PRELIMINARY TECHNOLOGY READINESS ASSESSMENT OF THE CALCINE DISPOSITION PROJECT
VOLUME TWO

Anthony F. Kluk
Hoyt C. Johnson
Clyde Phillip McGinnis
Michael Rinker
Steven L. Ross
Herbert G. Sutter
John Vienna

February 2011

Prepared by the U.S. Department of Energy
Washington, DC

Appendix C

Checklists for Critical Technology Elements and Technology Readiness Levels

This appendix provides the CTE and TRL checklists for the CTEs. For the TRL questions that receive a "Y" (yes) response, the supporting documentation is provided with a complete reference at the end of the TRL checklists for each CTE. For the TRL questions that receives a "N" (no) response, the required action and/or document is provided.

3.0 Waste Form/Additives

Table C-1. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No	Notes
• Does the technology directly impact a functional requirement of the process or facility?	X		The additives are required to make a final waste form that meets performance/acceptance criteria.
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	X		The additives have been tested, but do not perform as required for Hg and Cd. The additives will require modification to mineralize the Hg and Cd. The additives have not been tested for the bounding calcine waste forms.
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	X		The waste loading could decrease increasing the disposition volume which increases the life-cycle costs.
• Do limitations in the understanding of the technology impact the safety of the design?	X		The additives are not hazardous. The quantity does not impact safety. However, the mixing could be hazardous.
• Are there uncertainties in the definition of the end state requirements for this technology?	X		The Resource Conservation and Recovery Act (RCRA) land disposal restriction (LDR) (40 CFR 268) universal treatment standard (UTS) (40 CFR 268.48) toxicity characteristic leaching procedure (TCLP) (EPA 1992) nonwastewater standards and the *Civilian Radioactive Waste Management System - Waste Acceptance System Requirements Document* (WASRD) (DOE 2008) are the performance/acceptance standards. However, the final disposition and its waste acceptance criteria (WAC) are undefined.

Table C-1. (continued).

Set 2—Criteria	Yes	No	Notes
• Is the technology new or novel?	X		The use of additives to make a mineralized waste form for calcine is a new application.
• Is the technology modified?	X		The additives have been tested, but do not perform as required for Hg and Cd. The additives will require modification to mineralize the Hg and Cd. The additives have not been tested for the bounding calcine waste forms and actual HLW calcine.
• Have the potential hazards of the technology been assessed?	X		A preliminary hazard and operabilitiy review was completed (EDF-7748) with no negative results noted to date.
• Has the technology been repackaged so a new relevant environment is realized?	X		The waste-form testing has not performed at full scale and actual HLW calcine.
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	X		The waste form has been tested at 1 kg and 25 kg, not full scale. The additives have not been tested for the bounding calcine waste forms and actual HLW calcine.

3.0 Waste Form/Additives (continued)

Table C-2. TRL 3 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Academic (basic science) environment	Basic science described in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	Y	2. Some key process and safety requirements are identified; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Hazards are identified in the Preliminary Hazard and Operability Review of the Calcine Disposition Project (HAZOP) report (EDF-7748).
T	Y	3. Predictions of elements of technology capability validated by analytical studies	Waste form performance tested as described in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	Y	4. The basic science has been validated at the laboratory scale	Laboratory testing conducted. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	5. Science known to extent that mathematical and/or computer models and simulations are possible	Scientific data for computer modeling provided in Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	Y	6. Preliminary system performance characteristics and measures have been identified and estimated	Waste form performance and acceptance criteria provided in PLN-3448, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy."
T	NA	7. Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	Do not need Modeling and Simulation (M&S) as actual waste-form testing has been completed. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
M	Y	8. No system components, just basic laboratory research equipment to verify physical principles	Laboratory equipment tested in waste-form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993 1998), Nelson and Vinjamuri (1995).

Table C-2. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	9. Laboratory experiments verify feasibility of application	Laboratory experiments verify HIP feasibility. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).
T	Y	10. Predictions of elements of technology capability validated by laboratory experiments	Technology capability proven in laboratory tests. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).
P	Y	11. Customer representative identified to work with development team	DOE representatives are Ron Ramsey, Barbara Beller, and Joel Case.
P	Y	12. Customer participates in requirements generation	DOE participated in 30% design review where draft PLN-3448 with requirements was presented. Review comments were resolved, and the plan was revised and issued. The issued plan is currently being reviewed by DOE, EPA, and Idaho DEQ.
P	Y	13. Requirements tracking system defined to manage requirements creep	Requirements are in PLN-3448 and the CDP requirements tracking system (TFR-401).
T	Y	14. Key process parameters/variables and associated hazards have begun to be identified; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters/variables are included in INL and ANSTO (2009), BEA (2008), and PLN-3448. Hazards are identified in the HAZOP report (EDF-7748).
M	Y	15. Design techniques have been identified/developed	Design techniques provided in the 30% design review package.
T	Y	16. Paper studies indicate that system components ought to work together	Actual testing show that the components will work together to produce waste form. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995).
P	Y	17. Customer identifies technology need date.	The technology need dates are provided in PLN-3448.
T	Y	18. Performance metrics for the system are established (What must it do)	The performance and acceptance criteria are defined in PLN-3448.
P	Y	19. Scaling studies have been started	Scaling approach defined in PLN-3448. Actual scaling tests performed for 1 kg scaled to 25 kg (INL and ANSTO 2009).

Table C-2. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	20. Current manufacturability concepts assessed	Additives are composed of TiO_2, SiO_2, ZrO_2, and S which are commercially available.
M	Y	21. Sources of key components for laboratory testing identified	Components for waste-form testing available at HIP vendors.
T	Y	22. Scientific feasibility fully demonstrated	Scientific feasibility is fully demonstrated for the waste form as shown in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).
T	Y	23. Analysis of present state of the art shows that technology fills a need	PLN-3448 and INL and ANSTO (2009) show that the HIP technology at laboratory scale meets the expected performance and acceptance criteria for treating calcine.
P	Y	24. Risk areas identified in general terms	The risks for the waste-form development are identified in PLN-3448 and PLN-2477.
P	Y	25. Risk mitigation strategies identified	The risks mitigation strategies for the waste-form development are identified in PLN-3448 and PLN-2477.
P	Y	26. Rudimentary best value analysis performed for operations	The best value analysis for HIP versus other technologies is in *Calcine Disposition Project Calcine Treatment Options Summary* (ICP 2009).
T	Y	27. Key physical and chemical properties have been characterized for a number of waste samples	The physical and chemical properties are provided in Staiger and Swenson (2007), and summarized in PLN-3448. Physical properties in Berreth (1988). Actual HLW calcine sampling and analysis from Patterson and Prather (2004), EDF-6185, and Swenson and Thomas (2006).
T	Y	28. A simulant has been developed that approximates key waste properties	The composition of the three types of calcine surrogates has been developed as shown in PLN-3448.
T	Y	29. Laboratory scale tests on a simulant have been completed	Laboratory testing on 2 surrogate calcine types is reported in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).
T	Y	30. Specific waste(s) and waste site(s) has (have) been defined	Specific wastes and waste sites are defined Staiger and Swenson (2007), and summarized in PLN-3448.

Table C-2. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	31. The individual system components have been tested at the laboratory scale	System components to make waste form has been test and reported in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-4 from DOE Guide 413.3-4.

3.0 Waste Form/Additives (continued)

Table C-3. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters/variables are included in INL and ANSTO (2009), BEA (2008), and PLN-3448. Issued. Hazards are identified in the HAZOP report (EDF-7748).
M	N	2. Laboratory components tested are surrogates for system components	Laboratory tests included components mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste-form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007). Issued. Need tests with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with $CaSO_4$ additive formulation.
T	N	3. Individual components tested in a laboratory or by supplier	Laboratory tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste-form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007). Issued. Need tests with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with S additive formulation.
T	N	4. Subsystems composed of multiple components tested at laboratory scale using simulants	Laboratory tests included subsystems for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste-form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007). Issued. Need tests with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with additive formulation.
T	NA	5. Modeling and Simulation used to simulate some components and interfaces between components	Will use actual testing. HIP can modeling in progress.
P	Y	6. Overall system requirements for end user's application are <u>known</u>	Overall system requirement for the waste form and additives are provided in PLN-3448.

Table C-3. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	7. Overall system requirements for end user's application are documented	Overall system requirement for waste form/ additives are provided in PLN-3448.
P	Y	8. System performance metrics measuring requirements have been established	Waste form performance/acceptance criteria are provided in PLN-3448.
P	Y	9. Laboratory testing requirements derived from system requirements are established	Waste form performance/acceptance criteria are provided in PLN-3448.
M	N	10. Available components assembled into laboratory scale system	Laboratory tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007). Issued. Need tests with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with additive formulation.
T	N	11. Laboratory experiments with available components show that they work together	Laboratory tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007). Need tests with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with S additive formulation.
T	N	12. Analysis completed to establish component compatibility (Do components work together)	Need analysis of component compatibility with Al, Zr, and Al nitrate/SBW with maximum RCRA metals with additive formulation.
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	Demonstration and data requirements established in PLN-3448. DOE concurrence of PLN-3448.
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Additives and waste form tested in hot cell environment by BEA (2008). BEA data report in progress.

Table C-3. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Additives have been tested at 1 kg and scaled to 25 kg (INL and ANSTO 2009). Commercial vendors have HIP treated powder mixtures at large scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	Conceptual Design Report (CDR) (ICP 2010).
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Scale-up approach provided in PLN-3448.
T	Y	18. Controlled laboratory environment used in testing	BEA testing performed in HFEF hot cell (BEA 2008).
P	Y	19. Initial cost drivers identified	Cost drivers provided in Calcine Treatment Options Summary (ICP 2009) and the CDR (ICP 2010).
M	Y	20. Integration studies have been started	30% design process flow sheets. HIP can and waste form integration in SDD-266.
P	Y	21. Formal risk management program initiated	PLN-2477.
M	Y	22. Key manufacturing processes for equipment systems identified	Additives are composed of TiO_2, SiO_2, ZrO_2, and $CaSO_4$ which are commercially available.
P	Y	23. Scaling documents and designs of technology have been completed	Scaling of waste form defined in PLN-3448.
M	NA	24. Key manufacturing processes assessed in laboratory	Additives are composed of TiO_2, SiO_2, ZrO_2, and $CaSO_4$ which are commercially available.
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	The CDR (ICP 2010) identifies systems/subsystems and the process descriptions.
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Reported in INL and ANSTO (2009).
M	NA	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Additives are composed of TiO_2, SiO_2, ZrO_2, and $CaSO_4$ which are commercially available.

Table C-3. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Detailed analyses of calcine complete (Staiger and Swenson 2007). Summarized in PLN-3448. Physical properties in Berreth (1988). Actual HLW calcine sampling and analysis from Patterson and Prather (2004); EDF-6185; and Swenson and Thomas (2006). Issued.
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Surrogate calcine for testing developed from pilot plant calcines. EDF in progress.
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Tests reported in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri 1995, Tripp and Maio (2006), and Carter et al. (2007).
T	Y	31. Process/parameter limits and safety control strategies are being explored	Key process parameters/variables are included in INL and ANSTO (2009), BEA Process Worksheets, and PLN-3448. Safety controls are addressed in the HAZOP report (EDF-7748).
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Test plans prepared.
P	Y	33. Technology availability dates established	Critical path schedule provided in PLN-3448.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

3.0 Waste Form/Additives (continued)

Table C-4. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Need to perform full-scale waste form testing with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	Need to update reliability, availability, maintainability, and inspectability (RAMI) during preliminary design.
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Need preliminary design drawings for final plant system.
T	N	4. Operating environment for final system known	Need preliminary design equipment arrangements and dose calculations.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale waste form testing with full-scale HIP mockup system.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Need Performance Baseline (including total project cost, schedule, and scope).
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Need operating limits for components determined (from design, safety and environmental compliance).
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008.	Need operational requirements document available; to include compliance with DOE-STD-1189-2008.
P	N	9. Off-normal operating responses determined for engineering scale system	Need off-normal operating responses determined for full-scale mockup system.
T	N	10. System technical interfaces defined	Need system interface control documents (ICDs) finalized.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale waste form testing with full-scale HIP mockup system.

Table C-4. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale waste form testing with full-scale HIP mockup system.
P	N	13. Analysis of project timing ensures technology will be available when required	Need to perform full-scale waste form testing with full-scale HIP mockup system.
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	Need acquisition program milestones established for start of final design.
M	Y	16. Critical manufacturing processes prototyped	Additives are composed of TiO_2, SiO_2, ZrO_2, and $CaSO_4$ which are commercially available.
M	N	17. Most pre-production hardware is available to support fabrication of the system	Need to assemble full-scale HIP mockup system.
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale waste form testing with full-scale HIP mockup system.
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Need to perform full-scale waste form testing with full-scale HIP mockup system.
P	N	20. Technology "system" design specification complete and ready for detailed design	Need to perform full-scale waste form testing with full-scale HIP mockup system to validate preliminary design.
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale waste form testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale waste form testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	Defined in PLN-2478.
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale waste form testing with full-scale HIP mockup system.

Table C-4. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Need final technical report on technology.
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Need finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls
M	N	27. Process and tooling are mature to support fabrication of components/system	Need completion of preliminary design to affirm all equipment is commercially available.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale waste form testing on the full range of calcine surrogates with full-scale HIP mockup system.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	Need to perform full-scale waste form testing with full-scale HIP mockup system.
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale waste form testing with full-scale HIP mockup system and comparison to laboratory scale testing.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale waste form testing with full-scale HIP mockup system to validate variables/parameters and safety controls.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale waste form testing with full-scale HIP mockup system to validate preliminary design.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale waste form testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

3.0 Waste Form/Additives References

40 CFR 268, 2010, "Land Disposal Restrictions," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 268.48, 2010, "Universal Treatment Standards," *Code of Federal Regulations*, Office of the Federal Register.

BEA, 2008, Process ANSTO Can #1133 in Hot Isostatic Press, PWS No. 2-4125, Battelle Energy Alliance, October 20, 2008.

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste*, WINCO-1050, Westinghouse Idaho Nuclear Company.

Carter, Melody L., Martin W. A. Stewart, Eric R. Vance, Bruce D. Begg, Sam Moricca, and Julia Tripp, "HIPed Tailored Ceramic Waste Forms for the Immobilization of Cs, Sr, and Tc," INL/CON-07-12875, *Preprint for Global 2007, Boise Idaho, September 9–13, 2007*.

DOE, 2008, *Civilian Radioactive Waste Management System - Waste Acceptance System Requirements Document,* DOE/RW-0351, Rev. 5, U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

DOE-STD-1189-2008, 2008, "Integration of Safety into the Design Process," U.S. Department of Energy.

EDF-6185, 2005, "Investigation into Low Aluminum Results Found in Alumina Calcine from Bin Set 2," Rev. 0, Idaho Cleanup Project, September 20, 2005.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EPA, 1992, Method 1311, "Toxicity Characteristic Leaching Procedure," Rev. 0, in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*, SW-846, Third Edition, U.S. Environmental Protection Agency.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

INL and ANSTO, 2009, *Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration,* FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Nelson, L. O., and K. Vinjamuri, 1995, *Results of Intermediate-Scale Hot Isostatic Can Experiments*, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

Patterson, Michael W., and Allen R. Prather, 2004, *D-Cell Calcine Sampling and Analysis*, ICP/EXT-04-00423, Rev. 0, Idaho Completion Project, Idaho National Engineering and Environmental Laboratory.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences*, Vol. 33, Issue 7.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, *Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms*, HLW-REF-5076/BAS-12-88.

Swenson, M. C., and T. R. Thomas, 2006, *Comparison of Analytical and Modeled Zirconia Calcine Composition Data*, RPT-221, Rev. 0, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Tripp, Julia, and Vince Maio, 2006, *Evaluation of the Use of Synroc to Solidify the Cesium and Strontium Separations Product from Advanced Aqueous Reprocessing of Spent Nuclear Fuel*, INL/EXT-06-01377, Battelle Energy Alliance.

Vinjamuri, K., and S. V. Raman, 1991, *Progress Report for FY 1991: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High-Level Waste*, HLW-REF-5059.

5.5.1 Calcined Solids Storage Facility (CSSF) 1 Reconfiguration

The CSSF 1 reconfiguration includes the following major items; core drilling through the roof of the existing CSSF 1 bin vault, remotely cutting holes and installing access risers in the existing bins, extending the existing vault walls and building a new "roof" over the existing vault to provide a large flat working platform for the hose management system, and reconfiguring the bin vent system.

Table C-5. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No	Notes
• Does the technology directly impact a functional requirement of the process or facility?	X		CSSF 1 reconfiguration will require modifications to install bin access risers, and modify the bin vent system, and shielding (vault roof). CSSF 1 has facility functional requirements for these systems.
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	X		Modification of the bin vault roof and installation of bin access risers pose a schedule risk if the technology is not ready or fails to operate as designed.
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	X		Limitations in understanding the technologies needed to modify CSSF 1 could affect the accuracy of Project cost estimates, which could result in significant cost overruns.
• Do limitations in the understanding of the technology impact the safety of the design?		X	The safety implications of modifying CSSF 1 are well understood and are not affected by technology understanding limitations.
• Are there uncertainties in the definition of the end state requirements for this technology?	X		The final state of the CSSFs is uncertain because there is no final, approved, closure plan for the CSSFs.

Table C-5. (continued).

Set 2—Criteria	Yes	No	Notes
• Is the technology new or novel?		**X**	The technology (such as core drilling and remote welding) needed to make the needed modifications to CSSF 1 is not new or novel.
• Is the technology modified?	**X**		The modifications needed for CSSF 1 will use standard technology that will be modified for use in a radioactive and contaminated environment.
• Have the potential hazards of the technology been assessed?	a	a	The potential hazards will be identified and evaluated in a future update of the existing CSSF Safety Analysis Report (SAR-105).
• Has the technology been repackaged so a new relevant environment is realized?	**X**		Standard technology will be used in a radioactive and contaminated environment.
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		X	The modifications needed on CSSF 1 will be designed for the CSSF 1 environment and conditions.

a. In this and subsequent locations in this appendix, these cells have been left blank intentionally.

5.1.1 Calcined Solids Storage Facility (CSSF) 1 Reconfiguration (continued)

Table C-6. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters such as calcine composition and characteristics have been identified (Staiger and Swenson 2007). CSSF 1 is an existing facility. Key CSSF 1 facility requirements and parameters are identified in the existing CSSF Safety Analysis Report (SAR-105). SAR-105 also identifies existing CSSF hazards. Hazards associated with the modification of CSSF 1 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
M	N/A	2. Laboratory components tested are surrogates for system components	Laboratory surrogates will not be used for the CSSF 1 modifications.
T	N/A	3. Individual components tested in laboratory/or by supplier	Individual components that will be used in the CSSF 1 modification will not be tested in a laboratory. Any testing of materials or components (such as concrete tests or material certifications) will be determined in preliminary design and incorporated into appropriate material specifications which will be developed in preliminary design.
T	N/A	4. Subsystems composed of multiple components tested at laboratory scale using simulants	The CSSF 1 modifications will not involve process/equipment systems involving multiple components that require laboratory scale testing.
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Conceptual level designs, modeling, and simulation of some CSSF 1 changes and interfaces between components are complete and documented in the CDR (ICP 2010); EDF-8444; EDF-8639; EDF-8727; EDF-8784; Lopez (1999); and Raytheon (1995). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 1 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	6. Overall system requirements for end user's application are known	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
T	Y	7. Overall system requirements for end user's application are documented	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).

Table C-6. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	8. System performance metrics measuring requirements have been established	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	N/A	9. Laboratory testing requirements derived from system requirements are established	The CSSF 1 modifications have no laboratory testing requirements.
M	N/A	10. Available components assembled into laboratory scale system	The CSSF 1 modifications have no laboratory testing requirements.
T	N/A	11. Laboratory experiments with available components show that they work together	The CSSF 1 modifications have no laboratory testing requirements.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 1 equipment after CSSF facility modifications (Nevins 2005, 2006a, 2006b). Conceptual layout drawings are complete for CSSF 6 in the CDR (ICP 2010). CSSF 1 will be modified to implement the CSSF 6 conceptual design. Conceptual studies are complete to show CSSF 1 could be modified to have a flat working platform similar to that of CSSF 6 (EDF-8784). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 1 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	CSSF 1 modifications are included in this Technology Maturation Plan.
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Safety functions of CSSF 1 are identified in SAR-105. CSSF modification designs will maintain SAR-required safety functions. A formal hazard analysis (EDF-7748) and conceptual safety design report (Abbott 2010) have been written to address safety issues with the CSSF modifications. Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 1 equipment after CSSF facility modifications (Nevins 2005, 2006a, 2006b). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 1 has been performed at West Valley (Jackson and Gessner 1988).

Table C-6. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N/A	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	CSSF 1 already exists. There are no scaling issues with CSSF 1 modifications that are not integral to the development of the retrieval equipment. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 1 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	The modified CSSF system is described in SDD-291 and PDD-175. A material balance has been developed that includes calcine from all CSSFs (EDF-8549). System descriptions and process flow diagrams have been developed and are in the CDR (ICP 2010). Details and applicable drawings for the modification of CSSF 6 are in the CDR (ICP 2010]). CSSF 1 will be modified to use the same design concepts as those for CSSF 6. Detailed CSSF 1 drawings will be developed during preliminary design.
M	N/A	17. Equipment scale-up relationships are understood/accounted for in technology development program	There are no technology development or consequent scale-up issues with the CSSF 1 modifications that are not integral to the development of the retrieval equipment.
T	N/A	18. Controlled laboratory environment used in testing	There is no laboratory testing for the CSSF 1 modifications.
P	Y	19. Initial cost drivers identified	Cost drivers for the CSSF 1 modifications are included in the CDR (ICP 2010). A formal risk management program (PLN-2477) identifies the cost risk drivers.
M	Y	20. Integration studies have been started	Process integration studies for CSSF 1 have started and are reflected in the system design descriptions (SDD-291), a time and motion study (EDF-9692), general arrangement drawings the CDR (ICP 2010), program description document (PDD-175), and other CSSF 1 integration studies (EDF-8444).
P	Y	21. Formal risk management program initiated	A formal risk management program has been developed (PLN-2477).
M	Y	22. Key manufacturing processes for equipment systems identified	Modifications to CSSF 1 will use readily available equipment.
P	N/A	23. Scaling documents and designs of technology have been completed	CSSF 1 already exists. There are no scaling issues with CSSF 1 modifications that are not integral to the development of the retrieval equipment.

Table C-6. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	NA	24. Key manufacturing processes assessed in laboratory	CSSF 1 modifications will involve standard manufacturing processes that have a proven track record. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 1 has been performed at West Valley (Jackson and Gessner 1988).
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	The existing CSSF 1 has a functional process description (SDD-189). The functional process description for the modifications to CSSF 1 needed for calcine retrieval is included in the system design description and the program design description (SDD-291 and PDD-175).
T	N/A	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	There will be no laboratory environment for the CSSF 1 modifications.
M	N/A	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Shortfalls in the capability to be manufactured or produced are not an issue with CSSF 1 modifications because needed materials are readily available.
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	CSSF 1 is an existing facility and its physical properties are documented in plant drawings, specifications, and SAR-105. Key chemical and physical properties of the calcine are documented in Staiger and Swenson (2007).
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Waste simulants are not required for the CSSF 1 modifications.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Laboratory waste simulants are not needed for the CSSF 1 modifications.
T	Y	31. Process/parameter limits and safety control strategies are being explored	CSSF 1 is an existing facility. Key CSSF 1 facility safety requirements have been identified in SAR-105. SAR-105 also identifies control strategies. Hazards associated with the modification of CSSF 1 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
T	N/A	32. Test plan documents for prototypical laboratory scale tests completed	There will be no laboratory scale work for the CSSF 1 modifications, consequently no laboratory scale tests.

Table C-6. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N/A	33. Technology availability dates established	CSSF 1 modifications are included in this Technology Maturation Plan.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.1.1 Calcined Solids Storage Facility (CSSF) 1 Reconfiguration References

Abbott, David G., 2010, *Conceptual Safety Design Report for the Calcine Disposition Project*, RPT-366, Rev. 3 (draft pending final DOE approval), Idaho Cleanup Project.

DOE-STD-1189-2008, 2008, "Integration of Safety into the Design Process," U.S. Department of Energy.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-8444, 2010, "Installation of Large Risers on the Calcined Solids Storage Facilities Bins Feasibility Evaluation," Rev. 2, Idaho Cleanup Project, August 3, 2010.

EDF-8549, 2010, "Calcine Disposition Project Material Balance for HIP Treatment," Rev. 2, Idaho Cleanup Project, August 17, 2010.

EDF-8639, 2010, "Calcined Solids Storage Facilities Bin Obstructions Alternatives Evaluation," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8727, 2010, "Evaluation of Alternatives for Retrieval of Calcine from a Full Calcined Solids Storage Facility Bin," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8784, 2008, "Conceptual Design for CPP-729 (CSSF-1) Retrieval Equipment Roof Platform," Rev. 0, Idaho Cleanup Project, June 12, 2008.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Jackson, Jacqueline P., and Ralph F. Gessner, 1988, *Remote Installation of Risers on Underground Nuclear Waste Storage Tanks*, DOE/NE/44139—45, DE88 010531, West Valley Nuclear Services Company, West Valley, New York.

Lopez, Daryl Anthony, 1999, *Bin Set 1 Feasibility Study,* INEEL/EXT-2000-00952, Rev. 0, Idaho National Engineering and Environmental Laboratory.

Nevins, P. W., 2005, *Calcine Bins Retrieval and Transfer System: Test Report*, ESI Document No. 2156-6-004, AEA Technology Engineering Services, January 2005.

Nevins, P. W., 2006a, *Calcine Bins Retrieval and Transfer System Enhancements*, ESI Document No. 2200-4-001, Rev. 1, AEA Technology Engineering Services, April 2006.

Nevins, P. W., 2006b, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PDD-175, 2010, "Calcine Solids Storage Facility Design Description for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270372, Idaho Cleanup Project.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

Raytheon, 1995, *Idaho Chemical Processing Plant Bin Set 1 Calcine Recovery Project, Phase I & II Special Studies Report,* Project No. 9354.200,204, HLW-103-100, Raytheon Engineers & Constructors.

SAR-105, 2007, "Safety Analysis Report for the Calcined Solids Storage Facilities," Rev. 2, Idaho Cleanup Project, August 16, 2007.

