The Consortium for Risk Evaluation with Stakeholder Participation III

Consortium Universities: ***Vanderbilt University****, Georgia Institute of Technology, Howard University, New York University School of Law, Oregon State University, Rutgers University, University of Arizona, University of Wisconsin - Madison*

C R E S P

December 2, 2013

Mr. William Hamel
Federal Project Director/Assistant Manager, Hanford Waste Treatment Plant
U.S. Department of Energy
PO Box 450, MSIN H6-60
Richland, WA 99352

Re: CRESP WTP PTF Technical Issues Review Team, Letter Report 1

Dear Mr. Hamel:

The review team (Attachment 1) formed by the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) at the request of DOE Office of River Protection met with representatives of DOE Office of River Protection, DOE Office of Environmental Management and Bechtel National, Inc. on November 14, 2013 to review and propose changes to the current strategy pursued by the Hanford waste treatment plant (WTP) pretreatment facility (PTF). These changes are focused on resolving the design confirmation and technical issues for pulse jet mixed (PJM) vessels. Supporting documentation was provided to the CRESP team and is identified in Attachment 2.

The primary elements of the proposed revised strategy identified above are as follows:

1. Replacing 4 PJM vessels (HLP-22, HLP-27A/B and HLP-28) in PTF intended to store Newtonian and non-Newtonian slurries that currently have 3 different designs with an increased number of smaller PJM vessels having a single common design. The currently planned vessels range in size from nominal sizes of 80,000 to 160,000 gallons and dimensions of 25 to 38 feet in diameter. The proposed replacement vessel should be no larger than 14 feet in diameter and have a nominal volume of no more than ca. 30,000 gallons with complete specifications yet to be determined. An increased number of vessels will be required to provide adequate processing volumes using a single vessel design that is smaller than the currently planned vessels.
2. Focusing the full-scale vessel testing to:
    a. Using testing on RLD-8, currently planned for Spring 2014, to demonstrate and validate PJM control strategies for Newtonian fluids having low concentrations of suspended solids;

b. Using testing on the new, single vessel design for non-Newtonian fluids to verify compliance with the functional requirements for the vessel; and,

c. Using definitive smaller-scale tests to understand vessel performance relationships and test conditions needed for full-scale vessel testing and thereby limiting the extent of full-scale vessel testing. Dimensional and computational analysis along with sub-scale testing should be used to inform the design of the common vessel.

The Review Team considers substantial benefits to the proposed revised strategy, including (i) potential simplification of the resolution of technical issues associated with hydrogen accumulation and release, criticality safety, structural integrity and corrosion/erosion, (ii) establishing common bases for control, safety, operations, sampling, training, commissioning and in-service inspection, and (iii) reducing the schedule for full-scale vessel testing by several years and reducing the associated cost of testing by several hundred million dollars. Thus, the Review Team fully endorses the proposed approach of using a single design for all PJM vessels for processing high solids Newtonian and non-Newtonian slurries, contingent on adequate resolution of the uncertainties identified below. The Review Team also considers that the proposed change in strategy should be used as an opportunity to fully evaluate all aspects of the design to be used for the common vessel to resolve current non-Newtonian vessel challenges.

At the time of the CRESP review, several aspects of the proposed strategy require further clarification prior to formalizing the decision to proceed:

1. Verification that PTF infrastructure and utilities (i.e., compressed air, ventilation, piping and connections, space, etc.) can support implementation of the increased number of vessels. It is possible that the revised design may result in either increased or decreased demands on footprint and PTF utilities;
2. Verification that the current sampling and analysis systems can support the increased number of samples expected from the increased number of vessels. It is possible that the changes in the safety basis and operational strategy associated with the proposed design change may actually reduce the number of samples required; and,
3. Verification that the number of transfers to and within the PTF required to support a decrease in total available storage volumes and an increased number of vessels will not have a significant adverse impact on operability and the waste processing throughput of PTF.

