Independent Oversight Review of the Savannah River Site Salt Waste Processing Facility Safety Basis and Design Development

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Acronyms

ADS	Air Dilution System
APA	Air Pulse Agitator
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASP	Alpha Strike Process
ATS	Automatic Transfer Switch
BOP	Balance of Plant
BPCS	Basic Process Control System
CFR	Code of Federal Regulations
CGD	Commercial Grade Dedication
CGDP	Commercial Grade Dedication Package
CGI	Commercial Grade Item
CLFL	Composite Lower Flammability Limit
CSSX	Caustic-Side Solvent Extraction
DCN	Design Change Notice
DCS	Distributed Control System
DOE	U.S. Department of Energy
dP	Differential Pressure
DSA	Documented Safety Analysis
ENH	Potential Enhancement
FICV	Flow Indicating Control Valve
FIT	Flow Indicator Transmitter
GS	General Service
H_2	Hydrogen
HART	Hardware Addressable Remote Transducer
HAZOP	Hazard and Operability
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
I&C	Instrumentation and Control
kV	kilovolt
LIT	Level Indicator Transmitter
LCO	Limiting Conditions for Operation
MCC	Motor Control Center
NPH	Natural Phenomena Hazard
NRC	Nuclear Regulatory Commission
OFI	Opportunity for Improvement
P&ID	Piping and Instrumentation Diagram
PC	Performance Category
PCV	Pressure Control Valve
PDIT	Pressure Differential Indicator/Transmitter
PDSA	Preliminary Documented Safety Analysis
PIT	Pressure Indicator/Transmitter
psig	pounds per square inch gauge
PVVS	Process Vessel Ventilation System
RCN	Requisition Control Number
RICP	Receiving Inspection Criteria Package
SAC	Specific Administrative Control
SAR	Safety Analysis Report
scfh	Standard Cubic Feet Per Hour

scfm	Standard Cubic Feet Per Minute
SDC	Supplier Data Control
SDG	Standby Diesel Generator
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SS	Safety Significant
SSC	Structure, System, and Component
SWGR	Switch Gear
SWPF	Salt Waste Processing Facility
TSRs	Technical Safety Requirements
SWPFPO	SWPF Project Office
UPS	Uninterruptible Power Supply
w.c.	Water Column

**Independent Oversight Review of the
Savannah River Site
Salt Waste Processing Facility
Safety Basis and Design Development**

1.0 PURPOSE

The Office of Enforcement and Oversight (Independent Oversight), within the Office of Health, Safety and Security, conducted an independent review of the safety basis and design development for the Salt Waste Processing Facility (SWPF) at the U.S. Department of Energy (DOE) Savannah River Site, located near Aiken, South Carolina.

The purpose of the review was to evaluate the safety basis, design, and the associated technical documents developed for selected systems of the SWPF, and to evaluate whether they complied with applicable requirements and standards. The review also included certain aspects of configuration management and component procurement specifications processes to ensure that changes to safety bases and design are adequately controlled and that safety systems meet safety basis requirements.

2.0 BACKGROUND

The SWPF, a Hazard Category 2 nuclear facility, is being designed and constructed for DOE by the Parsons Corporation. Oversight for this project is provided by the SWPF Project Office (SWPFPO) within the DOE Savannah River Operations Office. The majority of the design is finished, and approximately two-thirds of the construction has been completed.

The overall mission of the SWPF is to separate and concentrate radioactive cesium, strontium, and selected actinides from the salt solutions removed from the liquid waste tanks in the F- and H-Area Tank Farms at the Savannah River Site. The concentrated waste containing these constituents will be sent to the Defense Waste Processing Facility, where it will be immobilized in borosilicate glass through a vitrification process. The decontaminated salt solution will be sent to the Saltstone Production Facility for immobilization in a grout mixture and disposal in grout vaults.

The DOE requirements applicable to the SWPF include the nuclear facility safety basis requirements of Title 10 Code of Federal Regulations (CFR) 830, *Nuclear Safety Management*, Subpart B, *Safety Basis Requirements*, and DOE Order 420.1B, *Facility Safety*.

The current safety basis for the SWPF is the preliminary documented safety analysis (PDSA), as required by 10 CFR 830, which was approved by SWPFPO in October 2008. Parsons is in the process of developing a documented safety analysis (DSA) for the authorization of future operation of the facility. The DSA is being developed according to DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Non-Reactor Nuclear Facility Documented Safety Analyses*, a safe harbor standard for meeting the requirements of 10 CFR 830, Subpart B. The DSA is scheduled to be completed and submitted to DOE six months prior to the proposed “Cold Commissioning” milestone in late 2017.

Parsons recently distributed a draft DSA (Revision A3) for interdisciplinary review by SWPFPO and contractor personnel. The PDSA and draft DSA are supported by a number of technical documents, including Basis of Design documents, preliminary hazard analysis, hazard and operability (HAZOP) reviews, accident analyses, and consequence studies. The design documentation for SWPF safety systems includes system descriptions, analyses, calculations, piping and instrumentation diagrams (P&IDs), electrical one-line diagrams, and commercial grade dedication packages (CGDPs). Parsons has also developed procedures to control changes in design and safety basis documentation, and to procure equipment and components as the facility construction progresses toward completion.

3.0 SCOPE AND METHODOLOGY

Consistent with the purpose of this review, the Independent Oversight team focused on the integration of selected safety structures, systems, and components (SSCs) defined in the SWPF safety basis into the facility design by evaluating pertinent aspects of the draft DSA; hazards analyses; supporting calculations; and design, procurement, and configuration management documentation. Specifically, the team selected for its focused review the safety significant (SS) Process Vessel Ventilation System (PVVS), the Air Dilution System (ADS), and associated supporting/interfacing systems, including electrical power and certain instrumentation and control (I&C) functions. The team also reviewed selected aspects of Parsons' configuration management and component procurement processes that are used to maintain and implement the safety and design bases.

The Independent Oversight team initiated its review with a scoping and familiarization visit to the SWPF from February 12 – 14, 2013. The visit included tours of the SWPF facility under construction and the Parsons Technology Center, and technical discussions with SWPF management, nuclear safety, and engineering personnel. Concurrently, the team requested and received documents in support of its review. Based on their review of the documents, team members submitted written questions to the SWPF project and exchanged key information with SWPF project personnel to follow up on specific questions.

The principal Independent Oversight results, including identified strengths and potential improvements, are summarized in Section 4. The results of the review are arranged to flow from discussion of the safety analysis assumptions and supporting calculations, which establish the hazard controls and safety functions, to the reviewed systems and finally to important supporting processes. Section 4.1 covers the review of the safety basis. Sections 4.2 through 4.4 provide specific comments on the two safety systems selected by the team, the PVVS and ADS, and important support systems. In addition, commercial grade dedication (CGD) is discussed in Section 4.5, and configuration management topics are addressed in Section 4.6. Section 5 summarizes Independent Oversight's conclusions. Based on the results, Independent Oversight identified both good practices (Section 6) and opportunities for improvement or OFIs (Section 7) for Parsons to consider in the development of its safety basis and design. OFIs are suggestions offered by the Independent Oversight review team that may assist line management in identifying options and potential solutions to various issues identified during the review. Section 8 identifies potential areas for Independent Oversight follow-up as Parsons develops a more detailed safety basis.

The Independent Oversight team also identified a number of minor discrepancies or potential shortcomings that are less significant, which may be corrected in the normal design process. For such items, Independent Oversight identified potential enhancements (ENHs) to increase the effectiveness and safety of the analysis and design. These are included in Appendix A. Supplemental information about the Independent Oversight review is provided in Appendix B, and a comprehensive list of the documents reviewed is included as Appendix C.

4.0 RESULTS

The Independent Oversight team reviewed representative samples of Parsons' work to assess the integration of safety into the design of the facility. The reviewed items, described in the following sections, range from the overall facility safety analysis documents to the detailed supporting design drawings, calculations, and CGDPs. Since the engineering and safety bases of the facility are concurrent works-in-progress, the Independent Oversight team determined that the draft DSA (rather than the PDSA) would provide the most mature SWPF design and safety information, and thus represented the best source of information for the Independent Oversight team to assess ongoing efforts and provide feedback to line management.

4.1 Safety and Design Basis, DSA Assumptions, and Supporting Analyses

4.1.1 Safety and Design Basis

The PDSA concludes that, based on offsite consequences, no events challenge the offsite evaluation guidelines for establishing safety class SSCs. The safety analysis identifies three events that have the potential to challenge the thresholds of concern for the Onsite-2 receptor (co-located worker): explosions in process vessels, aerosolization involving the vessel air pulse agitators (APAs), and seismic events. The PDSA appropriately identifies the PVVS and ADS as SS SSCs and summarizes their safety functions and functional requirements.

The draft DSA represents the most current evaluation of nuclear safety basis hazards and controls for the facility, and incorporates design change notices (DCNs) through DCN-1100. As with the PDSA, the draft DSA does not identify any events with offsite consequences that challenge the offsite evaluation guidelines. In addition to explosion, aerosolization, and seismic events, the draft DSA identifies fires in the vicinity of process vessels or related sumps as events with the potential to challenge the thresholds of concern for the Onsite-2 receptor. The draft DSA appropriately identifies SS SSCs, including the PVVS and ADS, and administrative controls for controlling hazards, and summarizes the SS SSCs together with their safety functions and functional requirements. Chapter 4, *Safety Structures, Systems and Components*, appropriately addresses the safety function, system design, system description, functional requirements (top level), system evaluation, and controls for the currently identified SS SSCs.

The draft DSA contains a number of changes from the approved PDSA that demonstrate the evolution of the facility safety basis and improvements to the definition of the SS SSC safety functions and performance requirements. These changes include an additional accident analysis for fires and additional details in Chapter 4 of the DSA with separate subsections for instrumentation alarms and interlocks. The draft DSA also includes specific administrative controls (SACs) that were not included in the PDSA.

The draft DSA identifies several safety functions for portions of the PVVS. The PVVS piping and high efficiency particulate air (HEPA) filters ensure that non-negligible airborne releases from non-natural phenomena hazard (NPH) events are not allowed to exit the Central Processing Area without being filtered. The PVVS piping from the vessels to the header is credited with ensuring that the header vacuum and its associated PVVS low-flow alarm are indicators that air flow through the vessels is occurring. The PVVS air flow through the process vessels, along with the credited process vessel vent orifices, ensures that the bulk vapor space is maintained below 25% of composite lower flammability limit (CLFL), an initial condition assumed in design and accident analyses. The in-cell PVVS piping from the process vessels also allows post-seismic defense-in-depth ventilation of the vessels.

