LAW Pilot Melter Facility Lessons Learned

Glenn Diener – Energy*Solutions*

December 2007

Overview

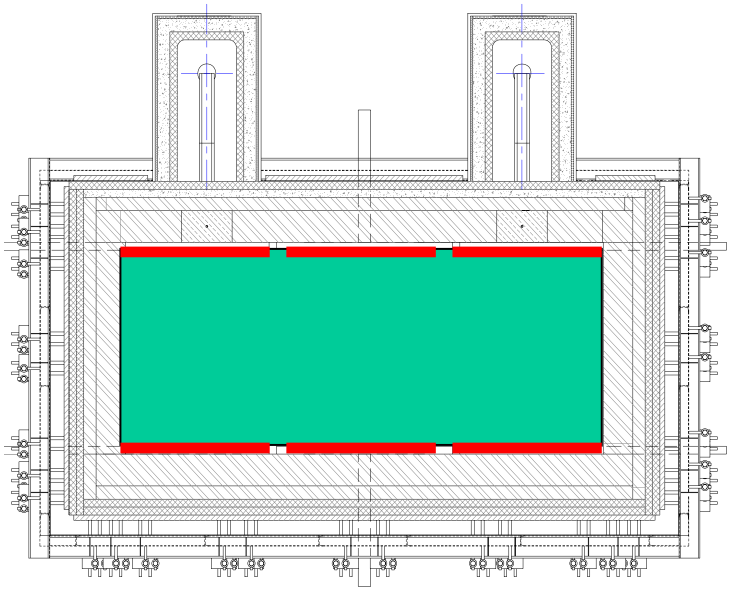
- Pilot Melter Background
- Design/Construction/Installation
- Commissioning
- Testing
- Melter Feed Studies Program

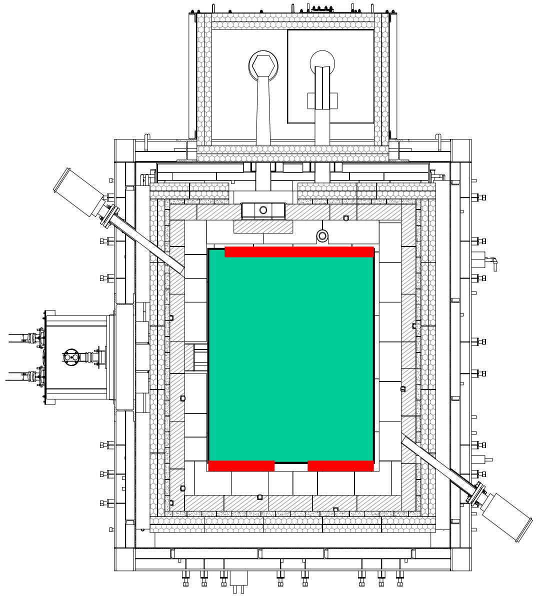
LAW Pilot Melter Background

- Under Part B1, BNFL awarded RPP privatization contract
- LAW production rate requirements were deemed a very high risk
- Energy*Solutions* designed, constructed, and operated large scale melter using Hanford simulated waste
- Funded separately from RPP Part B1 contract

