EM U.S. Department of Energy
Office Of Environmental Management

Slurry Retrieval, Pipeline Transport & Plugging and Mixing Workshop

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Slurry Handling Workshop

- Background: A critical responsibility of DOE's Office of Environmental Management is the design, construction, and operation of equipment and facilities to process legacy radioactive waste slurries for safe, long-term disposal.
- Goal: DOE Office of Engineering and Technology, Office of Environmental Management sponsored a slurry handling workshop.
  - Identify technical vulnerabilities and to reduce risk.
  - Understand and disseminate lessons learned and best practices in the areas of waste slurry retrieval, transport, and mixing.
- Objective: Raise the level of awareness of slurry handling and processing.
  - Focus on the risks associated with slurry retrieval, mobilization, pipeline plugging, and stratification of slurries in vessels.
  - Provide technical education and expert commentary on slurry handling.
  - Generate a technical report documenting slurry transport to include mobilization and transport technologies.

Slurry Handling Workshop Overview

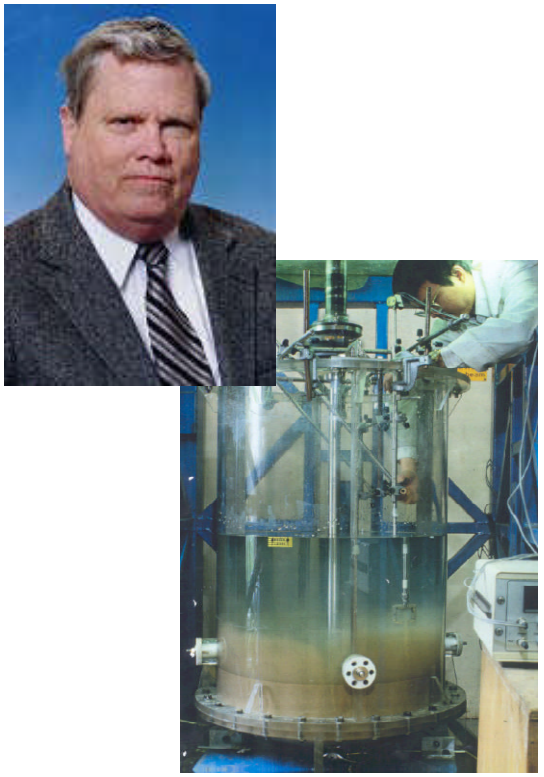
Workshop: Monday – Friday, January 14-18, 2008:

- Two-day short course on specialized slurry mixing and handling, conducted by private sector experts:
  - Dr. Art Etchells, Retired DuPont Fellow–Slurry mixing
  - Dr. Nigel Heywood, BHR Group – Slurry rheology & transport
- Three-day slurry handling workshop presentations and discussions on best practices, lessons learned from all attendees
  - DOE site presentations
  - Private sector, academia, and invited site keynote speakers
  - Breakout sessions specific to the retrieval, transport, and processing of slurries

Short Course: Slurry Handling Workshop

Slurry mixing – Dr. Art Etchells

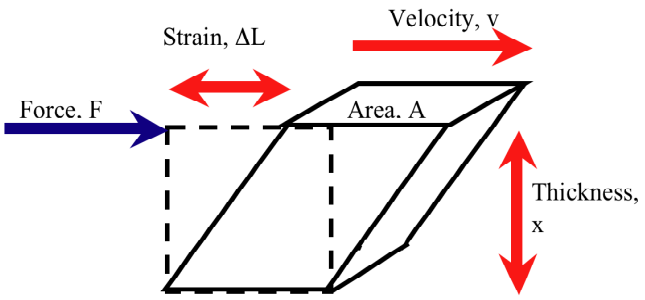
- What is Mixing and Why It Matters
- Process Result - Mixing Equipment
- Mixing Concepts – turbulence, power, flow patterns, settling, blending liquids, liquid-liquid dispersions
- Liquid Blending – yield stress materials
- Solid-Liquids Mixing – off bottom and distribution and attrition
- CFD (Computational Fluid Dynamics) to Solve Single Phase and Solid-Liquid Mixing Problems



Short Course: Slurry Handling Workshop

Slurry rheology & transport – Dr. Nigel Heywood

- Viscosity and the Flow Curve
- Flow Curve Measurement
- Physical Basis of Dispersion Rheology
- Pumps and Pumping
- Yield Stress Measurements
- Chemical Basis of Dispersion Rheology
- Pipeline Design for Non-Settling Slurries
- Pipeline Design for Settling Slurries



