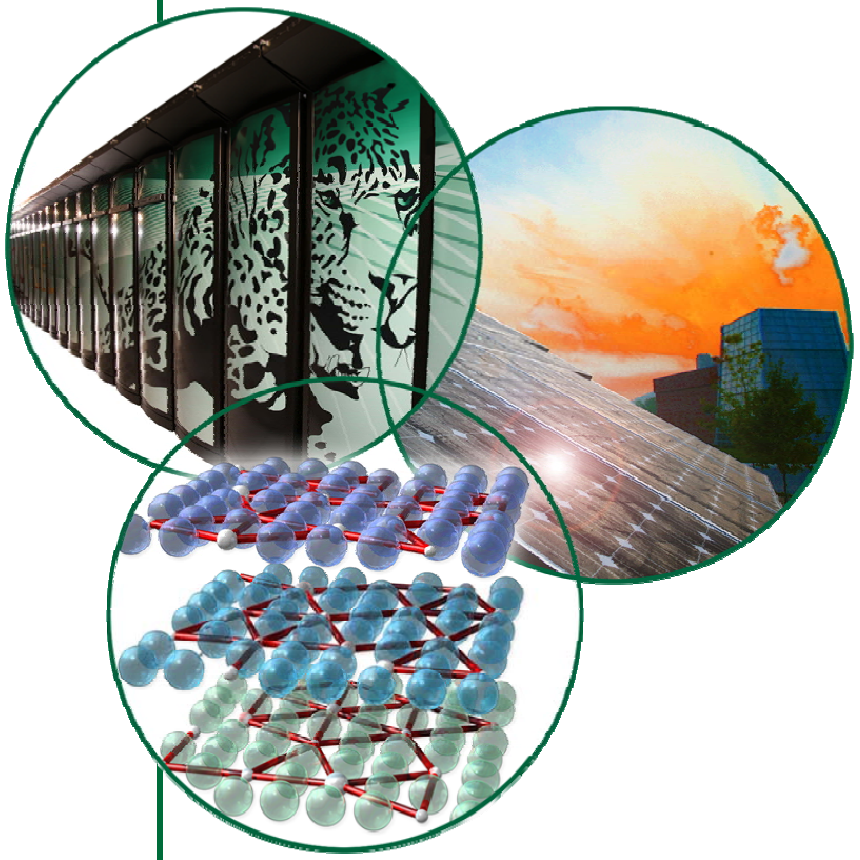
Mercury-Related Materials Studies



Van Graves

IDS-NF Phone Meeting
Jan 26, 2010 – updated Feb 3, 2010

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

ORNL Material Reports Reviewed

- IDS-NF requested ORNL research any past SNS-sponsored reports dealing with Hg-compatible materials
- Steve Pawel headed the SNS-related research
  - SNS research not a comprehensive, wide-ranging materials review, but rather a series of shorter, more focused experiments
  - Results documented mostly in ORNL reports, but some journal articles
  - Most work focused on SS316L/316LN in thermal convection loops and cavitation testing
  - Also investigated some 316L variants (composition changes, coatings, treatments, etc)

Cavitation Related Papers

- S. J. Pawel and E. T. Manneschmidt, “Preliminary Evaluation of Cavitation Resistance of Type 316LN Stainless Steel in Mercury Using a Vibratory Horn,” J. Nucl. Mater. 318 (2003) 122.
- S. J. Pawel, “Assessment of Cavitation-Erosion Resistance of 316LN Stainless Steel as a Function of Surface Treatment,” J. Nucl. Mater. 343 (2005) 101.
- S. J. Pawel, “Assessment of Cavitation-Erosion Resistance of Potential Pump Impeller Materials for Mercury Service at the Spallation Neutron Source,” Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2007/033, March 2007.
- S. J. Pawel and L. K. Mansur, “Cavitation-Erosion Resistance of 316LN Stainless Steel in Mercury Containing Metallic Solutes,” J. Nucl. Mater. 377 (2008) 174.
- J. R. Haines, B. W. Riemer, D. K. Felde, J. D. Hunn, S. J. Pawel, C. C. Tsai, "Summary of Cavitation Erosion Investigations for the SNS Mercury Target," J. Nucl. Mater. 343 (2005) 58.

