or equal to 1 percent moisture, the glassformers, ZrO_2 and B_2O_3 were added and the product mixed for approximately 3 minutes. Dryer product and condensate samples were collected before each increment addition and after glassformer addition. A portion of the product was reserved for aging tests and measurement of physical flow properties. Antifoaming agent was also added to one of the 130-L dryer tests, due to observations of foaming in the 5-L dryer. However, the foaming observed during the 130-L tests was minimal and the antifoam did not appear to make a significant difference in the foaming of the material or in any other drying characteristic. The motor shaft speed for the wet batch runs was half speed (80 rpm).

Dry Batch

The methodology of the successful dry-batch run is shown in the block flow diagram in Fig. 2. The goal of the dry-batch process was to maintain the dryer contents visibly free of liquid throughout the run. Similar to the wet batch method, glassformers were added to an intermediate dry product to avoid undesirable process and product properties. Antifoaming agent was not required for the dry-batch method.

For the dry-batch tests the dryer was charged with the total required amount of soil and the simulant was added in frequent and small increments relative to the wet batch procedure. The rate of simulant addition (amount added over a selected time interval) was based on the real-time monitoring of product temperature. The product temperature was selected as a process control input because it had proven to be successful in previous dry-batch tests for the Hanford CH-TRUM WPU (1).

The target product temperature was gradually decreased from 190 °F to approximately 140 °F by increasing the simulant addition rate. The objective of increasing the simulant addition rate was to determine the maximum dryer throughput capacity. This was defined as the point at which the product began to agglomerate and caking began to form on the dryer drum walls due to excess moisture content. This condition was not achieved during this test series due to schedule constraints. However, the final product temperature achieved (140 °F) was comparable to nominal conditions identified for the CH-TRUM WPU dry batch processing.

The first step in the dry batch procedure was to preheat the soil was to approximately 190 °F. The simulant additions were made in small increments during the drying process by being aspirated under vacuum through a single-feed port in the 130-L dryer. The rate of simulant additions was kept constant over a 30-minute drying period. The amount of simulant added was recorded every 10 minutes by reporting the changing weight of the simulant drum. Simulant was added at a rate which kept the product above a minimum target temperature. The temperature was tracked as the product cooled and reheated. If the product did not reach the target minimum temperature upon addition, the simulant addition rate was increased. If the product temperature went below the minimum target, the simulant addition rate was decreased. The target minimum temperature was lowered by 5 °F each time a new 30-minute drying period started. After each 30-minute drying period, a sample of the dryer contents was collected and the percent moisture was measured. Condensate was also collected periodically throughout the test run. The dryer contents were maintained at 0.2- to 2-percent moisture during the simulant additions.