Three-Day Slurry Handling Workshop

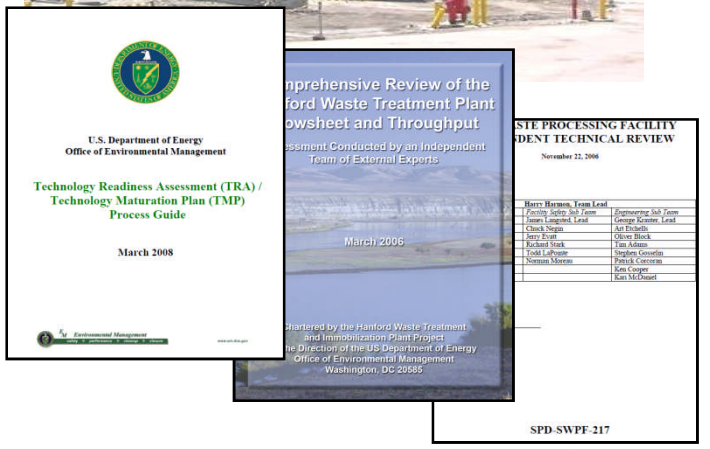
- DOE site presentations
  - Discuss current issues facing the DOE sites to share technical information
  - Hanford, Savannah River, Idaho, Oak Ridge

- Keynote speakers
  - Dr. Rick Bockrath, DuPont - Third Party Reviews – An Industrial Best Practice
  - Dr. David Gottslich, Independent Project Analysis, Inc. – The Problem with Solids
  - Prof. David Boger, University of Melbourne – Rheology and Surface Chemistry of Slurries
  - Dr. Robert Cooke, Patterson & Cooke – Slurry Retrieval & Transport

- Breakout sessions
  - Retrieval, Transport, and Processing
  - Special Sessions
    - Retrieval – Mobilization to Overcome Shear Strength
    - Transport – Open Channel Flow and Critical Velocity w/ Viscosity Adjustment
    - Processing – Pulse Jet Mixers
    - Computational Fluid Dynamics (CFD) Modeling
  - Selected talks in the areas of retrieval, transport, and processing from private sector, academia, DOE sites, and UK experience

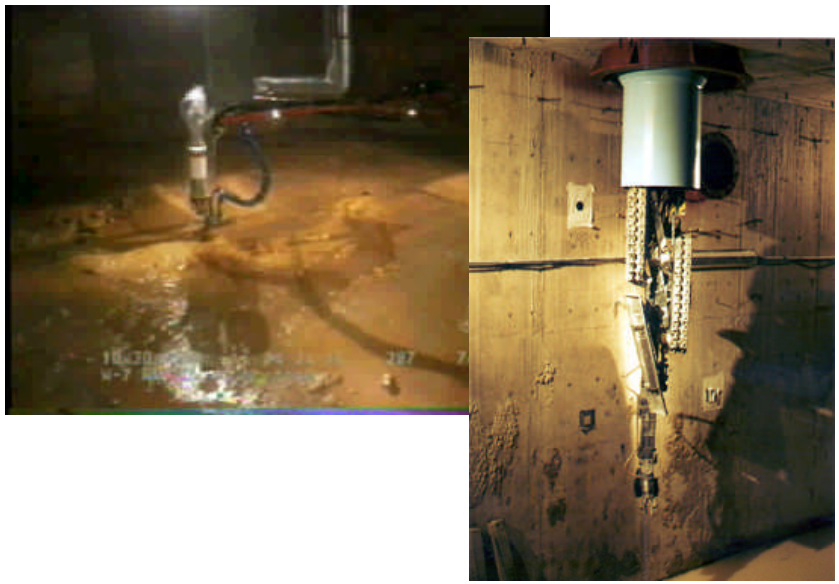
Key Messages from Industry/Academia Experts