SDD-189, 2005, "Calcined Solids Storage Facility Vault 1 at INTEC," Rev. 0, Idaho Cleanup Project, January 25, 2005.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.1.2 Calcined Solids Storage Facility (CSSF) 2 Reconfiguration

The CSSF 2 reconfiguration includes the following major items; extending the existing vault walls and building a new "roof" over the existing vault to provide a large flat working platform for the hose management system, and reconfiguring the bin vent system. If more than one access riser is required per bin, then CSSF 2 modification will also require core drilling through the roof of the existing CSSF 2 bin vault, remotely cutting holes and installing access risers in the existing bins. This form is filled out with the assumption that new risers will be installed on CSSF 2.

Table C-6. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No	Notes
• Does the technology directly impact a functional requirement of the process or facility?	X		CSSF 2 reconfiguration will require modifications to install bin access risers, and modify the bin vent system, and shielding (vault roof). CSSF 2 has facility functional requirements for these systems.
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		X	Modification of the bin vault roof and installation of bin access risers pose a schedule risk if the technology is not ready or fails to operate as designed.
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		X	Limitations in understanding the technologies needed to modify CSSF 2 could affect the accuracy of Project cost estimates, which could result in significant cost overruns.
• Do limitations in the understanding of the technology impact the safety of the design?		**X**	The safety implications of modifying CSSF 2 are well understood and are not affected by technology understanding limitations.
• Are there uncertainties in the definition of the end state requirements for this technology?	X		The final state of the CSSFs is uncertain because there is no final, approved, closure plan for the CSSFs.

Table C-6. (continued).

Set 2—Criteria	Yes	No	Notes
• Is the technology new or novel?		**X**	The technology (such as core drilling and remote welding) needed to make the needed modifications to CSSF 2 is not new or novel.
• Is the technology modified?		**X**	The modifications needed for CSSF 2 will use standard technology that will be modified for use in a radioactive and contaminated environment.
• Have the potential hazards of the technology been assessed?			The potential hazards will be identified and evaluated in a future update of the existing CSSF Safety Analysis Report (SAR-105).
• Has the technology been repackaged so a new relevant environment is realized?	**X**		Standard technology will be used in a radioactive and contaminated environment.
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		X	The modifications needed on CSSF 2 will be designed for the CSSF 2 environment and conditions.

5.1.2 Calcined Solids Storage Facility (CSSF) 2 Reconfiguration (continued)

Table C-7. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters such as calcine composition and characteristics have been identified (Staiger and Swenson 2007). CSSF 2 is an existing facility. Key CSSF 2 facility requirements and parameters are identified in the existing CSSF Safety Analysis Report (SAR-105). SAR-105 also identifies CSSF hazards. Hazards associated with the modification of CSSF 2 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
M	N/A	2. Laboratory components tested are surrogates for system components	Laboratory surrogates will not be used for the CSSF 2 modifications.
T	N/A	3. Individual components tested in laboratory~~/~~or by supplier	Individual components that will be used in the CSSF 2 modification will not be tested in a laboratory. Any testing of materials or components (such as concrete tests or material certifications) will be determined in preliminary design and incorporated into appropriate material specifications which will be developed in preliminary design.
T	N/A	4. Subsystems composed of multiple components tested at laboratory scale using simulants	The CSSF 2 modifications will not involve process/equipment systems involving multiple components that require laboratory scale testing.
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Conceptual level designs, modeling, and simulation of some CSSF 2 changes and interfaces between components are complete and documented in the CDR (ICP 2010), EDF-8444, EDF-8639, EDF-8727, and EDF-8744. Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 2 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	6. Overall system requirements for end user's application are <u>known</u>	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).

Table C-7. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	7. Overall system requirements for end user's application are documented	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	Y	8. System performance metrics measuring requirements have been established	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	N/A	9. Laboratory testing requirements derived from system requirements are established	The CSSF 2 modifications have no laboratory testing requirements.
M	N/A	10. Available components assembled into laboratory scale system	The CSSF 2 modifications have no laboratory testing requirements.
T	N/A	11. Laboratory experiments with available components show that they work together	The CSSF 2 modifications have no laboratory testing requirements.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 2 equipment after CSSF facility modifications (Nevins 2005, 2006a, 2006b). Conceptual layout drawings are complete for CSSF 6 in the CDR (ICP 2010). CSSF 2 will be modified to implement the CSSF 6 conceptual design. Conceptual studies are complete to show CSSF 2 could be modified to have a flat working platform similar to that of CSSF 6 (EDF-8744). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 2 has been performed at West Valley (Jackson and Gessner 1988).
P	N/A	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	CSSF 2 modifications are included in the technology maturation plan (PLN-1482).
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Safety functions of CSSF 2 are identified in SAR-105. CSSF modification designs will maintain SAR-required safety functions. A formal hazard analysis (EDF-7748) and conceptual safety design report (Abbott 2010)) have been written to address safety issues with the CSSF modifications.

Table C-7. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
			Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 2 equipment and CSSF facility modifications (Nevins 2005, 2006a, 2006b). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 2 has been performed at West Valley (Jackson and Gessner 1988).
M	N/A	15. Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	CSSF 2 already exists. There are no scaling issues with CSSF 2 modifications that are not integral to the development of the retrieval equipment. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 2 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	The modified CSSF system is described in SDD-291 and PDD-175. A material balance has been developed that includes calcine from all CSSFs (EDF-8549). System descriptions and process flow diagrams have been developed and are in the CDR (ICP 2010). Details and applicable drawings for the modification of CSSF 6 are in the CDR (ICP 2010). CSSF 1 will be modified to use the same design concepts as those for CSSF 6. Detailed CSSF 1 drawings will be developed during preliminary design.
M	N/A	17. Equipment scale-up relationships are understood/accounted for in technology development program	There are no technology development or consequent scale-up issues with the CSSF 2 modifications that are not integral to the development of the retrieval equipment.
T	N/A	18. Controlled laboratory environment used in testing	There is no laboratory testing for the CSSF 2 modifications.
P	Y	19. Initial cost drivers identified	Cost drivers for the CSSF 2 modifications are included in the CDR (ICP 2010). A formal risk management program (PLN-2477) identifies the cost risk drivers.

Table C-7. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	20. Integration studies have been started	Process integration studies for CSSF 2 have started and are reflected in the system design descriptions (SDD-291), a time and motion study (EDF-9692), general arrangement drawings in the CDR (ICP 2010), program description document (PDD-175), and other CSSF 2 integration studies (EDF-8444).
P	Y	21. Formal risk management program initiated	A formal risk management program has been developed (PLN-2477).
M	Y	22. Key manufacturing processes for equipment systems identified	Modifications to CSSF 2 will use readily available equipment.
P	N/A	23. Scaling documents and designs of technology have been completed	CSSF 2 already exists. There are no scaling issues with CSSF 2 modifications that are not integral to the development of the retrieval equipment.
M	NA	24. Key manufacturing processes assessed in laboratory	CSSF 2 modifications will involve standard manufacturing processes that have a proven track record. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 2 has been performed at West Valley (Jackson and Gessner 1988).
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	The existing CSSF 2 has a functional process description (SDD-189). The functional process description for the modifications to CSSF 2 needed for calcine retrieval is included in the system design description and the program design description (SDD-291 and PDD-175).
T	N/A	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	There will be no laboratory environment for the CSSF 2 modifications.
M	N/A	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Shortfalls in the capability to be manufactured or produced are not an issue with CSSF 2 modifications because needed materials are readily available.
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	CSSF 2 is an existing facility and its physical properties are documented in plant drawings, specifications, and SAR-105. Key chemical and physical properties of the calcine are documented in Staiger and Swenson (2007).

Table C-7. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Waste simulants are not required for the CSSF 2 modifications.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Laboratory waste simulants are not needed for the CSSF 2 modifications.
T	Y	31. Process/parameter limits and safety control strategies are being explored	CSSF 2 is an existing facility. Key CSSF 2 facility safety requirements have been identified in SAR-105. SAR-105 also identifies control strategies. Hazards associated with the modification of CSSF 2 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
T	N/A	32. Test plan documents for prototypical laboratory-scale tests completed	There will be no laboratory scale work for the CSSF 2 modifications, consequently no laboratory scale tests.
P	N/A	33. Technology availability dates established	CSSF 2 modifications are included in this Technology Maturation Plan.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.1.2 Calcined Solids Storage Facility (CSSF) 2 Reconfiguration References

Abbott, David G., 2010, *Conceptual Safety Design Report for the Calcine Disposition Project*, RPT-366, Rev. 3 (draft pending final DOE approval), Idaho Cleanup Project.

DOE-STD-1189-2008, 2008, "Integration of Safety into the Design Process," U.S. Department of Energy.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-8444, 2010, "Installation of Large Risers on the Calcined Solids Storage Facilities Bins Feasibility Evaluation," Rev. 2, Idaho Cleanup Project, August 3, 2010.

EDF-8549, 2010, "Calcine Disposition Project Material Balance for HIP Treatment," Rev. 2, Idaho Cleanup Project, August 17, 2010.

EDF-8639, 2010, "Calcined Solids Storage Facilities Bin Obstructions Alternatives Evaluation," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8727, 2010, "Evaluation of Alternatives for Retrieval of Calcine from a Full Calcined Solids Storage Facility Bin," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8744, 2008, "Conceptual Report for Additional Roof on CSSF 2, 3, and 4 for Calcine Retrieval," Rev. 0, Idaho Cleanup Project, June 12, 2008.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Jackson, Jacqueline P., and Ralph F. Gessner, 1988, *Remote Installation of Risers on Underground Nuclear Waste Storage Tanks*, DOE/NE/44139—45, DE88 010531, West Valley Nuclear Services Company, West Valley, New York, March 1988.

Nevins, P. W., 2005, *Calcine Bins Retrieval and Transfer System: Test Report*, ESI Document No. 2156-6-004, AEA Technology Engineering Services, January 2005.

Nevins, P. W., 2006a, *Calcine Bins Retrieval and Transfer System Enhancements*, ESI Document No 2200-4-001, Rev. 1, AEA Technology Engineering Services, April 2006.

Nevins, P. W., 2006b, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PDD-175, 2010, "Calcine Solids Storage Facility Design Description for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270372, Idaho Cleanup Project.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

SAR-105, 2007, "Safety Analysis Report for the Calcined Solids Storage Facilities," Rev. 2, Idaho Cleanup Project, August 16, 2007.

SDD-189, 2005, "Calcined Solids Storage Facility Vault 1 at INTEC," Rev. 0, Idaho Cleanup Project, January 25, 2005.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.1.3 Calcined Solids Storage Facility (CSSF) 3 Reconfiguration

The CSSF 3 reconfiguration includes the following major items; extending the existing vault walls and building a new "roof" over the existing vault to provide a large flat working platform for the hose management system, and reconfiguring the bin vent system. If more than one access riser is required per bin, then CSSF 3 modification will also require core drilling through the roof of the existing CSSF 3 bin vault, remotely cutting holes and installing access risers in the existing bins. This form is filled out with the assumption that new risers will be installed on CSSF 3.

Table C-8. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No	Notes
• Does the technology directly impact a functional requirement of the process or facility?	X		CSSF 3 reconfiguration will require modifications to install bin access risers, and modify the bin vent system, and shielding (vault roof). CSSF 3 has facility functional requirements for these systems.
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		X	Modification of the bin vault roof and installation of bin access risers pose a schedule risk if the technology is not ready or fails to operate as designed.
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		X	Limitations in understanding the technologies needed to modify CSSF 3 could affect the accuracy of Project cost estimates, which could result in significant cost overruns.
• Do limitations in the understanding of the technology impact the safety of the design?		**X**	The safety implications of modifying CSSF 3 are well understood and are not affected by technology understanding limitations.
• Are there uncertainties in the definition of the end state requirements for this technology?	X		The final state of the CSSFs is uncertain because there is no final, approved, closure plan for the CSSFs.

Table C-8. (continued).

Set 2—Criteria	Yes	No	Notes
• Is the technology new or novel?		**X**	The technology (such as core drilling and remote welding) needed to make the needed modifications to CSSF 3 is not new or novel.
• Is the technology modified?		**X**	The modifications needed for CSSF 3 will use standard technology that will be modified for use in a radioactive and contaminated environment.
• Have the potential hazards of the technology been assessed?	**X**		The potential hazards will be identified and evaluated in a future update of the existing CSSF Safety Analysis Report (SAR-105).
• Has the technology been repackaged so a new relevant environment is realized?	**X**		Standard technology will be used in a radioactive and contaminated environment.
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		X	The modifications needed on CSSF 3 will be designed for the CSSF 3 environment and conditions.

5.1.3 Calcined Solids Storage Facility (CSSF) 3 Reconfiguration (continued)

Table C-9. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters such as calcine composition and characteristics have been identified (Staiger and Swenson 2007). CSSF 3 is an existing facility. Key CSSF 3 facility requirements and parameters are identified in the existing CSSF Safety Analysis Report (SAR-105). SAR-105 also identifies CSSF hazards. Hazards associated with the modification of CSSF 3 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
M	N/A	2. Laboratory components tested are surrogates for system components	Laboratory surrogates will not be used for the CSSF 3 modifications.
T	N/A	3. Individual components tested in laboratory/or by supplier	Individual components that will be used in the CSSF 3 modification will not be tested in a laboratory. Any testing of materials or components (such as concrete tests or material certifications) will be determined in preliminary design and incorporated into appropriate material specifications which will be developed in preliminary design.
T	N/A	4. Subsystems composed of multiple components tested at laboratory scale using simulants	The CSSF 3 modifications will not involve process/equipment systems involving multiple components that require laboratory scale testing.
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Conceptual level designs, modeling, and simulation of some CSSF 3 changes and interfaces between components are complete and documented in the CDR (ICP 2010), EDF-8444, EDF-8639, EDF-8727, and EDF-8744. Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 3 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	6. Overall system requirements for end user's application are known	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).

Table C-9. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	7. Overall system requirements for end user's application are documented	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	Y	8. System performance metrics measuring requirements have been established	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	N/A	9. Laboratory testing requirements derived from system requirements are established	The CSSF 3 modifications have no laboratory testing requirements.
M	N/A	10. Available components assembled into laboratory scale system	The CSSF 3 modifications have no laboratory testing requirements.
T	N/A	11. Laboratory experiments with available components show that they work together	The CSSF 3 modifications have no laboratory testing requirements.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 3 equipment and CSSF facility modifications (Nevins 2005, 2006a, 2006b). Conceptual layout drawings are complete for CSSF 6 the CDR (ICP 2010). CSSF 2 will be modified to implement the CSSF 6 conceptual design. Conceptual studies are complete to show CSSF 3 could be modified to have a flat working platform similar to that of CSSF 6 (EDF-8744). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 3 has been performed at West Valley (Jackson and Gessner 1988).
P	N/A	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	CSSF 3 modifications are included in this Technology Maturation Plan.

Table C-9. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Safety functions of CSSF 3 are identified in SAR-105. CSSF modification designs will maintain SAR-required safety functions. A formal hazard analysis (EDF-7748) and conceptual safety design report (Abbott 2010) have been written to address safety issues with the CSSF modifications. Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 3 equipment and CSSF facility modifications (Nevins 2005, 2006a, 2006b). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 3 has been performed at West Valley (Jackson and Gessner 1988).
M	N/A	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	CSSF 3 already exists. There are no scaling issues with CSSF 3 modifications that are not integral to the development of the retrieval equipment. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 3 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	The modified CSSF system is described in SDD-291 and PDD-175. A material balance has been developed that includes calcine from all CSSFs (EDF-8549). System descriptions and process flow diagrams have been developed and are in the CDR (ICP 2010). Details and applicable drawings for the modification of CSSF 6 are in the CDR (ICP 2010). CSSF 1 will be modified to use the same design concepts as those for CSSF 6. Detailed CSSF 1 drawings will be developed during preliminary design.
M	N/A	17. Equipment scale-up relationships are understood/accounted for in technology development program	There are no technology development or consequent scale-up issues with the CSSF 3 modifications that are not integral to the development of the retrieval equipment.
T	N/A	18. Controlled laboratory environment used in testing	There is no laboratory testing for the CSSF 3 modifications.

Table C-9. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	19. Initial cost drivers identified	Cost drivers for the CSSF 3 modifications are included in the CDR (ICP 2010). A formal risk management program (PLN-2477) identifies the cost risk drivers.
M	Y	20. Integration studies have been started	Process integration studies for CSSF 3 have started and are reflected in the system design descriptions (SDD-291), a time and motion study (EDF-9692), general arrangement drawings the CDR (ICP 2010), program description document (PDD-175), and other CSSF 3 integration studies (EDF-8444).
P	Y	21. Formal risk management program initiated	A formal risk management program has been developed (PLN-2477).
M	Y	22. Key manufacturing processes for equipment systems identified	Modifications to CSSF 3 will use readily available equipment.
P	N/A	23. Scaling documents and designs of technology have been completed	CSSF 3 already exists. There are no scaling issues with CSSF 3 modifications that are not integral to the development of the retrieval equipment.
M	NA	24. Key manufacturing processes assessed in laboratory	CSSF 3 modifications will involve standard manufacturing processes that have a proven track record. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 3 has been performed at West Valley (Jackson and Gessner 1988).
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	The existing CSSF 3 has a functional process description (SDD-189). The functional process description for the modifications to CSSF 3 needed for calcine retrieval is included in the system design description and the program design description (SDD-291 and PDD-175).
T	N/A	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	There will be no laboratory environment for the CSSF 3 modifications.
M	N/A	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Shortfalls in the capability to be manufactured or produced are not an issue with CSSF 3 modifications because needed materials are readily available.

Table C-9. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	CSSF 3 is an existing facility and its physical properties are documented in plant drawings, specifications, and SAR-105. Key chemical and physical properties of the calcine are documented in Staiger and Swenson (2007).
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Waste simulants are not required for the CSSF 3 modifications.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Laboratory waste simulants are not needed for the CSSF 3 modifications.
T	Y	31. Process/parameter limits and safety control strategies are being explored	CSSF 3 is an existing facility. Key CSSF 3 facility safety requirements have been identified in SAR-105. SAR-105 also identifies control strategies. Hazards associated with the modification of CSSF 3 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
T	N/A	32. Test plan documents for prototypical laboratory-scale tests completed	There will be no laboratory scale work for the CSSF 3 modifications, consequently no laboratory scale tests.
P	N/A	33. Technology availability dates established	CSSF 3 modifications are included in this Technology Maturation Plan.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.1.3 Calcined Solids Storage Facility (CSSF) 3 Reconfiguration References

Abbott, David G., 2010, *Conceptual Safety Design Report for the Calcine Disposition Project*, RPT-366, Rev. 3 (draft pending final DOE approval), Idaho Cleanup Project.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-8444, 2010, "Installation of Large Risers on the Calcined Solids Storage Facilities Bins Feasibility Evaluation," Rev. 2, Idaho Cleanup Project, August 3, 2010.

EDF-8549, 2010, "Calcine Disposition Project Material Balance for HIP Treatment," Rev. 2, Idaho Cleanup Project, August 17, 2010.

EDF-8639, 2010, "Calcined Solids Storage Facilities Bin Obstructions Alternatives Evaluation," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8727, 2010, "Evaluation of Alternatives for Retrieval of Calcine from a Full Calcined Solids Storage Facility Bin," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8744, 2008, "Conceptual Report for Additional Roof on CSSF 2, 3, and 4 for Calcine Retrieval," Rev. 0, Idaho Cleanup Project, June 12, 2008.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Jackson, Jacqueline P., and Ralph F. Gessner, 1988, *Remote Installation of Risers on Underground Nuclear Waste Storage Tanks*, DOE/NE/44139—45, DE88 010531, West Valley Nuclear Services Company, West Valley, New York, March 1988.

Nevins, P. W., 2005, *Calcine Bins Retrieval and Transfer System: Test Report*, ESI Document No. 2156-6-004, AEA Technology Engineering Services, January 2005.

Nevins, P. W., 2006a, *Calcine Bins Retrieval and Transfer System Enhancements*, ESI Document No. 2200-4-001, Rev. 1, April 2006.

Nevins, P. W., 2006b, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PDD-175, 2010, "Calcine Solids Storage Facility Design Description for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270372, Idaho Cleanup Project.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

SAR-105, 2007, "Safety Analysis Report for the Calcined Solids Storage Facilities," Rev. 2, Idaho Cleanup Project, August 16, 2007.

SDD-189, 2005, "Calcined Solids Storage Facility Vault 1 at INTEC," Rev. 0, Idaho Cleanup Project, January 25, 2005.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.1.4 Calcined Solids Storage Facility (CSSF) 4 Reconfiguration

The CSSF 4 reconfiguration includes the following major items; extending the existing vault walls and building a new "roof" over the existing vault to provide a large flat working platform for the hose management system, and reconfiguring the bin vent system. If more than one access riser is required per bin, then CSSF 4 modification will also require core drilling through the roof of the existing CSSF 4 bin vault, remotely cutting holes and installing access risers in the existing bins. This form is filled out with the assumption that new risers will be installed on CSSF 4.

Table C-10. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No	Notes
• Does the technology directly impact a functional requirement of the process or facility?	X		CSSF 4 reconfiguration will require modifications to install bin access risers, and modify the bin vent system, and shielding (vault roof). CSSF 4 has facility functional requirements for these systems.
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		X	Modification of the bin vault roof and installation of bin access risers pose a schedule risk if the technology is not ready or fails to operate as designed.
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		X	Limitations in understanding the technologies needed to modify CSSF 4 could affect the accuracy of project cost estimates, which could result in significant cost overruns.
• Do limitations in the understanding of the technology impact the safety of the design?		**X**	The safety implications of modifying CSSF 4 are well understood and are not affected by technology understanding limitations.
• Are there uncertainties in the definition of the end state requirements for this technology?	X		The final state of the CSSFs is uncertain because there is no final, approved, closure plan for the CSSFs.

Table C-10. (continued).

Set 2—Criteria	Yes	No	Notes
• Is the technology new or novel?		**X**	The technology (such as core drilling and remote welding) needed to make the needed modifications to CSSF 4 is not new or novel.
• Is the technology modified?		**X**	The modifications needed for CSSF 4 will use standard technology that will be modified for use in a radioactive and contaminated environment.
• Have the potential hazards of the technology been assessed?			The potential hazards will be identified and evaluated in a future update of the existing CSSF Safety Analysis Report (SAR-105).
• Has the technology been repackaged so a new relevant environment is realized?	**X**		Standard technology will be used in a radioactive and contaminated environment.
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		X	The modifications needed on CSSF 4 will be designed for the CSSF 4 environment and conditions.

5.1.4 Calcined Solids Storage Facility (CSSF) 4 Reconfiguration (continued)

Table C-11. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Key process parameters such as calcine composition and characteristics have been identified (Staiger and Swenson 2007). CSSF 4 is an existing facility. Key CSSF 4 facility requirements and parameters are identified in the existing CSSF Safety Analysis Report (SAR-105). SAR-105 also identifies CSSF hazards. Hazards associated with the modification of CSSF 4 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
M	N/A	2. Laboratory components tested are surrogates for system components	Laboratory surrogates will not be used for the CSSF 4 modifications.
T	N/A	3. Individual components tested in laboratory~~/~~or by supplier	Individual components that will be used in the CSSF 4 modification will not be tested in a laboratory. Any testing of materials or components (such as concrete tests or material certifications) will be determined in preliminary design and incorporated into appropriate material specifications which will be developed in preliminary design.
T	N/A	4. Subsystems composed of multiple components tested at laboratory scale using simulants	The CSSF 4 modifications will not involve process/equipment systems involving multiple components that require laboratory scale testing.
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Conceptual level designs, modeling, and simulation of some CSSF 4 changes and interfaces between components are complete and documented in the CDR (ICP 2010), EDF-8444, EDF-8639, EDF-8727, and EDF-8744. Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 4 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	6. Overall system requirements for end user's application are <u>known</u>	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).

Table C-11. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	7. Overall system requirements for end user's application are documented	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	Y	8. System performance metrics measuring requirements have been established	Overall system requirements are given in project technical and functional requirements, system design descriptions, and program description documents (TFR-401; SDD-291; PDD-175).
P	N/A	9. Laboratory testing requirements derived from system requirements are established	The CSSF 4 modifications have no laboratory testing requirements.
M	N/A	10. Available components assembled into laboratory scale system	The CSSF 4 modifications have no laboratory testing requirements.
T	N/A	11. Laboratory experiments with available components show that they work together	The CSSF 4 modifications have no laboratory testing requirements.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 4 equipment and CSSF facility modifications (Nevins 2005, 2006a, 2006b). Conceptual layout drawings are complete for CSSF 6 in the CDR (ICP 2010). CSSF 4 will be modified to implement the CSSF 6 conceptual design. Conceptual studies are complete to show CSSF 4 could be modified to have flat working platform similar to that of CSSF 6 (EDF-8744). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 4 has been performed at West Valley (Jackson and Gessner 1988).
P	N/A	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	CSSF 4 modifications are included in this Technology Maturation Plan.

Table C-11. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Safety functions of CSSF 4 are identified in SAR-105. CSSF modification designs will maintain SAR-required safety functions. A formal hazard analysis (EDF-7748) and conceptual safety design report (Abbott 2010) have been written to address safety issues with the CSSF modifications. Prototype fabrication and testing showed the conceptual retrieval equipment design will work with CSSF 4 equipment and CSSF facility modifications (Nevins 2005, 2006a, 2006b). Installation of tank access risers in a remote, hot-cell environment similar to that of CSSF 4 has been performed at West Valley (Jackson and Gessner 1988).
M	N/A	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	CSSF 4 already exists. There are no scaling issues with CSSF 4 modifications that are not integral to the development of the retrieval equipment. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 4 has been performed at West Valley (Jackson and Gessner 1988).
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	The modified CSSF system is described in SDD-291 and PDD-175. A material balance has been developed that includes calcine from all CSSFs (EDF-8549). System descriptions and process flow diagrams have been developed and are in the CDR (ICP 2010). Details and applicable drawings for the modification of CSSF 6 are in the CDR (ICP 2010). CSSF 1 will be modified to use the same design concepts as those for CSSF 6. Detailed CSSF 1 drawings will be developed during preliminary design.
M	N/A	17. Equipment scale-up relationships are understood/accounted for in technology development program	There are no technology development or consequent scale-up issues with the CSSF 4 modifications that are not integral to the development of the retrieval equipment.
T	N/A	18. Controlled laboratory environment used in testing	There is no laboratory testing for the CSSF 4 modifications.