Under normal operating conditions, the ADS operates continuously to supply sufficient purge air flow from the Plant Air System to the solvent drain tank, solvent hold tank, solvent strip feed tank, and contactor vent header to maintain the flammable vapor concentration in the vapor spaces to less than 25% of CLFL. Upon loss of normal purge air flow, the ADS must continuously supply sufficient purge air from the back-up air receivers to selected process vessel and equipment vapor spaces to maintain the flammable vapor concentration below 100% of CLFL for a period of four days. Under accident conditions with total loss of power, the ADS is designed to provide dilution air flow for four days. Sections 3.4.1.2 (Caustic-Side Solvent Extraction [CSSX] vessels) and 3.4.1.4 (Seismic Event) of the draft DSA discuss explosion events and design features and administrative actions that can be taken after 4 days to prevent explosions. In both these sections, 10 days to CLFL is expressed in terms of a duration for defining credible explosion scenarios. However, in Section 3.4.1.2.2.4, it states "to prevent an explosion in these process vessels within 10 days…at least one of the following actions will be performed." In this context, 10 days is discussed as a performance period in which an administrative action is credited with preventing an explosion. In Section 3.4.1.4, it is clear that the time frame after 10 days is defense-in-depth, but the period between 4 days and 10 days is not adequately addressed. The 10-day performance requirement results in a question concerning the functional classification of administrative actions after 4 days but within 10 days. Most importantly, the Limiting Condition for Operations, LCO 3.3.1, addresses operability of the ADS (Section 5.5.3.1) and the required actions taken after 4 days. (See Section 7, **OFI-01**.)

4.1.2 DSA and Supporting Analyses

In addition to the PDSA, draft DSA, and Basis of Design documents, Independent Oversight examined selected documents associated with the technical analysis of the PVVS and ADS safety functions. These documents included the S-CLC-J-00033, *Time to Reach the Composite Lower Flammability Limit (CLFL) for SWPF Process Vessels*; S-CLC-J-00084, *Radiological Consequences of a Seismic Event at SWPF*; and P-SAR-J-00001, *SWPF Safety Analysis Mass Balance Run*. The team also reviewed several HAZOP studies, including the HAZOP Review Summary Report (V-PHR-J-00001) and later reports, and spreadsheet outputs such as those produced by the Mass Balance Model (SWPF MBM 020306.xls). The calculations, specifications, drawings, and other documents provide the basis for the performance requirements and capabilities of the systems described in the DSA, as well as projected radiologic and toxic exposures expected under accident scenarios.

Overall, the review, including sample verification checks of many of the calculations, demonstrated that the evaluations, calculations, and supporting testing performed by Parsons were thorough and accurate. The calculations used standard accepted industry approaches, physical parameter references, and calculational methods. A noteworthy strength of these lengthy, complex calculations was the effective architecture, which presented a systematic progression of steps along with descriptions of the context for each section. The framework avoided the need to cross-reference multiple pages and contributed to the ease of review. The technical analysis for the calculations was supported by empirical data, key assumptions, and bounding conditions. Calculations that generated a question regarding technical validity were confirmed with comprehensive empirical testing that was specifically designed to bound or validate the process and sensitivity to reasonable parametric changes. Many of the assumptions and bounding conditions were conservatively applied to ensure an adequate margin of safety was embedded into the overall design strategy. The numerical computations were found to follow recognized analytical (standardized) methods. Generally, the calculations were clear, precise, well characterized, and thoroughly executed. The SWPF calculations (discussed in this and other sections of the report) were developed in accordance with procedure PP-EN-5004, *Preparation of Calculations*, and, where specifically reviewed by the Independent Oversight team, were found to be consistent with the engineering documents and suitably integrated into the project design and draft DSA.

Specific Assumptions in the Safety and Design Basis

The Independent Oversight team focused on verifying assumptions in documents that describe the bases for safety and facility design, specifically technical and operational assumptions associated with functions of the PVVS and ADS systems. The team found that the assumptions (those that are explicitly listed in the DSA and various calculations, as well as those that appear to be implicit) were generally appropriate, based on accepted guidelines, properly described, and conservatively based. In cases where questions on the assumption may have arisen, empirical testing was performed (as discussed above). Overall, the assumptions were presented using appropriate descriptions and highly effective visual tools, such as DSA Table 3.3-5, Chemical Mixing Study for SWPF. Some questions regarding the clarity of the assumptions and exceptions, which are discussed below, were raised; however, these questions do not detract from the overall conclusion that the use of assumptions was responsible and conservative.

Since most of the topics of technical assumptions are addressed not only in the DSA, but also in several background calculations and other documents, the topics are discussed below under separate headings.

Explosions

Explosions are described in the draft DSA as potentially occurring in piping, components, vessels, or spaces. Explosions are categorized into deflagrations and detonations. To avoid ambiguity, these terms are addressed separately below.

The context of detonations discussed below focuses on the effects on SS, performance category 3 (PC-3) systems relative to the ability to perform their SS functions after a detonation, and does not refer to detonation effects on facility personnel unless specifically stated.

Deflagrations:

DSA Assumption 11 (Section 3.3.1.2.2, SWPF Inputs and Assumptions) indicates that a deflagration in a vessel will not cause immediate structural damage to the cell and equipment adjacent to the vessel and will not cause death or serious injury to facility workers outside the cell. This assumption is considered reasonable and is supported by an evaluation.

Detonations in Piping:

Detonations in piping are addressed generically in Table 3.3-12 (Event PA-15), which concludes that the events are mitigated with a variety of credited and non-credited design and administrative controls. These controls are based upon safety-in-design concepts that purposely locate equipment in a manner that prevents impact to the worker in the event of an explosion and provides locked doors or gates to ensure personnel are prevented from entering these locations. Administrative controls, such as cell entry and work control practices, are listed to prevent severe worker injury if worker entry is required. Further, calculation S-CLC-J-00137, *Pipe Length Required to Support Explosions With Significant Consequences*, determined the length of piping necessary to hold sufficient hydrogen (H_2) and solvent vapor to result in an explosion that would exceed the threshold of concern for the onsite receptor. The conclusion was that there are no cases where an isolated section of piping of any size at SWPF has sufficient length to require safety-related controls to prevent or mitigate an explosion in the pipe segment. Nevertheless, all piping segments in the facility have been evaluated and process-level controls put in place where needed to prevent explosions.

The team briefly examined the detonation effects on PC-3 SSCs performing SS functions where detonation shock can be transmitted. Parsons stated that Nuclear Safety personnel performed an evaluation of potential interaction effects of piping explosions on the ADS systems and effected design changes to preclude adverse interactions, and that the facility design incorporates safety-in-design concepts to ensure that the ADS cannot be adversely affected by the effects of a vessel or piping explosion. Parsons has also implemented a flammable gas control strategy to protect the primary confinement boundary in process vessels and piping systems, which is not yet described in the draft DSA. The team did not conduct a complete review of this control strategy.

Detonations in PC-3 Vessels:

Vessels with significant radiological consequences have SS/PC-3 controls to maintain their vapor space below CLFL to prevent detonations. Parsons concludes that keeping the vessel vapor space below CLFL maintains the process vessel cell below CLFL, should the contents be released to the cell.

Detonations in Vessels without PC-3 Controls:

Parsons stated that the ADS cannot be adversely affected from the effects of a vessel (or piping) explosion. Parsons has also shown that post-seismic environment detonations in a few vessels are acceptable with respect to their direct radiological effects. The Independent Oversight team considered whether the effects of a detonation in a PC-1 vessel in the same process cell with a PC-3 vessel, component, or containment boundary could adversely affect the ability of the safety SSCs to perform their safety functions, but the team did not conduct a complete review of Parsons' method of bounding the consequences of potential detonations, which is not described in the draft DSA. Independent Oversight will follow the analysis and the implementation of the flammable gas control strategy during future reviews of the DSA development.

Feed Strategy

The major constituents of the incoming and outgoing chemical waste streams, based on two earlier characterization studies of supernate and sludge, are described in P-SPC-J-00001, *SWPF Feed Strategy and Product and Secondary Waste Specification* (Feed Strategy). S-CLC-J-00029, *Radionuclide Concentrations in Process Vessels*, incorporates the supernate and sludge analyses into the calculation of the process vessel contents used for the SWPF safety analysis. Chemical and radiological constituents involved in SWPF process intake, separation, and disposal have been counted, characterized, and managed to determine that SWPF intake and disposal parameters are within required limits. Concentrations and reactions of the main products are incorporated properly in the various lower-tier calculations and assumptions (such as the flammability calculation and accident analysis).

CLFL Calculation Assumptions

Radiological processes, such as those at SWPF, involve the generation of flammable vapors, and preventing flammable and explosive environments is a primary preventive measure in the nuclear safety basis of the facility. The potential for flammable and explosive environments is reflected in the design of a number of the facility's SSCs, such as the PVVS and ADS; including for example, design details such as sloping the piping to drain liquids and avoid pockets for accumulating flammable gases. The

Independent Oversight team reviewed S-CLC-J-00033 and some of its supporting documents. Flammable gases and vapors are continuously generated in the vessels from both radiolysis (H_2 and hydrocarbon breakdown products) and the evaporation of the flammable organic solvents and other volatiles. The flammability of the solvent and breakdown products is highly dependent on the temperature of the vessel contents.

The team also reviewed documentation of various features of the equipment that describe the technical approaches to avoiding flammable environments. The following are specific observations related to flammability.

Dilution Air

The Independent Oversight team reviewed systems, operational configurations, and event scenarios to evaluate the adequacy of dilution air to prevent flammable and explosive mixtures and concluded that the facility design demonstrated satisfactory management of dilution air to vapor spaces. The team noted that Parsons has given significant credit for diffusion of H_2, but this was not clearly documented in some calculations, such as the CLFL and ADS flow rate calculations. Two open items from the HAZOP studies identify cases of potentially trapped gases in vapor spaces in components. These open items (EOI-1797 and EOI-1857) are being appropriately tracked and are in the process of being resolved.

Heat Addition

The Independent Oversight review of heat addition sources found several instances in which the heat addition from electrically powered components (mechanical and pneumatic agitators, pumps, and contactors) was either not addressed or not addressed conservatively in CLFL and ADS flow rate calculations. Further evaluation of these instances found that the contribution from these components was much less significant than the larger heat additions of pumps and only marginally contributed to inventory heat up. However, the rationale for not including these heat inputs in calculations should be documented. (See further discussion in Section 4.3.1.)

Assumption 24 and Section 6.1.3, Process Vessel Liquid Heat Up, of the CLFL calculation describe the method to calculate average maximum temperature that was assumed for immiscible liquids with different boiling points. For cases of immiscible liquids in which the lighter solvent fluids generate more heating than the heavier aqueous phase, this concept can be as much as a factor of 2 non-conservative for the rate of temperature rise, such as when more than small amounts of solvent are in the tank (for example, CSSX high Cesium-137 contactor stages). The thermally stratified (by density) higher heat capacity fluid would remain below and cooler, yet unable to absorb significant heat from the upper layer. This effect would result in faster temperature rise of the lighter, lower heat capacity fluid. Further, Assumption 4 of the CLFL calculation assumes equal heat capacities of the aqueous and solvent phases, which may be inaccurate for vessels with large solvent fractions.

Further communication with Parsons revealed that there are a limited number of tanks (contactors) in the facility that could have high Cesium-137 content during a power outage and a significant solvent and aqueous layer. Based on further review, the non-conservative factors in this assumption are not a significant issue and are bounded by numerous other conservatisms in the calculations. Also, these vessels are small in volume and contain radionuclides with low potential consequences. Thus, there were no impacts to SWPF controls identified regarding these assumptions for the current design. The limits of Assumptions 4 and 24 should be clarified to ensure that future process conditions are properly addressed or bounded. (See Appendix A, **ENH-01**.)

