TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

None

3.0 SAFETY PROGRAM

The three elements of the safety program defined in 10 CFR 70.62(a) (CFR, 2008d) are addressed below. The subject matter discussed below is identical to the National Enrichment Facility (NEF) SAR (LES, 2005). The NRC staff previously concluded (NRC, 2005) that similar subject matter in the NEF SAR (LES, 2005) relative to the general guidelines of the safety program meets the requirements of 10 CFR 70.62(a)(1) through (3) to establish and maintain a safety program that includes process safety information, integrated safety analysis and management measures, and appropriate safety program records (LES, 2005). The staff also concluded that the program to establish and maintain records of IROFS failures that will be retrievable for NRC inspection is appropriate.

3.0.1 Process Safety Information

A. AES has compiled and maintains up-to-date documentation of process safety information. Written process-safety information is used in updating the ISA and in identifying and understanding the hazards associated with the processes. The compilation of written process-safety information includes information pertaining to:

1. The hazards of all materials used or produced in the process, which includes information on chemical and physical properties such as are included on Material Safety Data Sheets meeting the requirements of 29 CFR 1910.1200(g) (CFR, 2008e).

2. Technology of the process which includes block flow diagrams or simplified process flow diagrams, a brief outline of the process chemistry, safe upper and lower limits for controlled parameters (e.g., temperature, pressure, flow, and concentration), and evaluation of the health and safety consequences of process deviations.

3. Equipment used in the process including general information on topics such as the materials of construction, piping and instrumentation diagrams (P&IDs), ventilation, design codes and standards employed, material and energy balances, IROFS (e.g., interlocks, detection, or suppression systems), electrical classification, and relief system design and design basis.

The process-safety information described above is maintained up-to-date by the configuration management program described in Section 11.1, Configuration Management.

B. AES has developed procedures and criteria for changing the ISA. This includes implementation of a facility change mechanism that meets the requirements of 10 CFR 70.72 (CFR, 2008f). The development and implementation of procedures is described in Section 11.4, Procedures Development and Implementation.

C. AES uses personnel with the appropriate experience and expertise in engineering and process operations to maintain the ISA. The ISA Team for the various processes consists of individuals who are knowledgeable in the ISA method(s) and the operation, hazards, and safety design criteria of the particular process. Training and qualifications of individuals responsible for maintaining the ISA are described in Section 11.3, Training and Qualifications, Section 2.2, Key Management Positions, and Section 3.2, Integrated Safety Analysis Team.

3.0.2 Integrated Safety Analysis

A. AES has conducted an ISA for each process, such that it identifies (i) radiological hazards, (ii) chemical hazards that could increase radiological risk, (iii) facility hazards that could increase radiological risk, (iv) potential accident sequences, (v) consequences and likelihood of each accident sequence and (vi) IROFS and credited attributes of safe-by-design components, including the assumptions and conditions under which they support compliance with the performance requirements of 10 CFR 70.61 (CFR, 2008c).

A synopsis of the results of the ISA, including the information specified in 10 CFR 70.65(b) (CFR, 2008a), is provided in the Eagle Rock Enrichment Facility (EREF) Integrated Safety Analysis Summary.

B. AES has implemented programs to maintain the ISA and supporting documentation so that it is accurate and up-to-date. Changes to the ISA Summary are submitted to the NRC, in accordance with 10 CFR 70.72(d)(1) and (3) (CFR, 2008f). The ISA update process accounts for any changes made to the facility or its processes. This update will also verify that initiating event frequencies and reliability values of IROFS assumed in the ISA remain valid. Any changes required to the ISA as a result of the update process will be included in a revision to the ISA. Management policies, organizational responsibilities, revision time frame, and procedures to perform and approve revisions to the ISA are outlined in Chapter 11.0, Management Measures. Evaluation of any facility changes or changes in the process safety information that may alter the parameters of an accident sequence is by the ISA method(s) as described in the ISA Summary Document. For any revisions to the ISA, personnel having qualifications similar to those of ISA team members who conducted the original ISA are used.