Table C-11. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	19. Initial cost drivers identified	Cost drivers for the CSSF 4 modifications are included in the CDR (ICP 2010). A formal risk management program (PLN-2477) identifies the cost risk drivers.
M	Y	20. Integration studies have been started	Process integration studies for CSSF 4 have started and are reflected in the system design descriptions (SDD-264 and SDD-291), a time and motion study (EDF-9692), general arrangement drawings the CDR (ICP 2010), program description document (PDD-175), and other CSSF 4 integration studies (EDF-8444).
P	Y	21. Formal risk management program initiated	A formal risk management program has been developed (PLN-2477).
M	Y	22. Key manufacturing processes for equipment systems identified	Modifications to CSSF 4 will use readily available equipment.
P	N/A	23. Scaling documents and designs of technology have been completed	CSSF 4 already exists. There are no scaling issues with CSSF 4 modifications that are not integral to the development of the retrieval equipment.
M	NA	24. Key manufacturing processes assessed in laboratory	CSSF 4 modifications will involve standard manufacturing processes that have a proven track record. Installation of tank access risers in a remote, hot-cell environment with equipment of similar size to that of CSSF 4 has been performed at West Valley (Jackson and Gessner 1988).
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	The existing CSSF 4 has a functional process description (SDD-189). The functional process description for the modifications to CSSF 4 needed for calcine retrieval is included in the system design description (SDD-264 and -291) and the program design description (PDD-175) for the calcine retrieval and transfer system.
T	N/A	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	There will be no laboratory environment for the CSSF 4 modifications.

Table C-11. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N/A	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Shortfalls in the capability to be manufactured or produced are not an issue with CSSF 4 modifications because needed materials are readily available.
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	CSSF 4 is an existing facility and its physical properties are documented in plant drawings, specifications, and SAR-105. Key chemical and physical properties of the calcine are documented in Staiger and Swenson (2007).
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Waste simulants are not required for the CSSF 4 modifications.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Laboratory waste simulants are not needed for the CSSF 4 modifications.
T	Y	31. Process/parameter limits and safety control strategies are being explored	CSSF 4 is an existing facility. Key CSSF 4 facility safety requirements have been identified in SAR-105. SAR-105 also identifies control strategies. Hazards associated with the modification of CSSF 4 were identified in a formal hazard and operability review of the project (EDF-7748) and incorporated, as appropriate, into the conceptual safety design report (Abbott 2010).
T	N/A	32. Test plan documents for prototypical laboratory- scale tests completed	There will be no laboratory scale work for the CSSF 4 modifications, consequently no laboratory scale tests.
P	N/A	33. Technology availability dates established	CSSF 4 modifications are included in this Technology Maturation Plan.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.1.4 Calcined Solids Storage Facility (CSSF) 4 Reconfiguration References

Abbott, David G., 2010, *Conceptual Safety Design Report for the Calcine Disposition Project*, RPT-366, Rev. 3 (draft pending final DOE approval), Idaho Cleanup Project.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-8444, 2010, "Installation of Large Risers on the Calcined Solids Storage Facilities Bins Feasibility Evaluation," Rev. 2, Idaho Cleanup Project, August 3, 2010.

EDF-8549, 2010, "Calcine Disposition Project Material Balance for HIP Treatment," Rev. 2, Idaho Cleanup Project, August 17, 2010.

EDF-8639, 2010, "Calcined Solids Storage Facilities Bin Obstructions Alternatives Evaluation," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8727, 2010, "Evaluation of Alternatives for Retrieval of Calcine from a Full Calcined Solids Storage Facility Bin," Rev. 1, Idaho Cleanup Project, August 3, 2010.

EDF-8744, 2008, "Conceptual Report for Additional Roof on CSSF 2, 3, and 4 for Calcine Retrieval," Rev. 0, Idaho Cleanup Project, June 12, 2008.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Jackson, Jacqueline P., and Ralph F. Gessner, 1988, *Remote Installation of Risers on Underground Nuclear Waste Storage Tanks*, DOE/NE/44139—45, DE88 010531, West Valley Nuclear Services Company, West Valley, New York, March 1988.

Nevins, P. W., 2005, *Calcine Bins Retrieval and Transfer System: Test Report*, ESI Document No. 2156-6-004, AEA Technology Engineering Services, January 2005.

Nevins, P. W., 2006a, *Calcine Bins Retrieval and Transfer System Enhancements*, ESI Document No 2200-4-001, Rev. 1, April 2006.

Nevins, P. W., 2006b, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PDD-175, 2010, "Calcine Solids Storage Facility Design Description for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270372, Idaho Cleanup Project.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

SAR-105, 2007, "Safety Analysis Report for the Calcined Solids Storage Facilities," Rev. 2, Idaho Cleanup Project, August 16, 2007.

SDD-189, 2005, "Calcined Solids Storage Facility Vault 1 at INTEC," Rev. 0, Idaho Cleanup Project, January 25, 2005.

SDD-264, 2010, "Secondary Process Waste Systems for the Calcine Disposition Project (SEN 9.7) (Conceptual Design)," Rev. A, Record 3270400, Idaho Cleanup Project.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.2.1 Bin Set Interface Subsystem

Table C-12. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

5.2.1 Bin Set Interface Subsystem (continued)

Table C-13. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters have been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748; SDD-291
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: (Nevins 2006) Note: Full-scale test was performed as documented in the AEAT report.
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and simulation used to simulate some components and interfaces between components	Nevins (2006) SDD-291.
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401 SDD-291.
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-291 EDF-9582
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-291 DDN-003, "Retrieval System Design Development Needs."
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006).
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Nevins (2006). SDD-291
P	Y	13. Science and technology demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-291

Table C-13. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	*Conceptual Design Report for the Calcine Disposition Project* (CDR) (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Nevins (2006).
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	*Calcine Treatment Options Summary* (ICP 2009) CDR (ICP 2010)
M	Y	20. Integration studies have been started	SDD-291
P	Y	21. Formal risk management program initiated	PLN-2477; EDF-9638,
M	Y	22. Key manufacturing processes for equipment systems identified	Nevins (2006) Note: Using commercially available materials.
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-291
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Nevins (2006)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477; EDF-9638.

Table C-13. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007) EDF-9694 *Inventories and Properties of ICPP Calcined High-Level Waste* (Berreth 1988).
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006) Berreth (1988)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006).
T		31. Process/parameter limits and safety control strategies are being explored	SDD-291 EDF-9638 EDF-7748 DDN-003, "Retrieval System Design Development Needs."
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006).
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.2.1 Bin Set Interface Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9582, 2010, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project (SEN 5.5) (Conceptual Design)," Rev. A, Record 3270172, Idaho Cleanup Project.

EDF-9638, 2010, "Retrieval System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270155, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.2.2 Retrieval Nozzle Subsystem

Table C-14. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

5.2.2 Retrieval Nozzle Subsystem (continued)

Table C-15. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," SDD-291, "Retrieval System for the Calcine Disposition Project"
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: *Calcine Bins Retrieval and Transfer System, Final Report* (Nevins 2006) Note: Full-scale test was performed as documented in AEAT report
T	Y	3. Individual components tested in laboratory~~/~~or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Nevins (2006) SDD-291
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401, "Technical and Functional Requirements for the Calcine Disposition Project." SDD-291
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-291 EDF-9582, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project."
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-291 DDN-003, "Retrieval System Design Development Needs."
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006)
T	Y	11. Laboratory experiments with available components show that they work together	

Table C-15. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Nevins (2006) SDD-291
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-291
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	*Conceptual Design Report for the Calcine Disposition Project* (CDR) (ICP 2010 [RPT-366])
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Nevins (2006)
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	CDP Calcine Treatment Options Summary (ICP 2009) CDR (ICP 2010)
M	Y	20. Integration studies have been started	SDD-291
P	Y	21. Formal risk management program initiated	PLN-2477, "Calcine Disposition Project Risk Management Plan." EDF-9638, "Retrieval System Failure Modes and Effects Analysis."
M	Y	22. Key manufacturing processes for equipment systems identified	Nevins (2006) Note: Using commercially available materials.
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	

Table C-15. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-291
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Nevins (2006)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477 EDF-9638
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	*Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center* (Staiger and Swenson 2007) EDF-9694, "Synopsis of the Properties of Calcine for use in the Calcine Disposition Project," *Inventories and Properties of ICPP Calcined High-Level Waste* (Berreth 1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006) Berreth (1988)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006)
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-291 EDF-9638 EDF-7748 DDN-003, "Retrieval System Design Development Needs."
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006)
P	Y	33. Technology availability dates established	PLN-3448, "Calcine Disposition Project Waste-Form Delisting Petition and Technology Readiness Strategy Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.2.2 Retrieval Nozzle Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9582, 2010, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project (SEN 5.5) (Conceptual Design)," Rev. A, Record 3270172, Idaho Cleanup Project.

EDF-9638, 2010, "Retrieval System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270155, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.2.3 Slewing Subsystem

Table C-16. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.2.3 Slewing Subsystem (continued)

Table C-17. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	HAZOP report (EDF-7748) SDD-291
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: (Nevins 2006) Note: Full-scale test was performed as documented in AEAT report
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Nevins (2006) SDD-291
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401 SDD-291
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-291 EDF-9582
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-291 DDN-003, "Retrieval System Design Development Needs."
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Nevins (2006) SDD-291
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-291

Table C-17. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Nevins (2006)
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	Calcine Treatment Options Summary (ICP 2009) CDR (ICP 2010)
M	Y	20. Integration studies have been started	SDD-291
P	Y	21. Formal risk management program initiated	PLN-2477 EDF-9638
M	Y	22. Key manufacturing processes for equipment systems identified	Nevins (2006) Note: Using commercially available materials.
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-291
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Nevins (2006)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477 EDF-9638

Table C-17. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	(Staiger and Swenson 2007) EDF-9694 (Berreth 1998)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006) Berreth (1988)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006)
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-291 EDF-9638 EDF-7748 DDN-003, "Retrieval System Design Development Needs."
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006)
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.2.3 Slewing Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9582, 2010, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project (SEN 5.5) (Conceptual Design)," Rev. A, Record 3270172, Idaho Cleanup Project.

EDF-9638, 2010, "Retrieval System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270155, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.2.4 Hose Management Subsystem

Table C-18. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.2.4 Hose Management Subsystem (continued)

Table C-19. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	HAZOP report (EDF-7748) SDD-291, "Retrieval System for the Calcine Disposition Project."
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: *Calcine Bins Retrieval and Transfer System, Final Report* (Nevins 2006) Note: Full-scale test was performed as documented in AEAT report.
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Nevins (2006) SDD-291
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401, "Technical and Functional Requirements for the Calcine Disposition Project." SDD-291
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-291 EDF-9582, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project."
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-291 DDN-003, "Retrieval System Design Development Needs."
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Nevins (2006) SDD-291

Table C-19. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-291
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	RPT-270, CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Nevins (2006)
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	Calcine Treatment Options Summary (ICP 2009) CDR (ICP 2010)
M	Y	20. Integration studies have been started	SDD-291
P	Y	21. Formal risk management program initiated	PLN-2477 EDF-9638
M	Y	22. Key manufacturing processes for equipment systems identified	Nevins (2006) Note: Using commercially available materials.
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-291
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Nevins (2006)"
M		27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477 EDF-9638

Table C-19. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	(Staiger and Swenson 2007) EDF-9694 Berreth (1998)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006) Berreth (1998)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006)
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-291 EDF-9638 EDF-7748 DDN-003, "Retrieval System Design Development Needs."
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006)
P	Y	33. Technology availability dates established	PLN-3448,

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.2.4 Hose Management Subsystem (continued)

Table C-20. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	AEAT report: *Calcine Bins Retrieval and Transfer System, Final Report* (Nevins 2006)
T	N	2. Plant size components available for testing	Need to manufacture mockup
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	Nevins (2006) SDD-214, "Calcine Disposition Project Calcine Retrieval, Transport, and Storage – Conceptual Design" SDD-291, ""Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)"
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	SDD-214
T	N	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Test hose management system
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to manufacture mockup
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes required
T	N	9. High fidelity lab integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to manufacture mockup
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	No difficult manufacturing techniques are required
T	N	11. Laboratory-scale, similar system tested with range of simulants	Test hose management system
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to manufacture and test mockup

Table C-20. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	13. Availability and reliability (RAMI) target levels identified	Nevins (2006)
M	N	14. Some special purpose components combined with available laboratory components for testing	Test hose management system
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Need mockup design drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Test mockup system
T	Y	17. Component integration issues and requirements identified	Nevins (2006)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Need mockup design drawings
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	500 lb/hr of calcine per bin is the performance threshold SDD-291
P	Y	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-291
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Test hose management system
T	Y	22. Formal control of all components to be used in final prototypical test system	PLN-2478, "Configuration Management Plan for the Calcine Disposition Project"
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	Nevins (2006)
T	N	25. Simulants have been developed that cover the full range of waste properties	The full range is known, but simulants for the full range have not been prepared. PLN-3448

Table C-20. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	The simulants are actual calcine but without radioactive contaminants. PLN-3448
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	No testing of the hose management system has been done
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	No testing of the hose management system has been done
T	N	29. Test results for simulants and real waste are consistent	No testing is planned for real waste
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	No laboratory scale testing is planned.
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	Nevins (2006)
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	No testing plan for the hose management system exists.
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Test plan documents of testing the hose management system have not been prepared.
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	EDF-7748
P	N	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.2.4 Hose Management Subsystem (continued)

Table C-21. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	SDD-291
M	N	2. Availability and reliability (RAMI) levels established	Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Need preliminary drawings
T	Y	4. Operating environment for final system known	SDD-214, Section 3.2.6
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Start RAMI data collection
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	CDR (ICP 2010), and associated preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Establish operating limits from design and mockup testing
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Establish operational requirements document
P	N	9. Off-normal operating responses determined for engineering scale system	Establish off-normal operating responses
T	Y	10. System technical interfaces defined	SDD-291
T	N	11. Component integration demonstrated at an engineering scale	Full-scale mockup testing
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Full-scale mockup testing
P	Y	13. Analysis of project timing ensures technology will be available when required	This PLN-1482, TMP
P	N	14. Have established an interface control process	Establish ICDs
P	Y	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"

Table C-21. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	16. Critical manufacturing processes prototyped	Standard manufacturing processes will be utilized.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Standard manufacturing processes will be utilized.
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Full-scale mockup testing
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Full-scale mockup testing
P	N	20. Technology ”system” design specification complete and ready for detailed design	Need to finalize SPC-1279, (Preliminary Design Specification for CDP)
M	N	21. Components are functionally compatible with operational system	Full-scale mockup testing
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Full-scale mockup testing
P	Y	23. Formal configuration management program defined to control change process	PLN-3478, “Configuration Management Plan for the Calcine Disposition Project”
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Only the retrieval hose end has been tested. Full-scale mockup testing
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, “Integration of Safety into the Design Process.”	Need final report
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Part of preliminary design
M	Y	27. Process and tooling are mature to support fabrication of components/system	No special processes or tooling are required to fabricate the hose management system.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Full-scale mockup testing

Table C-21. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	SDD-291 There are no engineering-scale to full-scale, scale-up issues which are not understood with regard to the hose management system. The only scaling issue would be hose velocity
T	N	30. Laboratory and engineering-scale experiments are consistent	Full-scale mockup testing These will be inconsistent in flow regimes and calcine entrainment
T	N	31. Limits for all process variables/parameters and safety controls are defined	Only the empirical limits for calcine retrieval at full scale have been defined. Full-scale mockup testing
T	N	32. Plan for engineering-scale testing executed - results validate design	No engineering-scale testing has been done on the hose management system. Full-scale mockup testing
M	N	33. Production demonstrations are complete (at least one time)	Production-scale items have not been fabricated.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.2.4 Hose Management Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9582, 2010, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project (SEN 5.5) (Conceptual Design)," Rev. A, Record 3270172, Idaho Cleanup Project.

EDF-9638, 2010, "Retrieval System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270155, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-214, 2008, "Calcine Disposition Project – Calcine Retrieval, Transport, and Storage Systems – Conceptual Design," Rev. 1, Idaho Cleanup Project, September 16, 2008. (Note: This document is Official Use Only and may not be publicly available.)

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

SPC-1279, 2010, "Blanket Specification for Procurement of Hot Isostatic Pressing (HIP) Test Cans for the Calcine Disposition Project," Rev. 0, Idaho Cleanup Project, September 23, 2010.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.2.6 Bin Set Camera Subsystem

Table C-22. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.2.6 Bin Set Camera Subsystem (continued)

Table C-23. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748, "Preliminary Hazard and Operability Review of the Calcine Disposition Project" SDD-291, "Retrieval System for the Calcine Disposition Project."
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: *Calcine Bins Retrieval and Transfer System, Final Report* (Nevins 2006) Note: Full-scale test was performed as documented in AEAT report
T	Y	3. Individual components tested in a laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Nevins (2006) SDD-291
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401, "Technical and Functional Requirements for the Calcine Disposition Project." SDD-291
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-291 EDF-9582, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project."
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-291 DDN-003, "Retrieval System Design Development Needs."
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Nevins (2006) SDD-291

Table C-23. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-291
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Nevins (2006)
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	CDP Calcine Treatment Options Summary (ICP 2009) CDR (ICP 2010)
M	Y	20. Integration studies have been started	SDD-291
P	Y	21. Formal risk management program initiated	PLN-2477, "Calcine Disposition Project Risk Management Plan." EDF-9638, "Retrieval System Failure Modes and Effects Analysis."
M	Y	22. Key manufacturing processes for equipment systems identified	Nevins (2006) Note: Using commercially available materials.
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-291

Table C-23. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Nevins (2006)
M		27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477 EDF-9638
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	*Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center* (Staiger and Swenson 2007) EDF-9694, "Synopsis of the Properties of Calcine for use in the Calcine Disposition Project" *Inventories and Properties of ICPP Calcined High-Level Waste* (Berreth 1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006) Berreth (1988)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006)
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-291 EDF-9638 EDF-7748 DDN-003, "Retrieval System Design Development Needs."
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006)
P	Y	33. Technology availability dates established	PLN-3448, "Calcine Disposition Project Waste-Form Delisting Petition and Technology Readiness Strategy Plan," Rev. 0

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.2.6 Bin Set Camera Subsystem (continued)

Table C-24. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	AEAT report: *Calcine Bins Retrieval and Transfer System, Final Report* (Nevins 2006)
T	Y	2. Plant size components available for testing	High radiation tolerance camera systems are commercially available.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-291
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 and PLN-3448
T	N	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	No testing with the camera system integrated into the retrieval operations have been performed.
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	High radiation tolerance camera systems are commercially available.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	High radiation tolerance camera systems are commercially available, no new manufacturing required.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Full-scale mockup testing
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	High radiation tolerance camera systems are commercially available, no new manufacturing required.
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Full-scale camera systems are commercially available.
T	Y	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Full-scale camera systems are commercially available.
M	Y	13. Availability and reliability (RAMI) target levels identified	SDD-291; TFR-401; CDP Process System RAMI Analysis
M	N	14. Some special purpose components combined with available laboratory components for testing	No testing has been done using a remote camera system at the HLW calcine radiation levels.

Table C-24. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	RPT-270
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No testing has been done using a remote camera system at the HLW calcine radiation levels.
T	Y	17. Component integration issues and requirements identified	Nevins (2006); SDD-291
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	No detailed drawings other than layouts have been prepared.
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401; SDD-291
P	Y	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-291
T	Y	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Full-scale systems available.
T	Y	22. Formal control of all components to be used in final prototypical test system	Commercial systems available with controls.
P	Y	23. Configuration management plan in place	PLN-2478, "Configuration Management Plan for the Calcine Disposition Project"
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	Nevins (2006); SOW-8479, "Statement of Work for Calcine Disposition Project Hazen Research Surrogate Calcine Request for Proposal"; EDF-9694, "Calcine Properties for the Calcine Disposition Project"
T	Y	25. Simulants have been developed that cover the full range of waste properties	The composition the three types of calcine surrogates has been developed as shown in PLN-3448.

Table C-24. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	The composition the three types of calcine surrogates has been developed as shown in PLN-3448.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Full-scale mockup
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Full-scale mockup
T	N	29. Test results for simulants and real waste are consistent	Full-scale mockup
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	Full-scale mockup
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	Nevins (2006); SDD-291
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need test plans
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Need test plans
P	Y	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Preliminary hazard evaluation is complete EDF-7748, "Preliminary Hazard and Operability Review of the Calcine Disposition Project"
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477, "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.2.6 Bin Set Camera Subsystem (continued)

Table C-25. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Full-scale camera systems are commercially available; integrating the subsystem into the Retrieval System in full-scale mockup
M	Y	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Finalize preliminary design
T	Y	4. Operating environment for final system known	SDD-291; Inventory Models, Revit Layouts
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	CDR (ICP 2010), (PRD) and associated preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	Commercially available camera systems for use in high radiation environments have limits established.
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	From chosen manufacture.
P	Y	9. Off-normal operating responses determined for engineering scale system	Commercially available camera systems for use in high radiation environments have operating manuals with off-normal operations procedures.
T	Y	10. System technical interfaces defined	SDD-291
T	N	11. Component integration demonstrated at an engineering scale	Full-scale mockup testing
P	Y	12. Scaling issues that remain are identified and understood. Supporting analysis is complete.	Full-scale camera systems are commercially available

Table C-25. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Analysis of project timing ensures technology will be available when required	Full-scale camera systems are commercially available, no technology to develop, just integration with the Retrieval System components.
P	N	14. Have established an interface control process	Establish ICDs
P	Y	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	Y	16. Critical manufacturing processes prototyped	Full-scale camera systems are commercially available.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Full-scale camera systems are commercially available.
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	Full-scale camera systems are commercially available.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Full-scale camera systems are commercially available.
P	Y	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	Y	21. Components are functionally compatible with operational system	Full-scale camera systems are commercially available; integration into operational system is possible but hasn't been done.
T	Y	22. Engineering-scale system is high-fidelity functional prototype of operational system	Full-scale camera systems are commercially available.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478, "Configuration Management Plan for the Calcine Disposition Project"
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Camera system has yet to be integrated into Retrieval test system.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary Design

Table C-25. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Preliminary hazard evaluation is complete; EDF-7748; Finalize hazard evaluation.
M	Y	27. Process and tooling are mature to support fabrication of components/system	Full-scale camera systems are commercially available.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Full-scale mockup testing
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	Full-scale camera systems are commercially available.
T	Y	30. Laboratory and engineering-scale experiments are consistent	Full-scale camera systems are commercially available.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Finalize preliminary design
T	N	32. Plan for engineering-scale testing executed - results validate design	Full-scale mockup testing
M	N	33. Production demonstrations are complete (at least one time)	Full-scale mockup testing

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.2.6 Bin Set Camera Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9582, 2010, "Retrieval System Pressure Drop Calculation for the Calcine Disposition Project (SEN 5.5) (Conceptual Design)," Rev. A, Record 3270172, Idaho Cleanup Project.

EDF-9638, 2010, "Retrieval System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270155, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-291, 2010, "Retrieval System for the Calcine Disposition Project (SEN 5.2) (Conceptual Design)," Rev. A, Record 3270373, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.3.2 Surge Subsystem

Table C-26. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?	Y	

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

5.3.2 Surge Subsystem (continued)

Table C-27. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748, "Preliminary Hazard and Operability Review of the Calcine Disposition Project" SDD-265, "Transport and Surge System for the Calcine Disposition Project"
M	Y	2. Laboratory components tested are surrogates for system components	AEAT report: *Calcine Bin Retrieval and Transfer System, Final Report* (Nevins 2006)
T	Y	3. Individual components tested in laboratory or by supplier	Nevins (2006)
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	Nevins (2006)
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Nevins (2006); SDD-265
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401, "Technical and Functional Requirements for the Calcine Disposition Project"
T	Y	7. Overall system requirements for end user's application are documented	TFR-401
P	Y	8. System performance metrics measuring requirements have been established	SDD-265; EDF-9692, "Time and Motion Studies for the Calcine Disposition Project"
P	Y	9. Laboratory testing requirements derived from system requirements are established	SDD-265; Nevins (2006)
M	Y	10. Available components assembled into laboratory scale system	Nevins (2006); Commercially available components.
T	Y	11. Laboratory experiments with available components show that they work together	Nevins (2006)
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	SDD-265
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-265

Table C-27. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Nevins (2006)
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than lab scale)	Commercially available components.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-265; CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Commercially available components.
T	Y	18. Controlled laboratory environment used in testing	Nevins (2006)
P	Y	19. Initial cost drivers identified	Calcine Treatment Options Summary (ICP 2009); CDR (ICP 2010); EDF-9692
M	Y	20. Integration studies have been started	SDD-265
P	Y	21. Formal risk management program initiated	PLN-2477; EDF-9698
M	Y	22. Key manufacturing processes for equipment systems identified	Commercially available components.
P	Y	23. Scaling documents and designs of technology have been completed	SDD-265; Commercially available components.
M	Y	24. Key manufacturing processes assessed in laboratory	Commercially available components.
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-265
T	Y	26. Low fidelity technology “system” integration and engineering completed in a laboratory environment	Nevins (2006)
M		27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477; EDF-9698; Commercially available components.
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007); EDF-9694; Berreth (1988)

Table C-27. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Nevins (2006)
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Nevins (2006)
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-265; HAZOP (EDF-7748)
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Nevins (2006)
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.3.2 Surge Subsystem (continued)

Table C-28. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Full-scale testing complete. Nevins (2006)
T	Y	2. Plant size components available for testing	Components are readily commercially available.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-265
P	N	4. Preliminary design engineering begins	Begin preliminary design.
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 HAZOP (EDF-7748)
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Full-scale testing complete. Nevins (2006)
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	Components are readily commercially available.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	Full-scale testing complete. Nevins (2006)
T	Y	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Full-scale testing complete. Nevins (2006)
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Components are readily commercially available.
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Full-scale testing complete. Nevins (2006)
T	Y	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Full-scale testing complete. Nevins (2006)
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401; Preliminary CDP Process System RAMI Analysis

Table C-28. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	14. Some special purpose components combined with available laboratory components for testing	Components are readily commercially available. Full-scale testing complete. Nevins (2006)
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	Y	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Full-scale testing complete. Nevins (2006)
T	Y	17. Component integration issues and requirements identified	TFR-401
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup testing
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401
P	Y	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-265
T	Y	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Full-scale testing complete. Nevins (2006)
T	Y	22. Formal control of all components to be used in final prototypical test system	PLN-2478
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	Full-scale testing complete. Nevins (2006)
T	N	25. Simulants have been developed that cover the full range of waste properties	Surrogate development for full-scale mockup testing

Table C-28. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Surrogate development for full-scale mockup testing
T	Y	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Full-scale testing complete. Nevins (2006); EDF-8182, "Calcine Disposition Project Calcine Retrieval Rate Evaluation"
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Full-scale mockup testing.
T	N	29. Test results for simulants and real waste are consistent	Full-scale mockup testing.
T	N/A	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	Full-scale testing complete. Nevins (2006) EDF-8182
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	Preliminary design
P	Y	32. Test plan for prototypical lab-scale tests executed – results validate design; to include testing and validation of safety functions.	Full-scale testing complete. Nevins (2006) EDF-8182
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	Full-scale testing complete. Nevins (2006); EDF-8182
P	Y	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	HAZOP, EDF-7748
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.3.2 Surge Subsystem (continued)

Table C-29. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Full-scale testing complete. AEAT report: Nevins (2006) EDF-8182
M	N	2. Availability and reliability (RAMI) levels established	Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design.
T	Y	4. Operating environment for final system known	Full-scale testing complete. Nevins (2006); EDF-8182
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Full-scale mockup.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Complete preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	TFR-401
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	TFR-401
P	N	9. Off-normal operating responses determined for engineering scale system	To be generated in preliminary design and operating procedures
T	Y	10. System technical interfaces defined	SDD-265
T	Y	11. Component integration demonstrated at an engineering scale	Full-scale testing complete. Nevins (2006) EDF-8182
P	N/A	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	
P	Y	13. Analysis of project timing ensures technology will be available when required	
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	CDP acquisition plan
M	Y	16. Critical manufacturing processes prototyped	Components are readily commercially available.