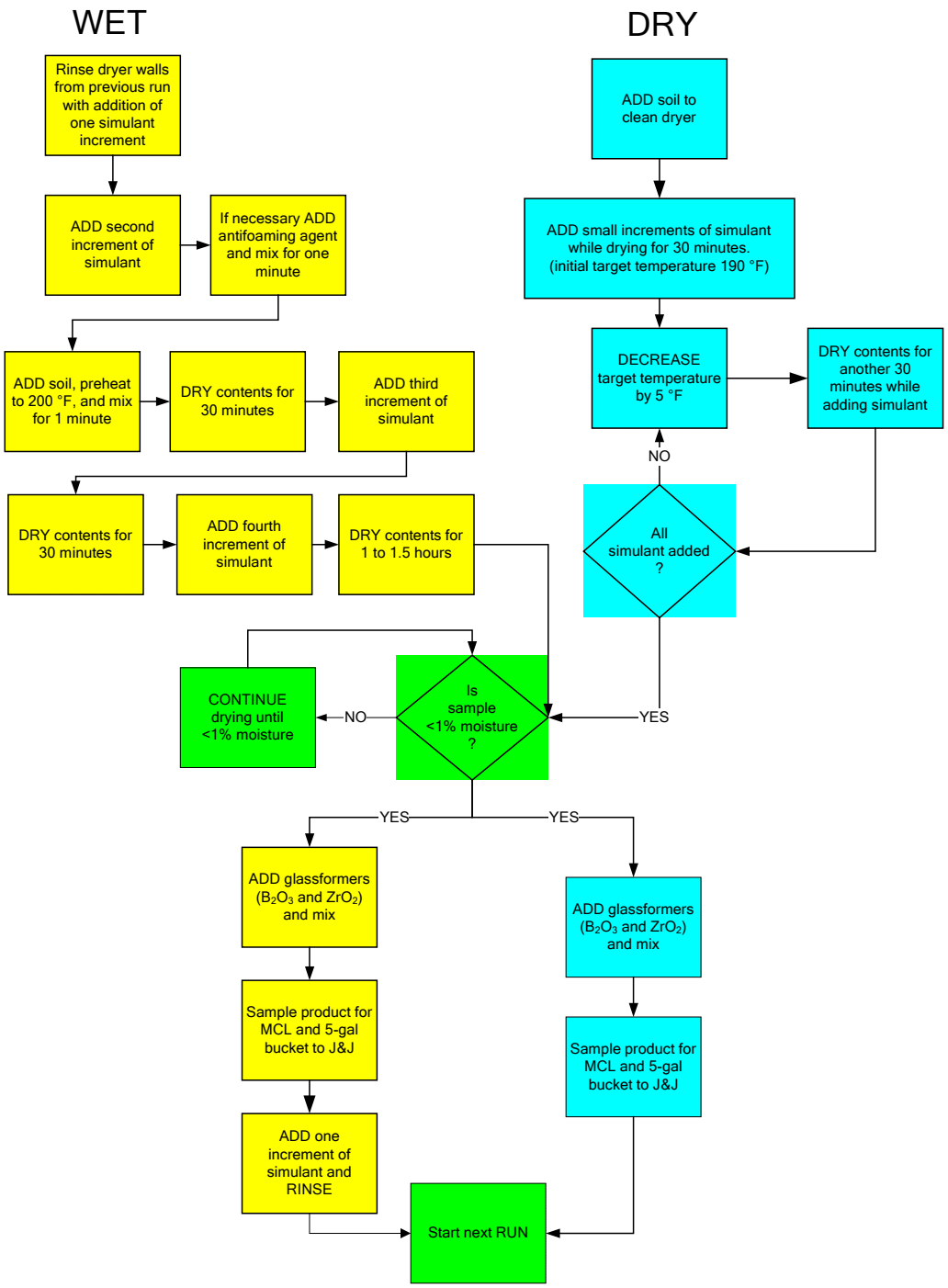

Fig. 2. Block Flow Comparison of Testing Methods for Wet and Dry Batch Runs in 130-L Dryer.

DRYER TEST RESULTS

The following sections describe the results of the DBVS pilot-scale verification testing. The two drying methods are each analyzed separately and consist of the results from Phase II testing.

Wet Batch

The HRTS soil and Tank 241-S-109 simulant successfully dried to a flowable product and blended with glassformers (ZrO_2 and B_2O_3) in the wet-batch process. Undesirable properties of scaling and a stalled dryer shaft motor resulted when the glassformers were added to an intermediate product that was 2.87 percent moisture (4). Glassformers were added with the dryer contents ≤1 percent moisture in subsequent and successful wet-batch verification tests. Product that had caked on the dryer walls was removed by addition of simulant after batch discharge. The following describes the observed physical properties, process and product measurements, and dryer throughput calculation results.

The dryer contents were observed to transition through two phases important to monitoring the progress of the wet batch method. These two phases are identified on the power demand chart provided in Fig. 3. The first or "mud" phase, is an intermediate product in which the dryer contents are no longer a flowing liquid, but is still very wet. The mud phase of drying appears to start when moisture drops below 15 percent and continues about 1.5 hours under the conditions tested in the 130-L dryer. During this phase, a caking of the dryer contents begins to form on the dryer drum walls. Additionally, the mud phase in the dryer cycle places a high power load on the motor. Based on comparison of two consecutive wet-batch tests, the peak power demand was approximately 440 hp (scaled to 10,000-L dryer). The peak demand was manageable for both runs with the current design basis (500-hp hydraulic motor).

The second or "post-mud" phase is the point where the dryer content begins to break over into smaller pieces that require less power to plow through. There is a distinctive leveling off of the power demand at the end of the mud phase. This leveling off occurs as the product continues drying from approximately 3 to 5 percent moisture to less than 1 percent moisture.