4.2 Process Vessel Ventilation System

The Independent Oversight team evaluated the PVVS to verify whether the design accurately implements the credited functions and system operability requirements in the draft DSA. Documented controls for preventing and mitigating radiological and chemical hazards associated with postulated off-normal operations and accident events, and technical assumptions were reviewed. The review also included major equipment and system components (including the exhaust fans, isolation dampers, pressure modulating and vacuum relief valves, pressure and temperature sensors, and HEPA filters) for each credited function, as well as the PVVS technical baseline (engineering drawings, P&IDs, technical reports, calculations, equipment specifications, and CGD documentation).

4.2.1 PVVS Supporting Analysis and Documentation

As described in the draft DSA, the PVVS has three primary safety design functions. It provides confinement by ensuring that airborne releases from non-NPH events in the process vessels are filtered prior to exiting the facility. It helps prevent fires and explosions by maintaining the process vessel and contactor header vapor spaces well below flammable conditions (at < 25% of CLFL). Finally, as a defense-in-depth function, the system provides an outlet flow path for tank ventilation following a seismic event with loss of power.

Independent Oversight reviewed S-CLC-J-00028, *HEPA Filter Radiological Loading for the Salt Waste Processing Facility (SWPF),* which calculated the estimated doses from maximum radiological loading for various potential events, and found that the calculation was well structured and suitably documented the purpose, inputs, open items, analytical method, and results/conclusions. The calculation was based on an assumed radiological loading of four pounds of worst-case material for the HEPA filters and a conservative estimate of flow through the system. The document concluded that the maximum potential doses were found to result from blast effect, unenclosed crushing, and pressurized gas venting, and that for the three most significant events, the unmitigated doses to the workers and the public were below the respective evaluation guidelines.

The design of the PVVS is appropriately based on the flammable vapor generation rate within each vessel and satisfies the National Fire Protection Association Code 69, *Standard on Explosion Prevention Systems Deflagration Prevention by Combustible Concentration Reduction*, requirement for maintaining the flammable vapor concentration in the vessel vapor space at less than or equal to 25% CLFL during normal operation. The Independent Oversight team evaluated the design basis for this functional requirement to ensure adequate ventilation had been calculated for the anticipated H_2 and volatile organic compound generation rates during normal operations.

Independent Oversight reviewed the process vessel ventilation sizing calculation, M-CLC-J-00134, *Process Vessel Ventilation System Sizing Calculation,* and found that the purpose of the calculation is clearly stated and supported by the inputs, assumptions, and supporting calculations. The calculation adequately verifies that the size of the PVVS header and ventilation return lines will be sufficient to maintain the vessels under a negative pressure during normal operations, verifies that the vessels will be maintained under a negative pressure during a pulse pot discharge, and confirms that the size of the flow orifices is sufficient to maintain the 25% CLFL concentration under normal operating conditions. The assumptions are appropriately conservative and considered, for example, the minimum vacuum (flow) in the vent header and the maximum process vessel fill rate (300 gallons per minute, creating an equivalent 40 standard cubic feet per minute (scfm) outflow from the vessel). The analysis confirmed that a vent size of 0.375 inch orifice for the Strip Effluent Hold Tank and a 0.25 inch orifice for all of the other vessels were satisfactory. The analysis also found that the PVVS flow would be adequate to maintain vessel pressure differentials during normal operations and the analyzed operational evolutions.

Although M-CLC-J-00134 is mostly sound, it does not incorporate the current level of detail required by the calculation procedure. For the analysis, the required inward air flow for normal operations is assumed to be four times the maximum ADS design flow rate (reference 5.11). This assumption is an open item that requires confirmation and closure by Parsons, and is being tracked in the engineering open items database.

Finally, review of the SWPF ventilation system description, M-SD-J-00004, *Heating, Ventilation, and Air Conditioning System Description,* revealed that the current system design has evolved further than the design described in the system description. The system description provides a general description of the PVVS equipment and system performance for different modes of operation, but it does not provide a clear description of the credited safety functions. The system description is scheduled for update using a new format towards the end of the construction phase, which Parsons expects will include identification of active safety functions. (See Appendix A, **ENH-02**.)

4.2.2 PVVS Components

The facility design includes the PVVS in an appropriately multi-layered, cascading confinement design to control the spread of contamination and provide a direct, filtered flow path from the process vessels to the environment. The PVVS design includes major equipment, such as the vent header piping and ductwork; connections to each of the process vessels and the contactors; redundant exhaust fans; and two parallel air treatment trains, each with a cooler, demister, heaters, pre-filters, and two stages of HEPA filtration. The current system design is to maintain the PVVS ventilation header at -12 inches water column (w.c.) to ensure sufficient flow through the process vessels and contactor header under normal operating conditions.

The PVVS piping from the process vessels to the PVVS vent header is appropriately classified and designed as SS to ensure that the header vacuum necessary to provide the required air flow through the vessels is maintained. Orifices (classified as SS/PC-3 for the large process vessels and general service (GS)-1/PC-1 for the CSSX process vessels) provide a PVVS air flow path from the process vessel cell atmosphere into the process vessel vapor spaces on all process vessels except the solvent drain tank, solvent strip feed tank, contactor header, and solvent hold tank.

The PVVS design also provides adequate post-seismic ventilation of six selected process vessels as a defense-in-depth design feature. The PVVS piping connected to these process vessels is correctly classified as SS/PC-3 from the tank out of the cell and to the first manual isolation damper external to the cell. Two seismically qualified manual dampers allow the remainder of the PVVS piping and components, which are categorized as SS/PC-1, to be isolated from the PC-3 qualified section of piping. In addition, a flanged pipe, isolated by a third qualified damper, provides a suitable potential connection point for attaching a temporary fan and HEPA filter to provide backup ventilation. For these manual isolation dampers (identified as seismic boundary valves), the SS/PC-3 design requirement is correctly specified to ensure the integrity of the valve/damper body and disk/seat.

The design criteria and engineering specifications for several components, including the manual butterfly valves, were analyzed for their credited confinement function and design features. All of these components perform an important role prior to, during, and after a seismic event. The review of these components by the team revealed that the design and specifications for this equipment were adequately documented on the engineering documents (P&IDs), and the supporting CGD documentation adequately described their credited functions.

4.2.3 PVVS Instrumentation and Controls

The Independent Oversight team determined that the PVVS I&C design is robust; facilitates operator monitoring, control, and surveillance of PVVS operational and safety functions; and meets DSA functional safety requirements. Credited SS I&C components include the ventilation header pressure differential indicator/transmitter (PDIT), which provides input to an SS alarm to alert operators when the negative pressure may not be sufficient to maintain the required PVVS air flow through process vessel and tank vapor spaces, and the PDITs on the final stage HEPA filters, which provide input to SS alarms to alert operators to potential filter plugging. All of the SS monitoring equipment has been appropriately designed to activate alarms consistent with the PVVS safety functions. The results of the review of key PVVS I&C components are discussed below.

All reviewed PVVS I&C components (except thermocouples, which are located within SS/PC-1 thermowells and not exposed to the PVVS ventilation stream) are appropriately designed for SS/PC-1 service, as required for their passive safety function – maintaining structural integrity following a seismic event. The associated CGDPs document that Engineering has confirmed that these passive components (material and dimensions) will meet the requisite seismic demand.

As a surrogate for PVVS flow, PDIT-4191 senses PVVS ventilation header vacuum relative to outside air and transmits an analog vacuum signal to the Safety Instrumented System (SIS) for developing the SS low-low vacuum (low flow) alarm. The SIS alarm alerts operators that the PVVS may not be maintaining sufficient air flow through process vessel vapor spaces to prevent flammable gas concentrations exceeding 25% CLFL. The SIS also provides a digital vacuum signal to the Basic Process Control System (BPCS) for indication and regulation of the ventilation header vacuum. Observations by Independent Oversight during the review include the following:

- The CGDP for the PDIT requires that it be calibrated from minus 5 (-5) to plus 1 (+1) in. w.c.; however, the planned control span and alarm setpoint range exceeds these values. (See Appendix A, **ENH-03**.)
- Appendix A, Table 1, Safety Significant Alarms, of the Software Requirements Specification refers to the SS alarm associated with PDIT-4191 as "PVVS Low-Flow Alarm" and indicates the "CR ANN-01 Engraving" will read "PROCESS VESSEL VENT HEADER DIFF PRESSURE LOW," while Appendix B, Annunciator Panel Alarm Listing, indicates that the alarm panel tile would read "PDIT-4191 PVV HEADER VACUUM LOW." (See Appendix A, **ENH-04**.)
- The high pressure side (outside atmospheric pressure) of PDIT-4191 is connected to the "Process Building Reference Leg Header for Differential Pressure Indicators" through a ½ inch ball valve (V0430) that if inadvertently left closed would invalidate the accuracy of the PDIT's vacuum signal. Although the future Conduct of Operations Program procedures will control the valve status, P&ID M-M6-J-0118 does not show this valve is locked open or that provisions have been established to prevent valve misposition. (See Appendix A, **ENH-05**.)

The PVVS ventilation header last stage HEPA filter PDITs (PDIT-4169 and -4204) provide a signal to the SIS for development of an SS high-high differential pressure (dP) alarm, and the SIS then sends a digital signal to the BPCS for indication and control. The high-high dP alarm on the PVVS final HEPA filters alerts operators to HEPA filter plugging. The HEPA filter dP indication provided on the BPCS also provides indication of HEPA filter loading, breakthrough, or bypass. During the review, the Independent Oversight team observed that:

- The calibrated range of the PDITs is currently specified as 0 to 5 inches w.c. This is up to several inches of water below the rated performance of the HEPA filters (typically 10 inches w.c. dP) and could restrict the operator's ability to analyze whether the filter integrity is being challenged. The SS high-high alarm is set at 4 inches w.c., which is near the high end of the calibrated range. Although the filter is isolated by the interlock, increasing the calibrated range could provide the operators with the option of using the filter to its full rated capacity and the ability to trend further loading of the HEPA filter, should that be necessary in an abnormal event. (See Appendix A, **ENH-06**.)
- Requisition Control Number (RCN) 00903, item number 222.01, associated with PDIT-4169, specifies the wrong receiving inspection criteria package (RICP). A thorough review by Parsons of the entries in RCN 00903 was conducted and verified that this was the only translation error. A condition report (CR-2013-51) has been initiated to track the resolution of the problem.
- Documentation of SS functions for the PVVS HEPA filter PDITs is inconsistent. Table 17-1 of the Balance of Plant (BOP) Basis of Design shows the safety function is to alarm on both low and high dP. The safety function described in the current revision of the DSA (DSA 4.4.11, 5.5.2.1) addresses only the high dP alarm, and current design documents (such as J-SPC-J-00011, Safety Instrumented System) are consistent with the DSA. A Parsons representative indicated that the BOP Basis of Design has not been updated to reflect the latest design information. (See Appendix A, **ENH-07**.)
- The BOP Basis of Design indicates that the PDITs that support the PVVS low flow and HEPA filter high-high alarms are required to be rated as safety integrity level (SIL)-2 (see Table 17-1). The draft DSA states that the SIL rating of the SIS logic solver is SIL-3 to "provide added confidence the alarm conditions will be highlighted" to the control room operator, but does not discuss the SIL rating of the PVVS instruments. Parsons engineers indicated that the BOP Basis of Design has not been updated to the latest determination that alarms are not safety instrumented functions as reflected in the draft DSA. (See Appendix A, **ENH-08**.)

