HLW Pilot Melter Facility (DM1200) Lessons Learned

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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

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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

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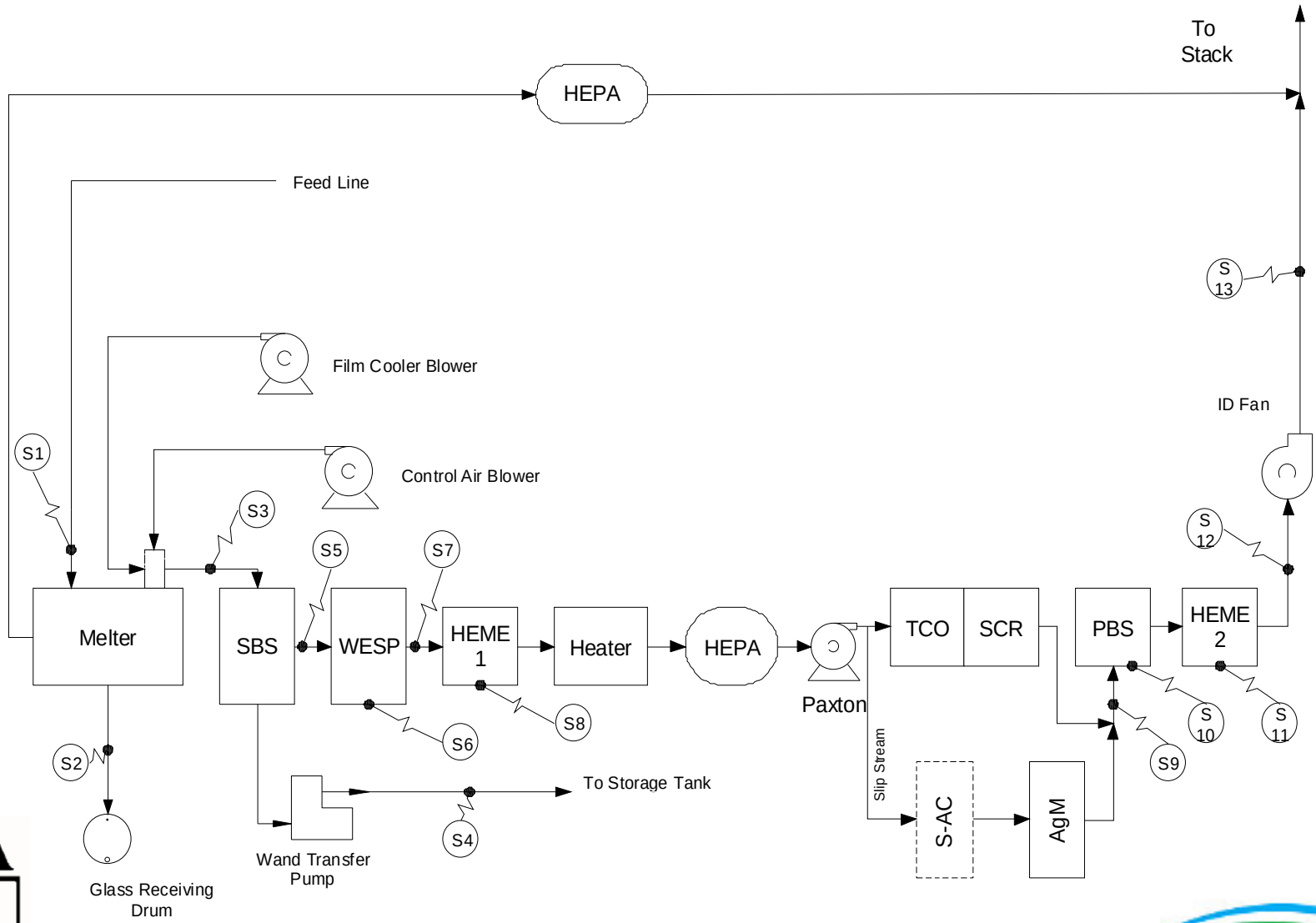
DM1200 HLW Pilot Melter System



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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

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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

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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

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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

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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)

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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

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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**

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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**

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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

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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

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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

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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

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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