At the end of each wet-batch run there was approximately 0.25 inch of buildup on the dryer drum walls. This cake depth is the minimal plow clearance for both the 130-L and 10,000-L dryers. The caking is effectively rinsed from the dryer walls by addition of waste simulant. When rinsing is used in the normal process cycle, the quantity of caking residue carried over to the next batch represents approximately 8 wt% of the dried batch in the 10,000-L dryer (assuming a dryer contents void fraction of 40 percent, a caking void fraction of 20 percent, and a dryer fill level of 40 vol%).

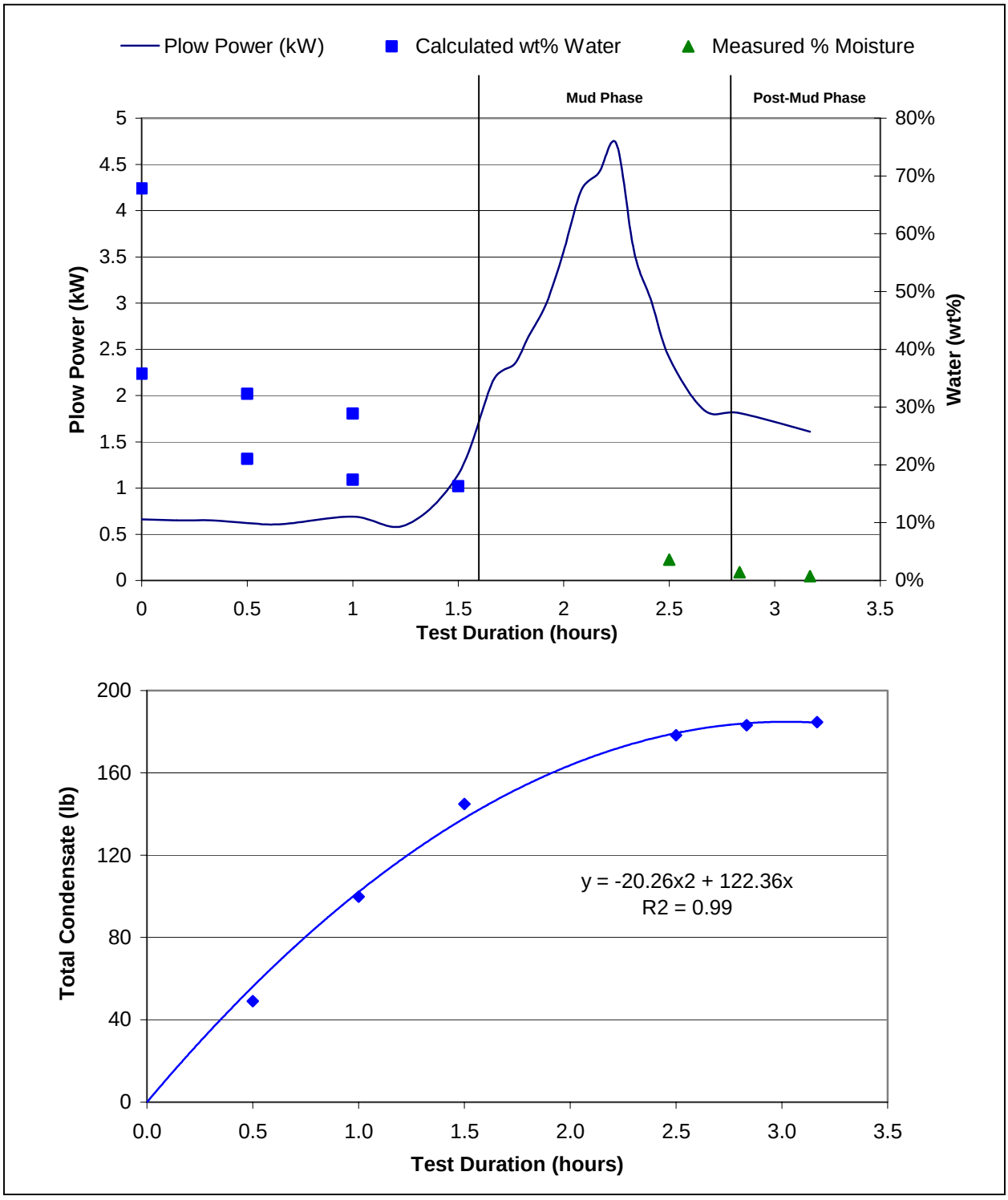

Fig. 3. Example of the Plow Power Profile, Percent Water, and Condensate Produced in the 130-L Dryer Wet Batch Runs.