4.3 Air Dilution System

The ADS is an SS fail-safe, passively actuated system whose function is to maintain a continuous air purge to select process vessels and equipment at rates sufficient to maintain the vapor space flammable gas concentrations below the CLFL in order to prevent deflagration or detonation. The draft DSA credits the ADS with several important safety functions, including (1) establishing the initial flammable gas concentration to prevent the explosive event in select CSSX vessels (the solvent drain tank, solvent hold tank, and strip solvent feed tank) and the CSSX contactor vent header, in order to maintain these vapor spaces below 25% CLFL; (2) protecting against the occurrence of explosions in the Alpha Strike Process (ASP) and select CSSX vessels and in the PVVS piping/ductwork following a loss of power or ventilation event; and (3) protecting against explosions in all of the SS/PC-3 ASP and CSSX vessels as a consequence of a seismic event. The draft DSA identifies three ADS low pressure alarms that provide an SS function by monitoring the operability of the normal and backup ADS purge air supplies.

During normal operation, ADS purge air is supplied by the active non-safety function of the Plant Air System (air flow through selected vessels is also supplied during normal operations by the active SS function of the PVVS to maintain concentrations below 25% CLFL). During accidents or off-normal conditions, when the active functions of both the Plant Air System and the PVVS may stop, the ADS backup air receivers will automatically supply purge air to maintain process vessel vapor spaces below 100% of the CLFL for at least four days. Additionally, the ADS design provides hookup features (both SS and non-safety) for connecting temporary air supplies to continue purging after the backup air receivers have been depleted. After the fourth day, it is assumed that other measures, if required, will have been implemented to maintain concentrations below CLFL. The established purge air flow ***rate*** is sufficient to ensure the flammable gas concentration in the vessel vapor space is maintained below CLFL up to ten days after the start of an event assuming bounding inputs and assumptions. Alternate flow rates may be justified by Engineering after the start of an event using known waste characterization data and inventories. Also, the vapor space volumes for the main process vessels with the highest potential for inhalation dose consequences are designed to passively accommodate flammable gas generation for up to ten days before reaching CLFL, assuming no active air dilution from the ADS.

This assessment focused on verifying the ability of the ADS to perform its safety functions, as credited in the current draft DSA. This focus included reviewing the accidents and events for which the system is credited, the qualitative required system performance levels for these events, and the analyses and calculations that defined and quantified the challenges to and corresponding performance levels required of this system. The verification also included reviewing the abilities of individual system components (such as, piping, air receivers, check valves, pressure regulators, pressure relief valves, compressors, rotameters, pressure gauges, pressure indicator/transmitters (PITs), and flow indicating control valves or FICVs) to perform their specific intended safety or support functions, and reviewing the system functional layout and interconnections with supporting and interfacing SSCs. Examples of documents reviewed included the current draft DSA, DOE-approved PDSA, P&IDs, equipment specifications, vendor drawings and manuals, detailed analyses and calculations, and procedures.

4.3.1 ADS Supporting Analyses

Three calculations are of primary importance in determining the required performance of the ADS. Calculation S-CLC-J-00042, *Process Vessel Air Purge Flowrates*, determined the individual process vessel and equipment flammable gas generation rates, their CLFLs, and the air purge flow rates required to maintain flammable gas concentrations below 100% CLFL. M-CLC-J-00179, *Minimum Required Capacity for Process Building Air Purge System*, determined the air-receiver size to provide these flows for four days. Calculation S-CLC-J-00033, which provides significant inputs to calculation S-CLC-J-00042, was discussed in Section 4.1 of this report. The following paragraphs address the first two of these calculations: S-CLC-J-00042 and M-CLC-J-00179.

In general, the calculations provide appropriate bases for the system's design. Both calculations are clear, concise, and well organized; approaches and methodologies are valid; inputs are clearly identified; assumptions are conservative and well justified; and results are clearly stated and conservative. Although the Independent Oversight team identified several non-conservatisms in each calculation, there were also numerous conservative elements identified. Additionally, the Independent Oversight team identified other conservatisms that had not been explicitly noted in the calculations. When these calculations are revised to account for all of the relevant factors, the conservatisms are likely to be sufficiently offsetting to maintain the validity of the conclusions. The conservative assumptions may also provide margins in the calculation that will help to accommodate future design changes, new information, and other discoveries during the design and construction processes, provided they are documented, tracked, and managed.

S-CLC-J-00042 was appropriately performed in accordance with the Parsons procedure on calculations to determine the required air purge rates for the process vessels and equipment. The required flow rates are a direct function of the rate of flammable gas generation in the vessels. The flammable gas generation rates due to chemical reactions and evaporation of flammable organic vapors are a function of the material temperature, which in turn is a function of the heat input rate to the materials. Two of the heat sources are the vessel recirculation pumps and the APAs, both of which normally operate to keep the vessel mixtures homogeneous and the solids in suspension.

As was observed with other reviewed calculations, this calculation contained a number of conservative assumptions or estimates, including:

- Process vessel conditions were assumed to be adiabatic (no heat losses) during design basis events; therefore, the calculated temperatures and the resultant calculated flammable gas generation rates used would be greater than actual.
- The calculation did not account for any non-flammable dilution gases, such as carbon dioxide, that may also be generated in the materials in the process vessels and equipment.
- The rated pump motor horsepower, which is greater than the actual shaft horsepower that would be input to the pumps to generate the required performances, was used as a basis for the pump heat input.
- The calculation based the required purge flow rate (constant for the duration of an event) on the maximum flammable gas generation rate, which would not occur until the end of ten days.

Although the calculation was mostly sound and implemented conservative assumptions, two non-conservative assumptions were identified. First, in spite of assuming a conservative *rated* motor horsepower basis for the recirculation pump heat loads inputs, another assumption with regard to the recirculation pumps and its basis was not correct or conservative. The heat addition from the recirculating pumps was assumed to be equal to the pump inefficiencies. The assumption did not recognize that the pump work to move the fluids would ultimately be manifested as friction heat within the fluids due to viscous shear and turbulent interactions with the system components and within the fluids themselves. Second, the initial gas concentration assumption was inconsistent with respect to the DSA statements. Assumption 20 of the calculation states that “the initial flammable gas concentration in the process vessel vapor space is at 0% of CLFL." This assumption contradicts DSA Section 4.4.11.1, which states, "The PVVS…ensures that air flow through the orifice and into the tank maintains the initial condition of bulk vapor space [flammable gas concentration] below 25 percent (%) of… CLFL." Additionally, this assumption is not relevant to the approach used for the calculation, as reflected in Equation 32. This equation was used to determine the required purge flow rates based on the flammable gas generation rates at ten days (when vessel temperatures and gas generation rates would be highest). Although these were the rates that were actually used, the calculation does not discuss this assumption’s differences from the DSA. (See Section 7, **OFI-02**.)

Similarly, although the assumed heat input for the APAs was conservative in using the heat-equivalent of the total work performed in expelling the fluid from the APAs (when in fact a portion of the heat would actually be lost to the atmosphere when the APAs were vented), the discussion of the basis was incorrect in that it stated in various forms and locations that the heat created as a result of work on the fluid was not deposited as heat into the system.

The second important calculation, M-CLC-J-00179, *Minimum Required Capacity for Process Building Air Purge System*, used the flow rates calculated in S-CLC-J-00042 to determine the required capacity of the ADS. The calculation is based on a number of conservative assumptions and estimates that are appropriately described in the calculation. In addition, the following conservatisms not explicitly identified in the calculation were noted by the Independent Oversight team.

- The calculation was based on the maximum flammable gas generation rate determined in the previous calculation. The required purge flow for the individual process vessels is to be preset to a constant value throughout an event and is based on the vessels' maximum flammable gas generation rates, which would not occur until the tenth day. Consequently, at all earlier event times in the calculation, the preset air flows would actually *exceed* required flows.
- The minimum receiver pressure assumed in the calculation was 120 pounds per square inch gauge (psig); however, in an actual event, the receivers would continue to provide purge air at the required flow rates for pressures considerably below this value. Informal testing, performed by Parsons subsequent to discussing this observation, indicated this full-flow ability might continue down to about 55 psig (representing approximately two additional hours) and flow would continue at slowly decreasing rates for some additional time.

These additional conservatisms offset the identified non-conservatisms described below:

- The required purge flow rate inputs to this calculation were determined by Calculation S-CLC-J-00042, which contained non-conservative elements, as described earlier. When that calculation is corrected, it is expected that the net change in required flow rates will be relatively small; regardless, this calculation will need to be revised.
- The assumption of the system leakage (in Section 3, Inputs) was not conservative. Only two points of potential system leakage were assumed – the two check valve boundaries between the ADS and the non-safety Plant Air System – at 1.5 standard cubic feet per hour (scfh) each. However, two other (unnumbered) check valves immediately upstream of FICV-7382 and FICV-7383 that could also have been potential leakage pathways were not included in the assumed system leakage. Subsequent to the identification of these pathways, the piping arrangement was modified (DCN-1270) to route these flow control valve outlets directly to a solvent drain tank, thereby eliminating these potential leakage pathways.
- The calculation indicated the source for the assumed valve leak rate as American Petroleum Institute (API) Standard 521, *Pressure-Relieving and Depressurization Systems*, which was incorrect. The source of the leakage rates should have been API Standard 598, *Valve Inspection and Testing*, which was Attachment 9.2. This reference identifies a maximum leakage rate of 1.5 scfh per valve, which is what was used in the calculation.
- Although at the time of the review the operating range for the air compressor was 2600 – 2850 psig, draft DCN-1210, which changed the operating range to 2450 – 2750 psig, was in process and was subsequently approved. The current design setpoint range is non-conservative with respect to the calculation. The calculation assumed that over the course of an event/accident the pressure in the ADS air receivers decays from 2,500 psig to 120 psig. The 50 psig difference between the compressor start setpoint and the starting pressure for the calculation represents an approximate 2% reduction in available air capacity. At the time the DCN was approved, Parsons had informally evaluated this non-conservatism and concluded that it was acceptable because it was more than offset by the numerous conservatisms in the calculation.

As a result of multiple non-conservative factors, the analyses do not fully reflect the actual design and formally document the capability of safety SSCs to perform their design safety function. (See Section 7, **OFI-02**.)

Although not a non-conservatism, M-CLC-J-00179 also includes an implied assumption that there will be no moisture accumulation in the ADS receivers (that would reduce the receivers' effective volume) because of the system design, which provides air dryers downstream of the backup air compressors (as well as for the normal air supply from the plant air compressors). Such an assumption should be explicitly documented to ensure that it will be protected by periodic surveillance, such as with drain blowdowns to verify no moisture accumulation. (See Section 7, **OFI-02**.)