C. Personnel used to update and maintain the ISA and ISA Summary are trained in the ISA method(s) and are suitably qualified. Training and Qualification of personnel used to update or maintain the ISA are described in Section 11.3, Training and Qualifications.

D. Proposed changes to the facility or its operations are evaluated by the ISA method(s) described in the ISA Summary. New or additional IROFS and appropriate management measures are designated as required. The adequacy of existing IROFS and associated management measures are promptly evaluated to determine if they are impacted by changes to the facility and/or its processes. If a proposed change results in a new type of accident sequence or increases the consequences or likelihood of a previously analyzed accident sequence within the context of 10 CFR 70.61 (CFR, 2008c), the adequacy of existing IROFS and associated management measures are promptly evaluated and the necessary changes are made, if required.

E. Unacceptable performance deficiencies associated with IROFS are addressed that are identified through updates to the ISA.

F. Written procedures are maintained on site. Section 11.4, Procedures Development and Implementation, discusses the procedures program.

G. All IROFS are maintained so that they are available and reliable when needed.

3.0.3 Management Measures

Management measures are functions applied to IROFS and any activities that may affect the function of IROFS. Management measures ensure compliance with the performance requirements assumed in the ISA documentation. The measures are applied to particular structures, systems, equipment, components, and activities of personnel, and may be graded commensurate with the reduction of the risk attributable to that IROFS. The management measures shall ensure that these structures, systems, equipment, components, and activities of personnel within the identified IROFS boundary are designed, implemented, and maintained, as necessary, to ensure they are available and reliable to perform their function when needed, to comply with the performance requirements assumed in the ISA documentation.

The following types of management measures are required by the 10 CFR 70.4 (CFR, 2008g) definitions of management measures. The description for each management measure reflects the general requirements applicable to each IROFS. Any management measure that deviates from the general requirements described in this section, which are consistent with the performance requirements assumed in the ISA documentation, are discussed in the ISA Summary.

Configuration Management

The configuration management program is required by 10 CFR 70.72 (CFR, 2008f) and establishes a system to evaluate, implement, and track each change to the site, structures, processes, systems, equipment, components, computer programs, and activities of personnel. Configuration management of IROFS and any activities that may affect the function of IROFS is applied to all items identified within the scope of the IROFS boundary. Any change to structures, systems, equipment, components, and activities of personnel within the identified IROFS boundary must be evaluated before the change is implemented. If the change requires an amendment to the License, Nuclear Regulatory Commission approval is required prior to implementation.

Maintenance

Maintenance of IROFS encompasses planned surveillance testing and preventative maintenance, as well as unplanned corrective maintenance. Implementation of approved configuration management changes to hardware is also generally performed as a planned maintenance function.

Planned surveillance testing (e.g., functional/performance testing, instrument calibrations) monitors the integrity and capability of IROFS, and any items that may affect the function of IROFS, to ensure they are available and reliable to perform their function when needed, to comply with the performance requirements assumed in the ISA documentation. All necessary periodic surveillance testing is generally performed on an annual frequency (any exceptions credited within the ISA are discussed in the EREF ISA Summary).

Planned preventative maintenance (PM) includes periodic refurbishment, partial or complete overhaul, or replacement of IROFS, as necessary, to ensure the continued availability and reliability of the safety function assumed in the ISA documentation. In determining the frequency of any PM, consideration is given to appropriately balancing the objective of preventing failures through maintenance, against the objective of minimizing unavailability of IROFS because of PM. In addition, feedback from PM and corrective maintenance and the results of incident investigations and identified root causes are used, as appropriate, to modify the frequency or scope of PM.

Planned maintenance on IROFS that do not have redundant functions available will provide for compensatory measures to be put into place to ensure that the IROFS function is performed until it is put back into service.

Corrective maintenance involves repair or replacement of equipment that has unexpectedly degraded or failed. Corrective maintenance restores the equipment to acceptable performance through a planned, systematic, controlled, and documented approach for the repair and replacement activities.