The Review Team also found that currently unresolved issues with respect to WTP design, design verification and operations are impeding efficient progress and completion of the non-Newtonian PJM vessel design for PTF:

1. Absence of an agreed upon strategy for the safety basis and criticality safety control that clearly defines the primary assumptions, conditions and approaches that are necessary for the PJM vessels design. This difficulty is further compounded by lack of flexibility and decisions in the feed vector and operational strategy as a foundation for the functional requirements and design basis, including the following examples:

a. Adherence to the contract feed vector and inclusion of processing waste from a limited number of tanks that contain plutonium (Pu) oxide that is not co-precipitated with neutron absorbers (e.g., iron) drives the current criticality control strategy and therefore requirements for non-Newtonian PJM vessels on sampling capabilities and stringent verification that fast-settling particles do not accumulate within the vessels. Definition of a feed vector that allowed for separate processing of waste containing non-co-precipitated Pu oxide, thus allowing vessel cleanout between a limited number of batches, or acceptance of direct feed to the High Level Waste vitrification facility would substantially simplify the design and design verification requirements.
b. Absence of acceptance of a single clear approach to assuring safety with respect to hydrogen in non-Newtonian PJM vessels is causing extensive analysis along multiple paths (i.e., structural integrity, hydrogen venting and probabilistic risk assessment) rather than a more limited set of sufficient analysis and design modifications.

2. Absence of sufficiently detailed specification of the functional requirements, in part dependent on definition of the safety basis (item 1 above), for the non-Newtonian PJM vessels that in turn can be used to establish the technical basis for design verification. For example, stated mixing requirements to “release gas,” “limit solids accumulation,” and “sample (for process control)” need more detailed specification for translation into clear design and design verification requirements.
3. Absence of clear specification of the important properties and limiting conditions for simulants with respect to testing for non-Newtonian PJM vessel design confirmation is resulting in development of overly complex and impractical specifications for waste simulants. The extent to which the simulants used need to fully represent the chemical as well as the physical and rheological properties of the waste has not been established.
4. Absence of a clear and detailed experimental test plan for either Newtonian or non-Newtonian full-scale vessel tests that includes i) objectives, ii) experimental design and approaches, iii) instrumentation strategies, iv) expected outcomes, and v) how the resulting data would be used to achieve the goal of providing essential missing data, and vi) the analysis required for validation of the computational models and verification of the vessel designs.
5. For Newtonian and non-Newtonian PJM vessels, absence of a comprehensive plan that leverages sub-scale testing and analysis to inform full-scale testing, minimizes the number of full-scale tests, provides guidance on instrumentation selection and placement, provides an efficient set of platforms to test a wider parameter space (e.g., simulants and chemistry effects), supports dimensional analysis to determine leading order parameters, defines how resulting data will be used, and verifies the choice of parameters to confirm a particular mixing requirement.

Based on the observations indicated above, the Review Team makes the following recommendations for the WTP project team to execute:

Recommendation 1. Within 90 days, complete the evaluation needed and finalize a decision on whether or not to proceed with the proposed approach to use a single common vessel design for high solids Newtonian and non-Newtonian PJM vessels in PTF. The proposed evaluation for a common vessel design should be extended to include vessels UFP-1 A/B and UFP-2 A/B in addition to the currently proposed replacement for HLP-22, HLP-27A/B and HLP-28 (a total of 8 vessels). The extension to include UFP-1 A/B and UFP-2 A/B will further simplify design verification and operations, including facilitating waste feed receipt into PTF with higher solids content than currently allowable based on UFP-01 A/B restrictions. The evaluation should be completed prior to the decision and should include (i) development of a conceptual design for PTF that incorporates the use of a common vessel design for high solids Newtonian and non-Newtonian PJM vessels, contains specification of the vessel arrangements, process flow configurations, and operational bounding conditions for key process variables (i.e., temperature, pressure, pH, solids content, slurry rheology, solids particle sizes, density and settling velocity distributions, particle hardness, erosion/corrosion requirements), (ii) verification that PTF infrastructure and utilities (i.e., compressed air, ventilation, piping and connections, space, etc.) can support implementation of the increased number of vessels, (iii) verification that the current sampling and analysis systems can support the number of samples expected from the increased number of vessels, and (iv) verification that the proposed design change will not have adverse impacts on operability and the waste processing throughput of PTF.