Currently, neither the DSA nor any supporting analyses explicitly address the credited flow path(s) from the process vessels and equipment to the atmosphere for ADS dilution flow in the accident mode (supplying dilution air to the process vessels and equipment whenever PVVS and normal Plant Air are not available). Implicit in the DSA descriptions and supporting analyses is that the flow path would be through the PVVS system to the facility stack and/or through the vent orifices located in some of the process vessels and thence to the process cells (see, for example, DSA Section 3.3.2.3.2.1.4). However, for certain event scenarios (such as loss of the PVVS without the loss of the Process Building Ventilation System), the PVVS backdraft damper (DMP-2115) would be closed, thus blocking the normal non-safety PVVS pathway. In such cases, the vessels' orifices would have to provide these exhaust pathways in order for ADS to function.

Engineering judgment in examination of calculation M-CLC-J-00134, *Process Vessel Ventilation System Sizing Calculation*, indicates that the orifices, which significantly exceed the sizes required to achieve the design PVVS air flow, would also allow the required ADS flow through each tank for this scenario, without causing excessive tank back pressure (because the tanks are cross-connected through their PVVS exhaust lines). However, this aspect of the ADS function was not explicitly and clearly addressed in the DSA or supporting documents. (See Section 7, **OFI-03**.)

4.3.2 ADS Components

The Independent Oversight team reviewed the design of key ADS components (i.e., piping, relief valves, pressure regulators, rotameters, and air compressors) and found that overall the designs were conservative and appropriate for the applications. The following observations relate to these SS components, including some opportunities to improve the design of the system that were identified during the review.

The Independent Oversight team did not identify any concerns with the design of the ADS piping. Although the air receiver and main supply header relief valve tailpipes are classified as GS-2, seismic PC-1, this classification was found to be acceptable, because the likelihood of simultaneous failure of this piping (in a manner that would prevent the relief pathway function) in combination with a pressure challenge to the components they protect is extremely low. Also, the receivers' separate individual relief valves provide redundant, full-capacity relief protection by virtue of their normally cross-connected operational mode. The design of the SS relief valves, manual isolation valves, pressure regulating valves, and rotameters is appropriate to their safety and operational functions.

No concerns were identified with the design of the backup high pressure compressors for the ADS. The accident purge flow requirement to the process vessels identified by calculation M-CLC-J-00179 is 3.9 scfm. Specification section 11842 includes a specific design requirement that the compressor be capable of delivering 10 scfm at a discharge pressure of 2,750 psig, which exceeds the design accident flow to the process vessels. Based upon vendor data, the air compressor is capable of delivering 10.4 scfm at 2,900 psig, thus providing sufficient capacity to be capable of supplying the process vessels while at the same time recharging the receivers.

Two non-safety plant sources supply compressed air for the ADS: the Plant Air System, which provides the normal supply to the process vessels and equipment, and the ADS compressor, which supplies air to the ADS backup air receivers. Both sources must provide air of high quality to ensure that the system's pressure reducing valves, flow control needle valves, and rotameters can provide accurate, reliable performance. The specifications for these components required both sources to supply dry (dew point ≤ minus 40ºF), oil-free air, and both specifications required an after filter. Although only the ADS compressor specification spelled out the required after filter performance rating, the actual filters provided for both systems were rated at 1 micron. (See Appendix A, **ENH-09**.)

The review found that a system check valve forming the boundary between the ADS air receivers and the non-safety backup air compressor portion of the system (SI 285) was originally specified as a simple swing check valve, but was subsequently replaced with a soft-seated, spring-operated poppet-type check valve, which should provide reliable, leak-tight isolation. An additional check valve with an SS isolation function in the system (located at the local second stage ADS flow controls for the solvent drain tank) was specified as a spring-loaded valve that, per the vendor's documentation, could require as much as 20 pounds per square inch differential backpressure to be fully seated. Because of the system layout, it is highly unlikely that this dP could be available at this location for any system operating mode; therefore, this valve design was inappropriate for this application. Subsequent to the review, this check valve was replaced with one suitable for the application (DCN-1270); however, the remaining check valves at the corresponding locations in the final pressure reduction stations were similarly of inappropriate design, as described in Section 4.3.3.

Review of the design specifications for the two ADS air receivers, which are specified as American Society of Mechanical Engineers (ASME) Code, Section VIII pressure vessels, identified no concerns. Calculation M-CLC-J-00179 determined the receivers required a total volume of 148 cubic feet. The actual total receiver volume is 160 cubic feet; however, this design margin may be reduced as a result of the calculation concerns identified above.

The designs for the temporary backup purge air supply equipment have not been completed at this stage of the project.

4.3.3 ADS Functional Arrangements and Interconnections

The Independent Oversight team reviewed the functional arrangements and interconnections of ADS and found that, in general, they were sound. In numerous areas, the functional arrangements provide elements of redundancy that improve system reliability and maintainability. However, Independent Oversight found one instance where the system design included potentially unnecessary components. The following discussion addresses these observations.

There are two pressure reduction stages in the ADS: the first normally providing reduction from the receiver pressure (as high as 2,750 psig) down to the nominal 25 psig supply header pressure, and the second stage at the needle valves/rotameters down to the process vessel vapor space pressure. Although not required by regulation or standard for an SS system, the system arrangement has the following conservative feature to protect it from first stage single failure. The design incorporates redundant first stage pressure reduction packages (i.e., a parallel arrangement with two pressure control valves (PCVs) in series for each parallel leg). The first PCV in each package is set at 25 psig, and the second at 40 psig. Since the first valve controls at a lower pressure, the second normally remains wide open, providing no pressure control. However, should the first valve fail open, the second will take over control at 40 psig, thereby preventing the header pressure relief valve, set at 150 psig, from actuating and dumping the receiver to atmosphere.

Redundant backup connection points are also provided in the design by two engineered, temporary backup compressor air supply points (one within the SS, PC-3 boundaries and the other outside of these boundaries) should the system not be restored to normal operation within the design basis of four days of ADS supply from the SS receivers.

The design also incorporates redundant air flow paths to critical applications at the second pressure reduction stage, consisting of parallel individual pressure reducers, needle valves, and rotameters. At every service location, one path would normally be isolated and in standby, while the other is in service. This arrangement allows changeover from one path to the other for equipment maintenance, testing, replacement, etc., without interruption of service, as well as providing immediately available alternative flow paths if, in an accident, the in-service flow paths experienced degradation.

The design of the ADS also includes potentially unnecessary check valves in final ADS delivery stages. The design includes spring-loaded check valves in the piping upstream of all of the final pressure reduction stages supplying the individual process vessels and equipment (58 in total). A design function could be identified for only two of these valves (located at the ADS flow controls for the solvent drain tank), which is to prevent back-leakage of ADS purge air into the Plant Air System when the Plant Air System is depressurized (as described in the previous paragraph). No design function could be identified for the remaining 56 valves; consequently, they present potential unneeded failure points in the system. In particular, being spring-loaded in the closed direction, these valves present substantial flow resistance in the normal flow direction, which could unnecessarily reduce the actual available system capacity for ADS receiver pressures below the analyzed 120 psig value, as discussed previously in this report. While not invalidating the design, these components have the potential to reduce the system's reliability somewhat and present unnecessary maintenance and testing requirements to the facility. After this observation was made, the piping arrangement was modified (DCN-1270) to remove the check valves from the pathways.

4.3.4 ADS Instrumentation and Control

The Independent Oversight team determined that the ADS I&C design is robust and appropriately implemented; facilitates operator monitoring, control, and surveillance of ADS operational and safety functions; and meets DSA functional safety requirements. All ADS I&C components are designed and procured to meet SS/PC-3 passive safety functional requirements for maintaining integrity despite a design basis seismic event, and SS/PC-3 or PC-1 active functional requirements for accurately indicating the magnitude of sensed pressure or flow. Instruments with an active PC-1 classification are appropriately designed because they support monitoring only and serve no credited control function following a seismic event. The review of key ADS I&C components is discussed below.

The backup air storage tank has a local, calibrated pressure indicator, PI-7318. The pressure indicator is designed and procured as a PC-3 instrument and will perform its defense-in-depth function – locally indicating tank pressure – following a seismic event and loss of power (enabling operators to trend the loss of backup ADS air capacity as an input to post-event decision making). Although the ADS is designed to require no operator action for four days following a loss of the Plant Air System and electrical power, the availability of the electrically independent pressure indicating gauge and FICVs, discussed later in this section, provide adequate monitoring and control capability that can be used to ensure the system continues to operate properly.

As discussed previously, the ADS design incorporates redundant first stage pressure reduction packages (i.e., a parallel arrangement with two PCVs in series for each parallel leg). The design requires appropriate pressure testing, calibration, and coordination of the control valve pressure settings. The PCVs will be set to control their outlet pressure at 25 psig and 40 psig and have integral local downstream pressure indicators calibrated for 0-3000 psig and 0-100 psig, respectively.

The draft DSA identifies three PITs with low pressure alarms that provide an SS function, monitoring the operability of the normal and backup ADS purge air supplies. These PITs monitor the backup storage tank pressure, backup air header pressure, and Plant Air header pressure to ADS. Each PIT has been appropriately designed and specified in procurement documentation. As designed, the PITs are dependent on electric power and provide a local liquid crystal display pressure indication. The PITs provide analog pressure signals to the SIS for developing SS low-low pressure alarms. The SIS also passes a processed digital pressure signal to the BPCS for pressure indication; development of both high and low pressure alarms; and, in the case of the air storage tank pressure, control of the start (2,600 psig) and stop (2,850 psig) of the non-safety backup ADS air compressor.

During review of the PIT-7314, Back-up ADS Air Pressure Local Indicator and Transmitter, the Independent Oversight team noted the following.

- Since there is no check valve isolating the PIT from the Plant Air System pressure, the calibrated pressure range of 0-65 psig for PIT-7314 may not adequately cover the expected range of pressures at the instrument, which could be as high as 75 psig, assuming the operating first series Plant Air to ADS PCV failed open, placing the second series PCV in service. Parsons indicated the plan is to increase the calibrated pressure range to ≥ 75psig. (See Appendix A, **ENH-10**.)
- Given that the first backup ADS PCVs (PCV-7312 or 7316) are designed to control at 25 psig, the low pressure alarm setpoint (24 psig) may be too close to the pressure control setting to avoid nuisance alarms. This issue was addressed by DCN-1210, which was approved following this observation by the Independent Oversight team.
- Given that the first and second series Plant Air to ADS PCVs are set at 60 and 75 psig, respectively, under normal operations with Plant Air feeding the ADS, the BPCS high pressure alarm (36 psig) will almost always be in alarm mode. Further, with the second series backup ADS pressure regulator set at 40 psig, the BPCS high alarm will always activate when the 25 psig regulator fails open. Parsons plans to increase the pressure setpoint to ≥ 75psig. (See Appendix A, **ENH-11**.)

FICVs indicate and provide control of the ADS purge air flow to each process vessel and the contactor vent header. Each FICV incorporates a rotameter for air flow indication, a manually adjustable needle valve to set the indicated purge air flow, and a regulator to maintain a constant dP across the needle valve. As discussed in Section 4.3.2, the solvent drain tank is supplied with two sources of purge air. Either of two high flow-capable FICVs is suitably designed to control and indicate Plant Air purge air flow to the solvent drain tank to prevent its vapor space from reaching 25% of CLFL during normal operations. In addition, either of two low flow FICVs is designed to properly control and indicate low volume ADS purge air flow to the solvent drain tank to prevent the vapor space from exceeding a post-seismic event condition of 100% of CLFL. The latter low flow FICVs are also typical of the rotameter/flow controllers that supply purge air flow to the other process vessels and the contactor vent header served by the ADS, with the same design but different calibrated ranges. All the FICVs have an appropriate design operating range for their assigned function and have been ordered with reasonable preliminary purge flow setpoints. Purchasing and CGD documentation properly require pressure testing and seismic qualification for the

FICVs, which have an SS/PC-3 active safety function for controlling and indicating the purge flow during and after a seismic event to allow operations personnel to monitor and adjust air flow to the process on an as-required basis.