Following any maintenance on IROFS, and before returning an IROFS to operational status, functional testing of the IROFS, as necessary, is performed to ensure the IROFS is capable of performing its intended safety function.

Training and Qualifications

Activities involving IROFS require that personnel involved at each level (from design through and including any assumed process implementation steps or actions) have and maintain the appropriate training and qualifications. Employees are provided with formal training to establish the knowledge foundation and on-the-job training to develop work performance skills. For process implemented steps or actions, a needs/job analysis is performed and tasks are identified to ensure that appropriate training is provided to personnel working on tasks related to IROFS. Minimum training requirements are developed for those positions whose activities are relied on for safety. Initial identification of job-specific training requirements is based on experience. Entry-level criteria (e.g., education, technical background, and/or experience) for these positions are contained in position descriptions.

Qualification is indicated by successful completion of prescribed training, demonstration of the ability to perform assigned tasks, and where required by regulation, maintaining a current and valid license or certification.

Continuing training is provided, as required, to maintain proficiency in specific knowledge and skill related activities. For all IROFS involving process implemented steps or actions, annual refresher training or requalification is required (any exceptions credited within the ISA are discussed in the EREF ISA Summary).

Procedures

All activities involving IROFS and any items that may affect the function of IROFS are conducted in accordance with approved procedures. Each of the other IROFS management measures (e.g., configuration management, maintenance, training) is implemented via approved procedures. These procedures are intended to provide a pre-planned method of conducting the activity in order to eliminate errors due to on-the-spot analysis and judgments.

All procedures are sufficiently detailed that qualified individuals can perform the required functions without direct supervision. However, written procedures cannot address all contingencies and operating conditions. Therefore, they contain a degree of flexibility appropriate to the activities being performed. Procedural guidance exists to identify the manner in which procedures are to be implemented. For example, routine procedural actions may not require the procedure to be present during implementation of the actions, while complex jobs, or checking with numerous sequences may require valve alignment checks, approved operator aids, or in-hand procedures that are referenced directly when the job is conducted.

To support the requirement to minimize challenges to IROFS, specific procedures for abnormal events are also provided. These procedures are based on a sequence of observations and actions to prevent or mitigate the consequences of an abnormal situation.

Audits and Assessments

Audits are focused on verifying compliance with regulatory and procedural requirements and licensing commitments. Assessments are focused on effectiveness of activities and ensuring that IROFS are reliable and are available to perform their intended safety functions as documented in the ISA. The frequency of audits and assessments is based upon the status and safety importance of the activities being performed and upon work history. However, at a minimum, all activities associated with maintaining IROFS will generally be audited or assessed on an annual basis (any exceptions credited within the ISA are discussed in the EREF ISA Summary).

Incident Investigations

Incident investigations are conducted within the Corrective Action Program (CAP). Incidents associated with IROFS and any items that may affect the function of IROFS encompass a range of items, including (a) processes that behave in unexpected ways, (b) procedural activities not performed in accordance with the approved procedure, (c) discovered deficiency, degradation, or non-conformance with an IROFS, or any items that may affect the function of IROFS. Additionally, audit and assessment results are tracked in the Corrective Action Program.

Feedback from the results of incident investigations and identified root causes are used, as appropriate, to modify management measures to provide continued assurance that the reliability and availability of IROFS remain consistent with the performance requirements assumed in the ISA documentation.

Records Management

All records associated with IROFS, and any items that may affect the function of IROFS, shall be managed in a controlled and systematic manner in order to provide identifiable and retrievable documentation. Applicable design specifications, procurement documents, or other documents specify the QA records to be generated by, supplied to, or held, in accordance with approved procedures are included.

Other Quality Assurance Elements

Other quality assurance elements associated with IROFS or any items that may affect the function of IROFS that are required to ensure the IROFS are available and reliable to perform the function when needed to comply with the performance requirements assumed in the ISA documentation, are discussed in the EREF ISA Summary.