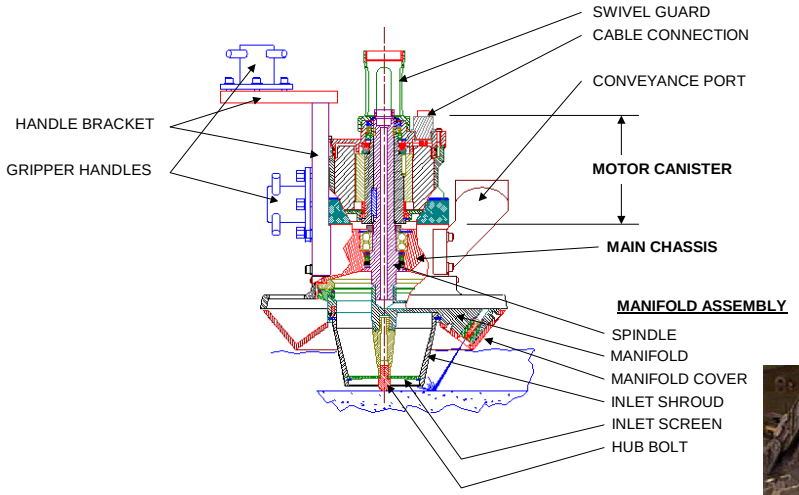
- Handling **slurries with solids is many times more difficult** than handling gases or liquids.
- Experience tells us that low cost innovation in process steps places success at high risk.
  - Even the **best projects** only have successful innovative process steps about **one-half the time**.
  - Too many innovative steps can lead to failure.
  - **Contingency plans** are needed around innovative processing steps.
- A common practice is **third-party independent technical reviews** throughout the project.
- Processes **must be designed** over a robust range of variable properties of slurries.



Key Messages from Retrieval Breakout Sessions

- The ability to design and field effective retrieval systems is **dependent upon having and understanding** the chemical, physical and rheological properties of the waste slurries.

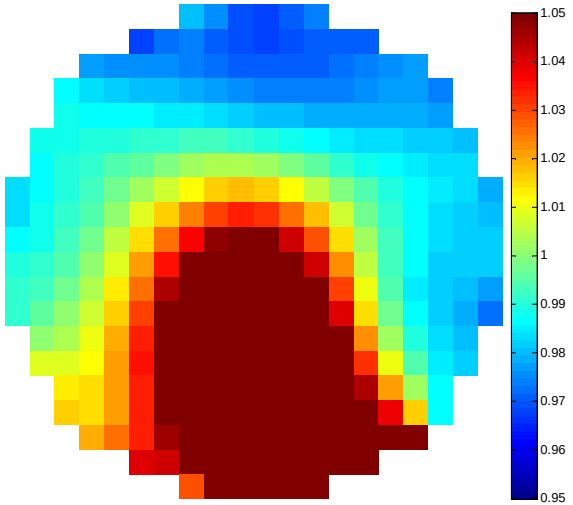




- Waste retrieval equipment utilized today **has little ability to control properties of the resulting slurries** that are conveyed out of the tanks.

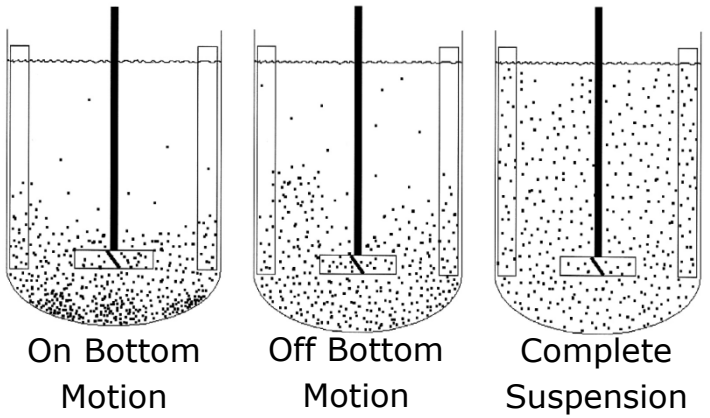
Key Messages from Transport Breakout Sessions

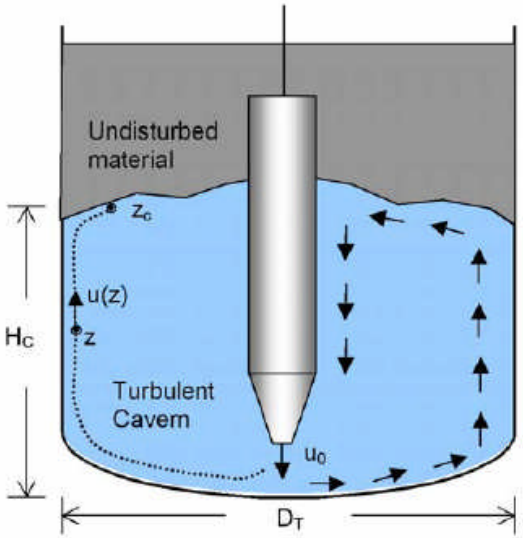
- An aggressive slurry physical and rheological characterization campaign is needed for proper design of slurry transport systems.
- Laminar flow regimes should be avoided in slurry pipeline design.
- While similar, typical mineral industry correlations are not appropriate for the particle property ranges encountered in DOE cleanup applications.
  - Recent data show that correlations are different for Newtonian and non-Newtonian slurries.