Table C-29. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Components are readily commercially available.
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	Full-scale testing complete. Nevins (2006) EDF-8182
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	
P	N	20. Technology "system" design specification complete and ready for detailed design	Complete preliminary design.
M	N	21. Components are functionally compatible with operational system	Full-scale mockup.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Full-scale mockup.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	Y	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Preliminary hazard evaluation is complete; EDF-7748.
M	Y	27. Process and tooling are mature to support fabrication of components/system	Components are readily commercially available.
T	Y	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Full-scale testing complete. Nevins (2006) EDF-8182
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	
T	Y	30. Laboratory and engineering-scale experiments are consistent	
T	N	31. Limits for all process variables/parameters and safety controls are defined	Preliminary design.

Table C-29. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	32. Plan for engineering-scale testing executed - results validate design	Summarized in this TMP.
M	Y	33. Production demonstrations are complete (at least one time)	Full-scale mockup

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.3.2 Surge Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-8182, 2010, "Calcine Disposition Project Calcine Retrieval Rate Evaluation," Rev. 2, Idaho Cleanup Project, August 12, 2010.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9698, 2010, "Transport and Surge System Failure Modes and Effects Analysis," Rev. A, Idaho Cleanup Project, Idaho National Laboratory.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, *Conceptual Design Report for the Calcine Disposition Project (Draft),* RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Nevins, P. W., 2006, *Calcine Bins Retrieval and Transfer System: Final Report*, ESI Document No. 2223-4-002, Rev. 1, AEA Technology Engineering Services, October 2006.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-265, 2010, "Transport and Surge System for the Calcine Disposition Project," Rev. 0, Draft, Idaho Cleanup Project, Idaho National Laboratory.

SOW-8479, 2008, "Statement of Work for Calcine Disposition Project Hazen Research Surrogate Calcine Request for Proposal," Rev. 0, Idaho Cleanup Project, March 16, 2010.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.4.1 HIP Feed Blender Subsystem

Table C-30 Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.4.1 HIP Feed Blender Subsystem (continued)

Table C-31. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete EDF-7748; Key process parameters/ variables are included in PLN-3448 and SDD-266.
M	Y	2. Laboratory components tested are surrogates for system components	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009); Staples (1988); Vinjamuri (1991); Raman (1993), Nelson (1995); Raman (1998); Tripp (2006), and Carter (2007)
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and simulation used to simulate some components and interfaces between components	Mixers are commercially available. EDF-9704; EDF-9705; and SDD-266
P	Y	6. Overall system requirements for end user's application are known	PLN-3448; SDD-266; and TFR-401
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	PLN-3448; SDD-266; and Staiger and Swenson (2007); Berreth (1988)
P	Y	9. Laboratory testing requirements derived from system requirements are established	The percent of additive required and the time to generate a homogenous mixture is established in DDN 038 and PLN-3448.
M	Y	10. Available components assembled into laboratory scale system	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	

Table C-31. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	PLN-3448, SDD-266
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Lab tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Full-scale systems are commercially available, www.shoes.com
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-266; CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Full-scale systems are commercially available, www.shoes.com
T	Y	18. Controlled laboratory environment used in testing	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	Y	19. Initial cost drivers identified	EDF-9704, ICP (2009)
M	Y	20. Integration studies have been started	SDD-266
P	Y	21. Formal risk management program initiated	PLN-2477 (Calcine Disposition Project Risk Management Plan), EDF-9706 (Feed Canning System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.4) (Conceptual Design))

Table C-31. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	22. Key manufacturing processes for equipment systems identified	Full-scale systems are commercially available, www.shoes.com
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-266
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Full-scale systems are commercially available, www.shoes.com
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448, Staiger and Swenson 2007, Berreth (1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-266, EDF-7748
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	DDN-038, PLN-3448
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.4.1 HIP Feed Blender Subsystem (continued)

Table C-32. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Laboratory tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	2. Plant size components available for testing	Mixer manufacturers make both laboratory-scale and full production-scale equipment. Scaling documents are not required.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	Laboratory tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007); SDD-266
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 PLN-3448 This TMP
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-266
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	Mixer and ancillary equipment manufacturers make laboratory scale to full production scale. These are readily available
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	Mixer manufacturers make lab-scale to full-production-scale equipment.

Table C-32. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Full-scale mockup testing
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Mixer drawings available for all proven sizes
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Laboratory tests included components that worked in each step of the process together for mixing of additives with surrogate calcine and other test results See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	See DDN 038. Test will handle range of waste material, sizes for scale up, etc.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 Preliminary design RAMI
M	N	14. Some special purpose components combined with available laboratory components for testing	See EDF-9704, Analysis of Mixing Options; see DDN 038
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	See DDN 038 for operational environment. A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at MFC (Bateman 2002).
T	Y	17. Component integration issues and requirements identified	SDD-266.
P	Y	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Mixer manufacturers make both laboratory-scale to full production-scale equipment. Vendor equipment cut sheets are readily available

Table C-32. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	See PLN-3448
P		20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	See EDF-9705 Mixer Design
T		21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at MFC (Bateman 2002). Additional laboratory tests included components mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	22. Formal control of all components to be used in final prototypical test system	These have been established in the commercially available HIP machine and are provided within a large Avure HIP machine operator's manual (SE008552).
P	Y	23. Configuration management plan in place	PLN-2478
T	N	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	DDN 038: Broad range of simulant calcine/additive tested.
T	N	25. Simulants have been developed that cover the full range of waste properties	See DDN 038: Broad range of simulant calcine/additive tested.
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	See DDN 038: Broad range of simulant calcine/additive tested.

Table C-32. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	See DDN 038, Broad range of simulant calcine/additive tested.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	See DDN 038, Broad range of simulant calcine/additive tested.
T	N	29. Test results for simulants and real waste are consistent	See DDN 038, Broad range of simulant calcine/additive tested.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	See DDN 038, full-scale mockup
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Process variable parameters are set by the mixer manufacturer.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	See DDN 038
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Full-scale mockup test plans.
P	Y	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in INL and ANSTO 2009, PLN-3448, EDF-9716; PFD SO-11; SDD-270; and BFD
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477 "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.4.1 HIP Feed Blender Subsystem (continued)

Table C-33. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The Mixer is widely available commercially. Therefore, relationships between the mixer and connections, power supply, and control are well understood.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary design
T	Y	4. Operating environment for final system known	Additives and simulated calcine tested in hot cell environment by BEA in 2008 using MIH-9 HIP machine (BEA 2008). Navisworks modeling providing the operating environment layout and component interface simulation will be demonstrated in EDF-9705 (Mixer Design) and SDD-266 (Feed Canning System)
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	EDF-9705 (Mixer Design) provides actual reliability, maintainability, and supportability information on the mixer. DDN-038 provides the mixer component integration (full-scale mockup-mixer operation, lifting and handling, remote maintenance, etc demonstrated at full scale)
P	P	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the mixer O&M Manual and SDD-266 (Feed Canning System)
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	These have been established in the mixer O&M Manual and SDD-266 (Feed Canning System)

Table C-33. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	9. Off-normal operating responses determined for engineering scale system	These have been established in the mixer O&M Manual and SDD-266 (Feed Canning System)
T	Y	10. System technical interfaces defined	Mixer manufacturers make full production-scale equipment with well established interface requirements for connections, instrumentation, power, etc. SDD-266 (Feed Canning System) details the interface requirements.
T	Y	11. Component integration demonstrated at an engineering scale	Mixing machines are widely available commercially. The manufacturers / designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design Mixer are proven technology
P	Y	12. Scaling issues that remain are identified and understood. Supporting analysis is complete.	Mixer vendors make laboratory to full production equipment. Scaling issues are not applicable
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, “Calcine Disposition Project Federal Acquisition Strategy (Draft)”
M	Y	16. Critical manufacturing processes prototyped	Mixing machines are widely available commercially. The manufacturers / designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Mixers are proven technology.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Mixing machines are commercially available. The manufacturers/designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Mixers are proven technology.

Table C-33. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	Mixing machines are commercially available. The manufacturers / designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Mixers are proven technology.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Mixing machines are commercially available. The manufacturers/designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Mixers are proven technology.
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification
M	N	21. Components are functionally compatible with operational system	Full-scale mockup.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	DDN-038 establishes mixer machine modifications that allow remote removal of: components as well as operational tasks. Full-scale mockup.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-038 will establish administrative and engineered safety control on the full scale mixer machine environment. Full-scale mockup.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	Y	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Preliminary hazard evaluation is complete; EDF-7748

Table C-33. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	27. Process and tooling are mature to support fabrication of components/system	Mixing machines are widely available commercially. The manufacturers/ designers of these machines have modeled interfaces between components. The interfaces have worked well to provide a good design. Mixers are proven technology.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-038 Full-scale mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	Mixing machines are commercially available. The manufacturers/designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Mixers are proven technology.
T	N	30. Laboratory and engineering-scale experiments are consistent	Full-scale mockup.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Mixing machines are commercially available. The manufacturers/designers of these machines have modeled interfaces between components. The interfacing has worked well to provide a good design. Full-scale mockup.
T	N	32. Plan for engineering-scale testing executed - results validate design	Full-scale mockup.
M	N	33. Production demonstrations are complete (at least one time)	Full-scale mockup.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.4.1 HIP Feed Blender Subsystem References

Bateman, K. J., R. H. Rigg, and J. D. Wiest, "Hot Isostatic Pressing of Ceramic Waste from Spent Nuclear Fuel," *Proceeding of ICONE1010th International Conference on Powder on Nuclear Engineering,* April 2002.

BEA, 2008, *Process ANSTO Can #1133 in Hot Isostatic Press*, PWS No. 2-4125, October 20, 2008.

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

Carter, Melody L., Martin W. A. Stewart, Eric R. Vance, Bruce D. Begg, Sam Moricca, and Julia Tripp, "HIPed Tailored Ceramic Waste Forms for the Immobilization of Cs, Sr, and Tc," INL/CON-07-12875, *Preprint for Global 2007, Boise Idaho, September 9–13*, 2007.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9704, 2010, "Calcine Mixer Trade Options for the Calcine Disposition Project (SEN 5.4.) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9705, 2010, "Mixer Design for the Calcine Disposition Project (SEN 5.4.) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9706, 2010, "Feed Canning System Failure Modes and Effects Analysis for the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9716, 2010, "Hot Isostatic Pressing Machine Failure Modes and Effects Analysis (SEN 6.3) (Conceptual Design)," Rev. A, Record 3270197, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Nelson, L. O., and K. Vinjamuri, 1995, *Results of Intermediate-Scale Hot Isostatic Can Experiments*, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company, December 1993.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences,* Vol. 33, Issue 7, 1998.

SDD-266, 2010, "Feed Canning System for the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, *Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms*, HLW-REF-5076/BAS-12-88, September 30, 1988.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Tripp, Julia, and Vince Maio, 2006, *Evaluation of the Use of Synroc to Solidify the Cesium and Strontium Separations Product from Advanced Aqueous Reprocessing of Spent Nuclear Fuel*, INL/EXT-06-01377, Battelle Energy Alliance, LLC, March 2006.

Vinjamuri, K., and R. V. Raman, "Progress Report for FY91: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High Level Waste," September 30, 1991.

5.4.3 HIP Can Fill and Sealing Subsystem

Table C-34. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	Y	
• Do limitations in the understanding of the technology impact the safety of the design?	Y	
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?	Y	
• Have the potential hazards of the technology been assessed?	Y	
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

5.4.3 HIP Can Fill and Sealing Subsystem (continued)

Table C-35. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in PLN-3448 and SDD-266.
M	Y	2. Laboratory components tested are surrogates for system components	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009); Staples (1988); Vinjamuri (1991); Raman (1993, 1998); Nelson (1995); Tripp (2006), and Carter (2007); MCE (2008), MCE (2009a)
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Full-scale testing and studies have been completed on a fill station for IWTU, MCE-TR-DP-006-002, MCE-DRR-DP006-004,
P	Y	6. Overall system requirements for end user's application are <u>known</u>	PLN-3448, SDD-266, and TFR-401
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	MCE-TR-DP-006-002 MCE-DRR-DP006-004
P	Y	9. Laboratory testing requirements derived from system requirements are established	System performance requirements are established in TFR-401, SDD-266, MCE-TR-DP-006-002, MCE-DRR-DP006-004, DDN-004
M	Y	10. Available components assembled into laboratory scale system	Laboratory tests included component mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO 2009; Staples 1988; Vinjamuri 1991; Raman
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	

Table C-35. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
			1993; Nelson 1995; Raman 1998; Tripp 2006; and Carter 2007; MCE-TR-DP-006-002; MCE-DRR-DP006-004.
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	Demonstration and data requirements established in PLN-3448, SDD-266, MCE-TR-DP-006-002, MCE-DRR-DP006-004
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Full-scale testing and studies have been completed on a fill station for IWTU in a simulated environment, MCE-TR-DP-006-002, MCE-DRR-DP006-004
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Full-scale equipment has been made for IWTU, MCE-TR-DP-006-002, MCE-DRR-DP006-004
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-266, CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Full-scale equipment has been made for IWTU, MCE-TR-DP-006-002, MCE-DRR-DP006-004
T	Y	18. Controlled laboratory environment used in testing	Controlled laboratory was used for testing of IWTU fill station, MCE-TR-DP-006-002, MCE-DRR-DP006-004
P	Y	19. Initial cost drivers identified	ICP (2009); SDD-229
M	Y	20. Integration studies have been started	SDD-266
P	Y	21. Formal risk management program initiated	PLN-2477; EDF-9706

Table C-35. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	22. Key manufacturing processes for equipment systems identified	Components are machined or commercially available. SDD-266, SDD-229, ww.younginds.com, www.binmaster.com
P	Y	23. Scaling documents and designs of technology have been completed	Full-scale testing and studies have been completed on a fill station for IWTU, MCE-TR-DP-006-002, and MCE-DRR-DP006-004.
M	Y	24. Key manufacturing processes assessed in laboratory	Components are machined or commercially available. SDD-266; SDD-229; ww.younginds.com, www.binmaster.com
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-266
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Full-scale testing and studies have been completed on a fill station for IWTU, MCE-TR-DP-006-002, MCE-DRR-DP006-004
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Components are machined or commercially available. SDD-266; SDD-229; ww.younginds.com, www.binmaster.com
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448; Staiger and Swenson (2007); Berreth (1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-266; PLN-7748

Table C-35. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	PLN-3448; DDN-004, MCE-ATP-DP006-001 (Factory Acceptance Test)
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.4.3 HIP Can Fill and Sealing Subsystem (continued)

Table C-36. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Equipment has been tested for the IWTU filling process. MCE-DPR-DP006-004
T	Y	2. Plant size components available for testing	Acceptance testing has been completed for IWTU, MCE-DPR-DP006-004
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-266
P	N	4. Preliminary design engineering begins	Preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 (Technical and Functional Requirements for the CDP – Conceptual Design) and PLN-3448
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-266
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	System and components have been created for IWTU, MCE-DPR-DP006-004
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	Equipment was constructed for IWTU fill station. MCE-DPR-DP006-004
T	Y	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Similar system for IWTU has been constructed, MCE-DPR-DP006-004
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Fill stations have been fabricated for the IWTU facility. MCE-DPR-DP006-004
T	N	11. Laboratory-scale, similar system tested with range of simulants	Full-scale mockup
T	Y	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Full-scale tests have been completed, MCE-DPR-DP006-004
M	N	13. Availability and reliability (RAMI) target levels identified	Preliminary CDP Process System RAMI Analysis

Table C-36. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Modifications to the IWTU system will be made on DDN-004.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Three dimensional drawings will be started in Preliminary design. Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	DDN-004
T	N	17. Component integration issues and requirements identified	DDN-004
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary design
T	Y	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Demonstrated on IWTU tests, MCE-DPR-DP006-004
T	Y	22. Formal control of all components to be used in final prototypical test system	Control of components has been demonstrated in IWTU tests, MCE-DPR-DP006-004
P	Y	23. Configuration management plan in place	PLN-2478, "Configuration Management Plan for the Calcine Disposition Project"
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	Detailed analyses of calcine complete (Swenson and Staiger 2007). EDF-9694, summarized in PLN-3448 and TMP
T	Y	25. Simulants have been developed that cover the full range of waste properties	The composition the three types of calcine surrogates has been developed as shown in PLN-3448 and TMP.

Table C-36. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	The composition the three types of calcine surrogates has been developed as shown in PLN-3448 and this TMP.
T	Y	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Simulants tested for IWTU system, MCE-DPR-DP006-004
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	DDN-004 Full-scale mockup
T	N	29. Test results for simulants and real waste are consistent	DDN-004 Full-scale mockup
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	Full-scale prototype has been built and tested for IWTU. MCE-DPR-DP006-004
T	N	31. Limits for all process variables/parameters and safety controls are being refined	DDN-004 Full-scale mockup
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	DDN-004 Full-scale mockup
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Full-scale mockup
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	To be completed during Preliminary design.
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477, "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.4.3 HIP Can Fill and Sealing Subsystem (continued)

Table C-37. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Full-scale testing completed for IWTU, MCE-DPR-DP006-004
M	N	2. Availability and reliability (RAMI) levels established	DDN-004
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary Design
T	N	4. Operating environment for final system known	Preliminary Design
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	DDN-004
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Preliminary Design
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary Design
P	N	9. Off-normal operating responses determined for engineering scale system	Full-scale mockup
T	N	10. System technical interfaces defined	SDD-290
T	N	11. Component integration demonstrated at an engineering scale	DDN-004
P	Y	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	No scaling will take place. Full-scale models have and will be constructed, MCE-DPR-DP006-004.
P	N	13. Analysis of project timing ensures technology will be available when required	TMP
P	N	14. Have established an interface control process	Establish ICDs

Table C-37. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	15. Acquisition program milestones established for start of final design (CD-2)	Acquisition plan
M	Y	16. Critical manufacturing processes prototyped	Full-scale prototype has been built, MCE-DPR-DP006-004
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Full-scale prototype has been built, MCE-DPR-DP006-004
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	Full-scale testing completed for IWTU, MCE-DPR-DP006-004
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Full-scale prototype has been built, MCE-DPR-DP006-004
P	N	20. Technology "system" design specification complete and ready for detailed design	Design Specification
M	N	21. Components are functionally compatible with operational system	Full-scale mockup
T	Y	22. Engineering-scale system is high-fidelity functional prototype of operational system	Full-scale prototype has been built, MCE-DPR-DP006-004
P	Y	23. Formal configuration management program defined to control change process	PLN-2478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-004 Full-scale mockup
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	EDF-7748
M	Y	27. Process and tooling are mature to support fabrication of components/system	Full-scale prototype has been built, MCE-DPR-DP006-004

Table C-37. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-004 Full-scale mockup
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	Full-scale testing will and has been done, MCE-DPR-DP006-004
T	Y	30. Laboratory and engineering-scale experiments are consistent	Full-scale testing will and has been done, MCE-DPR-DP006-004
T	N	31. Limits for all process variables/parameters and safety controls are defined	DDN-004 Full-scale mockup
T	Y	32. Plan for engineering-scale testing executed - results validate design	Full-scale tests completed, MCE-DPR-DP006-004
M	N	33. Production demonstrations are complete (at least one time)	DDN-004 Full-scale mockup

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.4.3 HIP Can Fill and Sealing Subsystem References

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9776, 2010, "HIP Can Fill and Sealing Station for the Calcine Disposition Project," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

MCE, 2008, *Prototype Proof-of-Principle Test, Canister Filling and Decon Cell System Project*, MCE-TR-DP006-002, Rev. 1, Mid Columbia Engineering, March 2008.

MCE, 2009a, *Final Design Review Report, Canister Filling and Decontamination Cell System*, MCE-DPR-DP006-004, Rev. 0, Mid Columbia Engineering, December 2009.

MCE, 2009b, *Factory Acceptance Test*, MCE-DPR-DP006-004, Rev. 0, Mid Columbia Engineering, December 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-229, 2009, "IWTU – Product Transfer and Loadout," Rev. 3, Idaho Cleanup Project.

SDD-266, 2010, "Feed Canning System For The Calcine Disposition Project, (SEN 5.4) (Conceptual Design)," Rev. A, Draft, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.4.5 HIP Can Subsystem

Table C-38. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	Y	
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?	Y	

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?	Y	
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

5.4.5 HIP Can Subsystem (continued)

Table C-39. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete; EDF-7748; Key process parameters/variables are included in: PLN-3448; EDF-9718; SDD-270 SDD-292
M	Y	2. Laboratory components tested are surrogates for system components	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated calcine and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); Argonne drawing F3640-0114-ED, Rev 2, includes a small can drawing tested at ANL-W (now MFC). Nelson, L. O., and K. Vinjamuri (1995).
T	Y	3. Individual components tested in laboratory~~/~~or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Initial modeling was performed piecemeal by INL Argonne in the 1990s for initial HIP treatment studies. Modeling and simulation utilized available software and hardware consistent with the time period. The modeling and simulation work is being reviewed and enhanced for the CDP. EDF-9644
P	Y	6. Overall system requirements for end user's application are known	TFR-401

Table C-39. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	The performance metrics are be established in the technology development document, PLN-3448; EDF-9644
P	Y	9. Laboratory testing requirements derived from system requirements are established	EDF-9644, PLN-3448
M	Y	10. Available components assembled into laboratory scale system	Laboratory-scale testing with available components Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); S. Raman (1993); Nelson, L. O., and K. Vinjamuri (1995)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); DF-9643; EDF-9644; Nelson, L. O., and K. Vinjamuri (1995)
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	PLN-3448
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); S. Raman (1993); Nelson, L. O., and K. Vinjamuri, 1995; PLN-3448
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	PLN-3448; EDF-9643; H. T. Larker, R. Tegman, "Treatment of Cladding Hulls by the HIPOW Process," High-Pressure Laboratory ASEA AB, S-915 00 Robertsfors, Sweden, *Scientific Basis for Nuclear Waste Management*, Vol. 3, 1981, Plenum Press, N.Y. ed. J. Moore.

Table C-39. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	EDF-9643 SDD-292; CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	PLN-3448; EDF-9643; EDF-9644
T	Y	18. Controlled laboratory environment used in testing	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); Nelson, L. O., and K. Vinjamuri, 1995
P	Y	19. Initial cost drivers identified	EDF-9578; Calcine Treatment Options Summary (ICP 2009).
M	Y	20. Integration studies have been started	SDD-266; SDD-268; SDD-269; SDD-270; SDD-285; SDD-292
P	Y	21. Formal risk management program initiated	PLN-2477; EDF-9718; EDF-9643
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9578; EDF-9643; SDD-292,
P	Y	23. Scaling documents and designs of technology have been completed	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); EDF-9643; EDF-9644; EDF-9794; PLN-3448; SDD-292; Larker, H. T., and R. Tegman, (1981); Staples, B. A., (1988); ANSTO, (2009) 1:6 scaling ratio based on diameter
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9578; SDD-292
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	CDR (ICP 2010); SDD-270; SDD-292; SDD-266; SDD-268; SDD-269; SDD-285
T	Y	26. Low fidelity technology “system” integration and engineering completed in a laboratory environment	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); Nelson, L. O., and K. Vinjamuri, 1995

Table C-39. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M		27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	PLN-2477; EDF-9578; EDF-9718
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Detailed analyses of calcine complete Swenson and Staiger (2007); EDF-9694; PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Surrogate calcine for testing being developed from pilot plant calcines. PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); H. T. Larker and R. Tegman (1981); M. W. Wilding and D. W. Rhodes (1971); Vinjamuri, K. and S. V. Raman (1991); Nelson, L. O. and K. Vinjamuri (1995); Raman (1993, 1998)
T	Y	31. Process/parameter limits and safety control strategies are being explored	Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, (2002); H. T. Larker and R. Tegman (1981); PLN-3448; Staples (1988); SDD-270; SDD-292, PLN-2477; PWS No. 2-4125, "Process ANSTO can #1133 in Hot Isostatic Press"
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	PLN-3448; DDN-001, HIP Can and HIP Mix Material Properties. This DDN enhances the material properties data for can and HIP mixture materials. DDN-002, COMSOL Multiphysical Software. This DDN implement multi-physics simulation capabilities in the analysis organization. DDN-034, HIP Can Oxide Thermal Properties. This DDN

Table C-39. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
			enhances material and mixture data properties in the areas of softening and melting temperature and viscosity at high temperatures and pressures. DDN-039, Calibration and Experimental Verification of Calcine Mix Properties. This DDN enhances DDN-001 is the areas of calcine and mixture properties. DDN-041, HIP Can Material Properties and Behavior. This DDN enhances the reliability of the FEM/FEA analysis models and simulations through calibration with actual test data for predictive interpretation of the results.
P	Y	33. Technology availability dates established	PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy"

Source: Table F-5 from DOE Guide 413.3-4.

5.4.5 HIP Can Subsystem (continued)

Table C-40. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The basic details of the underlying physics (thermal, structural, fluid flow, and chemistry) are not understood for the full range of simulants. Full-scale HIP can testing.
M	Y	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Prelim design planning, 3D models and drawings. Shutdown philosophy, thresholds, and parameters.
T	N	4. Operating environment for final system known	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Commercial levels have been established: Example Avure HIP machine operator's manual (SE008552). SDD-270 (HIP Can Treatment System) Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	Commercial levels for engineering scale studies have been established: Example: Avure HIP machine operator's manual (SE008552). SDD-270 (HIP Can Treatment System)
T	Y	10. System technical interfaces defined	SDD-292 identifies system interfaces.

Table C-40. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	11. Component integration demonstrated at an engineering scale	DDN-025 Provides the HIP component integration (HIP can, HIP furnace/HCC, lifting and handling, remote maintenance) to be demonstrated at a full scale
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	EDF-9648; EDF-9647 Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP and PEP
P	N	14. Have established an interface control process	Establish ICDs
P	Y	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	N	16. Critical manufacturing processes prototyped	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Cans are designed to utilize commercially available fabrication techniques. SDD-292
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Bench scale: Laboratory HIP tests with surrogate calcine are captured in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007). Need to perform full-scale HIP can testing with full-scale HIP mockup system.
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	Need to perform full-scale HIP can testing with full-scale HIP mockup system.