3.1 INTEGRATED SAFETY ANALYSIS METHODS

This section outlines the approach utilized for performing the Integrated Safety Analysis (ISA) of the process accident sequences. The approach used for performing the ISA is consistent with Example Procedure for Accident Sequence Evaluation, Appendix A to Chapter 3 of NUREG-1520 (NRC, 2002a). This approach employs a semi-quantitative risk index method for categorizing accident sequences in terms of their likelihood of occurrence and their consequences of concern. The risk index method framework identifies which accident sequences have consequences that could exceed the performance requirements of 10 CFR 70.61 (CFR, 2008c) and, therefore, require designation of Items Relied on for Safety (IROFS) and supporting management measures. Descriptions of these general types of higher consequence accident sequences are reported in the ISA Summary.

The ISA is a systematic analysis to identify plant and external hazards and the potential for initiating accident sequences, the potential accident sequences, the likelihood and consequences, and the IROFS.

The ISA uses a hazard analysis method to identify the hazards which are relevant for each system or facility. The ISA Team reviewed the hazard identified for the "credible worst-case" consequences. All credible high or intermediate severity consequence accident scenarios were assigned accident sequence identifiers, accident sequence descriptions, and a risk index determination was made.

The risk index method is regarded as a screening method, not as a definitive method of proving the adequacy or inadequacy of the IROFS for any particular accident.

The tabular accident summary resulting from the ISA identifies, for each sequence, which engineered or administrative IROFS must fail to allow the occurrence of consequences that exceed the levels identified in 10 CFR 70.61 (CFR, 2008c).

For this license application, two ISA Teams were formed. This was necessary because the sensitive nature of some of the facility design information related to the enrichment process required the use of personnel with the appropriate national security clearances. This team performed the ISA on the Cascade System, Dump System, Centrifuge Test System and the Centrifuge Post Mortem System. This ISA Team is referred to as the Classified ISA Team. The Non-Classified Team, referred to in the remainder of this text as the ISA Team, performed the ISA on the remainder of the facility systems and structures. In addition, the (non-classified) ISA Team performed the External Events and Fire Hazard Assessment for the entire facility.

Experienced personnel with familiarity with the gas centrifuge enrichment technology safety analysis were used on the ISA Team. This provides a good peer check of the final ISA results.

A procedure was developed to guide the conduct of the ISA. This procedure was used by both teams. In addition, there were common participants on both teams for the core process systems to further integrate the approaches employed by both teams. These steps were taken to ensure the consistency of the results of the two teams. A non-classified summary of the results of the Classified ISA has been prepared and incorporated into the ISA Summary.

The non-classified ISA Team performed a review of the changes associated with the expansion of the facility from 3.3 million SWU to 6.6 million SWU. Additional accident sequences and events were identified to address the addition of new structures, systems, and components. The new accident sequences and events were not unique or original in concept. They are an application of the previously identified accident sequences and events to the new structures, systems, and components. A classified ISA team review was not required as there were no functional changes to classified systems and components. The non-classified ISA team review

included external events and facility fires for any site-wide impact on structures, systems, and components as well as system integration. No new IROFS were required to cope with the new accident sequences or events. The consequences of the new accident sequences and events were bounded by the original analyses.

3.1.1 Hazard Identification

The hazard and operability (HAZOP) analysis method was used for identifying the hazards for the Uranium Hexafluoride (UF_6) process systems and Technical Support Building systems. This method is consistent with the guidance provided in NUREG-1513 (NRC, 2001a) and NUREG-1520 (NRC, 2002a). The hazards identification process results in identification of physical, radiological or chemical characteristics that have the potential for causing harm to site workers, the public, or to the environment. Hazards are identified through a systematic review process that entails the use of system descriptions, piping and instrumentation diagrams, process flow diagrams, plot plans, topographic maps, utility system drawings, and specifications of major process equipment. In addition, criticality hazards identification were performed for the areas of the facility where fissile material is expected to be present. The criticality safety analyses contain information about the location and geometry of the fissile material and other materials in the process, for both normal and credible abnormal conditions. The ISA input information is included in the ISA documentation and is available to be verified as part of an on-site review.