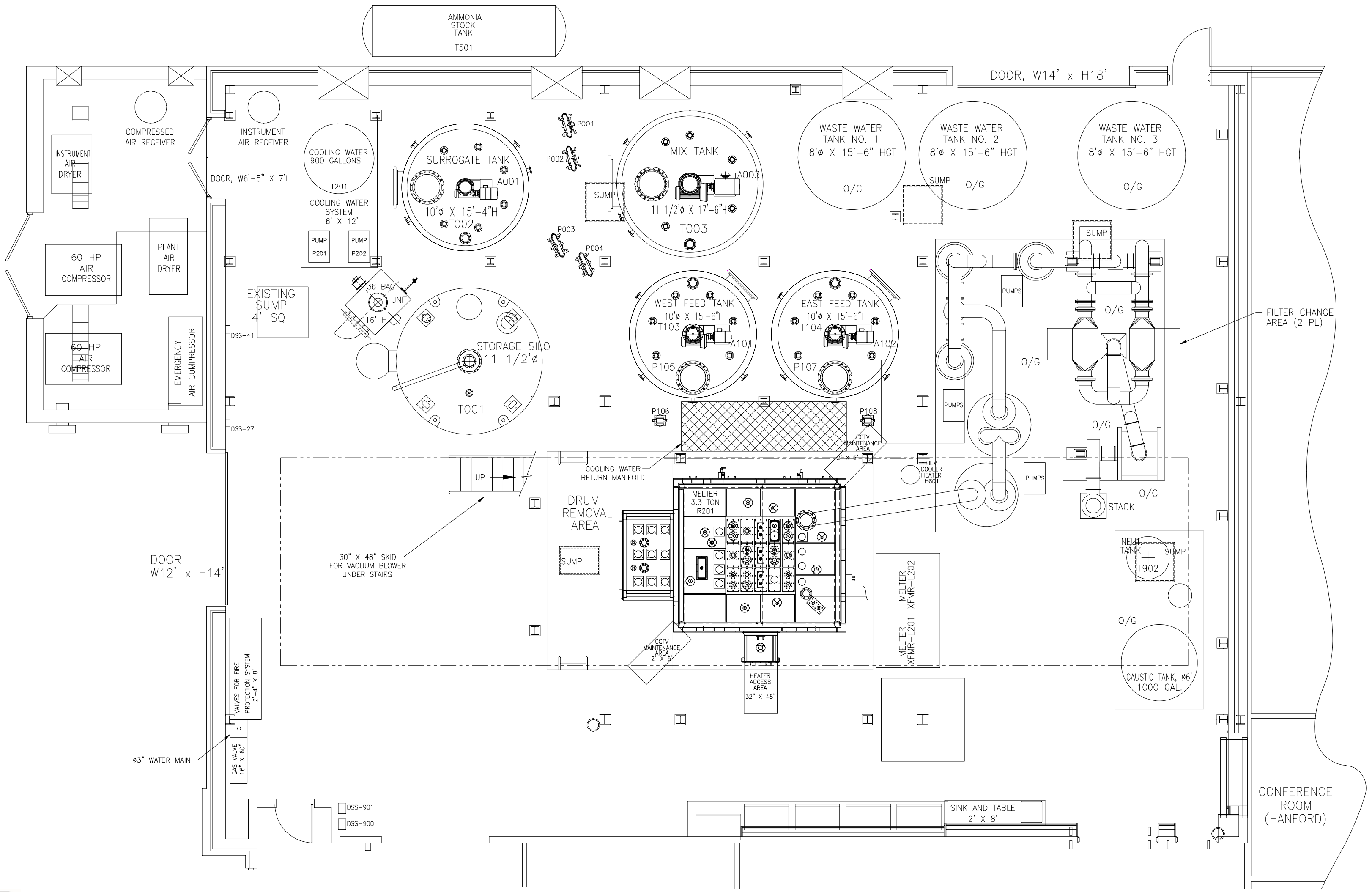
LAW Pilot Melter Facility

- Initial investment of $15 million included:
  - Pilot melter (1/3 section of the WTP LAW melter)
  - Melter feed preparation system
  - Off-gas treatment and wastewater collection system
  - Utilities (air, steam, cooling)





LAW Pilot Melter Facility Layout



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LAW Pilot Melter System

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LAW Pilot Melter Feed System

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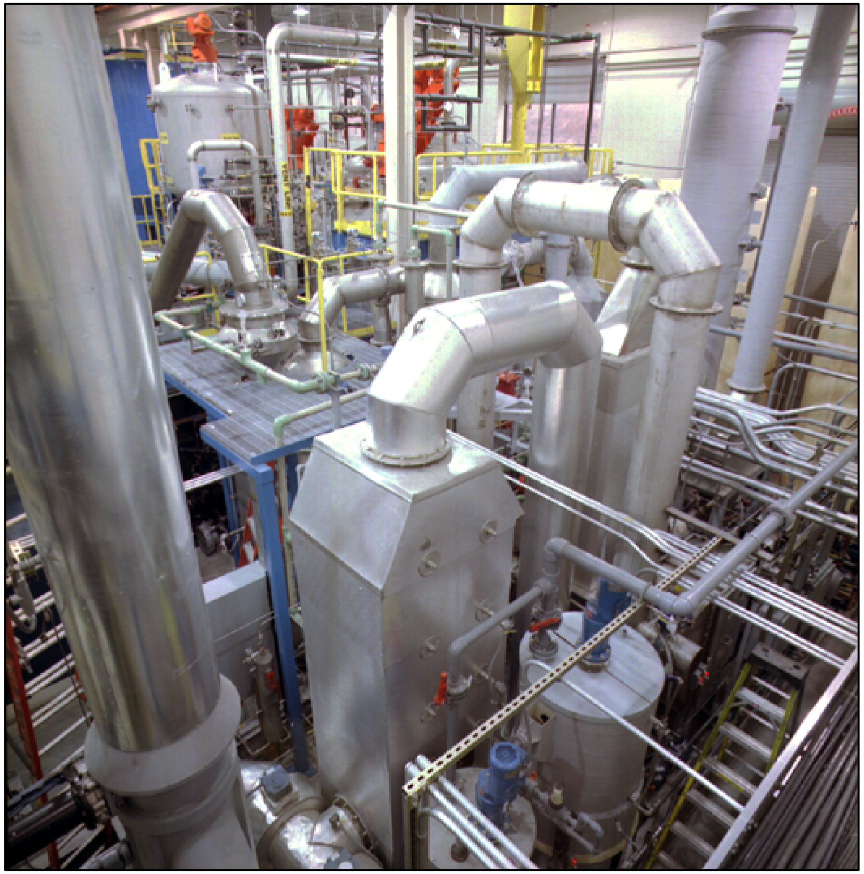
LAW Pilot Melter Off-Gas System



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LAW Pilot Melter History

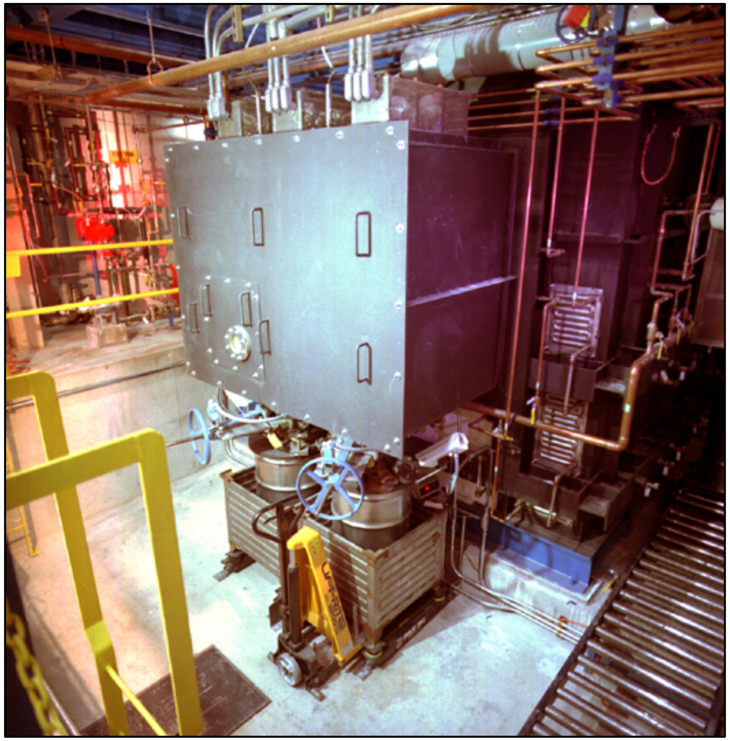
- Jan. 1998: BNFL funding approved (start design)
- July 1998: Begin construction
- Dec. 1998: Melter startup
- April 1999: Begin feeding
- May 1999: Start phase 1 testing
- Aug. – Sept. 1999: Sustained throughput test
- Nov. 1999 – Oct. 2000: Phase 2 testing
- May 2001: Transfer of Pilot Melter to DOE
- June 2001 – May 2003: BNI R&T LAW testing
- Sept. 2003: Full-scale HLW/LAW canister filling
- Oct. 2003: ORP melter testing
- Feb. 2004: Completed D&D of facility