The data demonstrated that a steady product and jacket temperature profile persisted through the wet-batch runs (4). The temperature differential (between the product and dryer wall) stayed above 100 °F throughout the run, which is a favorable condition for heat transfer. The product temperature range during the run was 125 to 145 °F with an increase to approximately 150 °F before the glassformer addition. The effectiveness of the antifoaming agent to mitigate foaming during normal operations was inconclusive, primarily because very little foaming (less than one inch thick) was observed. The foaming observed was significantly less than previous observed tests from April 2004 (3) and April 2003 (2). This is attributed in part to the absence of B_2O_3 during high-liquid content periods.

The percent moisture measurements and amount of condensate collected were used to calculate an nominal dryer capacity. The cumulative quantity of condensate recovered as a function of test duration is shown in Fig. 3. An average rate of 59.0 lb/hr of condensate was calculated from a polynominal fit of this curve. The portion of the average rate that is attributed to plow heating is approximately 13.5 percent and the balance of the rate is attributed to jacket heating. To scale-up this rate to the 10,000-L dryer, net plow heating is assumed to scale-up strictly on size and jacket heating scales up on size and time using a time scaling factor of 1.75. The 8,037-kg batch of 67.8 wt% water feed prescribed in the Process Design Criteria (5) is projected to require 4.4 hours to dry using the wet batch method.

Dry Batch

The HRTS soil and Tank 241-S-109 simulant successfully dried to a flowable product and blended with glassformers (ZrO_2 and B_2O_3) in the dry-batch process. From the experience in the wet-batch testing the blended soil and waste were dried to less than 1 wt% water before addition of glassformers to avoid undesirable scaling and setup of the product. The internal dryer components remained cleaned (no caking or scaling) throughout the duration of the test. The following describes the observed physical properties, process and product measurements, and dryer throughput calculation results.

No visible change in the dryer contents was observed throughout the duration of the dry batch test. The plow-power demand profile for a dry-batch verification test is shown in Fig. 4. The gradual increase over time is attributed to the dryer fill level increasing as waste simulant is added and dried product accumulates in the dryer. Note that power does not peak as it does in a wet batch, because in a dry batch there is no transitional mud phase. Also, note the reduced final plow power for the wet batch relative to the dry batch, approximately 1.8 kW and 3 kW, respectively. Both wet batch and dry batch methods produce similar final flowable products. However, the dry batch method is conducted at standard speed which requires additional power at equivalent dryer fill volumes. The power demand for both methods is within the design basis.