The hazard identification process documents materials that are:

- Radioactive
- Fissile
- Flammable
- Explosive
- Toxic
- Reactive.

The hazard identification also identifies potentially hazardous process conditions. Most hazards were assessed individually for the potential impact on the discrete components of the process systems. However, hazards from fires (external to the process system) and external events (seismic, severe weather, etc.) were assessed on a facility wide basis.

For the purpose of evaluating the impacts of fire hazards, the ISA team considered the following:

- Postulated the development of a fire occurring in in-situ combustibles from an unidentified ignition source (e.g., electrical shorting, or other source)
- Postulated the development of a fire occurring in transient combustibles from an unidentified ignition source (e.g., electrical shorting, or other source)
- Evaluated the uranic content in the space and its configuration (e.g., UF_6 solid/gas in cylinders, UF_6 gas in piping, UF_6 and/or byproducts bound on chemical traps, Uranyl Fluoride (UO_2F_2) particulate on solid waste or in solution, etc.). The appropriate configuration was considered relative to the likelihood of the target releasing its uranic content as a result of a fire in the area.

In order to assess the potential severity of a given fire and the resulting failures to critical systems, the facility Fire Hazard Analysis was consulted. However, since the design supporting

the license submittal for this facility is not yet at the detailed design stage, detailed in-situ combustible loading and in-situ combustible configuration information is not yet available. Therefore, in order to place reasonable and conservative bounds on the fire scenarios analyzed, the ISA Team estimated in-situ combustible loadings based on information of the in-situ combustible loading for facilities of comparable capacity and configuration.

Further, preliminary layouts of the facility were used to identify where bulk electrical cabling routings would be expected and which areas, based on operations present, might use/store combustible materials in significant quantity. This is in addition to the reviews described in the NEF SAR. Combustible loading in areas where bulk UF_6 storage/handling occurs are expected to be very low.

The Fire Safety Management Program will limit the allowable quantity of transient combustibles in critical plant areas (i.e., uranium areas). Nevertheless, the ISA Team still assumed the presence of moderate quantities of ordinary (Class A) combustibles (e.g., trash, packing materials, maintenance items or packaging, etc.) in excess of anticipated procedural limits. This was not considered a failure of the associated administrative IROFS feature for controlling/ minimizing transient combustible loading in all radiation/uranium areas. Failure of the IROFS is connoted as the presence of extreme or severe quantities of transients (e.g., large piles of combustible solids, bulk quantities of flammable/combustible liquids or gases, etc.). Given the orientation and training that facility employees will receive indicating that these types of fire hazards are unacceptable, the administrative IROFS preventing severe accumulations has been assigned a high degree of reliability. Refer to the EREF ISA Summary for additional discussion.

Fires that involve additional in-situ or transient combustibles from outside each respective fire area could result in exposure of additional uranic content being released in a fire beyond the quantities assumed above. For this reason, fire barriers are needed to ensure that fires cannot propagate from non-uranium containing areas with significant combustible content into uranium (U) areas or from one U area to another U area (unless the uranium content in the space is insignificant, i.e., would be a low consequence event or the propagation of fire into the adjacent area would not result in the release of additional material). This is a change from the NEF where the combustible content and the material release were not used to determine the need for fire barriers. A more detailed evaluation of the need for fire barriers is performed by accounting for combustible content and additional material release.

Fire barriers shall be designed with adequate safety margin such that the total combustible loading (in-situ and transient) allowed to expose the barrier will not exceed 80% of the hourly fire resistance rating of the barrier.

For external events, the impacts were evaluated for the following hazards:

External events were considered at the site and facility level versus at individual system nodes. Specific external event HAZOP guidewords were developed for use during the external event portion of the ISA. The external event ISA considered both natural phenomena and man-made hazards. During the external event ISA team meeting, each area of the plant was discussed as to whether or not it could be adversely affected by the specific external event under consideration. If so, specific consequences were then discussed. If the consequences were known or assumed to be high, then a specific design basis with a likelihood of highly unlikely would be selected.