LAW Pilot Melter Scope

- Phase 1 Scope - BNFL
  - Establish melter throughput/reliability
  - Establish refractory performance
  - Define melter operating parameters
- Phase 2 Scope - BNFL
  - Sulfate management
  - Melter component improvements
  - Continued validation of melter design
- B2 Scope - BNI
  - Enhanced throughput demonstration - commissioning goals
  - Bubbler life extension - enhanced availability
  - Continued design confirmation and validation

LAW Pilot Melter Statistics

- At temperature for 4.86 years
- Melter fed for 628 days
  - 1,075,395 gallons of feed processed
  - 7,762,390 pounds of glass produced
- Outstanding safety record
- All LAW sub-envelopes processed (nominal, variations, and turnovers)



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Design, Construction and Installation

- Design of melter, feed system, off-gas system and I&C performed in-house
  - Utilized engineering personnel with first-hand operations experience
  - Integrated team approach
  - Design guided by the goals of the facility
- Final detailed design of off-gas system and I&C out-sourced

Design, Construction, Installation (cont)

- Things that went well
  - Melter and feed system installation
  - Excellent mechanical/electrical contractor
    - Worked well together
    - Communication was key
- Things that could have gone better
  - Meeting desired installation schedule
  - Change control issues with off-gas and I&C vendors
  - Automation of equipment controls
  - Quality of instrumentation supplied by vendor
  - Quality of equipment supplied by vendor

Design, Construction, Installation Recommendations

- Fully define operating requirements during design
- Do not always rely on success-driven schedule
  - Allow sufficient time for all phases
  - Put contingency into schedule for unknowns
- Do not allow schedule to dictate design and installation
  - Correct design issues upfront
  - Do not "put off" design issues to commissioning
    - Schedule may slip, design cost may increase
    - More cost efficient in long run
- Remember that facility is operated by people
  - Safety considerations
  - Equipment placement (operability, maintenance, etc.)
- Utilize best instrumentation possible for data collection

Commissioning

- Commissioning performed in phases
  - Component checkout
  - System checkout
  - Water runs
  - Simulant testing
- Checklists developed by test engineers
  - Verify interlocks and control strategy
  - Verify proper operation of equipment
  - Determine limits of operation
  - Verify instrumentation calibration

Commissioning (cont)

- Commissioning performed by operations
  - Responsible for developing operating procedures
  - Verify operating procedures are correct
  - Used to help train operators
- Initial commissioning performed on days
- Once melter was hot, 24 hour operator coverage
  - 12-hour shift rotation, 4 shifts
  - 1 supervisor, 2 melter operators, 1 auxiliary operator
- Full implementation of conduct of operations
  - Based on manual from Energy*Solutions*' M-Area vitrification facility at SRS

Commissioning (cont)

- Commissioning used to fully train operators
  - Basic sciences (math, physics, fluid dynamics, etc)
  - System training (component interaction)
  - Job Performance Measures (task related)
  - Regulatory training (HAZWOPER, L/T, confined space, etc.)
  - Comprehensive oral test with Operations Manager
- What went well
  - Operator training
  - Conduct of Operations implementation
  - Commissioning process and methodology

Commissioning (cont)

- What could have gone better
  - Commissioning cut short due to delays
  - Lingering equipment/design issues carried into testing – deemed an acceptable risk
  - Testing of automatic controls – overly complex
- Recommendations
  - Utilize operation staff for commissioning, not just engineers
  - Allow sufficient time for commissioning – always takes longer than estimated
  - Resolve problems before turnover – may impact schedule

Testing Methodology

- Testing program plan
  - Identified roles and responsibilities
  - Identified how testing is conducted
    - Requirements for test plans and test procedures
    - Configuration and change control
  - Test report development, review, and approval
- Test engineer assigned for each test
  - Receives approved Project test specification
  - Develops test plan and test procedure
  - Trains operations staff on test procedure
  - Coordinates testing with shift
  - Collects data and performs data reduction
  - Develops test report

Testing Methodology (cont)

- Configuration Control
  - Controlled documents, drawings, and ECNs
  - Test Authorization Document
    - Identified authorized test procedures
    - Identified configuration of facility equipment and operating conditions
    - Identified authorized plant maintenance
    - Identified allowed routine operations
    - Controlled copy maintained in the control room
  - Test procedures modified by field changes or revision
  - Test procedure, operating logs and electronic data (via PLC) used to collect required test data

Testing Methodology (cont)

- Operations
  - Facility operated as a production plant – 24 hrs/day, 7 days per week
  - Operators followed operating procedures
    - Test procedures used by engineers to guide operations
    - Test procedures referenced operating procedures
  - Conduct of Operations fully implemented
    - Documented shift turnovers between operators
    - Temporary operating changes handled by shift/standing orders
    - Operating logs maintained
  - Communications
    - Face-to-face or by radio
    - Management available 24/7 via mobile phone

Simulants Used in Testing

- LAW simulants based on VSL formulations
  - Based on TFCOUP data
  - Mixed chemical simulant
- Simulants produced by Optima Chemical
  - Simulants manufactured in ~3500 gallon quantities
  - Simulants shipped by tanker truck
  - Simulants received at higher molarity than needed
  - Received COC – Al, Na, K content, density, and pH
  - Received completed batch sheets
- 685,850 gallons received and processed