Key Messages from Processing Breakout Sessions

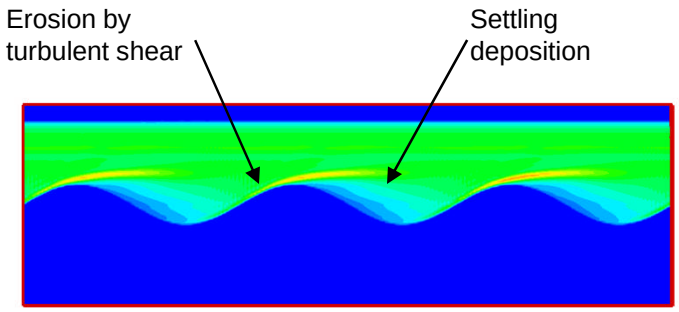
- There is high value in thorough cold testing of unit operations of slurry processing.
  - Each processing unit operation affects slurry chemical and physical properties—known extent is crucial to processing success.
- Pulse Jet Mixers (PJM):
  - PJMs are not designed to mix tall tanks by themselves.
  - Due to high velocities, PJMs must be checked experimentally for erosion potential.
- Mixing system devices handling slurries—such as tank farm waste—will be subject to a wide variety of feeds and cannot be designed based on average properties.





Key Messages from CFD and Process Modeling Breakout Session

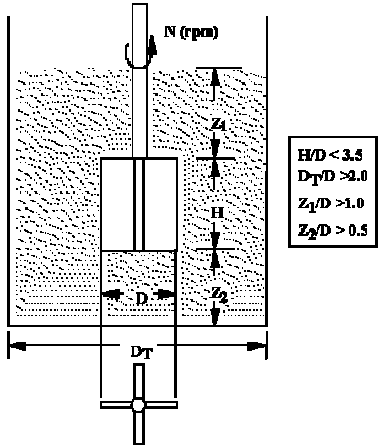
- It has not been proven that CFD is capable of accurate predictions when applied to multi-phase, chemically reacting mixtures with complex rheologies, such as non-Newtonian.
- Current CFD codes do not take advantage of DOE's investment in high performance computing.
- Validation against known data is crucial. Ability to predict behavior prior to actual experiments is the true test.



Traveling Sediment Waves in a Pipe

Recommendations on the Establishment of Technical Guidelines for Slurry Handling

- Use of standardized guidelines are valuable to ensure comparable results from all actual radioactive waste and simulant-based tests conducted within the DOE complex.
- Three sets of technical guidelines for use by engineers and scientists working on slurry issues were documented and recommended.
  - Waste Slurry Sampling and Measurement Techniques
  - Performing Chemical, Physical, and Rheological Properties Measurements
  - Simulant Development, Approval, Validation, and Documentation



Conclusions and Recommendations

- Private Sector experts: **slurry handling is difficult at best**
  - Independent third-party review with senior private sector experts is critical to success of slurry handling projects.
  - Characterization of slurry properties is necessary to reduce technical risk.
  - Large-scale testing of slurry handling equipment is essential.
- Slurry handling **workshops should be held every two years**.
  - Technology exchange meetings help assure maximum benefits from outcomes of technology development performed across the DOE complex.
  - Broader collaboration between private sector, academic, and DOE Sites through technical short courses, workshops, and exchanges are needed to ensure DOE mission success.
  - Sharing technical expertise and lessons learned is vital to reducing risk and technical uncertainties.
- An ongoing effort to develop and maintain a slurry handling core competency within the DOE Complex is required.

Final Words…

"The conviction was that the key to the design of slurry systems which would operate reliably lay, not in the selection of exotic materials or the design of special equipment, but in the *understanding* and control of the slurry environment."

EJ Wasp

Documentation: Slurry Handling Workshop

- EM Home > Engineering & Technology > Tank Waste & Waste Processing > Technical Assistance > Workshops: http://www.em.doe.gov/Pages/Workshops.aspx
  - CD Available upon request
    - Gary L. Smith, Gary.Smith@em.doe.gov
  - Report: Available November 21, 2008