4.4 Support Systems (Electrical and Distributed Control Systems)

The Independent Oversight team also reviewed the design of the SS and defense-in-depth systems and components that support the operation of the ADS and PVVS to verify that the safety functions described in the DSA can be performed. The review was limited to the components of the electrical system and distributed control system (DCS) that support ADS and PVVS design functions. The required system and component design functions and capabilities were determined through review of the DSA, Basis of Design documents, draft system descriptions, flow capacity calculations, alarm and setpoint schedules, electrical single line diagrams, and panel board schedules, and communication with Parsons engineers and managers. This section describes the results of the abbreviated evaluation of some of the key features of the electrical system and DCS, the latter including the BPCS and SIS. The evaluation did not include a detailed review of the design of the system hardware or software.

4.4.1 Electrical System

The Independent Oversight team concluded that the SWPF electrical system is a robust design with appropriate capacity, redundancy, protection, and interlock features to support normal SWPF operations, maintenance, and testing, and to provide standby power for essential production functions following loss of power. The DSA does not require the electrical system to facilitate the safety functions of any SS equipment; however, the electrical system is designed to provide normal power for essential process functions (pumps, fans, I&C, and auxiliaries), to support SSCs that are relied upon to establish the initial conditions used in the accident analysis, and to mitigate radioactive material releases from non-NPH events. The electrical system is also designed to provide standby power to essential production equipment following the loss of normal power, in support of post-event recovery and consequence mitigation activities.

The electrical distribution system is functionally classified as GS-2, and the design incorporates appropriate power input from two 13.8 kilovolt (kV) normal power feeds (with SS manual disconnect switches) and one standby diesel generator (SDG). Normal electric power is distributed within SWPF through an appropriate, redundant series of buses, substations, transformers, switchgear, motor control centers (MCCs), and panel boards, each with cross-connects or normal and alternate sources of power, where appropriate. The electrical power supplies for the redundant SWPF components are split between redundant switchgear and MCCs. Standby power is provided to essential support systems and equipment components whose operating continuity is necessary to support essential process functions. The SDG and the switchgear and MCC breakers can be operated locally. Essential process equipment receives power from automatic transfer switches (ATSs) that select power feed from the normal electrical distribution system switchgear or on sensing loss of power, start the SDG and transfer the power feed to the SDG switchgear once the SDG frequency and voltage stabilize. The uninterruptible power supply (UPS) provides power to essential I&C equipment and receives power from the MCCs powered by the ATSs.

Key electrical system components include the 13.8 kV manual disconnect switches, ATSs, SDG, UPS, and essential MCCs.

As required to support the DSA safety functions, the 13.8 kV manual disconnect switches have an SS/PC-3 function to provide a reliable backup means of manually de-energizing vessel heat sources.

These switches are credited as available SS controls for response to a seismic event that severely damages SWPF by facilitating timely operator efforts to reduce the heat input to process tanks and contactors. All active and passive components associated with the credited 13.8 kV manual disconnect switches are appropriately designed to satisfy PC-3 seismic requirements.

To provide adequate power reliability, the design provides for two ATSs that determine the source of power for their assigned essential power MCC, and start and align the SDG on under voltage and under frequency conditions to their essential power switchgear. ATS setpoints for initiating an SDG start or transferring loads to the SDG feeds have not yet been established.

The SDG and associated components are designated GS/PC-1, which is appropriately consistent with the DSA requirement that the SDG only provides standby power. The primary role is to facilitate recovery operations and restoration of production after a loss of normal power. The SDG is capable of automatically starting and accepting loads after a ten-second stabilization period, during which time the SDG attains rated speed and voltage. The design also suitably incorporates a separate ATS to determine the appropriate essential power source for the SDG support systems.

The electrical system design includes two essential MCCs that provide power to plant equipment that performs and monitors essential process functions, e.g., PVVS fans and heaters, UPS, and control room HVAC. Further, the DCS provides control over the essential equipment and facilitates the coordinated restart actions for all process equipment following a loss of power. By design, the DCS restarts plant loads in the same priority and sequence that existed immediately prior to the interruption of normal power. For example, the operating PVVS fan and filter train vent heater trip on a loss of normal MCC power; however, they start again under control of the DCS load sequencer once the MCC is re-energized from the SDG. Restarting the PVVS on standby power is a defense-in-depth function to induce contaminated and potentially flammable process vessel vent flow through the PVVS HEPA filter train; however, this function is not credited by the DSA, and standby electrical power is not required for the PVVS system.

The 80 kilovolt-amperes (KVA) UPS design is suitable to shield the essential I&C system loads (that need to operate continuously and must be energized in order to maintain operational functions) from frequency, voltage fluctuations, transients, surges, and power interruptions. The UPS panel boards provide distortion-free power to these loads, normally and on loss of normal electrical power, and the UPS provides “bumpless transfer” to backup power. The UPS battery is sized to carry the required connected loads (plus additional capacity) for at least 30 minutes. A bypass supply to the UPS output isolation transformer is provided for performing any repair or maintenance service to the UPS. On UPS failure or degraded performance (e.g., inverter section failure), an internal, normal power-seeking, static bypass switch automatically aligns the bypass power source to the UPS output bus.

4.4.2 SWPF Distributed Control System

For those attributes reviewed, the Independent Oversight team determined the SWPF DCS is appropriate for use to remotely monitor and control the majority of SWPF processes, equipment, and support systems. The operating systems and interfaces for equipment that is not under direct DCS control are supplied as non-SS vendor packages, generally with local indication and control and an interface with the DCS. The DCS incorporates two subsystems: a BPCS and an SIS. The function of the BPCS is to monitor and control the processes and provide the human interface to allow safe, effective, and efficient operation. The function of the SIS is to receive analog signals from field devices with active SS functions; transmit sensor hardware addressable remote transducer (HART) diagnostics information to the BPCS; process all

SS alarm and interlock functions; and forward all measured process variables to the BPCS for indication, control, and further non-safety alarm and interlock functions. The SIS design limits and isolates the interface with the BPCS and field devices such that a failure in the BPCS or corruption of the HART signal cannot cause a failure in the SIS logic solver.

The electrical system is an important support system for the DCS. Further, in light of their importance, both the BPCS and SIS are capable of being fed from two independent 120 volt alternating current (VAC) power sources, one of which is the UPS. The DCS is also an important support system for the SWPF electrical system, providing both monitoring and control functions. Following a loss of normal power, the BPCS selects the priority and specific machines and systems that will be restarted on SDG power, restarting of the plant loads in the same priority and sequence that existed immediately prior to the interruption of primary power.

Basic Process Control System

The BPCS is designed to display PVVS operating parameters and provide appropriate non-SS interlocks, controls, and alarms for the PVVS. Although BPCS parameter displays and alarms do not perform credited safety functions, they are provided to support operator monitoring of PVVS operation. For example, the indication and alarm functions of the PVVS HEPA filter dP and discharge air beta radiation instruments provide indication of the level of filter loading, breakthrough, or bypass. In addition, the BPCS provides automatic control of the PVVS vent header vacuum at -12 in. w.c. by modulating the fast acting PVVS bleed valve (PV-4191) and slower acting variable frequency drive fan speed, thereby supporting a PVVS credited safety function. Further, the BPCS provides automatic switching of control to the redundant PVVS components or trains when a failure is detected in the operating equipment. For example, by design, the PVVS treatment/filtration units are interlocked such that failure of the operating train (as indicated by high or low dP across one of the filters or high exhaust radiation level) will isolate the operating unit and start the standby unit. The PVVS exhaust fans are also interlocked such that failure of one fan will start the standby fan, and stop and isolate the operating fan. The standby fan outlet isolation damper is gradually opened as the fan is started and slowly ramped up in speed. Automatic dampers on the outlet of each fan are suitably designed to close when their associated fan is not operating to prevent backflow through the idle fan. Although these control functions are not SS, they appropriately support the SS functions of the PVVS system.

The BPCS design also provides for monitoring and display of operating parameters and non-SS alarms for the ADS, including the backup ADS air storage tank, backup ADS air header, and Plant Air to ADS header pressures, to support operator monitoring and response to abnormal ADS operations. As discussed previously, the BPCS also controls starting and stopping of the backup ADS (non-safety) air compressor. With the exception of those instruments that only provide local indication, all ADS parameters and alarms are first communicated to the SIS before being sent to the BPCS for indication, non-safety alarms, and non-safety backup compressor control.

Safety Instrumented System

The Independent Oversight team reviewed the U.S. Nuclear Regulatory Commission (NRC)-approved Topical Report 7286-545-1-A, Rev. 4, for the SIS computer system (Tricon V10), which was prepared for commercial nuclear power plant applications. The team determined that this comprehensive report also applies to the logic solver being used at SWPF, and accepted its conclusions without further analysis. The NRC report concluded that (on the basis of the NRC staff review documented in their Safety Evaluation Report) the Tricon V10 platform is acceptable for use in the development, installation, and operation of safety-related systems in nuclear power plants, pending acceptable resolution of the generic open items identified in their report. An identified generic open item that applies to the use of the SIS logic solver in SWPF is the NRC finding that the Tricon V10 system did not fully meet the requirements of Electric Power Research Institute Technical Report-107330 for seismic requirements. As a result of this generic open item, the NRC requires licensees to confirm that their site-specific seismic conditions are bounded by the seismic testing performed for the Tricon V10 SIS logic solver. Parsons has properly included this requirement in their supplier's contract. The contractor, Invensys, is performing shake table testing using SWPF-specific seismic input to adequately address the NRC generic open item. Parsons plans to review the Invensys test report results for adequacy once submitted.

The team reviewed the procurement specifications for the highly reliable, fault tolerant SIS logic solver (Tricon V10) and found that PC-3 seismic qualification is appropriately required for the SIS logic solver. PC-1 seismic qualification is suitably required for the SS annunciator panel and maintenance interface. The specifications also require that the annunciator panel and maintenance interface be evaluated for any negative II/I interactions and that any negative interactions be mitigated. The specifications require that no single component failure in the SIS logic solver shall prevent it from fulfilling its function when action is required, and that no single component failure shall initiate unnecessary system actions where implementation does not conflict with the first criterion.

The SIS logic solver performs the input logic processing for safety instrumented functions (SS interlocks) as well as identified SS control room alarms. The SIS design incorporates a SIL-3 capable logic solver that was conservatively selected for its high level of functional reliability. That design, in concert with the field elements and transmitters that provide input to the logic solver (most of which are rated for use in SIL-2 systems), ensures that SS alarm conditions will be reliably indicated on the SS annunciator panel and that SS interlocks will be appropriately initiated.