GFCs Used in Testing

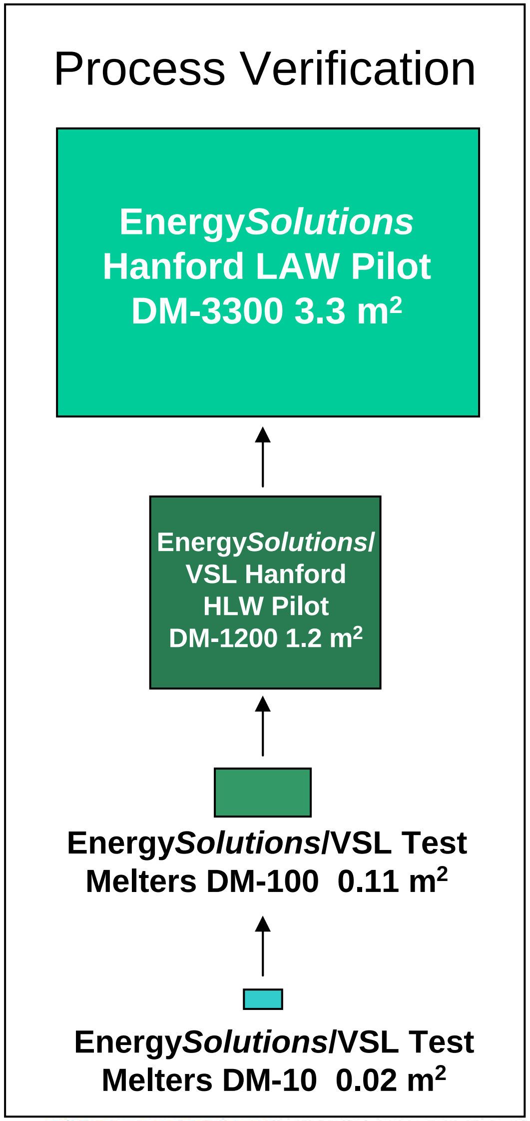
- GFCs based on VSL glass formulations
  - GFC grade/particle size based on VSL testing
  - GFC grades eventually specified by BNI
  - GFC added to achieve a specific solids loading and rheology
- GFCs blended by Colonial Chemical
  - GFCs received by hopper truck (~45,000 lbs)
  - Received completed batch sheets
- 7,059,186 lbs received and processed
- Solids handling issues during summer
- Chemical purity problems – vendor replaced

Testing - Safety

- Modifications and maintenance initially handled verbally with shift
- LTA resulted in complete implementation of a work control process
  - All work not covered by procedures required work packages
  - Based on Energy*Solutions*' work control manual from M-Area vitrification facility at SRS
  - Scope of work and boundaries clearly defined
  - All facility changes required safety and operations review
- LTA reduced to zero after integrated safety program implemented (over 3.75 years)

Testing – What Went Well

- Safety program
- Training program
- Facility operations
  - Skilled, experienced people
  - Maintained core competency
  - Roles and responsibilities clearly defined
- Testing Program
  - Goals and testing identified early
  - Success ensured by process verification at smaller scale
- Analysis by VSL



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Testing – What Could Have Been Better

- Maintenance of off-gas equipment
  - Materials/equipment selected based on facility life
  - Replaced piping and pumps
- Transfer of operating experience
  - Success may foster complacency
  - Important for effective facility design
  - Prevents loss of competency

Organization Testing Philosophies

- BNFL
  - Design confirmation testing
  - Technology improvement
  - Testing requirements generalized, allowed for innovation
- BNI
  - Design confirmation/validation testing
  - Operation, engineering, permit data collection
  - Testing duration limited by funding
  - Testing requirements prescriptive, little innovation
- ORP
  - Technology improvement and enhancement
  - End of melter life testing
  - General testing requirements

Melter Feed System Lessons Learned

Melter Feed Studies Overview

- Wasteform qualification testing for LAW/HLW
  - Verify tank homogeneity over range of tank levels
  - Verify prototype sampling system collects representative sample
  - Quantify accuracy/precision of radar level and density measurements
- Testing conducted with bounding simulants
  - LAW pretreated waste and melter feed
  - HLW pretreated waste and melter feed
  - Simulants developed by SRNL
- Testing performed on day shifts

Melter Feed Studies Equipment

- 8-foot diameter scaled tank (2500 gallons)
  - LAW CRV (57% scale)
  - LAW and HLW MFPV (73% scale)
- Scaled tank contains
  - Prototypic agitator (scaled)
  - Prototypic transfer pump (full-scale)
  - Prototypic density probe (full-scale)
  - Prototypic radar level detector (full-scale)
- Full-scale Isolok sampling valve
- Hydraulically similar transfer piping
- GFC unloading station for prototypic addition rates

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Melter Feed Studies Facility