More Cavitation Related Papers (added Feb 3, 2010)

- S. J. Pawel, E. T. Manneschmidt, R. P. Taleyarkhan, S. H. Kim, and J. R. DiStefano, "Cavitation as a Mechanism to Enhance Wetting in a Mercury Thermal Convection Loop," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2001/086, May 2001.
- S. J. Pawel and E. T. Manneschmidt, "Examination of Compatibility of Cavitation-Resistant Modifications to Type 316LN Stainless Steel in a Mercury Thermal Convection Loop," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2002/169, September 2002.
- S. J. Pawel, "Comparison of Cavitation-Erosion Resistance of Carburized and Carburized-Plus-Nitrided 316LN Stainless Steel in Mercury," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2007/058, May 2007.
- S. J. Pawel, "Assessment of End-of-Life Behavior of the Surface Modification to Improve Cavitation-Erosion Resistance in the Mercury Target at the Spallation Neutron Source," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2007/063, June 2007.
- S. J. Pawel and J. R. Nicholls, "Preliminary Assessment of Multi-Layer TiB2-Cr Applied to Ti-Based Alloys to Improve Cavitation-Erosion Resistance in Mercury," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2009/141, May 2009.
- S. J. Pawel, "Assessment of Cavitation-Erosion Resistance of Nitrogen-Alloyed CF3M Stainless Steel in Mercury Using a Vibratory Horn Technique," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2009/170, June 2009.
- S. J. Pawel, "Assessment of Cavitation-Erosion Resistance of 316LN Stainless Steel Following a Nitro-Carburizing Surface Treatment," Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2009/287, November 2009.

Hg Compatibility Papers

- J. R. DiStefano, S. J. Pawel, and E. T. Manneschmidt, “Materials Compatibility Studies for the Spallation Neutron Source,” Oak Ridge National Laboratory Technical Memorandum ORNL/TM-13675, September 1998.
- S. J. Pawel, J. R. DiStefano, J. P. Strizak, C. O. Stevens, and E. T. Manneschmidt, “Screening Test Results of Fatigue Properties of Type 316LN Stainless Steel in Mercury,” Oak Ridge National Laboratory Technical Memorandum ORNL/TM-13759, March 1999.
- S. J. Pawel, J. R. DiStefano, and E. T. Manneschmidt, “Thermal Gradient Mass Transfer of Type 316L Stainless Steel and Alloy 718 in Flowing Mercury,” J. Nucl. Mater. 296 (2001) 210.
- S. J. Pawel, R. P. Taleyarkhan, D. K. Felde, and E. T. Manneschmidt, “Influence of Mercury Velocity on Compatibility with Type 316L/316LN Stainless Steel in a Flow Loop,” J. Nucl. Mater. 318 (2003) 313.
- S. J. Pawel and E. T. Manneschmidt, “Corrosion of Type 6061-T6 Aluminum in Mercury and Mercury Vapor,” J. Nucl. Mater. 318 (2003) 355.
- S. J. Pawel and L. K. Mansur, "Preliminary Evaluation of Cavitation-Erosion Resistance of Ti-alloys in Mercury for the Spallation Neutron Source," J. Nucl. Mater. Xxx (2009) xxx. (in publication process)
- Added Feb 3, 2010
- S. J. Pawel, J. R. DiStefano, and E. T. Manneschmidt, “Effect of Surface Condition and Heat Treatment on Corrosion of Type 316L Stainless Steel in a Mercury Thermal Convection Loop,” Oak Ridge National Laboratory Technical Memorandum ORNL/TM-2000/195, July 2000.

IDS-NF Materials Research

- Pawel's Hg laboratory and waste handling capabilities still available
  - 4ft x 4ft walk-in hood
  - Standard lab hood (6ft x 2.5ft working surface)
  - Thermal convection loop tests
- Can perform small-scale Hg compatibility experiments with minimal overhead related to Health/Safety documentation & preparations
- Experiments related to exposure of most materials to Hg or Hg vapor
  - Potential wetting
  - Chemical interaction
  - Corrosion (mass transfer) of any type (general, pitting, liquid metal embrittlement, etc)
  - No radiation testing
- In the past, have also performed tensile & fatigue tests on materials immersed in Hg (special containers)
  - Much more expensive tests