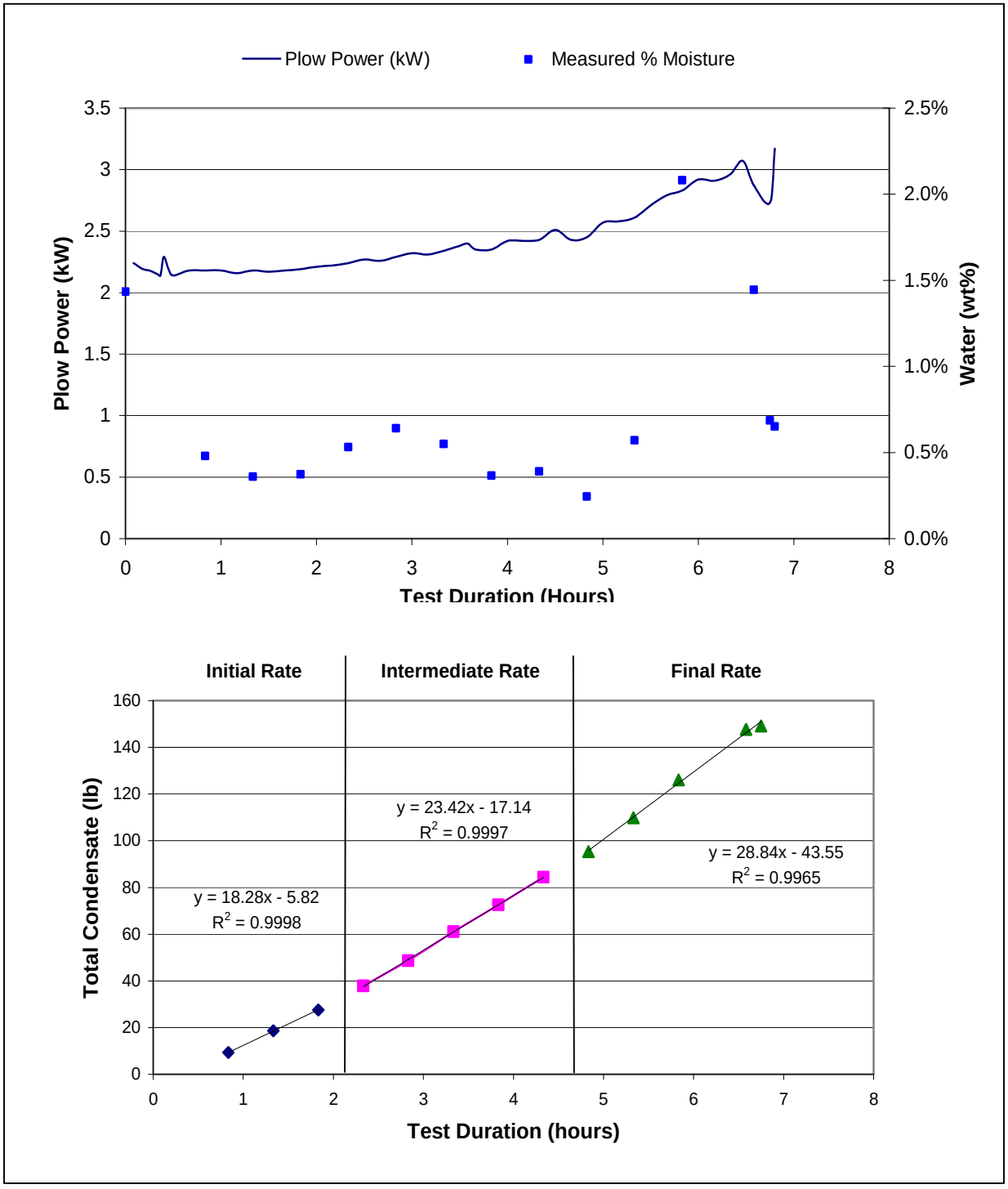

Fig. 4. Example of the Plow Power Profile, Percent Water, and Condensate Produced in the 130-L Dryer Wet Batch Runs.

During the initial phase (first two hours) of this run, when the feed rate was relatively low, product temperature was at approximately 190 °F and the temperature differential between the dryer contents and the dryer steam jacket was approximately 60 °F. During the final phase (final two hours), when a higher feed rate was established, the product temperature leveled off at approximately 140 °F and the temperature differential was approximately 110 °F. A maximum sustainable feed rate was not reached during the test because of time constraints.

The general temperature trends observed during the dry batch method can be explained as follows. As liquid simulant is added to the product the energy produced by the dryer is used to evaporate the newly added water. As more energy is used to evaporate water and less is used to heat the product, the product cools (i.e., evaporative cooling). As the product becomes dryer (there is less water to evaporate) more energy is used to heat the product and the product temperature rises again. This drying pattern was used to guide the rate of simulant addition for the dry-batch tests.

The percent moisture measurements and amount of condensate collected were used to calculate a nominal dryer capacity. The cumulative quantity of condensate recovered as a function of test duration is shown in Fig. 4. An average rate of 59.0 lb/hr of condensate was calculated from a polynominal fit of the curves. The portion of the average rate that is attributed to plow heating is approximately 13.5 percent and the balance of the rate is attributed to jacket heating. To scale-up this rate to the 10,000-L dryer, net plow heating is assumed to scale-up strictly on size. Jacket heating scales up on size and time; a time scaling factor of 1.75 is used. The 8,037-kg batch of 67.8 wt% water feed prescribed in the Process Design Criteria (5) is projected to require 4.4 hours to dry using the wet batch method.