Table C-40. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	20. Technology "system" design specification complete and ready for detailed design	Need to complete can specification. Need to perform full-scale HIP can testing with full-scale HIP mockup system.
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final technical report on technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP (EDF-7748)
M	N	27. Process and tooling are mature to support fabrication of components/system	Build full-scale cans for full-scale testing.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
T	Y	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale HIP can testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale HIP can testing with full-scale HIP mockup system.

Table C-40. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale HIP can testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.4.5 HIP Can Subsystem References

ANL-W, Argonne Drawing F3640-0114-ED, Rev. 2. Argonne National Laboratory-West, Idaho Falls, Idaho.

Bateman, Kenneth J., Richard H. Rigg, and James D. Wiest, 2002, "Hot Isostatic Pressing of Ceramic Waste from Spent Nuclear Fuel," ICONE10-22199," *Proceedings of ICONE10 10th International Conference on Nuclear Engineering, Arlington, VA, USA, April 14–18, 2002*, American Society of Mechanical Engineers.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9578, 2010, "Hot Isostatic Press Can Trade Study for the Calcine Disposition Project (SEN 5.4.5) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9643, 2010, "HIP Can for the Calcine Disposition Project (SEN 5.4.5) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9644, 2010, "HIP Small Can Conceptual Design and Analysis with Abaqus Model (SEN 5.4.5) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9718, 2010, "Hot Isostatic Pressing Machine Failure Mode and Effects Analysis (SEN 6.3) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

EDF-9794, 2010, "Calcine Disposition Project Hot Isostatic Pressing Process Parametric Calculation (SEN 6.3) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Larker, H. T., and R. Tegman, 1981, "Treatment of Cladding Hulls by the HIPOW Process, High-Pressure Laboratory ASEA AB, S-915 00, Robertsfors, Sweden," J. Moore, ed., *Scientific Basis for Nuclear Waste Management*, Vol. 3, Plenum Press, New York.

Nelson, L. O., and K. Vinjamuri, 1995, *Results of Intermediate-Scale Hot Isostatic Can Experiments*, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

PWS No. 2-4125, "Process ANSTO can #1133 in Hot Isostatic Press" Idaho National Laboratory Material Fuels Complex (MFC) Process Work Sheet, October 20, 2008, Idaho National Laboratory.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company, December 1993.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences,* Vol. 33, Issue 7, 1998.

SDD-266, 2010, "Feed Canning System for the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

SDD-268, 2010, "Bakeout System for the Calcine Disposition Project (SEN 6.1) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

SDD-269, 2010, "HIP Furnace/HIP Can Confinement System for the Calcine Disposition Project (SEN 6.2)(Conceptual Design)," Rev. A, Idaho Cleanup Project.

SDD-270, 2010, "HIP Can Treatment System for the Calcine Disposition Project (SEN 6.3) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

SDD-285, 2010, "In-Cell Transfer System for the Calcine Disposition Project (SEN 7.4) (Conceptual Design)," Rev. A, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, *Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms*, HLW-REF-5076/BAS-12-88, September 30, 1988.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Vinjamuri, K., and S. V. Raman, 1991, *Progress Report for FY 1991: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High-Level Waste*, HLW-REF-5059, September 30, 1991.

Wilding, M. W., and D. W. Rhodes, *Characteristics of Radioactive Zirconia Calcine after Heating to High Temperature*, HLW-REF-6118/IN-1486, U.S. Atomic Energy Commission, June 1, 1971.

5.6.1 Retrieval Subsystem Remote Maintenance and Tools

Table C-41. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.6.1 Retrieval Subsystem Remote Maintenance and Tools (continued)

Table C-42. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in INL and ANSTO (2009); PLN-3448; SDD-267
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-267
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per Remote Maintenance Design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-267

Table C-42. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-267. CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-267 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689; SDD-267
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689 SDD-267
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-267
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	Systems and/or subsystems are not defined as process systems. Completion Date: October 4, 2010.

Table C-42. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-267
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448.
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-267
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.6.1 Retrieval Subsystem Remote Maintenance and Tools (continued)

Table C-43. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-267
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 "Technical and Functional Requirements for the CDP – Conceptual Design"
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-267
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Prototype tooling will need to be designed during full-scale mock-up as required per DDN-032.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-267

Table C-43. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	CDR (RPT-270)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-267
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-267

Table C-43. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	TMP
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-267
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477 "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.6.1 Retrieval Subsystem Remote Maintenance and Tools (continued)

Table C-44. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-267
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-267 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required.	This TMP

Table C-44. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-267
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-267
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-267
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	DDN-032. High-fidelity functional prototypes of operational system will have to be designed at full-scale for mockup testing.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-032 provides the remote maintenance and tools integration with the process systems to be demonstrated at full-scale mock-up.

Table C-44. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-267
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-267
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.6.1 Retrieval Subsystem Remote Maintenance and Tools References

Draper, John V., and Reid L. Kress, 2000, *Remote Maintenance Design Guide for Compact Processing Units*, ORNL/TM-2000/124, Robotics and Process Systems Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9689, 2010, "Retrieval Remote Design, Maintenance and Tools for the Calcine Disposition Project," Rev. 0, Draft, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-267, 2010, "Retrieval Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.6.2 Transport and Surge Subsystem Remote Maintenance and Tools

Table C-45. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.6.2 Transport and Surge Remote Maintenance and Tools (continued)

Table C-46. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in INL and ANSTO (2009); PLN-3448; SDD-267
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-267
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per Remote Maintenance Design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory scale system	
T	Y	11. Laboratory experiments with available components show that they work together	

Table C-46. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-267
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-267 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-267 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689; SDD-267
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689 SDD-267

Table C-46. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-267
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	Systems and/or subsystems are not defined as process systems. Completion Date: October 4, 2010.
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-267
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448.
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-267
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.6.2 Transport and Surge Subsystem Remote Maintenance and Tools (continued)

Table C-47. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-267
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-267
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Prototype tooling will need to be designed during full-scale mock-up as required per DDN-033.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-267

Table C-47. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	CDR (RPT-270)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-267
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-267

Table C-47. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-267
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP (EDF-7748)
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.6.2 Transport and Surge Subsystem Remote Maintenance and Tools (continued)

Table C-48. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-267
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-267 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	TMP

Table C-48. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-267
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-267
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-267
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	DDN-033 High-fidelity functional prototypes of operational system will have to be designed at full-scale for mockup testing.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-033 provides the remote maintenance and tools integration with the process systems to be demonstrated at full-scale mock-up.

Table C-48. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-267
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-033 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-267
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.6.2 Transport and Surge Subsystem Remote Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9689, 2010, "Retrieval Remote Design, Maintenance, and Tools for the Calcine Disposition Project (SEN 5.6) (Conceptual Design)," Rev. A, Record 3270180, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-267, 2010, "Retrieval Remote Design, Maintenance, and Tools (SEN 5.6) (Conceptual Design)," Rev. A, Record 3270399, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.6.3 Feed Canning Subsystem Remote Maintenance and Tools

Table C-49. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.6.3 Feed Canning Remote Maintenance and Tools (continued)

Table C-50. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete EDF-7748 ("Preliminary Hazard and Operability Review of the Calcine Disposition Project"). Key process parameters/variables are included in INL and ANSTO 2009, PLN-3448, SDD-267 "Remote Maintenance and Tools for the Calcine Disposition Project".
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-271
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).

Table C-50. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per remote maintenance design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-271
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-271 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-271 RPT-260

Table C-50. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689, SDD-267, System Engineering Integration Matrix, and Inventor Modeling.
P	Y	21. Formal risk management program initiated	PLN-2477 "Calcine Disposition Project Risk Management Plan"
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689 SDD-271
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-271
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-271
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-271
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-271

Table C-50. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.6.3 Feed Canning Subsystem Remote Maintenance and Tools (continued)

Table C-51. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-271
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 "Technical and Functional Requirements for the CDP – Conceptual Design"
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-271
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-271

Table C-51. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	CDR (RPT-270)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-271
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-271

Table C-51. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	TMP
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-271
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477 "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.6.3 Feed Canning Subsystem Maintenance and Tools (continued)

Table C-52. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-271
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-271 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-52. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Analysis of project timing ensures technology will be available when required	TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-271
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-271
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-271
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-52. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-271
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-271
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.6.3 Feed Canning Subsystem Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-271, 2010, "Treatment Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

5.6.4 Offgas Subsystem Remote Maintenance and Tools

Table C-53. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

5.6.4 Offgas Subsystem Remote Maintenance and Tools (continued)

Table C-54. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete EDF-7748 ("Preliminary Hazard and Operability Review of the Calcine Disposition Project"). Key process parameters/variables are included in INL and ANSTO 2009, PLN-3448, SDD-267 "Remote Maintenance and Tools for the Calcine Disposition Project".
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-271
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are
M	Y	10. Available components assembled into laboratory scale system	

Table C-54. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	11. Laboratory experiments with available components show that they work together	commercially available at full scale. Tooling will be designed per remote maintenance design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-271
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-271 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-271 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689, SDD-267, System Engineering Integration Matrix, and Inventor Modeling.

Table C-54. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	21. Formal risk management program initiated	PLN-2477 "Calcine Disposition Project Risk Management Plan"
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689 SDD-271
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-271
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-271
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-271
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-271
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

5.6.4 Offgas Subsystem Remote Maintenance and Tools (continued)

Table C-55. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-271
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 "Technical and Functional Requirements for the CDP – Conceptual Design"
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-271
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-271

Table C-55. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	CDR (RPT-270)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-271
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-271

Table C-55. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	TMP
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-271
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477 "Calcine Disposition Project Risk Management Plan"

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

5.6.4 Offgas Subsystem Maintenance and Tools (continued)

Table C-56. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-271
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-271 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-56. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Analysis of project timing ensures technology will be available when required	TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548, "Calcine Disposition Project Federal Acquisition Strategy (Draft)"
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-271
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-271
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-271
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478 "Configuration Management Plan for the Calcine Disposition Project"
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-56. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-271
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-271
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

5.6.4 Offgas Subsystem Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-271, 2010, "Treatment Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

6.1.1 Bakeout Subsystem

Table C-57. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

6.1.1 Bakeout Subsystem (continued)

Table C-58. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748; PLN-3448; EDF-9678; EDF-9712; SDD-268
M	Y	2. Laboratory components tested are surrogates for system components	Staples 1988 Vinjamuri 1991 Raman 1993 Nelson 1995 Raman 1998 Bateman 2002 Carter 2007 INL and ANSTO 2009
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	SDD-268 EDF-9712
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR 401 SDD-268
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	SDD-268 EDF-9678
P	Y	9. Laboratory testing requirements derived from system requirements are established	CDP DDN-015 CDP DDN-040 SDD-268
M	Y	10. Available components assembled into laboratory scale system	Staples (1988) Vinjamuri (1991) Raman (1993) Nelson (1995) Raman (1998) Bateman (2002) Carter (2007) INL and ANSTO (2009)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	SDD-268
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	PLN-3448 CDP DDN-015 CDP DDN-040

Table C-58. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Staples (1988) Vinjamuri (1991) Raman (1993) Nelson (1995) Raman (1998) Bateman (2002) Carter (2007) INL and ANSTO (2009) SDD-268
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	SDD-268 http://www.grievecorp.com/
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-268 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	PLN-3448 SDD-268
T	Y	18. Controlled laboratory environment used in testing	Staples (1988) Vinjamuri (1991) Raman (1993) Nelson (1995) Raman (1998) Bateman (2002) Carter (2007) INL and ANSTO (2009)
P	Y	19. Initial cost drivers identified	RPT-260 EDF-9692 “Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)”
M	Y	20. Integration studies have been started	SDD-268 EDF-9678
P	Y	21. Formal risk management program initiated	PLN-2477 (Calcine Disposition Project Risk Management Plan) EDF-9681

Table C-58. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	22. Key manufacturing processes for equipment systems identified	SDD-268 http://www.grievecorp.com/
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-268
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Staples (1988) Vinjamuri (1991) Raman (1993) Nelson (1995) Raman (1998) Bateman (2002) Carter (2007) INL and ANSTO (2009)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-268 http://www.grievecorp.com/
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007) EDF-9694 Berreth (1988) PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Staples (1988) Vinjamuri (1991) Raman (1993) Nelson (1995) Raman (1998) Bateman (2002) Carter (2007) INL and ANSTO (2009)
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9681 SDD-268 EDF-7748

Table C-58. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	PLN-3448 CDP DDN-015 CDP DDN-040
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.1.1 Bakeout Subsystem (continued)

Table C-59. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in INL and ANSTO (2009), and PLN-3448; EDF-9678; SDD-268
T	N	2. Plant size components available for testing	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-268 details the interface requirements.
P	N	4. Preliminary design engineering begins	Begin preliminary design
T	N	5. Requirements for technology verification established; to include testing and validation of safety functions.	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup. TFR-401 EDF-7748
T	N	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-268 details the interface requirements and DDN-015 Indicates what interfaces are required as part of the full-scale mockup.
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Bakeout ovens are built to the size we need in industry. Also DDN-015 will outline a test plan in regard to the full-scale mockup.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	There will be no new tooling or manufacturing processes used on the CDP bakeout subsystem components.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	CDP DDN-015 bakeout system will define the needed system performance parameters for all bakeout subsystems. This will we used in coordination with a test plan that involves a full-scale mockup to assess bakeout system integration and validate safety functions.

Table C-59. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	There will be no new tooling or manufacturing processes used on the CDP bakeout subsystem components. SDD-268
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Laboratory tests on HIP included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	As part of the HIP tests, analysis was done to verify that parts worked together as stated in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007). DDN-015 and coordinating test plans will direct the development of an accurate full-scale mockup.
M	N	13. Availability and reliability (RAMI) target levels identified	TFR-401 Final CDP Process System RAMI Analysis
M	N	14. Some special purpose components combined with available laboratory components for testing	DDN-015 identifies the required full-scale testing.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Integrated of PLN-3448 and DDN 015 will support the buildup and operation of the full-scale mockup which will include validation of safety functions.
T	Y	17. Component integration issues and requirements identified	Bakeout Ovens are commercially available and have been used throughout industry for the past 50 years. Manufacturing techniques have been defined. EDF-9678; SDD-268

Table C-59. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Need detailed design drawings
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401; SDD-268
P	Y	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Integration studies have been performed as part of continuing integration efforts and are expressed in SDD-268, in facility layouts as well as in EDF-9678 on the Bakeout Subsystem.
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Integration studies have been performed as part of continuing integration efforts and are expressed in SDD-268, in facility layouts as well as in EDF-9678 on the Bakeout Subsystem. Need integration studies as defined in TMP.
T	N	22. Formal control of all components to be used in final prototypical test system	PLN-2478
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	SDD-268 and EDF-9678 on the Bakeout Subsystem will discuss the equipment in the Bakeout Subsystem. EDF-9694 will address Calcine properties. Also DDN-015 contributes to a test plan that will validate the physical and chemical properties that are required for placement into the bakeout oven and for extraction from the bakeout oven.
T	Y	25. Simulants have been developed that cover the full range of waste properties	The composition of three types of calcine surrogates has been developed as shown in PLN-3448 and this TMP.
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	The composition the three types of calcine surrogates has been developed as shown in PLN-3448.
T	Y	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Laboratory tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988),

Table C-59. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
			Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Test with HLW calcine at MFC.
T	Y	29. Test results for simulants and real waste are consistent	Laboratory tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	To further define scale up issues CDP DDN-015 is going to be used to help direct testing and full-scale mockup activities.
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	SDD-268
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	DDN-015.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	A test plan detailing the waste form and equipment testing will be provided.
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP (EDF-7748)
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.1.1 Bakeout Subsystem (continued)

Table C-60. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Bakeout Ovens capable of the temperature we are using for bakeout are commercially available. Other interfaces will be tested in the full-scale mockup under DDN-015.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	Y	4. Operating environment for final system known	RPT-270
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Documents that will discuss and contribute to RAMI include SDD-268 and DDN 015 full-scale testing.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary design SDD-268
P	N	9. Off-normal operating responses determined for engineering scale system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	10. System technical interfaces defined	SDD-268 details the interface requirements.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP

Table C-60. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	The bakeout oven will not require development of any new manufacturing processes. The technology we will be using for the bakeout oven is already available and manufacturable in industry.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	There are bakeout oven manufacturers that could build the furnace we need for this project including Grieve High Temperature Ovens and the Lanly Company.
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility.
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility.
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification
M	N	21. Components are functionally compatible with operational system	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final technical report on technology

Table C-60. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Finalize HAZOP analysis, EDF- 7748
M	Y	27. Process and tooling are mature to support fabrication of components/system	The bakeout oven will be built of industry standard components that already have mature manufacturing processes and tooling to support their fabrication.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	N	30. Laboratory and engineering-scale experiments are consistent	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup. This will allow verification of consistency between laboratory and engineering scale experiments.
T	N	31. Limits for all process variables/parameters and safety controls are defined	RPT-270 Full-scale testing as defined in DDN-015.
T	N	32. Plan for engineering-scale testing executed - results validate design	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
M	N	33. Production demonstrations are complete (at least one time)	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.1.1 Bakeout Subsystem References

75 FR 1, 2010, "Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement Revised by State 12/21/09," *Federal Register*, U.S. Department of Energy, pp. 137–140, January 4, 2010.

75 FR 7, 2010, "Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement; Correction," *Federal Register*, U.S. Department of Energy, pp. 1615–1616, January 12, 2010.

Bateman, K. J., R. H. Rigg, J. D. Wiest, "Hot Isostatic Pressing of Ceramic Waste from Spent Nuclear Fuel," *Proceeding of ICONE1010th International Conference on Powder on Nuclear Engineering*, April 2002.

Carter, Melody L., Martin W. A. Stewart, Eric R. Vance, Bruce D. Begg, Sam Moricca, and Julia Tripp, "HIPed Tailored Ceramic Waste Forms for the Immobilization of Cs, Sr, and Tc," INL/CON-07-12875, *Preprint for Global 2007, Boise Idaho, September 9–13*, 2007.

CDP Block Flow Diagrams

CDP Process flow Diagrams

DDN-015, 2010, "Bakeout Data Needs for Calcine Disposition Project" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

DDN-040, 2010, "HIP Mix Pack Density Effects Design Data Needs" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

DOE/RW-0351, "Waste Acceptance System Requirements Document," Rev. 5, United States Department of Energy, Office of Civilian Radioactive Waste Management, May 2007.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9678, 2010, "Calcine Disposition Project Bakeout System Design (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9679, 2010, "Bakeout Vacuum System Design for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9681, 2010, "Bakeout System Failure Mode Analysis for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9688, 2010, "Block Flow Diagram Description for Calcine Disposition Project"(Draft)," Rev. 0, Draft, Idaho Cleanup Project.

EDF-9687, 2010, "Process Flow Diagram Description for Calcine Disposition Project" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

EDF-9659, 2010, "Inlet and Vent Port Welding for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9716, 2010, "Calcine Disposition Project Hot Isostatic Pressing Machine Failure Mode and Effects Analysis (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9718, 2010, "HIP Can Failure Modes and Effects (Draft)," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Nelson, L. O., and K. Vinjamuri, 1995, *Results of Intermediate-Scale Hot Isostatic Can Experiments*, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

Project (P.1.10.02.02.6.01) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company, December 1993.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences,* Vol. 33, Issue 7, 1998.

SDD-268, 2010, "Bakeout System for the Calcine Disposition Project (SEN 6.1) (Conceptual Design)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-270, 2010, "Hot Isostatic Pressing System for the Calcine Disposition Project (P.1.10.02.02.6.03) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-292, 2010, "Hot Isostatic Pressing Can Subsystem for the Calcine Disposition Project (P.1.10.02.02.5.04.05) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SOW-8479, 2010, "Statement of Work for Calcine Disposition Project Waste Hazen Research Surrogate Request for Proposal," Rev 0, 16 March 2010.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, *Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms*, HLW-REF-5076/BAS-12-88, September 30, 1988.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Vinjamuri, K., and S. V. Raman, 1991, *Progress Report for FY 1991: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High-Level Waste*, HLW-REF-5059, September 30, 1991.

6.1.2 Inlet and Vent Port Welding Subsystem

Table C-61. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

6.1.2 Inlet and Vent Port Welding Subsystem (continued)

Table C-62. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-9659 SDD-268
M	Y	2. Laboratory components tested are surrogates for system components	SDD-268 Cannell, Gee, and Heise (1999)
T	Y	3. Individual components tested in laboratory-or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	SDD-268 EDF-9659
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR 401 SDD-268 (Cannell, Gee, and Heise 1999)
T	Y	7. Overall system requirements for end user's application are documented	TFR 401 SDD-268
P	Y	8. System performance metrics measuring requirements have been established	SDD-268 (Cannell, Gee, and Heise 1999)
P	Y	9. Laboratory testing requirements derived from system requirements are established	CDP DDN-015 CDP DDN-040 PLN-3448
M	Y	10. Available components assembled into laboratory scale system	SDD-268 (Cannell, Gee, and Heise 1999)
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	SDD-268
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-268
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	SDD-268 (Cannell, Gee, and Heise 1999)

Table C-62. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	SDD-268 (Cannell, Gee, and Heise 1999)
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-268 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	SDD-268 PLN-3448
T	Y	18. Controlled laboratory environment used in testing	SDD-268 (Cannell, Gee, and Heise 1999)
P	Y	19. Initial cost drivers identified	EDF-9692
M	Y	20. Integration studies have been started	SDD-268
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	SDD-268 (Cannell, Gee, and Heise 1999)
P	Y	23. Scaling documents and designs of technology have been completed	SDD-268 (Cannell, Gee, and Heise 1999)
M	Y	24. Key manufacturing processes assessed in laboratory	SDD-268 (Cannell, Gee, and Heise 1999)
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-268
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	SDD-268 (Cannell, Gee, and Heise 1999)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-268 (Cannell, Gee, and Heise 1999)
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson 2007; EDF-9694; PLN-3448; Berreth (1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	SDD-268 (Cannell, Gee, and Heise 1999)

Table C-62. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-268 EDF-7748
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	CDP DDN-015 CDP DDN-040
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-4 from DOE Guide 413.3-4.

6.1.2 Inlet and Vent Port Welding Subsystem (continued)

Table C-63. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448; EDF-9678; SDD-268
T	N	2. Plant size components available for testing	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-268 details the interface requirements.
P	Y	4. Preliminary design engineering begins	Begin preliminary design
T	N	5. Requirements for technology verification established; to include testing and validation of safety functions.	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup; TFR-401
T	N	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-268 (Bakeout System) details the interface requirements and DDN-016 Indicates what interfaces are required as part of the full-scale mockup.
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	Nuclear Canister welders are available in industry from companies like Arc Machines, Inc.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	There will be no new tooling or manufacturing processes used on the CDP Vent Port Welder subsystem components.
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	CDP DDN-016 Vent Port Welder Subsystem will define the needed system performance parameters for the vent port welder subsystem. This will we used in coordination with a test plan that involves a full-scale mockup to assess bakeout system and welder integration and validate safety functions.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	There will be no new tooling or manufacturing processes used on the welding subsystem components.

Table C-63. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Lab tests on HIP included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009); Staples (1988); Vinjamuri and Raman (1991); Raman (1993, 1998); Nelson and Vinjamuri (1995); Tripp and Maio (2006); and Carter et al. (2007).
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	As part of the HIP tests, analysis was done to verify that parts worked together as stated in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007). DDN-015 and coordinating test plans will direct the development of an accurate full-scale mockup.
M	N	13. Availability and reliability (RAMI) target levels identified	TFR-401 Final CDP Process System RAMI Analysis
M	N	14. Some special purpose components combined with available laboratory components for testing	DDN-016 provides for the full-scale mockup testing
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Completed mockup drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Information from the test plan documents is integrated into PLN-3448 and for the vent port weld subsystem test plans are developed to support CDP DDN-016. These documents will support the buildup and operation of the full-scale mockup which will include validation of safety functions.
T	Y	17. Component integration issues and requirements identified	Nuclear Canister Welders are commercially available from Arc Machines Inc. and others. Manufacturing techniques have been defined. EDF-9678; SDD-268

Table C-63. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Detailed design drawings
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	Industry Standard, TFR-401; and SDD-268. Also a time and motion model has been developed that is supported and discussed in EDF-9692.
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Integration studies have been performed as part of continuing integration efforts and are expressed in SDD-268, in facility layouts as well as in EDF-9678. Complete Preliminary technology feasibility engineering report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Integration studies have been performed as part of continuing integration efforts and are expressed in SDD-268, in facility layouts as well as in EDF-9659. DDN-016
T	N	22. Formal control of all components to be used in final prototypical test system	Formal Controls are defined in DDN-016 and in coordination with continued testing that will be performed by the technology development group.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	SDD-268 and EDF-9659 will discuss the equipment in the Vent Port Welder Subsystem. EDF-9694 will address Calcine properties. Also DDN-015 contributes to a test plan that will validate the physical and chemical properties that are required for placement into the bakeout oven and for extraction from the bakeout oven.
T	Y	25. Simulants have been developed that cover the full range of waste properties	The composition the three types of calcine surrogates has been developed as shown in PLN-3448. This TMP
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	The composition the three types of calcine surrogates has been developed as shown in PLN-3448. This TMP

Table C-63. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Lab tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Detailed analyses of calcine are complete (Swenson and Staiger 2007). EDF-9694, summarized in PLN-3448.
T	Y	29. Test results for simulants and real waste are consistent	Lab tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	DDN-016
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	SDD-268 DDN-015.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	DDN-016
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Need test plans
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	DDN-016

Table C-63. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.1.2 Inlet and Vent Port Welding Subsystem (continued)

Table C-64. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	Welders capable of the welding nuclear canisters are commercially available from Companies like Arc Machines Inc.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Preliminary design
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	SDD-268 DDN 016
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	Operating Limits will be defined as part of the testing activities directed under CDP DDN-016.
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008	This will be addressed in preliminary design SDD-268
P	N	9. Off-normal operating responses determined for engineering scale system	Need to perform full-scale testing with full-scale integrated HIP mockup system.
T	Y	10. System technical interfaces defined	SDD-268 (Bakeout System)
T	N	11. Component integration demonstrated at an engineering scale	CDP DDN-015 Provides the Vent port welder integration (HIP can, vacuum port, remote maintenance, etc.) demonstrated at a full-scale.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	DDN-016 Provides the Vent port welder oven integration demonstrated at a full scale.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs

Table C-64. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	The vent port welder will not require development of any new manufacturing processes. The technology we will be using for the vent port welder is already available and manufacturable in industry at companies like Arc Machines Inc.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	There are welder manufacturers that could build the welder we need for this project including Arc Machines Inc.
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility.
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	CDP DDN-015 outlines testing and mockup requirements that will fully demonstrate feasibility.
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification
M	N	21. Components are functionally compatible with operational system	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008	Final Technical Report on Technology

Table C-64. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Finalize HAZOP analysis in EDF-7748
M	Y	27. Process and tooling are mature to support fabrication of components/system	The inlet and vent port welder will be built of industry standard components that already have mature manufacturing processes and tooling to support their fabrication.
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
T	N	30. Laboratory and engineering-scale experiments are consistent	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup. This will allow verification of consistency between laboratory and engineering scale experiments.
T	N	31. Limits for all process variables/parameters and safety controls are defined	DDN-016
T	N	32. Plan for engineering-scale testing executed - results validate design	CDP DDN-016 outlines testing and mockup requirements that will fully demonstrate feasibility and compatibility including the development of a full-scale mockup.
M	N	33. Production demonstrations are complete (at least one time)	Summarized in Final Report

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.1.2 Inlet and Vent Port Welding Subsystem References

75 FR 1, 2010, "Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement Revised by State 12/21/09," *Federal Register*, U.S. Department of Energy, pp. 137–140, January 4, 2010.