Recommendation 2. Within 90 days, complete multi-disciplinary design review of all the current specifications for the high solids Newtonian and non-Newtonian PJM vessels and identification of all technical challenges associated with the current designs. The outcome of this review should be used to develop the technical strategy for resolving all of the identified issues followed by initiation of the detailed design for the proposed new common vessel which may have significantly different features than any single current vessel design.

Recommendation 3. As national laboratories and federal resources with extensive applicable expertise, the Naval Research Laboratory (NRL) and National Energy Technology Laboratory (NETL) should be directly and substantially engaged through a direct reporting relationship to DOE, with appropriate external support as needed, in the planning and execution of the development of test plans, simulant selection, dimensional and computation analysis, and sub-scale and full-scale vessel testing used to support vessel design confirmation.

Recommendation 4. Within 30 days, develop a program that focuses near-term full-scale vessel testing using RLD-8 on resolving PJM control uncertainties. The outcome of this testing should be a verified control strategy with appropriate supporting data obtained under NQA-1 requirements. Further testing using RLD-8, not necessarily under NQA-1 requirements, should emphasize developing the necessary understanding and experience with instrumentation, measurements and experimental design to facilitate efficient design verification testing for the new common high solids Newtonian and non-Newtonian PJM vessel design.

Recommendation 5. Within 30 days, develop a technical specification of the functional requirements and domain of process conditions (i.e., chemistry, temperature, etc.) for a single, commonly designed high solids Newtonian and non-Newtonian PJM vessel in sufficient detail to enable specification of the vessel testing simulants, testing conditions and required testing measurements.

Recommendation 6. Within 60 days, develop clear specifications for the important properties and limiting conditions for simulants with respect to each functional requirement for the high solids Newtonian and non-Newtonian PJM vessel design confirmation. Multiple simulants (e.g., potentially an individual simulant for each of the specific functional requirements) may be appropriate to achieve design confirmation for different functional requirements. Subsequently, simulant selection and/or development should proceed with the intention of using the simplest possible and practical simulant or set of simulants that satisfy the design verification requirements. For example, a three part simulant, based on an aqueous phase, a narrow size distribution of a single particle type representing the majority of particles, and a limited size distribution of very dense particles to represent fast settling solids of concern, may be sufficient. The need to simulate the chemical composition of the waste should be evaluated based on the current knowledge of waste chemistry impacts on fluid/slurry properties and on vessel performance with respect to achieving the functional design requirements. Subsequent evaluation of whether chemical composition simulation is required should be based on small-scale comparative testing of vessel performance with a proposed physical-rheological simulant compared to a proposed physical-rheological-chemical simulant. Instrumentation and measurement capabilities for full-scale vessel testing should also be considered during simulant development. Furthermore, use laboratory and small-scale testing to verify the expected behavior of the proposed simulants. Final specifications and testing for the proposed simulant or simulants should be completed within 180 days.

Recommendation 7. Within 90 days, develop an agreed upon strategy for the safety basis and criticality safety control that clearly defines the primary assumptions, conditions and approaches that are necessary for the common high solids Newtonian and non-Newtonian PJM vessel design.

Recommendation 8. Within 90 days, formalize a decision that allows flexibility in the feed vector and, or, WTP operational strategy to mitigate the added complexity in the PTF design basis that arises from the presence of Pu not co-precipitated with neutron absorbers in fewer than 8 high level waste tanks.