The cumulative quantity of condensate recovered as a function of test duration is shown in Fig. 4. An initial rate (18 lb/hr), intermediate rate (23 lb/hr), and final rate (29 lb/hr) were obtained by a straight-line fit of the three subsets of the data. The rate increases over time for two reasons. First, more of the heat transfer surface is utilized as dried simulant accumulates, and second, the increasing feed rate as the test proceeds drops the temperature of the bed which increases the temperature differential for heat transfer. To scale-up this rate to the 10,000-L dryer, the same methodology is used as was described in the wet-batch results above. The 8,037-kg batch of feed in the 10,000-L dryer will require 8.3 hours to dry. The condensate rate observed during the final third of the dry-batch run (29-lb/hr) was used in place of an average rate for calculating the scaled-up dryer throughput because a maximum sustainable feed rate was not obtained during the test. The throughput is therefore a conservative value and shorter dryer cycle-times may be realized during operations.

DRYER TEST CONCLUSIONS/RECOMMENDATIONS

The scale verification tests resulted in the following major design basis decisions:

- The dryer is operated in a dry-batch mode. This is a change from the wet-batch method used in the baseline.
- Glassformers (ZrO_2 and B_2O_3) are added after the waste and soil are blended and dried to $\leq$ 1 wt% water. This is a change from the baseline in which the glassformers were blended with the soil before addition of the liquid waste stream.
- Addition of anti-foaming agent is not required for nominal operations. Addition for rinsing steps (if required) is an option. The baseline flowsheet does not include addition of anti-foaming agent.
- The dryer motor shaft has the capacity to operate up to standard speed. This will be accommodated by the current design.
- The modified Becker plows are used, consistent with the tested system. The plows are coated with a flame-sprayed vendor coating to minimize erosion. These are refinements in the dryer specification.

A number of factors were evaluated in selection of the baseline dryer process and equipment configuration. Table II summarizes the key evaluation factors and the conclusions for the wet-batch and dry-batch methods. Table II describes these considerations in more detail.

Table II. Key Evaluation Factors and Conclusions for the Wet and Dry-Batch Methods (2 sheets)

Evaluation Factor	Requirement	Wet Batch	Dry Batch
Foaming	Minimize impact on throughput and potential for contamination	Minimal foaming in the absence of glassformers under wet conditions.	Not applicable.
Caking	Minimize impact on throughput, carry-over, and materials accountability	Caking observed on dryer surface and could cause carry-over.	Clean dryer surface.
Product[a] Flowability	Accommodates conveyance; does not set up; minimize powder to reduce dispersion	Flowable product obtained at end of process cycle.	Flowable product maintained throughout process cycle.

Table II. Key Evaluation Factors and Conclusions for the Wet and Dry-Batch Methods (2 sheets)

Evaluation Factor	Requirement	Wet Batch	Dry Batch
Plant Throughput	Does not become critical path; Flexible to accommodate upset conditions	Throughput not on critical path; not flexible to discharge during the drying cycle.	Throughput not on critical path; flexible to discharge during the drying cycle.
Dryer Configuration	Minimize changes to baseline specification; however, ensure robust	Glassformer addition at the end is a change to baseline specification.	Glassformer addition at the end is a change to baseline specification.
Process Control and Monitoring	Minimize complexity of controls to ensure a more reliable product	Straightforward waste addition rates and mostly automatic controls.	Controls can be automated; Waste addition rate controls dependent on dryer contents temperature.
Safety	Minimize potential safety concerns such as leakage or dried waste releases.	Potential for liquid leakage. Potential for dried waste release.	Less potential for liquid leakage. Potential for dried waste release.
ALARA	Minimize dose rates	Buildup of product (dose) is part of normal operations.	Dryer internal components remain clean throughout normal operations.
Maintenance	Minimize maintenance of the dryer components and ensure ease of routine maintenance	Routine maintenance must be conducted after complete dryer cycle.	Product can be discharged at any point during dryer cycle to allow routine maintenance. More plow wear than in wet batch.
Recovery from Upset	Enable ease of recovery from upset conditions.	Difficult during dryer cycle – liquid waste accumulated in dryer.	Possible any time during dryer cycle and lower risk of "setting up".

[a]Additional testing on transport properties of the final product were conducted by Jenike & Johanson and a Flow Properties Test Report was issued.

The following outcomes provide the basis for the recommended process:

1. Both dry-batch and wet-batch methods produced an acceptable product. The increased dryer throughput realized by the wet batch was not viewed as a discriminator because the overall facility throughput is constrained by the melting cycle.