75 FR 7, 2010, "Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement; Correction," *Federal Register*, U.S. Department of Energy, pp. 1615–1616, January 12, 2010.

Bateman, K. J., R. H. Rigg, J. D. Wiest, "Hot Isostatic Pressing of Ceramic Waste from Spent Nuclear Fuel," *Proceeding of ICONE1010th International Conference on Powder on Nuclear Engineering*, April 2002.

Cannell, Gary R., James T. Gee, and Roy B. Heise, 1999, *Sealing of Canistered High-Level Waste at SRS*, WSRC-MS-98-00626, Savannah River Site, Aiken, South Carolina, February 10, 1999.

Carter, Melody L., Martin W. A. Stewart, Eric R. Vance, Bruce D. Begg, Sam Moricca, and Julia Tripp, "HIPed Tailored Ceramic Waste Forms for the Immobilization of Cs, Sr, and Tc," INL/CON-07-12875, *Preprint for Global 2007, Boise Idaho, September 9–13*, 2007.

CDP Block Flow Diagrams

CDP Process flow Diagrams

DDN-015, 2010, "Bakeout Data Needs for Calcine Disposition Project" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

DDN-040, 2010, "HIP Mix Pack Density Effects Design Data Needs" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

DOE/RW-0351, "Waste Acceptance System Requirements Document," Rev. 5, United States Department of Energy, Office of Civilian Radioactive Waste Management, May 2007.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9659, 2010, "Inlet and Vent Port Welding for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9678, 2010, "Calcine Disposition Project Bakeout System Design (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9679, 2010, "Bakeout Vacuum System Design for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9681, 2010, "Bakeout System Failure Mode Analysis for use in the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9687, 2010, "Process Flow Diagram Description for Calcine Disposition Project" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

EDF-9688, 2010, "Block Flow Diagram Description for Calcine Disposition Project" (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9716, 2010, "Calcine Disposition Project Hot Isostatic Pressing Machine Failure Mode and Effects Analysis (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9718, 2010, "HIP Can Failure Modes and Effects (Draft)," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Nelson, L. O., and K. Vinjamuri, 1995, *Results of Intermediate-Scale Hot Isostatic Can Experiments*, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company, December 1993.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences,* Vol. 33, Issue 7, 1998.

SDD-268, 2010, "Bakeout System for the Calcine Disposition Project (P.1.10.02.02.6.01) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-270, 2010, "Hot Isostatic Pressing System for the Calcine Disposition Project (P.1.10.02.02.6.03) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-292, 2010, "Hot Isostatic Pressing Can Subsystem for the Calcine Disposition Project (P.1.10.02.02.5.04.05) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SOW-8479, 2010, "Statement of Work for Calcine Disposition Project Waste Hazen Research Surrogate Request for Proposal," Rev 0, 16 March 2010.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, *Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms*, HLW-REF-5076/BAS-12-88, September 30, 1988.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Vinjamuri, K., and S. V. Raman, 1991, *Progress Report for FY 1991: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High-Level Waste*, HLW-REF-5059, September 30, 1991.

6.2.3 HIP Furnace/HCC Loading Subsystem

Table C-65. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

6.2.3 HIP Furnace/HCC Loading Subsystem (continued)

Table C-66. TRL 3 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Academic (basic science) environment	SDD-269; EDF-9775; EDF-9712; HIP equipment is commercially available (see, for example, www.avure.com)
P	Y	2. Some key process and safety requirements are identified; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-9757; SDD-269; EDF-7748; Abbott (2010)
T	Y	3. Predictions of elements of technology capability validated by analytical studies	EDF-9712; HIP equipment is commercially available (see, for example, www.avure.com)
P	Y	4. The basic science has been validated at the laboratory scale	HIP equipment is commercially available (and includes accelerated cool down) (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	Y	5. Science known to extent that mathematical and/or computer models and simulations are possible	SDD-269; EDF-9712
P	Y	6. Preliminary system performance characteristics and measures have been identified and estimated	SDD-269; EDF-9712; EDF-9692
T	Y	7. Predictions of elements of technology capability validated by Modeling and Simulation (M&S)	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9712
M	Y	8. No system components, just basic laboratory research equipment to verify physical principles	
T	Y	9. Laboratory experiments verify feasibility of application	
T	Y	10. Predictions of elements of technology capability validated by laboratory experiments	
P	Y	11. Customer representative identified to work with development team	75 FR 1, 2010
P	Y	12. Customer participates in requirements generation	CTR-292 IPT Charter

Table C-66. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Requirements tracking system defined to manage requirements creep	SDD-269 HIP Furnace/HCC
T	Y	14. Key process parameters/variables and associated hazards have begun to be identified; to include compliance with DOE-STD-1189-2008	EDF-9757; SDD-269; EDF-7748; Abbott (2010); EDF-9794
M	Y	15. Design techniques have been identified/developed	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9775; SDD-269
T	Y	16. Paper studies indicate that system components ought to work together	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9712; SDD-269
P	Y	17. Customer identifies technology need date.	PLN-3448
T	Y	18. Performance metrics for the system are established (What must it do)	SDD-269; EDF-9692; EDF-9712
P	Y	19. Scaling studies have been started	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9794
M	Y	20. Current manufacturability concepts assessed	SDD-269 HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)

Table C-66. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	21. Sources of key components for laboratory testing identified	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) SDD-269; DDN-027, HIP Furnace/HCC Filter Testing
T	Y	22. Scientific feasibility fully demonstrated	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9712
T	Y	23. Analysis of present state of the art shows that technology fills a need	EDF-9775
P	Y	24. Risk areas identified in general terms	EDF-9757; SDD-269
P	Y	25. Risk mitigation strategies identified	EDF-9757; SDD-269; EDF-7748 Abbott (2010)
P	Y	26. Rudimentary best value analysis performed for operations	EDF-9712; EDF-9692; EDF-9775; SDD-269
T	Y	27. Key physical and chemical properties have been characterized for a number of waste samples	Staiger and Swenson (2007); PLN-3448
T	Y	28. A simulant has been developed that approximates key waste properties	Staiger and Swenson (2007); PLN-3448
T	Y	29. Laboratory scale tests on a simulant have been completed	PLN-3448
T	Y	30. Specific waste(s) and waste site(s) has (have) been defined	Staiger and Swenson (2007); PLN-3448
T	Y	31. The individual system components have been tested at the laboratory scale	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9712

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-4 from DOE Guide 413.3-4.

6.2.3 HIP Furnace/HCC Loading Subsystem (continued)

Table C-67. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008	Preliminary hazard evaluation is complete; EDF-7748; Abbott (2010); SDD-269; EDF-9692
M	Y	2. Laboratory components tested are surrogates for system components	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	EDF-9712; EDF-9794; EDF-9692
P	Y	6. Overall system requirements for end user's application are known	TFR-401; SDD-269
T	Y	7. Overall system requirements for end user's application are documented	TFR-401; SDD-269
P	Y	8. System performance metrics measuring requirements have been established	SDD-269
P	Y	9. Laboratory testing requirements derived from system requirements are established	DDN-027 HIP Furnace/HCC Filter Testing; SDD-269
M	N	10. Available components assembled into laboratory scale system	DDN-027 HIP Furnace/HCC Filter Testing
T	N	11. Laboratory experiments with available components show that they work together	DDN-027 HIP Furnace/HCC Filter Testing
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) SDD-269; EDF-9712

Table C-67. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	Demonstration and data requirements established in PLN-3448. DDN-027 HIP Furnace/HCC Filter Testing (December 2010)
T	N	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	DDN-027 HIP Furnace/HCC Filter Testing (December 2010) EDF-7748
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-269
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com) EDF-9712
T	N	18. Controlled laboratory environment used in testing	DDN-027 HIP Furnace/HCC Filter Testing (December 2010)
P	Y	19. Initial cost drivers identified	Cost drivers provided in ICP (2009); EDF-9794; EDF-9775; SDD-269
M	Y	20. Integration studies have been started	EDF-9712; SDD-269
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	

Table C-67. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P/T	Y	25. Functional process description developed.(Systems/subsystems identified)	SDD-269
T	N	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	DDN-027 HIP Furnace/HCC Filter Testing (December 2010)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007); PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Staiger and Swenson (2007); PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Staiger and Swenson (2007); PLN-3448
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-269; EDF-9712; EDF-7748; EDF-9757
T	N	32. Test plan documents for prototypical laboratory- scale tests completed	DDN-027 HIP Furnace/HCC Filter Testing (December 2010)
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.2.3 HIP Furnace/HCC Loading Subsystem (continued)

Table C-68. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	SDD-269 HIP Furnace/HCC
T	Y	2. Plant size components available for testing	DDN-027-Filter Test Furnace Manufacturer for existing furnace testing HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-269 HIP Furnace/HCC
P	N	4. Preliminary design engineering begins	Begin preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401; PLN-3448; EDF-7748
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-269
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	DDN-027-Filter Test DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)

Table C-68. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	DDN-027-Filter Test DDN-031-Full Sized Mockup Test HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	N	9. High fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	DDN-027-Filter Test DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing EDF-7748; Abbott (2010); EDF-9757
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	DDN-031-Full Sized Mockup Test HIP equipment is commercially available (see, for example, www.avure.com) Filters are commercially available (see, for example, www.mottcorp.com)
T	N	11. Laboratory-scale, similar system tested with range of simulants	DDN-027-Filter Test DDN-031-Full Sized Mockup Test
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	DDN-027-Filter Test DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing
M	N	13. Availability and reliability (RAMI) target levels identified	TFR-401 Technical and Functional Requirements Preliminary CDP Process System RAMI Analysis
M	N	14. Some special purpose components combined with available laboratory components for testing	DDN-027-Filter Test DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Inventor Modeling, the CDR (ICP 2010). Build To Print Drawings
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	DDN-027-Filter Test DDN-031-Full Sized Mockup Test

Table C-68. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	17. Component integration issues and requirements identified	SDD-269 HIP Furnace/HCC
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Inventor Modeling CDR (ICP 2010) Build To Print Drawings
T	N	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-269
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-269 HIP Furnace/HCC EDF-7748 Hazard Analysis
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	DDN-027-Filter Test DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing
T	Y	22. Formal control of all components to be used in final prototypical test system	PLN-2478
P	Y	23. Configuration management plan in place	PLN-2478
T	N	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	PLN-3448 Technology Readiness Plan DDN-026-Calcine and Cesium Study
T	N	25. Simulants have been developed that cover the full range of waste properties	PLN-3448 Technology Readiness Plan DDN-026-Calcine and Cesium Study
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	PLN-3448 Technology Readiness Plan DDN-026-Calcine and Cesium Study
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	DDN-027-Filter Test DDN-031-Full Sized Mockup Test DDN-026-Calcine and Cesium Study
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	DDN-027-Filter Test DDN-031-Full Sized Mockup Test DDN-026-Calcine and Cesium Study

Table C-68. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	29. Test results for simulants and real waste are consistent	PLN-3448 DDN-026-Calcine and Cesium Study
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	DDN-031-Full Sized Mockup Test EDF-7748
T	N	31. Limits for all process variables/parameters and safety controls are being refined	DDN-031-Full Sized Mockup Test EDF-7748
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	DDN-031-Full Sized Mockup Test EDF-7748
P	N	33. Test plan documents for prototypical engineering-scale tests completed	DDN-027-Filter Test DDN-031-Full Sized Mockup Test DDN-026-Calcine and Cesium Study PLN-3448
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Hazardous material forms Hazardous material inventories EDF-7748; EDF-9757; SDD-269
P	N	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477; EDF-7748

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.2.3 HIP Furnace/HCC Loading Subsystem (continued)

Table C-69. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	SDD-269; DDN-031-Full Sized Mockup Test; DDN-027-Filter Test Furnace Manufacturer for existing furnace testing
M	N	2. Availability and reliability (RAMI) levels established	TFR-401; Preliminary CDP Process System RAMI Analysis DDN-031-Full Sized Mockup Test
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary design
T	Y	4. Operating environment for final system known	SDD-269
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Preliminary CDP Process System RAMI Analysis DDN-031-Full Sized Mockup Test DDN-027-Filter Test
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	SDD-269 EDF-7748 DDN-031-Full Sized Mockup Test DDN-027-Filter Test
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-269 HCC L&U System EDF-7748 DDN-031-Full Sized Mockup Test DDN-027-Filter Test
P	N	9. Off-normal operating responses determined for engineering scale system	SDD-269 HCC L&U System EDF-9757 DDN-031-Full Sized Mockup Test
T	Y	10. System technical interfaces defined	SDD-269

Table C-69. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	11. Component integration demonstrated at an engineering scale	DDN-031-Full Sized Mockup Test
P	Y	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	SDD-269 EDF-9748
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	N	16. Critical manufacturing processes prototyped	SDD-269 DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing
M	N	17. Most pre-production hardware is available to support fabrication of the system	SDD-269 DDN-031-Full Sized Mockup Test Furnace Manufacturer for existing furnace testing
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	SDD-269 DDN-031-Full Sized Mockup Test DDN-027-Filter Test DDN-026-Calcine and Cesium Study
M	N	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	SDD-269 DDN-031-Full Sized Mockup Test DDN-027-Filter Test DDN-026- Calcine and Cesium Study Furnace Manufacturer for existing furnace testing
P	Y	20. Technology “system” design specification complete and ready for detailed design	Preliminary Design Specification
M	N	21. Components are functionally compatible with operational system	SDD-269 DDN-031-Full Sized Mockup Test DDN-027-Filter Test
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	DDN-031-Full Sized Mockup Test DDN-027-Filter Test
P	Y	23. Formal configuration management program defined to control change process	PLN-3478

Table C-69. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-027-Filter Test DDN-031 -Full Sized Mockup Test EDF-7748
P	Y	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Preliminary design and hazardous material forms
M	Y	27. Process and tooling are mature to support fabrication of components/system	Furnace Manufacturer for existing furnace testing
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-031-Full Sized Mockup Test DDN-027-Filter Test DDN-026-Calcine and Cesium Study
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	DDN-031-Full Sized Mockup Test SDD-269
T	N	30. Laboratory and engineering-scale experiments are consistent	DDN-031-Full Sized Mockup Test SDD-269 DDN-027-Filter Test
T	N	31. Limits for all process variables/parameters and safety controls are defined	EDF-9757 SDD-269 DDN-031-Full Sized Mockup Test DDN-027-Filter Test
T	N	32. Plan for engineering-scale testing executed - results validate design	DDN-031-Full Sized Mockup Test SDD-269 HIP Furnace/HCC
M	N	33. Production demonstrations are complete (at least one time)	DDN-031-Full Sized Mockup Test Summarized in Final Report

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.2.3 HIP Furnace/HCC Loading Subsystem References

75 FR 1, 2010, "Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement Revised by State 12/21/09," *Federal Register*, U.S. Department of Energy, pp. 137–140, January 4, 2010.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9692, 2010, "Time and Motion Studies for the Calcine Disposition Project (Conceptual Design)," Rev. A, Record 3270370, Idaho Cleanup Project.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9712, 2010, "Thermal Analysis for Calcine Disposition Project Conceptual Design (Draft)," Rev. A, Idaho Cleanup Project.

EDF-9748, 2010, "HIPing Process Analysis (Draft)," Rev. A, Idaho Cleanup Project.

EDF-9753, 2010, "Calcine Disposition Project HIP Can Confinement Trade Study (Draft)," Rev. A, Idaho Cleanup Project.

EDF-9757, 2010, "Calcine Disposition Project HIP Can Confinement Failure Modes and Effects Analysis (Draft)," Rev. A, Idaho Cleanup Project.

EDF-9794, Calcine Disposition Project Hot Isostatic Pressing Process Parametric Calculation (SEN 6.3) (Conceptual Design).

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

RPT-366, 2010, "Conceptual Design Safety Report of the Calcine Disposition Project (Draft)," Rev. A, Idaho Cleanup Project.

SDD-269, 2010, "HIP Can Confinement Loading and Unloading System for the Calcine Disposition Project (P.1.10.02.02.6.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-270, 2010, "HIP Can Treatment system for the calcine disposition project (SEN 6.3) (CONCEPTUAL DESIGN)," Rev. 0, Draft, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

6.3.1 HIP Treatment Subsystem

Table C-70. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	Y	
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?	Y	
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

6.3.1 HIP Treatment Subsystem (continued)

Table C-71. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete (EDF-7748); Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448; EDF-9716; PFD (Dwg. SO-12); SDD-270; and BFD (Dwg. SO-3).
M	Y	2. Laboratory components tested are surrogates for system components	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). The MIH-9 used a monolithic vessel with upper and lower o-ring sealed plugs and a large oval yoke. The yoke, when centered over the pressure vessel, holds the top and bottom plugs in place to maintain the vessel pressure. (Bateman 2002). EDF-9710 recommends the use of a wire-wound vessel over the monolithic design. The wire-wound HIP machine uses a wire-wound vessel with upper and lower o-ring sealed plugs and a large oval yoke similar in design and function to the MIH-9. The wire-wound design is supplied in a laboratory-scale size and has been used in both laboratory scale and full-scale production size in industry for the last 50 years. (Ref: Avure Technologies, AIP) Additional laboratory tests included components mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	HIP machines are commercially available. The manufactures / designers of these machines have modeled interfaces between components. Component interface simulation was demonstrated in EDF-9711

Table C-71. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	6. Overall system requirements for end user's application are known	TFR-401; System requirements for waste form/additives are provided in PLN-3448
T	Y	7. Overall system requirements for end user's application are documented	TFR-401; System requirements for waste form/additives are provided in PLN-3448
P	Y	8. System performance metrics measuring requirements have been established	Measuring requirement are temperature, pressure, power levels, and coolant flow. These have been established in the commercially available HIP machine and are provided within a large Avure HIP machine operator's manual (SDD-270 Appendix).
P	Y	9. Laboratory testing requirements derived from system requirements are established	HIP machines are commercially available. And have been used throughout industry for the past 50 years. (Ref: Avure Technologies, AIP). Components of the HIP machine have been demonstrated to work together. Lab tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009); Staples (1988); Vinjamuri and Raman (1991); Raman (1993, 1998); Nelson and Vinjamuri (1995); Tripp and Maio (2006); and Carter et al. (2007).
M	Y	10. Available components assembled into laboratory scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and technology demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	Demonstration and data requirements established in PLN-3448.
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). (Bateman 2002). Additives and simulated Calcine tested in hot cell environment by BEA in 2008 using MIH-9 HIP machine (BEA 2008).
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	HIP manufacturers make both laboratory-scale and full production-scale equipment.

Table C-71. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	PFD (Dwg. SO-12, SDD-270 (HIP Can Treatment System), GA (Dwg. M-12) and BFD (Dwg. SO-3).
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	HIP manufacturers make both laboratory scale and full production-scale equipment. Scale–up relationships are understood.
T	Y	18. Controlled laboratory environment used in testing	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of surrogate ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). (Bateman 2002). Lab tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	Y	19. Initial cost drivers identified	Cost drivers provided in CDP Calcine Treatment Options Summary (ICP 2009). Parametric cost data in SDD-270 and EDF-9794.
M	Y	20. Integration studies have been started	PFD (Dwg. SO-12), SDD-270, and HIP handling in EDF-9711, and Dwg. M-12.
P	Y	21. Formal risk management program initiated	PLN-2477 issued and being revised.
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9710
P	Y	23. Scaling documents and designs of technology have been completed	HIP manufacturers make both laboratory scale and full production-scale equipment. Scaling document are not required
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9710
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-270 will provide the process description.

Table C-71. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	HIP machines are commercially available.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	See Risk Management Plan and EDF-9716
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Detailed analyses of calcine complete (Swenson and Staiger 2007). EDF-9694, Summarized in PLN-3448. Completion Date: October 4, 2010
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	Surrogate calcine for testing being developed from pilot plant calcines (PLN-3448).
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of surrogate ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). (Bateman 2002). Lab tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007). Simulants summarized in PLN-3448
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9716; EDF-9713, and SDD-270.
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Lab tests included components that worked in each step of the process together for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).

Table C-71. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	33. Technology availability dates established	See CDP Project Schedule Summarized in PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.3.1 HIP Treatment Subsystem (continued)

Table C-72. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). (Bateman 2002). Additional laboratory tests included components mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	2. Plant size components available for testing	HIP machines are commercially available. And have been used throughout industry for the past 50 years (Ref: Avure Technologies, AIP). Plant size components of the HIP machine are available.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	HIP manufacturers make full production-scale equipment with well established interface requirements for coolant, vacuum, argon, instrumentation, and power. SDD-270 details the interface requirements. CDP Process and Facility System Integration provides the interface link between the HIP machine and all other systems.
P	N	4. Preliminary design engineering begins	Begin preliminary design SDD-269; SDD-270
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401 and this TMP
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-269; SDD-270

Table C-72. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	HIP manufacturers make both laboratory-scale and full production-scale equipment. Lab-scale prototypes of remotely replaceable hydraulic ram used to move the yoke has been created (Bateman 2002). Full-scale prototypes of remotely replaceable hydraulic rams used to remove the upper cap have not been created. DDN-021 establishes HIP machine modifications that allow remote removal of: (1) the hydraulic ram used to move the yoke, and (2) the hydraulic rams used to remove the upper enclosure.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	HIP machines are commercially available. And have been used throughout industry for the past 50 years (Ref: Avure Technologies, AIP). This is not a new manufacturing process.
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Testing and validation of safety functions has been performed on a Laboratory scale prototype in a hot cell environment. (Bateman 2002). Need to test full-scale integrated HIP treatment system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	HIP machines are commercially available. And have been used throughout industry for the past 50 years. Manufacturing techniques have been defined. (Ref: Avure Technologies, AIP)
T	Y	11. Laboratory-scale, similar system tested with range of simulants	Lab tests included components mixing of additives with simulant calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	HIP machines are commercially available. And have been used throughout industry for the past 50 years. Manufacturing techniques have been defined. (Ref: Avure Technologies, AIP). Reliability of machines has been proven.
M	N	13. Availability and reliability (RAMI) target levels identified	TFR-401 Preliminary CDP Process System RAMI Analysis

Table C-72. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	14. Some special purpose components combined with available laboratory components for testing	Lab tests included components mixing of additives with simulant calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Design full-scale HIP system
T	Y	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). (Bateman 2002). Additives and simulated Calcine tested in hot cell environment by BEA in 2008 using MIH-9 HIP machine (BEA 2008).
T	Y	17. Component integration issues and requirements identified	HIP machines are commercially available. And have been used throughout industry for the past 50 years. Manufacturing techniques have been defined. (Ref: Avure Technologies, AIP) EDF-9715; SDD-270; 30% design process flow sheets; and Inventor Modeling.
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Detailed design drawings for mockup
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	Industry Standard; TFR-401; and SDD-270
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008	Complete preliminary technology report

Table C-72. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	A HIP model MIH-9 was purchased in 1999 and used for laboratory-scale testing of simulated ceramic waste and irradiated material in several HIP can configurations performed in hot cell environment at Argonne National Laboratory (now MFC). The MIH-9 used a monolithic vessel with upper and lower o-ring sealed plugs and a large oval yoke. The yoke, when centered over the pressure vessel, holds the top and bottom plugs in place to maintain the vessel pressure. (Bateman 2002). Additional laboratory tests included components mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	22. Formal control of all components to be used in final prototypical test system	These have been established in the commercially available HIP machine and are provided within a large Avure HIP machine operator's manual (SE008552).
P	Y	23. Configuration management plan in place	PLN-2478
T	N	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A test plan detailing the waste form and equipment testing for determining the time/temperature/pressure requirements during the HIP process will be provided in an appendix to TMP.
T	Y	25. Simulants have been developed that cover the full range of waste properties	The composition the three types of calcine surrogates has been developed as shown in PLN-3448 and this TMP.
T	Y	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	

Table C-72. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Lab tests included components for mixing of additives with surrogate calcine, bakeout, HIP can sealing, HIP treatment, and waste form testing. See INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007).
T	Y	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Lab HIP tests with surrogate Calcine are captured in INL and ANSTO (2009), Staples (1988), Vinjamuri and Raman (1991), Raman (1993, 1998), Nelson and Vinjamuri (1995), Tripp and Maio (2006), and Carter et al. (2007). HIP treatment of HLW Calcine planned at MFC
T	N	29. Test results for simulants and real waste are consistent	
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	The wire wound HIP design is supplied in a laboratory-scale size and has been used in both laboratory scale and full-scale production size in industry for the last 50 years. (Ref: Avure Technologies, AIP)
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Process variable parameters are set by the HIP manufacturer. DDN-020 through 025 will establish administrative and engineered safety control on the full-scale HIP machine within a hot cell environment
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	DDN-020 through 025
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Develop test plan per DDN-020 through 025
P	Y	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize EDF-7748. Key process parameters/variables are included in INL and ANSTO 2009, PLN-3448, EDF-9716 HIP Failure Mode and Effects Analysis, PFD SO-11, SDD-270, and BFD

Table C-72. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.3.1 HIP Treatment Subsystem (continued)

Table C-73. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The HIP machine is commercially available. Therefore, relationships between the machine and the coolant supply, argon supply, power supply, and control are well understood.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008	Complete preliminary design
T	N	4. Operating environment for final system known	DDN-020 through 025
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	EDF-9710 provides actual reliability, maintainability, and supportability information on the HIP machine. DDN-025
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	CDR (ICP 2010); PRD; and associated preliminary design cost estimate and schedule
T	N	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Avure HIP machine operator's manual (SE008552). SDD-270 DDN-020 through 025
P	N	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008	
P	N	9. Off-normal operating responses determined for engineering scale system	

Table C-73. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	10. System technical interfaces defined	HIP manufacturers make full production-scale equipment with well established interface requirements for coolant, vacuum, argon, instrumentation, and power. SDD-270 details the interface requirements.
T	N	11. Component integration demonstrated at an engineering scale	DDN-020 through 025
P	Y	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	HIP manufacturers make both laboratory-scale and full production-scale equipment.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	Prototype of critical manufacturing process is not required. The wire wound HIP design is supplied and has been used in a full-scale production size for the last 50 years. (Ref: Avure Technologies, AIP)
M	Y	17. Most pre-production hardware is available to support fabrication of the system	The wire wound HIP design is supplied and has been used in a full-scale production size for the last 50 years. (Ref: Avure Technologies, AIP)
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification

Table C-73. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	21. Components are functionally compatible with operational system	The wire wound HIP design is supplied and has been used in a full-scale production size for the last 50 years. (Ref: Avure Technologies, AIP). Functionally is compatible with operational system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	DDN-021 establishes HIP machine modifications that allow remote removal of: (1) the hydraulic ram used to move the yoke, and (2) the hydraulic rams used to remove the upper enclosure. DDN-022 establishes HIP machine modifications that simplify manual detachment of the top cap, bottom cap, exposed wiring, limit switches, junction boxes, and other machine mounted electrical equipment
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-023 will establish administrative and engineered safety control on the full-scale HIP machine within a hot cell environment
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Finalize HAZOP (EDF-7748)
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. The wire wound HIP design is supplied and has been used in a full-scale production size for the last 50 years. (Ref: Avure Technologies, AIP)

Table C-73. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-020 through 025
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	DDN-023 will establish administrative and engineered safety control on the full-scale HIP machine within a hot cell environment.
T	N	30. Laboratory and engineering-scale experiments are consistent	DDN-020 through 025
T	N	31. Limits for all process variables/parameters and safety controls are defined	DDN-023 will establish administrative and engineered safety control on the full-scale HIP machine within a hot cell environment
T	N	32. Plan for engineering-scale testing executed - results validate design	DDN-020 through 025
M	N	33. Production demonstrations are complete (at least one time)	DDN-020 through 025

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.3.1 HIP Treatment Subsystem References

Bateman, K. J., R. H. Rigg, J. D. Wiest, "Hot Isostatic Pressing of Ceramic Waste from Spent Nuclear Fuel," Proceeding of ICONE1010th International Conference on Powder on Nuclear Engineering, April 2002.