Given that external events were considered at the facility level, the ISA for external events was completed after the ISA team meetings for all plant systems were completed. This provided the best opportunity to perform the ISA at the site or facility level. Each external event was assessed for both the uncontrolled case and then for the controlled case. The controlled cases

could be a specific design basis for that external event, IROFS, or a combination of both. An Accident Sequence and Risk matrix was prepared for each external event.

External events evaluated included:

- Seismic
- Tornado and Tornado Missile
- High Wind and Wind Missile
- Snow and Ice
- Flooding
- Local Precipitation
- Volcano
- Transportation and Nearby Facility Accidents
    - Aircraft
    - Pipelines
    - Highway
    - Railroad
    - Nearby Facilities
- Internal Flooding from On-Site Above Ground Liquid Storage Tanks.

Compared with the NEF, “Volcano” has been added to the list of external events evaluated as a result of the EREF surrounding geology and “On-site Use of Natural Gas” has been deleted as natural gas will not be used on-site at EREF.

The ISA is intended to give assurance that the potential failures, hazards, accident sequences, scenarios, and IROFS have been investigated in an integrated fashion, so as to adequately consider common mode and common cause situations. Included in this integrated review is the identification of IROFS function that may be simultaneously beneficial and harmful with respect to different hazards, and interactions that might not have been considered in the previously completed sub-analyses. This review is intended to ensure that the designation of one IROFS does not negate the preventive or mitigation function of another IROFS. An integration checklist is used by the ISA Team as a guide to facilitate the integrated review process.

Some items that warrant special consideration during the integration process are:

- Common mode failures and common cause situations.
- Support system failures such as loss of electrical power or water. Such failures can have a simultaneous effect on multiple systems.
- Divergent impacts of IROFS. Assurance must be provided that the negative impacts of an IROFS, if any, do not outweigh the positive impacts; i.e., to ensure that the application of an IROFS for one safety function does not degrade the defense-in-depth of an unrelated safety function.

- Other safety and mitigating factors that do not achieve the status of IROFS that could impact system performance.
- Identification of scenarios, events, or event sequences with multiple impacts, i.e. impacts on chemical safety, fire safety, criticality safety, and/or radiation safety. For example, a flood might cause both a loss of containment and moderation impacts.
- Potential interactions between processes, systems, areas, and buildings; any interdependence of systems, or potential transfer of energy or materials.
- Major hazards or events, which tend to be common cause situations leading to interactions between processes, systems, buildings, etc.

The potential for an external off-site wildland fire was dismissed as a non-credible threat to the facility. The topography as summarized from the facility Environmental Report is a mix of agricultural land, rangeland and barren. The agricultural vegetation consists of low grasses, predominantly crested wheatgrass and cheatgrass and the rangeland vegetation is dominated by Wyoming big sagebrush, dwarf goldenbush, and Sandberg bluegrass. All of these forms of vegetation are characterized by low density and low height with mean heights well below 1 m (3.3 ft).

The closest point of approach for any exterior UF_6 handling area is for an Empty Cylinder Storage Pad and a Full Tails Cylinder Storage Pad, which are approximately 30 m (100 ft) inside the controlled area boundary. The UF_6 cylinders that will be stored on these pads are protective against fires of a severity required for interstate transportation – an 800ºC (1,472ºF), 30-minute engulfing fire. All process structures are built of non-combustible materials with composite built-up roofing. The closest approach of a process structure to the security fence is about 213 m (700 ft). It is not credible for the rangeland or agricultural vegetation proximate to the EREF site to reach a fire severity that will threaten a process structure or cylinder storage area. On-site landscaping will be developed and maintained to ensure no fire hazardous configurations are introduced and any land use within the owner controlled property will similarly be managed to ensure no fire hazardous conditions are allowed to develop due to land use.