To maximize the reliability of SS alarms and interlocks, the PIT and PDIT design includes programming to produce an output signal out-of-range low upon internal detection of a failure. To use this feature, the transmitter input signals are checked in the SIS and "tagged out of range" when the input signal is outside the expected 4 to 20 milliamp (mA) input range. When this condition exists for an SS alarm input, the associated alarm light box is alarmed, and the individual transmitter "out of range" alarm is sent to the BPCS for display.

4.5 Commercial Grade Dedication

The Independent Oversight team reviewed the design, procurement specifications, and associated documentation for the SS and defense-in-depth systems and components that support the operation of the ADS and PVVS. The required system and component design functions and capabilities were determined through review of the DSA, Basis of Design documents, draft system descriptions, flow capacity calculations, alarm and setpoint schedules, P&IDs, purchase requisitions, CGDPs, seismic qualification testing reports, and communication with Parsons' engineers and managers. Overall, the reviewed design and procurement documents demonstrated that Parsons understood and appropriately specified design features and capabilities of systems and components, implemented the required design and procurement processes, and procured components that ensure an appropriate level of safety.

Because the majority of the reviewed ADS and PVVS components are being procured as commercial grade items (CGIs), they must be found acceptable for use in SS service using procedure PP-EN-5023, *Replacement Item Evaluation/Commercial Grade Item Dedication*. The Independent Oversight team reviewed the CGD procedure and the CGDPs associated with each PVVS and ADS CGI. Each CGDP was suitably prepared by the responsible engineer; reviewed by an appropriate subject matter expert and organizational representatives of nuclear safety, quality assurance, and quality control; and approved by the engineering/design manager. Independent Oversight verified that nearly all of the CGDPs appropriately described the CGI, the function of the CGI host, the results of the failure modes and effects analysis, the harsh environment and/or NPH for which the CGI must continue to function, the CGI functional classification and basis, the critical characteristics, the acceptance criteria and required method of verification, and the organization responsible for that verification. The Independent Oversight team also determined that the Parsons CGI procurement process and documentation met the requirements of ASME NQA-1-2004, *Quality Assurance Requirements for Nuclear Facility Application*, and that the reviewed CGDPs, purchase requisitions, RICPs, and seismic qualification testing reports were sufficient to ensure the reviewed components would have the appropriate critical characteristics necessary to perform their required safety function.

Independent Oversight noted that the CGDPs for several SS instruments (e.g., PDITs in PVVS and PITs in ADS) require SS/PC-1 active function qualification for providing SS analog signals to the SIS and SS alarm panel; however, the applicable CGDPs (for example, J-CGD-J-00033) do not address the basis for seismic qualification associated with this active function. Specifically, J-CGD-J-00033 states in part that "The SS function of the FITs, LITs, and PDITs is to provide an alarm signal (SS PC-1 active function) to the SS Alarm Panel in the Control Room…" However, Section 10 of that CGD document incorrectly states "NOTE 1: SEISMIC QUALIFICATION BASIS: These FITs, LITs and PDITs perform an SS/PC-1 passive function only for confinement/pressure boundary. As part of the design, Engineering has confirmed that these passive components (material and dimensions) will meet the requisite seismic demand." Section 10 does not address the basis for the adequacy of the seismic qualification associated with the SS/PC-1 active function of these devices. (See Appendix A, **ENH-12**.)

4.6 Configuration Management

Independent Oversight reviewed and evaluated the project plans and procedures that establish and implement the configuration management program and are intended to ensure that the final design adequately implements the safety basis hazard controls identified in the DSA.

A controlled list of high-level documents establishes the technical baseline of the project with the stated goal that the final design shall be consistent with the technical baseline. Technical baseline documents include P-DB-J-00002, *SWPF Design Criteria Database*; P-DB-J-00003, *SWPF Process Basis of Design*; and P-DB-J-00004, *SWPF Balance of Plant Basis of Design*, as well as drawings such as P&IDs and electrical single line drawings. All of the technical baseline documents are approved by DOE (design authority) and changed through the configuration management process. With some exceptions noted in this report, the technical baseline documents reviewed by the Independent Oversight team were found to contain sufficient detail and to be consistent with the project design basis.

P-CDM-J-00001, *Configuration Management Plan*, defines the objectives of the configuration management process for the SWPF project, describes the roles and responsibilities, and generally establishes a program that will satisfy the guidance in DOE-STD-1073, *Configuration Management*. The primary responsibilities for the project design belong to Parsons as the design agent and to DOE as the design authority. The plan is implemented by a set of procedures governing design control, document control, work control, interface management, and computer software management; the plan applies to all work at SWPF. The plan indicates the design basis is documented in the Process Basis of Design and BOP Basis of Design documents, which are approved by DOE and changed through the DCN process. Change control is implemented through a set of procedures, including a set of quality assurance procedures and processes for computer software. Documents are under design control when a numbered revision is issued.

PP-EN-5001, *Design Control*, establishes a controlled list of documents as the project technical baseline, all of which are approved by DOE and changed through the DCN process. This high-level document adequately addresses the important elements of design control, such as technical interfaces, design input and output, design process, design documents, design document review, design verification, design output documents, design change control, drawings and datasheets, specifications, and calculations. The design control activities are conducted using specific procedures. The design process requires that the final design shall specify the required tests and inspections, including critical characteristics to be verified. Design document review addresses both intradisciplinary checks and interdisciplinary review, which includes DOE participation. Design document review also addresses procurement pre-planning and functional classification methodology necessary to support selection and specification of appropriate requirements for purchases. Design change control is by DCN or field change notice.

PP-EN-5012, *Design Change Notices*, defines a suitable process to request, prepare, process, approve, and post DCNs, and applies to drawings, datasheets, specifications, design documents (Basis of Design), design output documents (databases, etc.), and system descriptions. Preparation of a DCN includes preparation of marked-up documents with "before" and "after" (cloud on drawings) to show changed areas. After an intradisciplinary check, Nuclear Safety reviews the DCN to determine whether the proposed change will invalidate the HAZOP study for high or moderate consequence events or require a new study. Nuclear Safety also identifies whether a safety basis change notice (change affects the safety basis) is required. Review and approval includes DOE approval for DCNs requiring a safety basis change notice or for changes to documents requiring design authority approval (deliverables). DCNs are posted against the affected documents and tracked until all of the affected documents have been revised.

The processing of a DCN involves two reviews by Nuclear Safety. A preliminary Nuclear Safety review is specified to be performed against the HAZOP studies, which were completed from 2005 – 2008. This is a good practice to utilize in order to avoid processing DCNs that may be rejected if the potential for impacting the HAZOP studies is not recognized. The use of information in the PDSA, the approved safety basis, to support the review is not mentioned. A subsequent Nuclear Safety review is required to assess whether a potential impact from the change may necessitate a safety basis change notice. This review is conducted against the safety basis. Notably, only two people in the Nuclear Safety organization review design changes for impact on the safety basis, and both are fully cognizant of the documented safety basis. During presentations, Parsons indicated that the SWPF safety basis consists of the PDSA and the approved safety basis change notices, but the procedure does not define what constitutes the SWPF safety basis. (See Section 7, **OFI-04**.)

The team reviewed a number of DCNs to verify that the SWPF design control process had been adequately implemented and that the DCNs were effective for managing design inputs as they related to nuclear safety. The SWPF reviews were completed by knowledgeable project engineering staff including the cognizant system engineer, nuclear safety manager, design/build manager, and engineering and design manager. Each DCN was screened for applicability to the HAZOP studies, and confirmed that an intradisciplinary check and interdisciplinary review had been performed as required. Considering the number and depth of the completed HAZOP studies and the number of resulting open items, these checks and reviews are important process elements. The Independent Oversight team observed that adequate controls for design had been established and that the reviews were providing an appropriate level of safety assurance for the SWPF project technical baseline.

PP-CS-7224, *Construction Field Change Notices*, applies to changes required during construction of GS SSCs. PP-CS-7224 is generally used for a single document unless the same change is made in several documents. Steps in the procedure appropriately state that the procedure is not to be used for SS SSCs as addressed in Table 4.4-1 of the PDSA (including safety basis change notices) or changes to the technical baseline documents. Since the PDSA is not being updated (that is, the safety basis includes the PDSA and approved safety basis change notices), Table 4.4-1 of the PDSA may not include all of the current SS SSCs, and documents other than the PDSA must be reviewed to determine whether a field change notice is acceptable. (See Section 7, **OFI-04**.)

5.0 CONCLUSIONS

The Independent Oversight review of the SWPF focused primarily on the safety functions and design bases of two SS systems (PVVS and ADS), their interfacing and supporting systems, and the process for establishing and maintaining the designs and their associated documentation. The Independent Oversight team found that the current draft DSA contains a number of changes from the existing approved PDSA, and reflects the evolution of the facility's design, refinements in the definition of the SS SSCs' safety functions and performance requirements, and other updates and improvements to the facility's safety bases. For the most part, configuration management processes have been effective in maintaining consistency between the safety basis and the system design. In addition, the integration of engineering and nuclear safety in the procurement and CGD processes has been effective in ensuring the appropriate characteristics, inspections, and tests are specified for the components in the sampled systems. Overall, the quality of the technical analyses and design products demonstrated high levels of technical knowledge within Parsons' management and staff. Within the sample, the approach to the design demonstrates an appropriate regard for establishing conservative designs to ensure facility safety.

The calculations supporting the safety analyses, some of which were of substantial length and complexity, were found to be generally clear, well organized, and conservative. The calculations used standard accepted industry approaches, physical parameter references, and calculational methods, and supporting testing performed by Parsons was thorough and accurate. A noteworthy strength was the effective architecture, which presented a systematic progression of the calculations steps along with descriptions of the context for each section. The assumptions and bounding conditions were conservatively applied to ensure an adequate margin of safety was embedded into the overall design strategy. Although some non-conservative aspects were identified in the analyses, numerous offsetting conservatisms were also present, which, when fully accounted for in revised calculations, are expected to result in the continued validity of the analyses and the required safety functions. Nevertheless, Independent Oversight identified some opportunities to clarify the assumptions for the calculations.

Generally, the designs of both systems were found to be robust and capable of meeting the established performance requirements for the systems' intended safety functions. The system arrangements and features were largely appropriate and conservative, and system components and hardware were typically well suited for their intended applications and conservative in design. The procurement and CGD process documents for the systems implemented the specified design attributes. Several notable features were incorporated into the designs to provide additional redundancy and performance. Some opportunities to improve the system arrangements were noted, and the Independent Oversight team raised questions about the abilities of several components to provide the required performance. In all such cases, Parsons had already initiated actions, immediately took actions, or committed to actions to correct them or appropriately account for them. Overall, Parsons has taken a consistent, proactive, and technically disciplined approach to develop the safety basis and engineered hazard controls for the facility.

6.0 GOOD PRACTICES

Independent Oversight identified three good practices that contribute positively to achieving a safe, reliable design.

- Parsons has established a testing facility and organization in which conceptual prototype testing is performed to demonstrate the viability of new or untried technologies intended to be incorporated into the facility safety analyses and designs. This facility and organization are also frequently used to validate analysis assumptions and resolve technical questions arising in the design processes.
- Parsons conservatively selected a qualified, SIL-3 capable SIS logic solver as the backbone for a highly reliable DCS to ensure that SS alarms are reliably received in the control room and SS interlocks operate when required.
- The strong and effective integration and involvement of the Engineering and Nuclear Safety organizations in developing and approving hazard and safety analyses, and in the design, procurement, and CGD processes is a notable strength that has contributed to the quality and consistency of engineering documentation.