BEA, 2008, Process ANSTO Can #1133 in Hot Isostatic Press, PWS No. 2-4125, October 20, 2008.

Carter, Melody L., Martin W. A. Stewart, Eric R. Vance, Bruce D. Begg, Sam Moricca, and Julia Tripp, "HIPed Tailored Ceramic Waste Forms for the Immobilization of Cs, Sr, and Tc," INL/CON-07-12875, *Preprint for Global 2007, Boise Idaho, September 9–13*, 2007.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9694, 2010, "Synopsis of the Properties of Calcine for Use in the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270161, Idaho Cleanup Project.

EDF-9710, 2010, "Calcine Disposition Project Hot Isostatic Pressing Machine Selection Trade Study (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9711, 2010, "Calcine Disposition Project Hot Isostatic Pressing Machine Handling Study (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9716, 2010, "Calcine Disposition Project Hot Isostatic Pressing Machine Failure Mode and Effects Analysis (Draft)," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

Nelson, L. O., and K. Vinjamuri, 1995, Results of Intermediate-Scale Hot Isostatic Can Experiments, INEL-95/0145, Lockheed Idaho Technologies Company, May 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

Raman, S., 1993, *Hot Isostatically-Pressed Aluminosilicate Glass-Ceramic with Natural Crystalline Analogues for Immobilizing the Calcined High-Level Nuclear Waste at the Idaho Chemical Processing Plant*, WINCO-1173, Westinghouse Idaho Nuclear Company, December 1993.

Raman, S., 1998, "Microstructures and Leach Rates of Glass-Ceramic Nuclear Waste Forms Developed by Partial Vitrification in a Hot Isostatic Press," *Journal of Material Sciences*, Vol. 33, Issue 7, 1998.

SDD-269, 2010, "HIP Can Containment Loading and Unloading System for the Calcine Disposition Project (P.1.10.02.02.6.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SDD-270, 2010, "Hot Isostatic Pressing System for the Calcine Disposition Project (P.1.10.02.02.6.03) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

SE008552, 2007, "Operator's Manual Quintus Hot Isostatic Press," Rev. 0, AVURE Technologies.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

Staples, B. A., 1988, Statistical Evaluation of Effects of Process Parameters on Properties of ICPP Ceramic Waste Forms, HLW-REF-5076/BAS-12-88, September 30, 1988.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

Vinjamuri, K., and S. V. Raman, 1991, *Progress Report for FY 1991: Glass-Ceramic Waste Form Development for Immobilization of the ICPP High-Level Waste*, HLW-REF-5059, September 30, 1991.

6.4.1 Bakeout Subsystem Remote Maintenance and Tools

Table C-74. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

6.4.1 Bakeout Subsystem Remote Maintenance and Tools

Table C-75. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete (EDF-7748). Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448, SDD-267
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401; SDD-271
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per remote maintenance design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory-scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-271

Table C-75. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-271 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-271 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689, SDD-267, System Engineering Integration Matrix, and Inventor Modeling.
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689; SDD-271
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689; SDD-271
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-271

Table C-75. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-271
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689; SDD-271
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.4.1 Bakeout Subsystem Remote Maintenance and Tools (continued)

Table C-76. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-271
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-271
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401; SDD-271

Table C-76. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Need to perform full-scale remote system design.
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	Y	17. Component integration issues and requirements identified	SDD-271
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401; SDD-271
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-271

Table C-76. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-271
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP (EDF-7748)
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.4.1 Bakeout Subsystem Remote Maintenance and Tools (continued)

Table C-77. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-271
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-271 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-77. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-271
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-271
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-271
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478

Table C-77. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP (EDF-7748)
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-271
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-271
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.4.1 Bakeout Subsystem Remote Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-271, 2010, "Treatment Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

6.4.2 Furnace/HCC Remote Subsystem Maintenance and Tools

Table C-78. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

6.4.2 Furnace/HCC Remote Subsystem Maintenance and Tools (continued)

Table C-79. TRL 4 questions for critical technical elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete; EDF-7748. Key process parameters/variables are included in INL and ANSTO 2009, PLN-3448, SDD-267
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-271
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per remote maintenance design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory-scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	

Table C-79. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-271
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-271 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-271 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689, SDD-267, System Engineering Integration Matrix, and Inventor Modeling.
P	Y	21. Formal risk management program initiated	PLN-2477 “Calcine Disposition Project Risk Management Plan”
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689 SDD-271
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.

Table C-79. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-271
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-271
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-271
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-271
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.4.2 Furnace/HCC Subsystem Remote Maintenance and Tools (continued)

Table C-80. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-271
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-271
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-271

Table C-80. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Design full-scale HIP system
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	CDR (RPT-270)
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401 SDD-271
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-271

Table C-80. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-271
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to develop test plans full-scale remote system testing with full-scale HIP mockup system.
P	N	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design.	Finalize HAZOP (EDF-7748)
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation.
Source: Table F-6 from DOE Guide 413.3-4.

6.4.2 Furnace/HCC Subsystem Maintenance and Tools (continued)

Table C-81. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401 SDD-271
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-271 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-81. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-271
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-271
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-271
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478

Table C-81. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP (EDF-7748)
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-271
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-271
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.4.2 Furnace/HCC Subsystem Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-271, 2010, "Treatment Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

6.4.3 HIP Treatment Subsystem Remote Maintenance and Tools

Table C-82. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		N
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

6.4.3 HIP Treatment Subsystem Remote Maintenance and Tools (continued)

Table C-83. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete EDF-7748. Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448, SDD-267.
M	Y	2. Laboratory components tested are surrogates for system components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-271
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale. Tooling will be designed per remote maintenance design Guide (ORNL/TM-2000/124) and proven to work together during full-scale mockup testing.
M	Y	10. Available components assembled into laboratory-scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	

Table C-83. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-271
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in solid modeling software. Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-271 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	SDD-271 RPT-260
M	Y	20. Integration studies have been started	Integration studies have been started and are provided in the following documents: EDF-9689, SDD-267, System Engineering Integration Matrix, and Inventor Modeling.
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	EDF-9689; SDD-271
P	Y	23. Scaling documents and designs of technology have been completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.

Table C-83. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	24. Key manufacturing processes assessed in laboratory	EDF-9689 SDD-271
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-271
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-271
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	PLN-3448
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9689 SDD-271
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	Remote handling equipment maintenance and associated specialty tooling are commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

6.4.3 HIP Treatment Subsystem Remote Maintenance and Tools (continued)

Table C-84. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between major system and subsystem parameters are understood on a laboratory scale.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	2. Plant size components available for testing	Plant size components will be procured for testing at full-scale mockup.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	SDD-271
P	N	4. Preliminary design engineering begins	Start preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	TFR-401
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Interfaces described in SDD-271
M	N	7. Prototypes of equipment system components have been created (know how to make equipment)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	No new manufacturing processes needed to make remote maintenance design components and tooling.
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Remote maintenance design and tools will be manufactured using standard fabrication processes.
T	N	11. Laboratory-scale, similar system tested with range of simulants	Tooling will be tested on full-scale mockup process equipment.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-84. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	13. Availability and reliability (RAMI) target levels identified	TFR-401 SDD-271
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Design full-scale HIP system
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	No laboratory environment has been designated for testing of remote maintenance design and tooling.
T	Y	17. Component integration issues and requirements identified	SDD-271
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Full-scale mockup system design
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	TFR-401; SDD-271
P	N	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary technology feasibility report
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	Formal control of all components is described in the Remote Maintenance Design Guide (ORNL/TM-2000/124). CWI procedures will be complied with for released drawings through EDMS.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	A high radiation and contamination environment has been realized and remote maintenance tooling materials will be selected accordingly. SDD-271

Table C-84. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	Y	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	All scale-up issues are understood. SDD-271
T	N	31. Limits for all process variables/parameters and safety controls are being refined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	33. Test plan documents for prototypical engineering-scale tests completed	
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize HAZOP (EDF-7748)
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

6.4.3 HIP Treatment Subsystem Maintenance and Tools (continued)

Table C-85. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	1. The relationships between system and subsystem parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	The remote maintenance handling equipment and tooling is commercially available but needs to be tested with full-scale HIP mockup system.
M	N	2. Availability and reliability (RAMI) levels established	TFR-401 Final CDP Process System RAMI Analysis
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	N	4. Operating environment for final system known	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary design cost estimate and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	These have been established in the Remote Maintenance Design Guide (ORNL/TM-2000/124) TFR-401; SDD-271
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	
P	Y	9. Off-normal operating responses determined for engineering scale system	
T	Y	10. System technical interfaces defined	SDD-271 and EDF-9689 defines system technical interfaces.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with full-scale HIP mockup system.

Table C-85. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	Y	16. Critical manufacturing processes prototyped	Remote maintenance handling equipment design and tooling are not critical manufacturing processes. SDD-271
M	Y	17. Most pre-production hardware is available to support fabrication of the system	Hardware for remote maintenance and tools are already available. Some tooling will need to be specially designed and fabricated. SDD-271
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	These have been verified by internal review using technical experts. SDD-271
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification for CDP
M	N	21. Components are functionally compatible with operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-2478

Table C-85. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	Need to perform full-scale remote system testing with full-scale HIP mockup system.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Final HAZOP (EDF-7748)
M	Y	27. Process and tooling are mature to support fabrication of components/system	Process and tooling are mature. SDD-271
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	DDN-032 establishes full-scale testing of remote maintenance and tooling to be used on process equipment at mockup.
T	Y	29. Engineering to full-scale scale-up issues are understood and resolved	All scale-up issues are understood. SDD-271
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Need to perform full-scale remote system testing with full-scale HIP mockup system.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	Need to perform full-scale remote system testing with full-scale HIP mockup system.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

6.4.3 HIP Treatment Subsystem Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

SDD-271, 2010, "Treatment Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

7.1.1 Canister Subsystem

Table C-86. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

7.1.1 Canister Subsystem (continued)

Table C-87. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	SDD-262; EDF-7748; EDF-6596; ICP/CON-04-00640; EDF-9650; DOE/RW-0351, WASRD Rev. 5 DOE/SNF/REP-091 DOE/SNF/REP-011
M	Y	2. Laboratory components tested are surrogates for system components	ICP/CON-04-00640 Existing systems have been tested.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	SDD-262 ABAQUS modeling has been performed on SNF canisters and the results closely matched the actual Drop Tests of the SNF canister. EDF-9650; EDF-4096
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401; SDD-262 The DOE requirements are detailed in WASRD and 10 CFR 71.73.
T	Y	7. Overall system requirements for end user's application are documented	TFR-401; SDD-262 The DOE requirements are detailed in WASRD and 10 CFR 71.73.
P	Y	8. System performance metrics measuring requirements have been established	TFR-401; SDD-262 The DOE requirements are detailed in WASRD and 10 CFR 71.73.

Table C-87. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	9. Laboratory testing requirements derived from system requirements are established	ICP/CON-04-00640 Existing systems have been tested.
M	Y	10. Available components assembled into laboratory-scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	ICP/CON-04-00640 Work has begun using interface modeling with Inventor. The following documents detail the component compatibility: EDF-9654; EDF-9650
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	WASRD and 10 CFR 71.73. EDF-9652 will establish the exit criteria. SDD-262
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	EDF-6596, ICP/CON-04-00640 DOE/SNF/REP-091 EDF-4096.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	ICP/CON-04-00640
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-262 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	ICP/CON-04-00640
T	Y	18. Controlled laboratory environment used in testing	ICP/CON-04-00640
P	Y	19. Initial cost drivers identified	EDF-9650; EDF-9658; Calcine Treatment Options Summary (ICP 2009) EDF-6596; ICP/EXT-05-00824

Table C-87. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	20. Integration studies have been started	SDD-262; EDF-9692; EDF-6596; ICP/CON-04-00640; EDF-9650
P	Y	21. Formal risk management program initiated	PLN-2477, EDF- 9721
M	Y	22. Key manufacturing processes for equipment systems identified	SDD-262; EDF-6596; ICP/CON-04-00640; EDF-9650
P	Y	23. Scaling documents and designs of technology have been completed	SDD-262; ICP/CON-04-00640
M	Y	24. Key manufacturing processes assessed in laboratory	SDD-262; EDF-6596; ICP/CON-04-00640; EDF-9650
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-262
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	ICP/CON-04-00640
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	SDD-262; EDF-6596; EDF-9650; ICP/CON-04-00640
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007), Berreth (1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-262 EDF-7748
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	DDN-009
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

7.1.1 Canister Subsystem References

10 CFR 71, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations,* Office of the Federal Register, November 18, 2005.

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

DOE/RW-0351, *Waste Acceptance System Requirements Document*, Rev. 5, United States Department of Energy, Office of Civilian Radioactive Waste Management, May 2007.

DOE/SNF/REP-011, "Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters," Rev. 3, United States Department of Energy, August 17, 1999.

DOE/SNF/REP-091, "NSNFP Activities in Support of Repository Licensing for Disposal of DOE SNF," Rev. 0, United States Department of Energy, September 2004.

EDF-4096, "FY-2003 Conceptual Design Effort for the High Level Waste Disposal Canister," Rev. 0, T. E. Rahl, August 29, 2003.

EDF-6596, 2006, "High-Level Waste Calcine Canister Design Concept," Rev. 0, Idaho Cleanup Project, Idaho National Laboratory, March, 27, 2006.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9650, 2010, "CDP Canister Analysis, Design, and Testing (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9654, 2010, "CDP Packaging Methodology (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9658, 2010, "CDP Trade Study to Compare 10 ft. Versus 15 ft. Canisters (Draft)," Rev. 0, Draft A, Idaho Cleanup Project.

EDF-9721, 2010, "Failure Mode and Effects Analysis for Packaging for the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9789, 2010, "Treatment Maintenance, Design, and Tools for the Calcine Disposition Project (SEN 6.4) (Conceptual Design)," Rev. A, Record 3270203, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

ICP/CON-04-00640, "Drop Testing Of DOE Spent Nuclear Fuel Canisters," D. K. Morton, S. D. Snow, T. E. Rahl, R. K. Blandford, T. J. Hill, July 17, 2005.

ICP/EXT-05-00824, "Cost Comparison for the Transfer of Select Calcined Waste Canisters to the Monitored Geologic Repository at Yucca Mountain, Nevada," M. B. Heiser, C. B. Millet, October 2005.

Idaho, 1995, *Settlement Agreement*, State of Idaho, Department of Energy, and Department of the Navy, to resolve all issues in Public Service Co. of Colorado v. Batt, No. CV-91-0035-S-EJL (D. Id.) and United States v. Batt, No. CV-91-0065-S-EJL (D. Id.), U.S. District Court of Idaho, dated October 16, 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-266, 2010, "Feed Canning System for the Calcine Disposition Project (SEN 5.4) (Conceptual Design)," Rev. A, Record 3270375, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

7.1.3 Canister Welding and Sealing Subsystem

Table C-88. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

7.1.3 Canister Welding and Sealing Subsystem (continued)

Table C-89. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	EDF-7748; SDD-262; 10 CFR 236 ISG-18, ISG-15
M	Y	2. Laboratory components tested are surrogates for system components	The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
T	Y	3. Individual components tested in laboratory~~/~~or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	SDD-262
P	Y	6. Overall system requirements for end user's application are <u>known</u>	TFR-401; WASRD; 10 CFR 236 ISG-18 ISG-15
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	EDF-9652; SDD-262
P	Y	9. Laboratory testing requirements derived from system requirements are established	The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
M	Y	10. Available components assembled into laboratory N/A scale system	
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Interface with PaR end of mast tool plate (EDF-9720) is being modeled. Welder and leak test compatibility with canisters being modeled. EDF-9654 addresses component compatibility SDD-262; WASRD; 10 CFR 236; ISG-18; ISG-15

Table C-89. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	EDF-9652 will establish the exit criteria. SDD-262
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	EDF-9652 The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	SDD-262 The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford. Web sites of Nuclear Welding Co's: AMI (Arc Machines Inc), http://www.arcmachines.com/prodMed/canister/canister.html Moog: http://www.berkeleyprocess.com/nuclear_canister.html
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	PFD SO-12, SDD-262, BFD, GA, EDF-9692 (Time and Motion Study) SDD-262, the CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	SDD-262 The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	Budgetary estimates received ~$250K for a welder. EDF-9652 identifies costs for leak test unit. DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) will establish full-scale mock-up costs. Calcine Treatment Options (ICP 2009); EDF-9692
M	Y	20. Integration studies have been started	Integration studies have been and are being addressed by EDF-9652, Inventor modeling SDD-262

Table C-89. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	21. Formal risk management program initiated	Formal risk programs include EDF- 9721 (Canister Loading FMEA) and EDF-7748; PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	The manufacturing processes are identified by EDF-9652, 10 CFR 236, ISG-18, ISG-15 The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford. Web sites of Nuclear Welding Co's: AMI (Arc Machines Inc), http://www.arcmachines.com/prodMed/canister/canister.html Moog: http://www.berkeleyprocess.com/nuclear_canister.html
P	Y	23. Scaling documents and designs of technology have been completed	
M	Y	24. Key manufacturing processes assessed in laboratory	
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-262
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	Staiger and Swenson (2007), Berreth (1988)
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	PLN-3448
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	
T	Y	31. Process/parameter limits and safety control strategies are being explored	EDF-9650; EDF- 9721; EDF-7748; SDD-262 The canister welding and sealing system have been tested and operated at full scale at Savanna River and Hanford.

Table C-89. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	DDN-007 (Canister Welding)
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

7.1.3 Canister Welding and Sealing Subsystem (continued)

Table C-90. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and sub-system parameters are understood on a laboratory scale.	SDD-262
T	N	2. Plant size components available for testing	Plant sized equipment is available from vendors. Design of the welder is detailed in EDF-9652 Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	EDF-9652 and EDF-9654 detail the operation and integration into the plant.
P	N	4. Preliminary design engineering begins	Begin preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	The requirements are detailed in TFR-401, WASRD, and 10 CFR 71. The validation of the safety functions will be included in EDF- 9721 and EDF-7748.
T	N	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	Prototypes of canister welders are well understood and detailed in EDF-9652.
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	The welders are OEM units and can be configured as required. WSRC-MS-2002-00122 is an example of a suitable orbital welder.
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	Not fully designed or tested. DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) will finalize this characterization of the weld and characterization of the weld. 10 CFR 236, ISG-18, ISG-15 PLN-3448. TFR-401, WASRD, 10 CFR 71 will define manufacturing.

Table C-90. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	Welders have been understood and used with good results in the nuclear industry. WSRC-MS-2002-00122. Qualification of the weld instead of leak testing is covered by 10 CFR 236, ISG-18, ISG-15
T	N	11. Laboratory-scale, similar system tested with range of simulants	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
M	N	13. Availability and reliability (RAMI) target levels identified	RAMI are included in EDF-9650 and the characterization is detailed in DDN-007.
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	17. Component integration issues and requirements identified	Not fully designed or tested. DDN-007 will finalize this characterization and integration. PLN-3448; TFR-401; WASRD; 10 CFR 71 will define manufacturing.
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Need to drawings for full-scale remote system testing.
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	Requirements are detailed in TFR-401, WASRD, 10 CFR 71, SDD-262.
P	Y	20. Preliminary technology feasibility engineering report completed; to include compliance with DOE-STD-1189-2008	EDF-9721, and EDF-7748
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	The canisters will be designed and tested according to EDF-9652, WASRD, and 10 CFR 71.

Table C-90. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	The properties addressed and directed by EDF-9652, WASRD, and 10 CFR 71.
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	Y	31. Limits for all process variables/parameters and safety controls are being refined	The process requirements are detailed by TFR-401. The variables and parameters are defined by EDF-9652, WASRD, and 10 CFR 71.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Full-scale mockup test plan
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Complete full-scale mockup test plans
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize EDF-7748. Key process parameters/variables are included in PLN-3448, EDF-9721, EDF-7748, PFD SO-12, SDD-262, and BFD
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

7.1.3 Canister Welding and Sealing Subsystem (continued)

Table C-91. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and sub-system parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	SDD-262
M	Y	2. Availability and reliability (RAMI) levels established	RAMI is included in EDF-9652 (CDP Canister Welding, Sealing and Leak Testing) and established in DDN-007 (CDP Canister Welding, Sealing, and Leak Testing).
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	Y	4. Operating environment for final system known	TFR-401 (Technical and Functional Requirements for the CDP – Conceptual Design) and EDF-9652 (CDP Canister Welding, Sealing and Leak Testing) establishes environment
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	RAMI are included in EDF-9652, but actual data will not be attained until CD-2 with DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) during full-scale mock-up.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Some cost drivers are understood, but only after DDN-007 is evaluated will the performance baseline be understood. Incorporating 10 CFR 236, ISG-18, ISG-15 is not well defined.
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	EDF-9652 establishes operating limits for components. EDF-7748 or safety. WASRD and TFR-401 establish environmental compliance requirements. 10 CFR 236, ISG-18, ISG-15 covers the leak test requirement.
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008	SDD-262; Preliminary hazard evaluation is complete (EDF-7748)
P	N	9. Off-normal operating responses determined for engineering scale system	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	Y	10. System technical interfaces defined	SDD-262 details the interface requirements.

Table C-91. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
P	N	13. Analysis of project timing ensures technology will be available when required	Technology is in use in nuclear industry today. An example of that would be GTAW of canisters in WSRC-MS-2002-00122. Typical lead times are 6–12 months.
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	N	16. Critical manufacturing processes prototyped	DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) will finalize this characterization, especially the weld qualification in instead of a leak test as per 10 CFR 236, ISG-18, ISG-15
M	Y	17. Most pre-production hardware is available to support fabrication of the system	OEM components necessary to support fabrication of the system are available. Detailed further in EDF-9652
T	N	18. Engineering feasibility fully demonstrated (e.g., would it work)	EDF-9652 (CDP Canister Welding, Sealing and Leak Testing). Welding and leak testing in nuclear industry currently exist. Need to perform full-scale remote system testing with integrated full-scale HIP mockup system. WSRC-MS-2002-00122 10 CFR 236, ISG-18, ISG-15
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	WSRC-MS-2002-00122 is an orbital welder that is similar to the design to be used in CDP.
P	N	20. Technology "system" design specification complete and ready for detailed design	Preliminary Design Specification
M	Y	21. Components are functionally compatible with operational system	EDF-9652 and EDF-9654
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478

Table C-91. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) will finalize this characterization. PLN-3448, TFR-401, WASRD, and EDF-9652 will define manufacturing.
P	N	25. Final Technical Report on Technology completed; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Finalize EDF-7748
M	Y	27. Process and tooling are mature to support fabrication of components/system	Welders have been designed and tested and used in industry as evidenced by WSRC-MS-2002-00122
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are defined	Completion of DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) and information included in EDF-9652 and SDD-262. The weld parameters need definition during testing as per DDN-007 with 10 CFR 236, ISG-18, ISG-15
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale remote system testing with integrated full-scale HIP mockup system.
M	N	33. Production demonstrations are complete (at least one time)	DDN-007 (CDP Canister Welding, Sealing, and Leak Testing) will be used to direct the demonstrations during mock-up.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

7.1.3 Canister Welding and Sealing Subsystem References

10 CFR 71, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations,* Office of the Federal Register, November 18, 2005.

10 CFR 72.236(e), "Specific Requirements for Spent Fuel Storage Cask Approval and Fabrication," *Code of Federal Regulations,* Office of the Federal Register, December, 2005.

Berreth, J. R., 1988, *Inventories and Properties of ICPP Calcined High Level Waste,* WINCO-1050, Westinghouse Idaho Nuclear Company.

DOE/RW-0351, *Waste Acceptance System Requirements Document*, Rev. 5, United States Department of Energy, Office of Civilian Radioactive Waste Management, May 2007.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9652, 2010, "CDP Canister Welding, Sealing and Leak Testing," Rev. Draft A, Idaho Cleanup Project.

EDF-9654, 2010, "CDP Packaging Methodology (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9721, 2010, "Failure Mode and Effects Analysis for Packaging for the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

Idaho, 1995, *Settlement Agreement*, State of Idaho, Department of Energy, and Department of the Navy, to resolve all issues in Public Service Co. of Colorado v. Batt, No. CV-91-0035-S-EJL (D. Id.) and United States v. Batt, No. CV-91-0065-S-EJL (D. Id.), U.S. District Court of Idaho, dated October 16, 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

Staiger, M. D., and M. C. Swenson, 2007, *Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Rev. 3, Idaho Cleanup Project, June 2007.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

U.S. NRC, Spent Fuel Storage and Transportation Division, Interim Staff Guidance – 15 (ISG-15), "Materials Evaluation," January, 2001.