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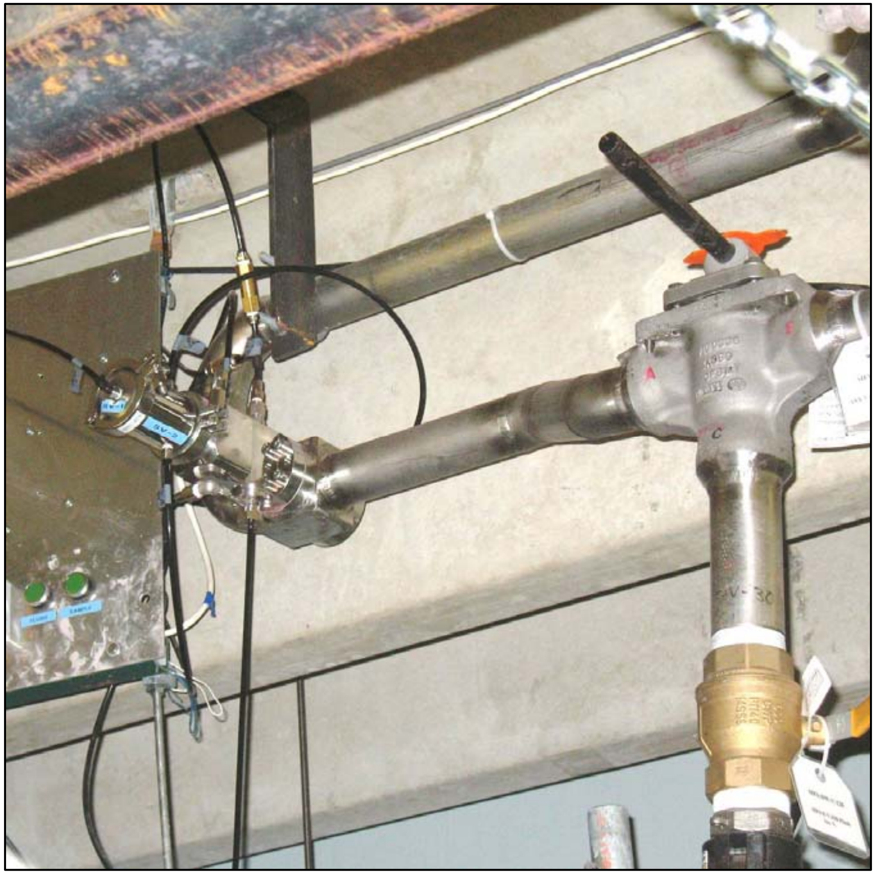
Melter Feed Studies Facility



Melter Feed Studies Testing

- What went right
  - Modular design of the tank system
    - Allows for quick reconfiguration
    - Part of design requirements
  - Tank sampling probe system
  - Automated sample labeling and handling system
    - Minimizes sample labeling errors
    - All paperwork automatically printed
    - Reduces manpower requirements
  - Sample analysis
  - Identified potential equipment operating problems
    - Isolok sampling system
    - Radar level detector

Melter Feed Studies Testing (cont)

- What could have been better
  - Equipment operating problems
    - Resolving equipment problems that were outside scope of testing
    - Delay in testing schedule/increase in cost
  - Simulant scale up testing
    - SRNL simulant development testing at small scale only
    - LAW high bound melter feed rheologically unstable at large scale (due to xanthum gum)
    - New simulant being developed by VSL
  - Testing requirements
    - Test Specifications too generic (time lapse between development and start of testing)
    - Project needs evolved over time

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Summary – Testing Recommendations

- Develop/implement a strong safety program
  - Needs to make people think
  - Needs to be focused on the people doing the work
- Develop/implement a strong training program
  - Focus on systems and their interactions
  - Qualify personnel on tasks
- Utilize experienced personnel (first hand, real life operating experience)
- Define requirements/needs of facility early
  - How long is it needed?
  - What needs to be determined/validated?
  - Are requirements operations or R&T based?

Summary – Testing Recommendations

- Involve engineering throughout testing, not just during design phase
  - Promotes competency of personnel
  - Promotes understanding of system interactions
  - Invaluable feedback for plant design
- Utilize smaller scale testing first
  - Identifies operating problems faster and cheaper
  - Engineering judgment needed for scale up

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HLW Pilot Melter Facility (DM1200) Lessons Learned

Glenn Diener – Energy*Solutions*

K.S. Matlack, T. Bennett, R.K. Mohr, M. Brandys, and I.L. Pegg – VSL

December 2007

DM1200 HLW Pilot Melter

Primary Objectives

- Design confirmation and flow-sheet data
- Determine glass production rates for HLW compositions
- Evaluate prototypical HLW and LAW off-gas systems
- Establish processing parameters for HLW waste compositions
- Collect regulatory data for the MACT permitting process

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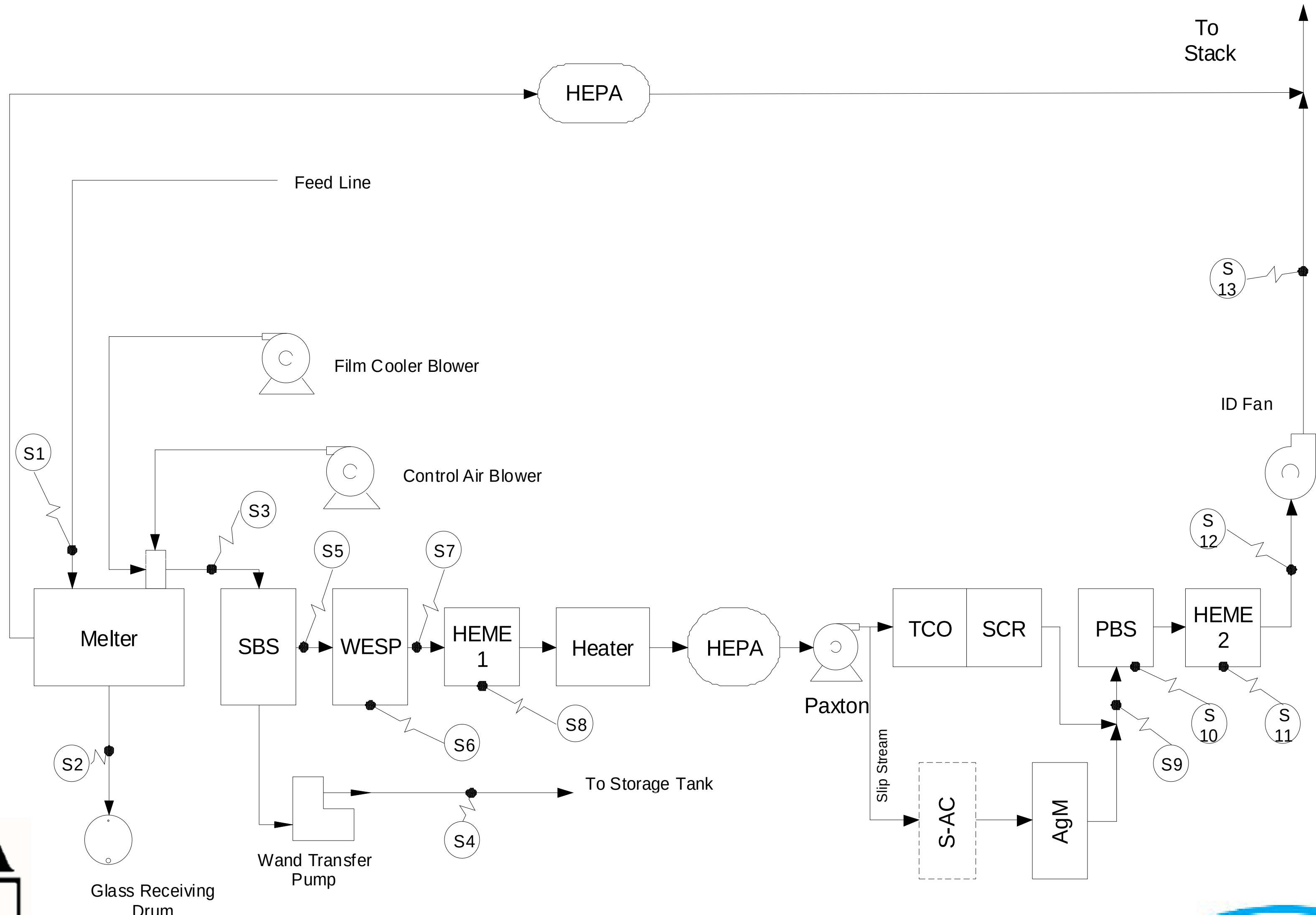
Background