Recommendation 9. Within 120 days, reconvene this review team to evaluate progress on the above recommendations and review additional topics as needed to facilitate timely completion of PJM vessel design verification. This review should include evaluation of a readiness assessment for full-scale vessel testing.

The Review Team would appreciate a written initial response to this set of recommendations within 30 days.

Sincerely,

David S. Kosson, Chair

Richard V. Calabrese

Chris Guenther

Gregory J. Orris

Robert Powell

Stanley I. Sandler

Stephen L. Yarbro

Attachments 1 and 2

Cc: DOE Office of River Protection: L. Holton, K. Smith
DOE Office of Environmental Management: K. Picha, R. Rimando, T. Schrader, A. Williams

ATTACHMENT 1 - CRESP WTP Review Team

David S. Kosson, Chair, CRESP WTP Review Team

David Kosson is Cornelius Vanderbilt Professor of Engineering at Vanderbilt University, where he has appointments as Professor of Civil and Environmental Engineering, Chemical Engineering, and Earth and Environmental Sciences. Professor Kosson also is the Principal Investigator for the multi-university Consortium for Risk Evaluation with Stakeholder Participation (www.CRESP.org), supported by the Department of Energy to improve the risk-informed basis for remediation and management of nuclear waste from former defense materials production and nuclear energy. Professor Kosson's research focuses on management of nuclear, energy production and industrial wastes, including process development and contaminant mass transfer applied to groundwater, soil, sediment, waste and cementitious materials systems. Dr. Kosson in collaboration with other Vanderbilt researchers, U.S. EPA and the Energy Research Centre of The Netherlands has developed the Leaching Environmental Assessment Framework (LEAF) for understanding the release of contaminants from wastes and construction materials under a wide range of use and disposal scenarios (www.vanderbilt.edu/Leaching). Dr. Kosson leads the Cementitious Barriers Partnership (www.CementBarriers.org) which is a multi-institution initiative focused on developing advanced tools for predicting the long-term performance of cementitious materials in nuclear applications. Professor Kosson has participated in or led many external technical reviews on nuclear waste processing for the Department of Energy including for tank wastes and a range of technology approaches at Hanford, Savannah River and Idaho sites. Dr. Kosson served as a member of U.S. DOE Secretary Chu's team to address design challenges associated with the Hanford Waste Treatment Plant. Professor Kosson also has provided expertise and leadership for the National Academies, and as advisory to the Department of Defense, for two decades on demilitarization of chemical weapons in the United States and abroad. Professor Kosson has authored more than 100 peer-reviewed professional journal articles, book, book chapters and other archival publications. He received his Ph.D. in Chemical and Biochemical Engineering from Rutgers University, where he subsequently was Professor of Chemical and Biochemical Engineering.

Richard V. Calabrese

Richard Calabrese is Professor of Chemical & Biomolecular Engineering at the University of Maryland, College Park. Before joining Maryland in 1981, he worked for Pickard, Lowe & Garrick and Stevens Institute of Technology. He received his BS degree from the University of Rochester and his MS and Ph.D. degrees from the University of Massachusetts. Rich's expertise is in the areas of turbulent mixing and multiphase flow, with emphasis on particle-eddy interactions, drop dispersion & coalescence, prediction & measurement of particle size distribution, and measurement & CFD simulation of velocity fields in stirred contactors and other process equipment. He is the author of more than 70 publications, has given more than