2. Both dry-batch and wet-batch methods required addition of the glassformers (ZrO_2 and B_2O_3) after the blended waste simulant and soil were dried to less than 1 wt% water. Addition of glassformers at the end of the drying cycle is a change from the baseline process flowsheet for both methods and thus was not a discriminator.

3. Minimal foaming was observed during the wet-batch method when the glassformers were not added under wet conditions. Addition of an antifoaming agent as a preventive measure for the wet-batch approach or during a rinse cycle for maintenance or final decontamination and decommissioning may be beneficial. Addition of an antifoaming agent would require a design change. An antifoaming agent is not required for the dry-batch approach.

4. The wet-batch method results in caking on the dryer drum walls which is removable by rinsing. The dry-batch method keeps the internal components relatively free of dried material thus avoiding the need for rinsing under normal operations. This method is consistent with material accountability and as low as reasonably achievable.

5. The wet-batch approach was run at half-standard shaft speed and the dry-batch approach was run at standard speed per the vendor's recommendation. This will be accommodated by the current design.

6. Intermediate product from the dry-batch method may be discharged from the dryer as a dry granular product with or without glassformers at essentially any time during the dryer processing. When compared with the wet batch method, the dry batch offers the most flexibility relative to routine maintenance and recovery from upset conditions.

7. The material properties during the dry-batch processing are expected to be relatively consistent (less than 1 wt% water and granular product) compared with the wet-batch method. As a result the risk of "setting up" during an upset condition is minimized in the dry-batch method.

8. The wet-batch method includes addition and mixing of a liquid phase with the potential for leaks during most of the drying cycle. A granular product is present throughout the dry batch process cycle and at the end of the wet batch cycle. Confinement implications would need to be considered for both process methods.

9. The dry-batch method causes more plow wear than the wet-batch method. To mitigate this plow wear it is recommended to add a hard coating onto the plow-facing and leading edge.

10. The dryer contents in the dry-batch process must be maintained at approximately 1 percent moisture or less during the entire process cycle to minimize the risk of caking and agglomeration. For the wet-batch in the full scale process the leveling off of the power demand could be used to control the duration of the dryer cycle and indicate when the glassformers should be added. Process controls and monitoring for waste addition rates may be more constraining than those required for the wet-batch method.

The scale dryer verification tests resulted in defining a feasible and flexible dryer process that meets the throughput requirements. The process steps and parameters identified in this test activity were incorporated into the engineering design media including the process flow diagram, piping and instrumentation diagram, process control strategy, and dryer specification, and are being used to prepare the operating procedures for the integrated testing and startup operations. These tests benefited from the results of recent tests with common systems. The projects utilizing economies of integration are expected to continue to benefit as they move forward with commonalities in safety, environmental, and engineering evaluations, process control systems, procurements of equipment and spare parts, factory acceptance testing, installation, and procedures and training for integrated systems testing, startup, operations, and decontamination and decommissioning.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Ron Orme and Kurt McCracken for their significant technical contributions to the original work.

The authors appreciate the contributions of the following individuals, who provided valuable assistance and advice during the dryer tests: Glenn Vice, George Ely, and Steve Schloemer of Littleford Day, Inc.; Bill Bostick of Materials & Chemistry Laboratory, Inc.; and Carl Ross of RWE NUKEM Corporation.

REFERENCES

1. DMJM. 2004. Dewatering System Dryer Simulant Design Verification Test Report for Phase IV. 20843.TRPT.003, Revision A, DMJM Technology, Richland, Washington.

2. Wilson, J.H., Ph.D. April 7-17, 2003. Drying of Mixtures of Hanford Tank Waste Simulant and Hanford Soil Testing at Littleford Day.

3. DMJM. 2004. Demonstration Bulk Vitrification System: Interim Dryer Test Report April 2004. A006.TRPT.001, Revision 0, DMJM Technology, Richland, Washington.

4. DMJM. 2004. Demonstration Bulk Vitrification System: Dryer Test Report August 2004. DBVS.TRPT.002, Revision 0, DMJM Technology, Richland, Washington.

5. AMEC. 2004. Demonstration Bulk Vitrification System Process Design Criteria. 143643-A-DC-002, Revision C, AMEC Earth & Environmental, Richland, Washington.

6. DMJM. 2004. Quality Assurance Project Plan for the Demonstration Bulk Vitrification System Project. DBVS.QAPP.001, Revision 0, DMJM Technology, Richland, Washington.