- DM1200 is approximately 1/3 scale of WTP HLW melter
  - 1.18 m^2 surface area
  - 25” glass pool depth (57% full scale)
- Prototypical HLW/LAW off-gas train:
  - Film-cooler/ SBS/ WESP/ HEME/ HEPA/ TCO/SCR/ AgM/SAC/PBS
- Installed at Vitreous State Lab in Washington, DC
- Commissioned Jan. 2001 and still in use
- Approximately 600,000 lbs of glass made from over 1.5 million lbs feed
- Operated continuously during testing by VSL staff
  - Three 8-hour shifts, 1 shift supervisor and 2 operators
  - Operations over seen by Operations Manger and Test Manager
- Non-radioactive, hazardous organic and inorganic chemical simulants used

Background, contd.

- WTP design was not static during testing
  - Evolved significantly during and as a consequence of test results
- Numerous post-commissioning configuration changes, including modification of unit ops. and addition of new unit ops.
  - Added TCO, SCR, AgM, ACS, FCC…
  - Complete replacement of SBS internals
- Ability to test both HLW and LAW flow-sheets required
- Modularity and ease of modification was a crucial facility requirement
- R&T environment with rapid and responsive analytical support in combination with seasoned, highly experienced operating staff and inventive engineering and design support worked very well
- Excellent safety record – no LTAs

DM1200 HLW Pilot Melter System



DM1200 Facility

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Design

- Design with safety in mind
- Define scope of testing
  - Provide for changes in direction
- One size doesn't fit all
  - VSL melter pilot facility included closely coupled
    - bench scale testing
    - ~1/200 scale
    - ~1/30 scale and
    - ~1/3 scale melters
  - Smaller units provide for rapid inexpensive testing, ensuring that the more costly large-scale system tests are appropriately focused
  - Larger units provide proof of scale for the most promising conditions
  - Efficient and economical tiered approach

Design, cont.

- Design so that parts can be easily added and changed
  - In the melter, be aware that hot components expand and warp
  - Design in adequate clearances for components
- Design in redundancy for critical components
  - More cost effective than aborting an expensive test
- Assume that maintenance and change out of components will be required
  - Design for ease of access
- Instrumentation platform should be easy to use and flexible
  - For VSL, LabView has worked well
  - Common operator interface structure (GUI, sofware, instrumentation, DAS, control) across all platforms to simplify operator cross-training

Design, cont.

- Design with QA requirements in mind
- Use familiar proven designs where possible
- If design is new or untested, assume that some adjustments will have to be made to make it work
  - e.g., on DM 1200, prototypical melter pressure control system – required several iterations to achieve desired control
  - Provide sufficient time to test out systems prior to utilization

Construct/Install

- Major components/systems fabricated by outside contractors
- Major assembly by outside contractors with close supervision by Energy*Solutions*/VSL engineers
  - Need to know the details of construction if later changes are required and to evaluate unexpected performance
- Major electrical by outside contractors
  - Final connections by outside contractor under close supervision or by VSL personnel
  - Instrumentation wiring done by VSL personnel or outside contractor under close supervision
- Test subsystems during installation if possible – before integrated test
- In many cases existing infrastructure was used as a cost saving measure (if it did not compromise the design)
- Invariably, parts are dropped in inconvenient places during assembly – need to take appropriate precautions

System Evaluations Prior to DM1200 Tests

- Electrical continuity
- Instrument calibration and operation
- Heater operation (Process heater, VOC start-up, VOC primary heater)
- Blower operation (Paxton, Blower #2,#3)
- Pump operation with electrical motor and air operated diaphragm pumps (SBS recycle, Scrubber recycle, liquid transfer pumps)
- Liquid transfer from SBS, SBS overflow tanks, WESP, HEME #1, HEME # 2 and caustic scrubber to sample tanks
- Liquid transfer from sample tanks to Landa evaporator
- Individual component operational checkout (SBS, WESP, HEME #1, HEME # 2, caustic scrubber, HEPA filters, VOC catalytic destruction system)

System Evaluations Prior to DM1200 Tests, continued

- SBS heat transfer systems (jacket cooler, plate/frame) operation and calibration
- System gas pressure drop and blower (#1, #2, #3, roof) vacuum balancing
- Steam tests
  - SBS operating pressure differential and column packing effectiveness
  - SBS pressure fluctuations
  - SBS heat removal
  - Solids removal from the SBS vessel
- WESP voltage /current optimization
- VOC catalytic destruction system tests
- Performance tests for local regulators