7.0 OPPORTUNITIES FOR IMPROVEMENT

During the review, Independent Oversight identified a number of issues that present opportunities for improvement. These issues are characterized in accordance with the *Independent Oversight Program Appraisal Process Protocols* and are annotated in the report (for example, OFI-01). OFIs are suggestions offered by the Independent Oversight review team that may assist line management in identifying options and potential solutions to various issues identified during the conduct of the review. OFIs are not mandatory, and they do not require formal resolution by management through a corrective action process.

OFI-01: Consider revising the draft DSA to explicitly address the safety significance of operator actions to restore ventilation or purge air to the affected process vessels and to maintain the vessel atmosphere below CLFL after 4 days following a seismic event, and resolving whether the operator actions should be designated as an SAC with an evaluation of the SAC in DSA, Chapter 4, if appropriate.

OFI-02: When updating calculations S-CLC-J-00042, *Process Vessel Air Purge Flowrates*, and M-CLC-J-00179, *Minimum Required Capacity for Process Building Air Purge System*, consider addressing the non-conservatisms and other weaknesses identified in Section 4.3.1 of this report.

OFI-03: Consider revising existing calculations (e.g., Calculation M-CLC-J-00134, *Process Vessel Ventilation System Sizing Calculation*) to address the credited process vessel and equipment exhaust flow paths for the ADS function, considering all credible event scenarios, and revise the DSA accordingly.

OFI-04: Consider revising the applicable procedure to identify the set of documents that constitute the foundation for the nuclear safety basis reviews of DCNs, and update the list of SS SSCs (to the most current established SS SSCs) used in the review of field change notices.

8.0 FOLLOW-UP ITEMS

Independent Oversight will continue to follow the development of the DSA, the implementation of the flammable gas control strategy, and the incorporation of the results of the fire hazards analysis into the safety basis of the facility.

Appendix A
Potential Design and Analysis Enhancements

During the review, the Independent Oversight team also identified a number of minor discrepancies or potential shortcomings that are less significant, which may be corrected in the normal design process. They represent potential enhancements to the design documents or related output documents. Potential enhancements are numbered to correspond to the annotations in the body of the report.

ENH-01: Consider updating calculation S-CLC-J-00033 to clarify assumptions 4 and 24.

ENH-02: Evaluate the need to update the HVAC system description to more accurately reflect the current system design, particularly the credited safety functions.

ENH-03: Consider the need to revise the calibrated pressure span for the PVVS ventilation header vacuum indicator/transmitter PDIT-4191 to avoid over-ranging.

ENH-04: Consider revising the nomenclature describing the alarm functions and the labeling of the Control Room annunciator tile associated with PDIT-4191 for consistency.

ENH-05: Consider establishing provisions to ensure that ½ inch ball valve V0430 is maintained open to protect the SS/PC-1 active safety function capability of PVVS PDIT-4191.

ENH-06: Consider increasing the calibrated range of the PVVS HEPA filter PDITs to encompass the rated performance of the HEPA filters (typically up to 10 inches w.c. dP and beyond), and enhance the operator's ability to analyze filter integrity issues beyond the SS high-high alarm setpoint.

ENH-07: Consider revising the BOP Basis of Design description of the safety functions of the PVVS HEPA filter dP alarms to be consistent with the DSA.

ENH-08: Consider revising the BOP document description of PVVS and ADS PIT SIL rating requirements to be consistent with the safety functions described in the DSA.

ENH-09: Update the specification for the Plant Air System (Specification Section Number 11841) to require that the compressor after-filter have a performance rating of 1 micron, to be consistent with the performance requirement for the ADS backup air compressor after-filter (Specification Section 11842).

ENH-10: Consider revising the backup ADS PIT-7314 calibrated pressure span to avoid over-ranging.

ENH-11: Consider revising the BPCS backup ADS PIT-7314 high pressure alarm setpoint to avoid nuisance alarms.

ENH-12: Consider the need to explicitly address in the CGDPs the seismic qualification basis for the active SS/PC-1 functions of the PVVS PDITs and ADS PITs that support the SS PVVS and ADS parameter monitoring functions.

Appendix B
Supplemental Information

Dates of Review

Onsite Review:	February 12-14, 2013
In-Office Review:	February 18 – March 29, 2013

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Mary Miller
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Appendix C
Documents Reviewed

Documents Reviewed

- 00668-SDC-001, Seismic Qualification Test Report Q0003.3 for Electrical Components, Rev. 0
- 00-700-17240, *Air Purge Flow Requirements for Backup Air Receiver Tanks (Tk-505 and Tk-506)*, 12/15/10.
- 00-700-21078, Memorandum, Subject: Table of Components Related to TSR LCOs, 10/12
- 00809-0100-4801, Rosemount Model 3051S HART Reference Manual, Rev AA
- 00903, Requisition for PDITs, Rev. 4
- 00903-SDC-024, Rosemount PDIT-4169 Specifications, Rev. 0
- 00903-SDC-025, Rosemount PDIT-4191 Specifications, Rev. 0
- 00903-SDC-049, Rosemount PDIT-4167 Specifications, Rev. 1
- 00903-SDC-050, Rosemount PDIT-4168 Specifications, Rev. 0
- 00903-SDC-053, Rosemount PDIT-4183 Specifications, Rev. 0
- 00906, Requisition for FEs, Rev. 5
- 00907, Requisition for FICVs, Rev. 3
- 00907-SDC-001, Brooks 1358 FICV-7382 Installation & Operation Manual, Rev. 0
- 00907-SDC-002, FICV-7370 Data Sheet, Rev. 0
- 00907-SDC-003, FICV-7370 & FICV-7382 Flow Controller Data Sheet , Rev. 0
- 00907-SDC-006, FICV-7382 Data Sheet, Rev. 0
- 00907-SDC-008, FICV-7382 Drawing, Rev. 0
- 00907-SDC-011, FICV-7370 Drawing, Rev. 1
- 00907-SDC-015, FICV-7382 Pressure Test Certifications, Rev. 2
- 00907-SDC-016, FICV-7370 Pressure Test Certifications, Rev. 2
- 00922, Requisition for PIs, Rev. 4
- 00922-SDC-001, PI-7318 Technical Specs, Rev. 1
- 00922-SDC-013, PI-7318 Data Sheet, Rev. 0
- 00924, Requisition for PSIVs, Rev. 10
- 00924-SDC-023, PSV-7315 Drawing, Rev. 4
- 00924-SDC-050, PSV-7315 Sizing Data Sheet, Rev. 3
- 00924-SDC-081, PSV-7307 Sizing Data Sheet, Rev. 0
- 00924-SDC-105, PSV-7307 Drawing, Rev. 0
- 00925, Requisition for PITs, Rev. 3
- 00925-SDC-004, Rosemount 3051S Technical Specifications, Rev. 0
- 00925-SDC-007, PIT-7311 Technical Specs, Rev. 0
- 00925-SDC-008, PIT-7314 Technical Specs, Rev. 0
- 00925-SDC-047, PIT-7323 Technical Specs, Rev. 1
- 00928, Requisition for TIs, Rev. 5
- 00972, Requisition for Butterfly Valves, Rev. 9
- 01029-SDC-001, Seismic Qualification Test Report Q0003.4 for Kepner Check Valves, Ashcroft Pressure Gage, ABZ Valve Butterfly Valve, and Flowserve Valves, Rev. 0
- 01821-SDC-002, Seismic Qualification Test Report Q0003.2 for Swing & Spring Check Valves, Rev. 0
- 05116, Requisition for Instrument Tubing, Rev. 2
- 05488, Requisition for Tube Fittings, Rev. 0

- 05623, Requisition for Swagelok BPO, Rev. 5
- 05629, Requisition for Instrument Tubing, Rev. 1
- 05940, Requisition for Instrument Tubing BPO, Rev. 3
- 06169, Requisition for Swagelok, Rev. 0
- 06200, Requisition for Swagelok, Rev. 0
- 30200, Requisition for High Pressure Back-up Air Purge Receivers, Rev. 4
- 30341-SDC-024, Tricon v10 Nuclear Qualified Equipment List, Rev. 0
- 30341-SDC-025, Invensys Triconex Topical Report (SER) Submittal, Rev. 0
- 51001, Requisition for Pipe and Fittings, Rev. 15
- 5100201, Requisition for SS Pipe and Fittings, Rev. 4
- 5100202, Requisition for SS Pipe and Fittings, Rev. 35
- 51011, Purchase Requisition Change Form, Rev. 17
- 51012, Requisition for Bolting and Gaskets, Rev. 10
- 51082, Requisition for Check Valves, Rev. 12
- 51082-SDC-005, V-8702 Check Valve Installation & Maintenance Manual, Rev. 0
- 51082-SDC-008, V-8702 Check Valve Drawing, Rev. 1
- 51086, Requisition for Alloy/CS Ball Valves, Rev. 11
- 51087, Requisition for Butterfly Valves, Rev. 7
- 51088, Requisition for Plug Valves, Rev. 9
- 51093, Requisition for Gate Valves, Rev. 14
- 51096, Requisition for Kepner Check Valves, Rev. 5
- 5310, Requisition for Tube Fittings, Rev. 3
- 60108-SDC-002, Seismic Qualification Test Report Q0003.1 for Spring Check and Ball Valves, Rev. 0
- Bulletin 71.1:1301, Fisher 1301F, High Pressure Regulator Description
- CAT EMCP 4.3 Diesel Generator Controller Documentation
- CM-CLC-J-00134, *Process Vessel Ventilation System Sizing Calculation*, Rev 0, 5/28/08.
- DCN-0465, Revise DCD Items 266 and 670, Rev. 0, 4/09
- DCN-0480, Design Criteria Database Changes for Preliminary Documented Safety Analysis, Rev. 0, 12/08
- DCN-0571, Strip Effluent Coalescer Feed Pumps, Rev. 0, 6/10
- DCN-0736, Turbidity Meter Additions and V-Cone Flow Meter Changes, Rev. 0, 5/10
- DCN-0777, Rev. 0, Electrical Classification Changes
- DCN-0824, Rev. 0, Revise Balance of Plant Basis Of Design
- DCN-0928, Rev. 0, Pressure Protection (AFF dimpled jackets, etc.) and Misc.
- DCN-0987, Oxalic Acid to Nitric Acid, Rev. 0, 9/11
- DCN-0990, 13.8 kV Manual Disconnect Switches for Electrical Isolation of SWPF Following an Earthquake, Rev. 0, 11/11
- DCN-1000, Delete WTE Flow Meters, SS Temperature Additions, and Misc. Cleanup, Rev. 0, 9/11
- DCN-1108, PMV Upgrade to PC-3 and Misc. P&ID Changes, Rev. 0, 4/12
- DCN-1138, RCN 00924 Relief Valve Datasheet Revisions (Group 3) Plus Misc. PSV Changes, Rev. 0, 11/12
- DCN-1183, DCD/BOD Teflon Requirements Update & Misc. Cleanup, Rev. 0, 8/12
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