300 presentations, and is a consultant to numerous chemical and pharmaceutical companies. Prof. Calabrese is director of the High Shear Mixing Research Program at Maryland, an industrial consortium with about 15 member companies. Prof. Calabrese has received AIChE's NAMF Award for Sustained Contributions to Mixing Research & Practice, and was elected to Tau Beta Pi as an eminent engineer. He was a Fulbright Senior Scholar and SERC Visiting Fellow at the University of Birmingham (UK), a Visiting Scientist in the Particle Science & Technology group at the DuPont Experimental Station, and a Technical Adviser in the Office of the Assistant Secretary for Fossil Energy at DOE, working on issues related to carbon capture and storage. Over the past 10 years, he has provided input to DOE, BNI and WRPS on design matters related to slurry transport and mixing phenomena at the Hanford Waste Treatment Plant. Rich is a Fellow of the AIChE and currently serves as chair of its Chemical Technology Operating Council (CTOC). He is a founding member, Treasurer and Past President of the North American Mixing Forum, and has served as NAMF's national programming chair and as the Chair of MIXING XV (NAMF's 1995 biennial conference). Rich has contributed several chapters to NAMF's Handbook of Industrial Mixing. He has also served as a Subject Editor for Chem. Eng. Res. & Design, the journal of the European Federation of Chemical Engineers.

Chris Guenther

Chris Guenther's research experience has focused on model development and validation of reacting, densely loaded multiphase systems. The primary focus of this research was centered on developing full-scale Eulerian-Eulerian models for advanced fossil energy coal gasification devices. His current work has been leading a team of NETL, contractor and university researchers in providing comments and recommendations into the use of Pulse Jet Mixers (PJM) at the Waste Treatment & Immobilization Plant (WTP) to process nuclear waste at the Hanford site located in the state of Washington. His team has provided surveillance of DOE's Office of River Protection (ORP) contractor's verification and validation of computational fluid dynamics software, as it was being applied for design confirmation of the Pulse Jet Mixing vessels. Recently, his efforts have shifted to reviewing and providing recommendations to ORP into the full-scale vessel test plans for design verification of WTP PJM vessels.

Gregory J. Orris

Since receiving his Ph.D. in Physics at the University of California, San Diego in 1991 Dr. Orris has been employed within the Acoustics Division at the Naval Research Laboratory, where he is now the head of the Acoustic Signal Processing and Systems Branch. His Branch consists of thirty staff scientists and post-doctoral fellows performing cutting edge research in underwater acoustics, anti-submarine warfare, and related national security issues. It maintains core competencies in the following National Naval Responsibilities: underwater acoustic signal processing, environmental ocean acoustics, environmental inversion methods, and acoustic wave propagation in fluctuating environments. As a part of the Navy's S&T ocean acoustics community he has led major efforts in laboratory and at-sea experiments, developing novel data analysis and signal processing techniques applicable to low signal-to-noise ratio acoustic environments. A key component of this effort has included the development of in-situ environmental inversion techniques using at-sea multidimensional acoustic field measurements combined with large-scale computational modeling that are capable of providing accurate regional information of the dynamic water column in addition to detailed physical properties of the ocean sediment. Dr. Orris has personally published 50 works in the fields of acoustic multiple scattering, reverberation, acoustic metamaterials, and signal processing and has developed varied techniques to solve largescale numerical scattering and wave propagation problems. He also has worked extensively on National Nuclear Security Administration programs providing expertise in multi-scale acoustic field modeling methods, including direct finite element analysis, two and three dimensional parabolic equation techniques, normal mode techniques, wave number integration, and three-dimensional acoustic ray-theory. His efforts on behalf of these programs were used to provide global-scale acoustic simulation capabilities for the Non-Proliferation Treaty compliance monitoring community.