Prerequisites to DM1200 Testing

- WTP Test Specifications, design information
- Design, construct, install (includes frequent post-commissioning modifications in response to tests results)
- VSL Test Plan
- Functionality verification of all system components and M&TE
- Readiness Review
  - Safety, training, procedures, Test Plan
  - System and M&TE
  - As-built configuration documented
  - Specific test configuration documented
  - Test Instructions

DM1200 Commissioning Tests

- Objectives
  - Bring the DM1200 system to full routine operating status by performing tests to diagnose and correct any remaining system issues
  - Refine operating procedures as needed in response to commissioning test findings
  - Complete operator training
  - Conduct final confirmation of instrumentation, control, and data acquisition systems
  - Determine routine operating parameter ranges for system components
  - Collect emissions data for local regulatory purposes

DM1200 HLW Test Overview

- Commissioning tests: 10.5 MT glass produced over 18 days
- Initial tests with AZ-101 simulants to determine the need for glass pool bubbling: 26.7 MT glass produced over 54 days
- Tests with AZ-101, AZ-102, C-106/AY-102, and C-104/AY-101 simulants to determine the effect of composition, bubbling rate, and feed solids content on production rate: 44.4 MT glass produced over 68 days
- Tests with AZ-101 and C-106/AY-102 simulants to determine the effect of reductants and nitrate feed additions on production rate and glass properties: 28.2 MT glass produced over 27 days
- Tests with AZ-101 simulants to optimize the design, use and location of bubblers: 56 MT glass produced over 48 days
- Tests with AZ-102 and C-106/AY-102 simulants to determine the effect of feed rheology on production rates. Additional test to verify the performance of optimized bubblers : 21.3 MT glass produced over 17 days
- Tests with mixed HLW feeds to turnover melt pool and provide scoping data on measuring alcohol emission rates: 2.8 MT glass produced over 2 days
- Tests with spiked C-106/AY-102 simulants to collect regulatory data for MACT permitting: 7.5 MT glass produced over 9 days
- Film cooler cleaner testing: 4 segments each approximately 3 days
- **A total of 197.6 MT of glass produced over 243 run-days from HLW simulants**

DM1200 LAW Test Overview

- Tests with LAW C simulants to collect regulatory and engineering data: 14.8 MT glass produced over 8 days
- Tests with LAW A simulants to collect regulatory and engineering data: 15.2 MT glass produced over 9 days
- Tests with LAW B simulants to collect engineering and production rate data as well as analysis of plenum gases: 9.6 MT glass produced over 7 days
- Tests with LAW C and A simulants to collect production rate data as well as study causes and mitigating strategies for foaming: 22.8 MT glass produced over 15 days
- Tests with mixed LAW feeds to provide scoping data on measuring alcohol emission rates: 5 MT glass produced over 3 days
- Tests with spiked LAW Sub-Envelope A2 simulants to collect regulatory data for MACT permitting: 15.2 MT glass produced over 9 days
- **A total of 82.8 MT glass produced over 45 run-days from LAW simulants**

Common Equipment Issues Noted

- Solids accumulation and clogging - Settled solids in piping and valves causing failures and or leaks due to pressure buildup
- Corrosion for some off-gas components - inline heater for the catalyst system is prone to failure caused by corrosion
- Pressure / temperature ports have a tendency to clog and/or corrode
- pH measuring probes have experienced frequent failure in the off-gas equipment
- EMF emission issues with instruments due to the proximity to high-power systems
- Film cooler clogging
- Clogging of the SBS blow-down wand
- WESP electrical issues

Operator Training

- Three Phases
  - Phase 1: Basic glass science and chemistry as it relates to the vitrification process
  - Phase 2: Classroom discussion of system design, function, and procedures
  - Phase 3: OJT
- Continual re-training as the system was modified
- Periodic HAZWOPER, confined space, and lock-out/tag-out certifications

Procedures

- Since the system was subject to essentially continual modifications, operating procedures had to be constantly modified to reflect the current status
- Review and approval included
  - Test Manager
  - Operations Manager
  - QA Administrator
  - VSL Principle Investigator (VSL Director)
  - CUA Director of Environmental Health and Safety
  - Specific system engineers, as applicable

Shift Management

- Shift Turnover
  - Oncoming shift supervisor arrived 1hr prior to the off-going shift ending
    - Reviews turnover log that provided information gained during the previous shift and included reminders about long term conditions
    - Reviews operations log for events from the previous shift
    - Questions the off-going supervisor about any issues, situations, and/or occurrences
  - Operations staff arrives 30 minutes prior to the off-going shift ending
    - Field operators question the off-going operators for plant status and relieve any ongoing operation
- Communication
  - On location was handled face-to-face or by phone
  - Operations Manager, Test Manager, and Instrumentation/Electrical Supervisor are available 24/7 via mobile phone

Information Logging

- Two forms with redundancy
  - Computer data logging
    - 24/7, typically at 2 min intervals, logged to a dedicated server
    - Data available real-time to VSL staff
  - Manual data and event recording
    - Log books and round sheets
    - Data interval based on importance: 0.25, 2, 4 , or 6 hrs
    - Event interval and general observations as they occur
    - Specific Test Plan requirements
    - Detailed post-test inspections and data logging

Laboratory Analysis

- Vast majority performed in-house at VSL
  - Feed, glass, off-gas system fluids/solids, samples from EPA method off-gas sampling, corrosion coupons, deposits, etc.
  - Essentially, a dedicated full-service analytical facility providing rapid turn-around
    - Very desirable situation to ensure maximum benefit from costly large-scale tests; minimize delays, maximize information feedback to Test Manager and operations staff
    - Since the VSL WTP PI is also the VSL Director, appropriate priority for resources was guaranteed
- Analysis for hazardous organics for regulatory purposes was subcontracted (STL-Knoxville) and employed an independent subcontracted data validator
- Both aspects worked very well