U.S. NRC, Spent Fuel Storage and Transportation Division, Interim Staff Guidance – 18 (ISG-18), "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage," October, 2008.

WSRC-MS-2002-00122, "GTA Welding Research and Development for Plutonium Containment," United States Department of Energy, February 21, 2002.

7.1.5 Canister Subsystem

Table C-92. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?	Y	
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?	Y	
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?		N
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?	Y	
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?	Y	

7.1.5 Canister Subsystem (continued)

Table C-93. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	The key process variable and parameters are detailed in DDN-009 (Canister Analysis, Design, and Testing). The following documents will detail the final design: EDF-6596; ICP/CON-04-00640; EDF-9650; DOE/RW-0351; WASRD Rev. 5; TFR-401; DOE/SNF/REP-091; DOE/SNF/REP-011; EDF-4096; PLN-3448
M	N/A	2. Laboratory components tested are surrogates for system components	No work will be done at the laboratory or engineering scale. All testing will be full-scale mock-ups. No work will be done with simulants.
T	N/A	3. Individual components tested in laboratory/or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Modeling and simulation have been done using Inventor and ABAQUS. The canisters will interface with PaR and the processing equipment. The components and interfaces are detailed in the following documents: EDF-4096; EDF-6596; EDF-9650; TFR-401
P	Y	6. Overall system requirements for end user's application are <u>known</u>	The system requirements are detailed locally for the project by TFR-401. The DOE requirements are detailed in WASRD and 10 CFR 71.73.
T	Y	7. Overall system requirements for end user's application are documented	The system requirements are detailed locally for the project by TFR-401. The DOE requirements are detailed in WASRD and 10 CFR 71.73.
P	Y	8. System performance metrics measuring requirements have been established	The system requirements are detailed locally for the project by TFR-401. The DOE requirements are detailed in WASRD and 10 CFR 71.73.
P	Y	9. Laboratory testing requirements derived from system requirements are established	All testing will be full-scale mock-ups.
M	Y	10. Available components assembled into laboratory-scale system	All testing will be full-scale mock-ups.

Table C-93. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	11. Laboratory experiments with available components show that they work together	All testing will be full-scale mock-ups.
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	Work has begun using interface modeling with Inventor. The following documents detail the component compatibility: EDF-9654; EDF-9650
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	The system targets are detailed locally for the project by TFR-401. The DOE targets are detailed in WASRD and 10 CFR 71.73. Demonstration and data requirements established in PLN-3448.
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	There is a body of work done to demonstrate that the technology is functional, including EDF-6596, ICP/CON-04-00640, DOE/SNF/REP-091, and EDF-4096. The basic safety functions are detailed in EDF- 9721 and EDF-7748. Safety testing will be conducted according to 10 CFR 71 and WASRD.
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	All testing will be full-scale mock-ups.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	The following local documents address the conceptual design. PFD SO-12, SDD-262, BFD, Revit GA, and SEN numbers.
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	All testing will be full-scale mock-ups.
T	Y	18. Controlled laboratory environment used in testing	All testing will be full-scale mock-ups.
P	Y	19. Initial cost drivers identified	The following documents all work to address the initial cost drivers: EDF-9650; EDF-9658; PLN-3448; ICP/EXT-05-00824
M	Y	20. Integration studies have been started	Integration studies have been and are being addressed by EDF-6596, ICP/CON-04-00640, EDF-9650

Table C-93. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	The manufacturing processes are identified by EDF-6596, ICP/CON-04-00640, EDF-9650, WASRD, TFR-401, DOE/SNF/REP-091, and 10 CFR 71.
P	Y	23. Scaling documents and designs of technology have been completed	All testing will be full-scale mock-ups.
M	Y	24. Key manufacturing processes assessed in laboratory	The manufacturing processes are identified by EDF-6596, ICP/CON-04-00640, EDF-9650, WASRD, TFR-401, DOE/SNF/REP-091, and 10 CFR 71.
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SEN-7.1.5, SDD-262, EDF-9650, and EDF-9654
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	All testing will be full-scale mock-ups.
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	EDF-7748 and PLN-2477
T	Y	28. Key physical and chemical properties have been characterized for a range of wastes	All testing will be full-scale mock-ups using surrogates.
T	Y	29. A limited number of simulants have been developed that approximate the range of waste properties	All testing will be full-scale mock-ups using surrogates.
T	Y	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	All testing will be full-scale mock-ups using surrogates.
T	Y	31. Process/parameter limits and safety control strategies are being explored	Ongoing PFD SO-12, GA, P&ID, EDF-9650, EDF-9721, and EDF-7748
T	Y	32. Test plan documents for prototypical laboratory- scale tests completed	All testing will be full-scale mock-ups.
P	Y	33. Technology availability dates established	This TMP

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

7.1.5 Canister Subsystem (continued)

Table C-94. TRL 5 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between major system and sub-system parameters are understood on a laboratory scale.	SDD-262
T	N	2. Plant size components available for testing	The key process variable and parameters are detailed in DDN-009. The following documents will detail the final design. EDF-6596, ICP/CON-04-00640, EDF-9650, WASRD, DOE/SNF/REP-011, EDF-4096. This TMP establishes the manufacture and testing of the canisters.
T	Y	3. System interface requirements known (How would system be integrated into the plant?)	EDF-9720, EDF-9654 all detail the operation and integration into the plant.
P	N	4. Preliminary design engineering begins	Preliminary work has been done in this design effort EDF-6596, ICP/CON-04-00640, EDF-9650, DOE/SNF/REP-091 Begin preliminary design
T	Y	5. Requirements for technology verification established; to include testing and validation of safety functions.	The requirements are detailed in TFR-401, WASRD, and 10 CFR 71. The validation of the safety functions will be included in EDF- 9721 and EDF-7748.
T	Y	6. Interfaces between components/subsystems in testing are realistic (bench top with realistic interfaces)	SDD-262
M	Y	7. Prototypes of equipment system components have been created (know how to make equipment)	This work has been done for Calcine "as is" and is detailed in EDF-6596, ICP/CON-04-00640
M	Y	8. Tooling and machines demonstrated in laboratory for new manufacturing processes to make component	This work has been done for Calcine "as is" and is detailed in EDF-6596, ICP/CON-04-00640
T	N	9. High-fidelity laboratory integration of system completed, ready for test in relevant environments; to include testing and validation of safety functions.	DDN-009 (Canister Analysis, Design, and Testing) will finalize this characterization. EDF-4096, TFR-401, WASRD, 10 CFR 71.73 will define manufacturing.
M	Y	10. Manufacturing techniques have been defined to the point where largest problems defined	The body of work done in EDF-6596 and ICP/CON-04-00640 detail the largest problems.
T	N	11. Laboratory-scale, similar system tested with range of simulants	All testing will be full-scale mock-ups.

Table C-94. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	12. Fidelity of system mock-up improves from laboratory to bench-scale testing	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
M	N	13. Availability and reliability (RAMI) target levels identified	RAMI are included in EDF-9650 and the characterization is detailed in DDN-009.
M	N	14. Some special purpose components combined with available laboratory components for testing	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	N	15. Three dimensional drawings and P&IDs for the prototypical engineering-scale test facility have been prepared	Three dimensional drawings and P&IDs for mockup facility
T	N	16. Laboratory environment for testing modified to approximate operational environment; to include testing and validation of safety functions.	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	17. Component integration issues and requirements identified	DDN-009 will finalize this characterization and integration. EDF-4096, PLN-3448, TFR-401, WASRD, 10 CFR 71.73 will define manufacturing.
P	N	18. Detailed design drawings have been completed to support specification of engineering-scale testing system	Complete full-scale mockup drawings
T	Y	19. Requirements definition with performance thresholds and objectives established for final plant design	Requirements are detailed in TFR-401, WASRD, 10 CFR 71, SDD-262.
P	Y	20. Preliminary technology feasibility engineering report completed; includes compliance with DOE-STD-1189-2008	Preliminary hazard evaluation is complete by EDF-7748, EDF-9721, and EDF-7748
T	N	21. Integration of modules/functions demonstrated in a laboratory/bench-scale environment	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	Y	22. Formal control of all components to be used in final prototypical test system	The canisters will be designed and tested according to EDF-9650, WASRD, and 10 CFR 71.
P	Y	23. Configuration management plan in place	PLN-2478
T	Y	24. The range of all relevant physical and chemical properties has been determined (to the extent possible)	The properties will be addressed and directed by EDF-9650, WASRD, and 10 CFR 71.
T	Y	25. Simulants have been developed that cover the full range of waste properties	This TMP

Table C-94. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	26. Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	27. Laboratory-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	28. Laboratory-scale tests on a limited range of real wastes using a prototypical system have been completed	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	29. Test results for simulants and real waste are consistent	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	30. Laboratory to engineering scale scale-up issues are understood and resolved; to include testing and validation of safety functions.	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	31. Limits for all process variables/parameters and safety controls are being refined	The process requirements are detailed by TFR-401. The variables and parameters are defined by EDF-6596, EDF-9650, WASRD, and 10 CFR 71. Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	N	32. Test plan for prototypical laboratory-scale tests executed – results validate design; to include testing and validation of safety functions.	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	N	33. Test plan documents for prototypical engineering-scale tests completed	Need to complete test plans for full-scale system testing with integrated full-scale HIP mockup system.
P	N	34. Finalization of hazardous material forms and inventories, completion of process hazard analysis, and identification of system/components level safety controls at the appropriate preliminary design phase.	Finalize EDF-7748. Key process parameters/variables are included in PLN-3448, EDF-9721, EDF-7748, SDD-262, and BFD
P	Y	35. Risk management plan documented; to include compliance with DOE-STD-1189-2008	PLN-2477

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-6 from DOE Guide 413.3-4.

7.1.5 Canister Subsystem (continued)

Table C-95. TRL 6 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. The relationships between system and sub-system parameters are understood at engineering scale allowing process/design variations and tradeoffs to be evaluated.	SDD-262
M	N	2. Availability and reliability (RAMI) levels established	RAMI is included EDF-9650. Preliminary design RAMI
P	N	3. Preliminary design drawings for final plant system are complete; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Complete preliminary design
T	Y	4. Operating environment for final system known	TFR-401; EDF-9650 establishes environment.
P	N	5. Collection of actual maintainability, reliability, and supportability data has been started	RAMI will be included in EDF-9650 and performed during DDN-009 (Canister Analysis, Design, and Testing) full-scale mock-up.
P	N	6. Performance Baseline (including total project cost, schedule, and scope) has been completed	Preliminary cost and performance are addressed by EDF-9658, ICP/EXT-05-00824, EDF-6596, ICP/CON-04-00640, EDF-9650, and DOE/SNF/REP-091. Preliminary design cost and schedule
T	Y	7. Operating limits for components determined (from design, safety and environmental compliance)	EDF-9650 establishes operating limits for components, EDF-7748 for safety, and WASRD, 10 CFR 71, and TFR-401 establishes environmental compliance requirements. Previous work that is leveraged to determine safety, design, and environmental compliance are EDF-6596, ICP/CON-04-00640, and DOE/SNF/REP-091
P	Y	8. Operational requirements document available; to include compliance with DOE-STD-1189-2008	SDD-262; Preliminary hazard evaluation is complete (EDF-7748)
P	N	9. Off-normal operating responses determined for engineering scale system	Need to perform full-scale system testing with integrated full-scale HIP mockup system.

Table C-95. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	10. System technical interfaces defined	SDD-262 details the interface requirements.
T	N	11. Component integration demonstrated at an engineering scale	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	N	12. Scaling issues that remain are identified and understood. Supporting analysis is complete.	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	Y	13. Analysis of project timing ensures technology will be available when required	Historically, canister qualification has taken as much as 4 years and the duration of the preliminary design will offer enough time to finalize the canister design and testing. WASRD, 10 CFR 71.73, 10 CFR 71.43, NUREG-1617 This TMP
P	N	14. Have established an interface control process	Establish ICDs
P	N	15. Acquisition program milestones established for start of final design (CD-2)	PLN-3548
M	N	16. Critical manufacturing processes prototyped	DDN-009 (Canister Analysis, Design, and Testing) will finalize this characterization. EDF-4096, PLN-3448 Draft. TFR-401, WASRD, 10 CFR 71.73 will define manufacturing. Completion requires drop testing.
M	Y	17. Most pre-production hardware is available to support fabrication of the system	EDF-9650, EDF-4096, EDF-6596, ICP/CON-04-00640, DOE/SNF/REP-091
T	Y	18. Engineering feasibility fully demonstrated (e.g., would it work)	ICP/CON-04-00640
M	Y	19. Materials, process, design, and integration methods have been employed (e.g., can design be produced?)	EDF-9650, EDF-4096, EDF-6596, ICP/CON-04-00640, DOE/SNF/REP-091
P	N	20. Technology “system” design specification complete and ready for detailed design	Preliminary design specification
M	N	21. Components are functionally compatible with operational system	EDF-9650, EDF-4096, EDF-6596, ICP/CON-04-00640, DOE/SNF/REP-091 Need to perform full-scale system testing with integrated full-scale HIP mockup system.

Table C-95. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N	22. Engineering-scale system is high-fidelity functional prototype of operational system	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	Y	23. Formal configuration management program defined to control change process	PLN-3478
M	N	24. Integration demonstrations have been completed (e.g., construction of testing system); to include testing and validation of safety functions.	DDN-009 (Canister Analysis, Design, and Testing) will finalize this characterization. EDF-4096, PLN-3448 Draft. TFR-401, WASRD, 10 CFR 71.73 will define manufacturing. Need to perform full-scale system testing with integrated full-scale HIP mockup system.
P	N	25. Final technical report on technology completed; to include compliance with DOE-STD-1189-2008	Final Technical Report on Technology
P	N	26. Finalization of hazardous material forms and inventories; completion of process hazard analysis, identification of system/components level safety controls at the appropriate preliminary/final design phase.	Finalize EDF-7748
M	Y	27. Process and tooling are mature to support fabrication of components/system	Canisters have been designed and tested as per EDF-9650, EDF-4096, EDF-6596, ICP/CON-04-00640, DOE/SNF/REP-091
T	N	28. Engineering-scale tests on the full range of simulants using a prototypical system have been completed	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	29. Engineering to full-scale scale-up issues are understood and resolved	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	N	30. Laboratory and engineering-scale experiments are consistent	Need to perform full-scale system testing with integrated full-scale HIP mockup system.
T	Y	31. Limits for all process variables/parameters and safety controls are defined	Information included in EDF-9650 and SDD-262 define the parameters and safety controls. In addition, the canisters will comply with safety restrictions from WASRD and 10 CFR 71.
T	N	32. Plan for engineering-scale testing executed - results validate design	Need to perform full-scale system testing with integrated full-scale HIP mockup system.

Table C-95. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
M	N	33. Production demonstrations are complete (at least one time)	DDN-009 will finalize this characterization. EDF-6596, ICP/CON-04-00640, EDF-9650, WASRD, TFR-401, DOE/SNF/REP-091 all will enter into the design and testing of the canister.

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-7 from DOE Guide 413.3-4.

7.1.5 Canister Subsystem References

10 CFR 71, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations,* Office of the Federal Register.

DOE/RW-0351, *Waste Acceptance System Requirements Document*, Rev. 5, United States Department of Energy, Office of Civilian Radioactive Waste Management, May 2007.

DOE/SNF/REP-011, "Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters," Rev. 3, United States Department of Energy, August 17, 1999.

DOE/SNF/REP-091, "NSNFP Activities in Support of Repository Licensing for Disposal of DOE SNF," Rev. 0, United States Department of Energy, September 2004.

EDF-4096, "FY 2003 Conceptual Design Effort for the High Level Waste Disposal Canister," Rev. 0, T. E. Rahl, August 29, 2003.

EDF-6596, 2006, "High-Level Waste Calcine Canister Design Concept," Rev. 0, Idaho Cleanup Project, Idaho National Laboratory, March, 27, 2006.

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

EDF-9650, 2010, "CDP Canister Analysis, Design, and Testing (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9654, 2010, "CDP Packaging Methodology (Draft)," Rev. Draft A, Idaho Cleanup Project.

EDF-9658, 2010 "CDP Trade Study to Compare 10 ft. Versus 15 ft. Canisters (Draft)," Rev. 0, Draft A, Idaho Cleanup Project.

EDF-9721, 2010, "Failure Mode and Effects Analysis for Packaging for the Calcine Disposition Project (Draft)," Rev. Draft A, Idaho Cleanup Project.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary,* RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

ICP, 2010, "Conceptual Design Report for the Calcine Disposition Project (Draft)," RPT-270, Rev. 3 draft, Idaho Cleanup Project.

ICP/CON-04-00640, "Drop Testing Of DOE Spent Nuclear Fuel Canisters," D. K. Morton, S. D. Snow, T. E. Rahl, R. K. Blandford, T. J. Hill, July 17, 2005.

ICP/EXT-05-00824, "Cost Comparison for the Transfer of Select Calcined Waste Canisters to the Monitored Geologic Repository at Yucca Mountain, Nevada," M. B. Heiser, C. B. Millet, October 2005.

Idaho, 1995, *Settlement Agreement*, State of Idaho, Department of Energy, and Department of the Navy, to resolve all issues in Public Service Co. of Colorado v. Batt, No. CV-91-0035-S-EJL (D. Id.) and United States v. Batt, No. CV-91-0065-S-EJL (D. Id.), U.S. District Court of Idaho, dated October 16, 1995.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2008, "Configuration Management Plan for the Calcine Disposition Project," Rev. 1, Idaho Cleanup Project, Idaho National Laboratory, July 22, 2008.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

PLN-3548, 2010, "Calcine Disposition Project Federal Acquisition Strategy (Draft)," Rev. 0 Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

7.5.1 Canister Loading Subsystem Remote Maintenance and Tools

Table C-96. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

7.5.1 Canister Loading Subsystem Remote Maintenance and Tools (continued)

Table C-97. TRL 4 Questions for Critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete (EDF-7748). Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448, and SDD-272
M	Y	2. Laboratory components tested are surrogates for system components	Remote maintenance equipment commercially available at full scale.
T	Y	3. Individual components tested in laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote maintenance technologies and tools modeled and interfaces established on Navisworks. SDD-272
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-272
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Laboratory testing is not required. Testing will be performed at full-scale mock-up.
M	Y	10. Available components assembled into laboratory-scale system	Remote maintenance equipment commercially available at full scale. Components will be designed per Remote Maintenance Design Guide (ORNL/TM-2000/124) and shown to work together during full-scale mock-up testing.
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and Technology Demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-272

Table C-97. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in Navisworks. SDD-272
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote maintenance equipment commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-272 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote maintenance equipment commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	Cost drivers provided in ICP (2009).
M	Y	20. Integration studies have been started	SDD-272
P	Y	21. Formal risk management program initiated	PLN-2477
M	Y	22. Key manufacturing processes for equipment systems identified	SDD-272
P	Y	23. Scaling documents and designs of technology have been completed	Remote maintenance equipment commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	Remote maintenance equipment commercially available at full scale.
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-272
T	Y	26. Low fidelity technology “system” integration and engineering completed in a laboratory environment	Remote maintenance equipment commercially available at full scale. Integration modeled in Navisworks (SDD-272)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Remote maintenance equipment commercially available at full scale.

Table C-97. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N/A	28. Key physical and chemical properties have been characterized for a range of wastes	Physical and chemical properties of wastes will not affect remote maintenance and tooling requirements.
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Physical and chemical properties of wastes will not affect remote maintenance and tooling requirements.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Simulants and real waste do not affect maintenance and tooling requirements.
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-272 EDF-7748
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Remote maintenance equipment commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

7.5.1 Canister Loading Subsystem Remote Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-272, 2010, "Packaging Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.

7.5.3 Cask Loading Subsystem Remote Maintenance and Tools

Table C-98. Identification of CTEs (A CTE is identified if there is at least one positive response for each set of criteria).

Set 1—Criteria	Yes	No
• Does the technology directly impact a functional requirement of the process or facility?	Y	
• Do limitations in the understanding of the technology result in a potential schedule risk, i.e., the technology may not be ready for insertion when required?		N
• Do limitations in the understanding of the technology result in a potential cost risk; i.e., the technology may cause significant cost overruns?		N
• Do limitations in the understanding of the technology impact the safety of the design?		
• Are there uncertainties in the definition of the end state requirements for this technology?		N

Set 2—Criteria	Yes	No
• Is the technology new or novel?	Y	
• Is the technology modified?		N
• Have the potential hazards of the technology been assessed?		
• Has the technology been repackaged so a new relevant environment is realized?		N
• Is the technology expected to operate in an environment and/or achieve performance beyond its original design intention or demonstrated capability?		N

7.5.3 Cask Loading Subsystem Remote Maintenance and Tools

Table C-99. TRL 4 questions for critical technology elements.

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	1. Key process variables/parameters been fully identified and preliminary hazard evaluations have been completed and documented; to include compliance with DOE-STD-1189-2008, "Integration of Safety into the Design Process."	Preliminary hazard evaluation is complete (EDF-7748); Key process parameters/variables are included in INL and ANSTO (2009), PLN-3448, and SDD-272
M	Y	2. Laboratory components tested are surrogates for system components	Remote maintenance equipment commercially available at full scale.
T	Y	3. Individual components tested in a laboratory or by supplier	
T	Y	4. Subsystems composed of multiple components tested at laboratory-scale using simulants	
T	Y	5. Modeling and Simulation used to simulate some components and interfaces between components	Remote maintenance technologies and tools modeled and interfaces established on Navisworks. SDD-272
P	Y	6. Overall system requirements for end user's application are known	TFR-401 SDD-272
T	Y	7. Overall system requirements for end user's application are documented	
P	Y	8. System performance metrics measuring requirements have been established	These requirements have been established and are provided in Remote Maintenance Design Guide (ORNL/TM-2000/124).
P	Y	9. Laboratory testing requirements derived from system requirements are established	Laboratory testing is not required. Testing will be performed at full-scale mock-up.
M	Y	10. Available components assembled into laboratory-scale system	Remote maintenance equipment commercially available at full scale. Components will be designed per Remote Maintenance Design Guide (ORNL/TM-2000/124) and shown to work together during full-scale mock-up testing.
T	Y	11. Laboratory experiments with available components show that they work together	
T	Y	12. Analysis completed to establish component compatibility (Do components work together)	
P	Y	13. Science and technology demonstration exit criteria established (S&T targets understood, documented, and agreed to by sponsor)	SDD-272

Table C-99. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	Y	14. Technology demonstrates basic functionality in simulated environment; to include test and validation of safety functions.	Remote maintenance technologies and tools will be modeled and interfaces will be simulated in Navisworks. SDD-272
M	Y	15. Scalable technology prototypes have been produced (Can components be made bigger than laboratory scale)	Remote maintenance equipment commercially available at full scale.
P	Y	16. The conceptual design has been documented (system description, process flow diagrams, general arrangement drawings, and material balance)	SDD-272 CDR (ICP 2010)
M	Y	17. Equipment scale-up relationships are understood/accounted for in technology development program	Remote maintenance equipment commercially available at full scale.
T	Y	18. Controlled laboratory environment used in testing	
P	Y	19. Initial cost drivers identified	Cost drivers provided in ICP (2009).
M	Y	20. Integration studies have been started	SDD-272
P	Y	21. Formal risk management program initiated	PLN-2477, "Calcine Disposition Project Risk Management Plan"
M	Y	22. Key manufacturing processes for equipment systems identified	SDD-272
P	Y	23. Scaling documents and designs of technology have been completed	Remote maintenance equipment commercially available at full scale.
M	Y	24. Key manufacturing processes assessed in laboratory	Remote maintenance equipment commercially available at full scale.
P/T	Y	25. Functional process description developed. (Systems/subsystems identified)	SDD-272
T	Y	26. Low fidelity technology "system" integration and engineering completed in a laboratory environment	Remote maintenance equipment commercially available at full scale. Integration modeled in Navisworks (SDD-272)
M	Y	27. Mitigation strategies identified to address shortfalls in manufacturing or production capability	Remote maintenance equipment commercially available at full scale.

Table C-99. (continued).

T/P/M	Y/N	Criteria	Basis and Supporting Documentation
T	N/A	28. Key physical and chemical properties have been characterized for a range of wastes	Physical and chemical properties of wastes will not affect remote maintenance and tooling requirements.
T	N/A	29. A limited number of simulants have been developed that approximate the range of waste properties	Physical and chemical properties of wastes will not affect remote maintenance and tooling requirements.
T	N/A	30. Laboratory-scale tests on a limited range of simulants and real waste have been completed	Simulants and real waste do not affect maintenance and tooling requirements.
T	Y	31. Process/parameter limits and safety control strategies are being explored	SDD-272 EDF-7748
T	Y	32. Test plan documents for prototypical laboratory-scale tests completed	Remote maintenance equipment commercially available at full scale.
P	Y	33. Technology availability dates established	PLN-3448

T-Technology, technical aspects; M-Manufacturing and quality; P-Programmatic, customer focus, documentation
Source: Table F-5 from DOE Guide 413.3-4.

7.5.3 Cask Loading Subsystem Remote Maintenance and Tools References

EDF-7748, 2010, "Preliminary Hazard and Operability Review of the Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, August 23, 2010.

ICP, 2009, *Calcine Disposition Project Calcine Treatment Options Summary*, RPT-650, Rev. 0, Idaho Cleanup Project, September 10, 2009. (Note: This document is Official Use Only and may not be publicly available.)

INL and ANSTO, 2009, Assessment of Hot Isostatic Pressing (HIP) Project Annual Report 2009, Project Number: 30047, Volume 2: Surrogate Calcine HIP Demonstration, FY09-71995-V2, Rev. 05, Idaho National Laboratory and Australian Nuclear Science and Technology Organization, November 2009.

ORNL/TM-2000/124, "Remote Maintenance Design Guide."

PLN-2477, 2010, "Calcine Disposition Project Risk Management Plan," Rev. 4, Idaho Cleanup Project, September 20, 2010.

PLN-2478, 2010, "Configuration Management Plan for The Calcine Disposition Project," Rev. 2, Idaho Cleanup Project, Idaho National Laboratory, May 19, 2010.

PLN-3448, 2010, "Calcine Disposition Project Waste-Form and Technology Readiness Strategy," Rev. 1, Idaho Cleanup Project, September 15, 2010.

SDD-272, 2010, "Packaging Remote Design, Maintenance and Tools for the Calcine Disposition Project (P.1.10.02.02) (Draft)," Rev. 0, Draft, Idaho Cleanup Project.

TFR-401, 2010, "Technical and Functional Requirements for the Calcine Disposition Project," Rev. 4, Idaho Cleanup Project, September 16, 2010.