Robert Powell

Robert Powell is a Professor of Chemical Engineering and Materials Science and a Professor of Food Science and Technology at the University of California Davis where he has been a faculty member since 1984. From 2002 until 2011 he was the Chair of the Department of Chemical Engineering and Materials Science. In academic year 2011-12 he served full time as the Vice Chair of the Academic Senate of the University of California System and served as Chair of the Systemwide Academic Senate through August 2013. In these roles he was the public face of the faculty in all issues facing the University of California, dealing with the Regents, state government and the media. At UC Davis, from 2008-11 he served as the Chair of the Academic Senate. He has held temporary positions at the Swedish Forest Products Research Laboratory, Sandia National Laboratory and the National Science Foundation. He was the Panel Manager for the USDA Nanoscale Science in Food and Agriculture program from 2005-20008. At UC Davis, in 1998-99 he was Special Assistant to the Chancellor with specific responsibilities to oversee the development Office of Outreach and International Programs in anticipation of the hiring of a new Vice Provost. From 1996-1998 he was the Faculty Assistant to the UC Davis Provost. Some responsibilities in this position included organizing academic planning for the growth in the student body that occurred in the late 1990s and early 2000s. Powell's research is focused on a variety of issues related to the flow of slurries and emulsions. These include foods like tomato paste or ketchup, personal care products like shampoos or creams, fiber suspensions like those used in making paper or cellulosic ethanol. He has published over 110 papers in peer-reviewed journals ranging from the Journal of Applied Physiology to the Journal of Rheology, Journal of Fluid Mechanics, Physics of Fluids and Journal of Food Science. His research interests include the development of ways to equip manufacturing facilities that allow a much greater degree of precision and optimization. He has been a pioneer in the development of novel experimental techniques, including the use of magnetic resonance imaging for applications in industrial processes. He is a member of the Society of Rheology, American Institute of Chemical Engineers, American Chemical Society and the American Physical Society. He is also a Fellow of the American Physical Society. Since 2006 Powell has been involved in review of science and technology issues related to the Hanford waste pretreatment facility through the Vanderbilt Consortium for Risk Evaluation with Stakeholder Participation. Beginning in 2011 he has served on the Science and Technology Committee of the Board of Governors of the Limited Liability Corporations that oversee the management of the two nuclear weapons laboratories co-managed by the University of California. He also serves on the Board of Advisors for the Lawrence Berkeley Laboratory.

Stanley I. Sandler

Stanley Sandler is the H. B. du Pont Chair of Chemical and Biomolecular Engineering and Professor of Chemistry and Biochemistry at the University of Delaware, where he has also been department chair and acting dean. He is the author of approximately 385 papers, and several books including the two textbooks “Chemical, Biochemical and Engineering Thermodynamics” and the recently published “Introduction to Applied Statistical Thermodynamics”. He has received numerous honors including the Professional Progress, Warren K. Lewis and Founder’s Awards from the AIChE, and the E. V. Murphree Award from the ACS and other international awards. He is a member of the National Academy of Engineering and has been the editor of the AIChE Journal, as well as serving on a number of editorial boards. His current and recent visiting professorships include the National University of Singapore, the University of Melbourne (Australia) and Harbin Institute of Technology (China). He is a fellow of both the American Institute of Chemical Engineers and the Institution of Chemical Engineers (England). He is a Chartered Engineer and Chartered Scientist in England and the European Union. He received in B.Ch.E. degree from the City College of New York and his Ph.D. from the University of Minnesota, both in chemical engineering. He has also served on three NRC committees dealing with the destruction of chemical weapons.

Stephen L. Yarbro

Los Alamos National Laboratory (LANL), has a Ph.D. in Chemical Engineering from New Mexico State University and is a licensed Professional Engineer in the state of New Mexico.   Dr. Yarbro began his career as a process engineer in Tanks Farms and the 234-5Z Plutonium Facility at Hanford. After Hanford, he moved to Los Alamos National Laboratory to the TA-55 Plutonium facility. During that time, he has participated in the following projects:

- Led the successful preparation of 125 kg of plutonium oxide using an anion exchange procedure for shipment to France for fabrication into MOX fuel for use in a Duke Power nuclear reactor.
- Led team that developed separation chemistry for the Accelerator Transmutation of Waste Program.
- Successfully managed and completed a two-year project to develop a conceptual design for a recovery system to remediate a double-shell underground, radioactive-waste storage tank (SY-102) at the Hanford plutonium production site.