Tank Waste and Melter Feed Simulants

Glenn Diener – Energy*Solutions*

I.S. Muller, W. K.Kot, and I.L. Pegg – VSL

December 2007

Overview

- Over 350 bench-scale and 50 pilot-scale waste and melter feed simulants tested at VSL (both HLW & LAW)
- To ensure validity and suitability of simulants used for vitrification tests:
  - Compared to existing waste characterization data
  - Adapted to suit each test for which they were used
- To provide a rational basis for selection of glass former additives:
  - Evaluated the impacts of glass former additives on feed properties and stability
  - Evaluated cost and availability of materials
- To provide a rational basis for selection of operating ranges for waste concentration and melter feed solids content

Test Objectives

- Support melter and feed mixing tests
- Provide specifications of glass former additives for the target waste streams
- Obtain waste simulant and melter feed characterization data
- Determine effects of process variations (i.e., pH, solids content, temperature …) on feed stability
- Determine operating ranges for waste concentration and melter feed solids content and correlate to rheological properties

Simulant Parameters

Controlled Variables

- Waste chemical composition (envelope definition)
- Chemical selected for waste simulant (e.g., $Al(NO_3)_3 \cdot 9H_2O$ vs. $Al(OH)_3$)
- Minerals vs. reagents or technical grade chemicals (e.g., kyanite vs. Al_2O_3) as glass former additives
- Chemical selected for glass former additives (e.g., Li_2CO_3 vs. LiOH)
- Water Content
- Temperature (25 to 40 °C)
- Aging (feed stability with time) from 1 to 30 days
- Glass former additive particle sizes
- Order of addition
- Others: waste organic content, use of reductant (sugar), use of simulant modifiers (e.g., PAA, xanthan gum), use of surfactants

Simulant Parameters

Response Variables

- Density
- pH
- Total solids content (total dissolved solids & total suspended solids)
- Settling rate
- Particle size distribution
- Rheological properties (shear viscosity vs. shear rate & yield stress)
- Glass yield
- Time dependence (i.e., feed stability)

Simulant Design Strategy

- Chemical compositions based on inventory (TFCOUP) data and actual waste characterization
- Physical properties of melter feeds simulated to the extent possible but generally secondary to chemical composition
- Selection of starting materials based on actual waste data (hydroxides and oxides), availability, and costs
- For HLW - selection of non-radioactive surrogates to replace radioactive components determined by test objectives (e.g., U, Th replaced by Ce, Zr, Hf, Nd, etc., or simply omitted based on properties measured of radioactive glass and surrogate glasses)

LAW Simulants

- LAW Waste Simulant:
  - Na: sodium nitrate, sodium nitrite, sodium hydroxide, and sodium carbonate
  - Al: $Al(NO_3)_3 \cdot 9H_2O$ or a blend of $Al(NO_3)_3 \cdot 9H_2O$ and $Al(OH)_3$
  - K: hydroxide or carbonate
- LAW Glass Former Additives:
  - Kyanite, H_3BO_3, wollanstonite,…

HLW Simulants

- HLW Waste Simulant:
  - Mixed chemicals
    - Precipitated hydroxide method screened out as unnecessary and impractical from a cost perspective
  - Major components: $Fe(OH)_3$ slurry, other oxides and hydroxides
- HLW Glass Former Additives:
  - Chemicals only (no minerals) provided better control of material purity
  - Major components: Technical grade borax, soda ash, silica

Simulant Scale Up

- Made in-house and by industrial vendors (NOAH Technologies, Optima Chemicals, Colonial Chemicals)
- Unit batch size: 50 L (in-house) to 10,000 L (vendor for Duratek LAW Plant)
- Required volume per test: 200 L to 42,500 L
- Total processed (2002-2007): 550,000 L (HLW) 130,000 L at VSL + 4 Million L at Duratek Pilot (LAW)
- Glass produced in pilot demonstrations:
  - 440,000 lbs (HLW)
  - 250,000 lbs at VSL + 7.7 million lbs at Duratek Pilot (LAW)
- Variability in Hanford Sample Compositions:

LAW: AP-101, AZ-101, AZ-102, AN-102, AN-103, AN-104, AN-105, AN-107, AW-101, AP-101 combined with SY-104 and SY-101 combined with AP-104

HLW: C-104, AY-102/C-106, AZ-101 and AZ-102

Issues in Shipping and Handling

- Importance of specifications (or lack thereof) in packaging size and container type
- Temperature variation and delay in transport leading to compaction, crystallization, settling and change in rheology
- Insufficient head space in shipping container to re-mix properly

Issues During Testing or Between Simulant Batches

- Consistency between feed batches: variations in both physical and chemical properties

  Response: a “preview sample” was shipped overnight for preliminary testing before approval for delivery (acceptable recourse discrepancy has to be agreed upon as part of the procurement as large-scale batches are costly)

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Issues During Testing or Between Simulant Batches (cont'd)

- Synchronization between test sequence and delivery frequency - logistics

  Response: Delivery scale and storage capacity were increased

- Interruption of testing (e.g., pump failure overnight) leads to feed simulant settling and re-suspension issues

  Response: Equipment redundancy and back-up equipment to allow the feed to be re-mixed in steps.

Issues During Testing or Between Simulant Batches (cont'd)

- Crystallization of LAW and HLW melter feeds which appeared minor at the bench scale, became a much larger problem (2 to 3 inch crystals) at pilot scale (50-gallon drums)

  Response: Avoid long-term storage of feed; keep the feed concentration within the given limits; external drum warmer was very successful in re-dissolving borate crystals

Other Issues

- Market depletion of certain chemicals (e.g., zircon no longer available following China entering WTO, vendor discontinuing an approved product)
- Need for appropriate substitutes when specified starting materials become unavailable