Dr. Yarbro has led a diverse set of major technical projects and organizations. As a part of that leadership, he develops and implements project management plans for complex and interdisciplinary multi-organizational projects. Examples of successfully leading complex programs and organizations:

International Research and Analysis - Dr. Yarbro led the technical intelligence analysis group that supported a variety of non-proliferation, foreign weapons assessment, export policy development, emergency response and other special projects.

Nuclear Materials Technology/Plutonium Manufacturing Technology - Dr. Yarbro successfully led NMT and PMT Divisions as the Division Leader from 2003 to 2007. NMT was a large division of 900 technical staff with a variety of technical and administrative backgrounds and educational levels. In that role, he had primary facility responsibility for four Hazard Category II nuclear facilities (TA-55, CMR, TA-18 and SST Pad). In addition, he managed an average $360M dollar annual budget for programmatic and facility activities in the TA-55, CMR, TA-18, and SST Pad facilities.

Actinide Process Chemistry - Dr. Yarbro led activities to safely and efficiently produce pure plutonium metal for certification and pit manufacturing. Major projects include stabilizing a variety of residues in accordance with the Defense Nuclear Facility Safety Board (DNFSB) recommendation 94-1; producing pure oxide for pit manufacturing and MOX fuel feed preparation activities.

ATTACHMENT 2

Documents Reviewed In Support of the CRESP WTP Review Meeting,

Washington, DC, 11/14/13

24590-WTP-RPT-PE-12-005 Rev 0. *River Protection Project – Waste Treatment Plant. Waste Mineralogy and Particle Physical Property Characterization.* (5 September, 2013).

24590-PTF-P1-P01T-00001. *Pretreatment Facility General Arrangement Plan at El. 0'0".* (9 November, 2011).

24590-WTP-3YD-50-00003 Rev. 0001. *Figure 2-2.* W*TP Vessels with PJMs to Scale, Arranged by Internal Diameter*. (14 November, 2013).

TP1201_21. *Waste Treatment Plant Overview, Pretreatment Facility, Low-Activity Waste Vitrification Facility, High-Level Waste Vitrification Facility, Analytical Laboratory*. (May, 2012)

Anderson, Scott. *Full Scale Vessel Testing (FSVT) Platform*. Presentation. (14 November, 2013).

Bronner, Aaron and Kilroy, Kyle. *Full Scale Testing / Vessel Analysis.* Presentation. (14 November 2013).

Brunson, Gary, Gilbert, Rob and Holton, Langdon K. *CRESP Review of the Waste Treatment and Immobilization Plant (WTP) Pulse Jet Mixer Program.* Presentation. (16 December, 2009).

Holton, Langdon K. *Design Verification Plan for Pulse-Jet Mixed Vessels in the Waste Treatment and Immobilization Plant - Revision 0.* Presentation. Department of Energy, Office of River Protection, Richland, Washington 99352. MSC-PRO-184. (10 October, 2013).

Holton, Langdon K. *Defense Nuclear Facilities Safety Board Mixing Letter*. Letter from John E. Mansfield, Ph.D., Vice Chairman. (6 January, 2010).

Holton, Langdon K. *Laboratories FSVT Cost Summary*. Document. (5 February, 2013).

Holton, Langdon K. and Daniel, Russell. *Strategy for Resolution of Technical Issues Associated With the WTP Pretreatment Non-Newtonian Vessels.* Presentation to the HAB Tank Waste Subcommittee. (4 February, 2012).

Rimando, Rodrigo V., Jr. *Design Optimization of Pulse Jet Mixed Vessels at Waste Treatment and Immobilization Plant: Streamlining Design Verification and Simplifying Designs. Deliberative Process - Pre-decisional Draft.* Presentation. (14 November, 2013).

Summers, Michael. *WTP Pretreatment Flow Diagram Rev. 4.* Presentation. (12 December, 2011)