3.1.2 Process Hazard Analysis Method

As noted above, the HAZOP method was used to identify the process hazards. The HAZOP process hazard analysis (PHA) method is consistent with the guidance provided in NUREG-1513 (NRC, 2001a). Implementation of the HAZOP method was accomplished by either validating the Enrichment Technologies (ETC), the EREF process system vendor, HAZOPs for the EREF design or performing a new HAZOP for systems where there were no existing HAZOPs. In general, new HAZOPs were performed for the Technical Support Building (TSB) systems; Blending Sampling and Preparation Building (BSPB) systems; Cylinder Receipt and Shipping Building (CRSB) systems; and for UF_6 material handling systems. The new HAZOPs performed for the BSPB, CRSB, and UF_6 material handling systems represents an expansion of new HAZOPs performed compared with the NEF. In cases where there was an existing HAZOP, the ISA Team, through the validation process, developed a new HAZOP.

For the UF_6 process systems, this portion of the ISA was a validation of the HAZOPs provided by ETC. The validation process involved workshop meetings with the ISA Team. In the workshop meeting, the ISA Team challenged the results of the ETC HAZOPs. As necessary the HAZOPs were revised/updated to be consistent with the requirements identified in 10 CFR 70 (CFR, 2008b) and as further described in NUREG-1513 (NRC, 2001a) and NUREG-1520 (NRC, 2002a).

To validate the ETC HAZOPs, the ISA Team performed the following tasks:

- The ETC process engineer described the salient points of the process system covered by the HAZOP being validated.
- The ISA Team divided the process "Nodes" into reasonable functional blocks.
- The process engineer described the salient points of the items covered by the "Node" being reviewed.
- The ISA Team reviewed the "Guideword" used in the ETC HAZOP to determine if the HAZOP is likely to identify all credible hazards. A representative list of the guidewords used by the ISA Team is provided in Table 3.1-1, HAZOP Guidewords, to ensure that a complete assessment was performed.
- The ISA Team Leader introduced each Guideword being considered in the ISA HAZOP and the team reviewed and considered the potential hazards.
- For each potential hazard, the ISA Team considered the causes, including potential interactions among materials. Then, for each cause, the ISA Team considered the consequences and consequence severity category for the consequences of interest (Criticality Events, Chemical Releases, Radiation Exposure, Environment impacts). A statement of "No Safety Issue" was noted in the system HAZOP table for consequences of no interest such as maintenance problems or industrial personnel accidents.
- For each hazard, the ISA Team considered existing safeguards designed to prevent the hazard from occurring.
- For each hazard, the ISA Team also considered any existing design features that could mitigate/reduce the consequences.
- The ETC HAZOP was modified to reflect: the ISA Team's input in the areas of hazards, causes, consequences, safeguards and mitigating features.
- For each external event hazard, the ISA Team determined if the external hazard is credible (i.e., external event initiating frequency $>10^{-6}$ per year).
- When all of the Guidewords had been considered for a particular node, the ISA Team applied the same process and guidewords to the next node until the entire process system was completed.

The same process as above was followed for the TSB, BSPB, CRSB, and UF_6 material handling systems, except that instead of using the validation process, the ISA Team developed a completely new HAZOP. This HAZOP was then used as the hazard identification input into the remainder of the process.

The results of the ISA Team workshops are summarized in the ISA HAZOP Table, which forms the basis of the hazards portion of the Hazard and Risk Determination Analysis. The HAZOP tables are contained in the ISA documentation. The format for this table, which has spaces for describing the node under consideration and the date of the workshop, is provided in Table 3.1-2, ISA HAZOP Table Sample Format. This table is divided into seven (7) columns:

GUIDEWORD	Identifies the Guideword under consideration.
HAZARD	Identifies any issues that are raised.
CAUSES	Lists any and all causes of the hazard noted.

CONSEQUENCES	Identifies the potential and worst case consequence and consequences severity category if the hazard goes uncontrolled.
PREVENTIVE FACTORS	Identifies the engineered and/or administrative protection designed to prevent the hazard from occurring.
MITIGATIVE FACTORS	Identifies any protection, engineered or otherwise, that can mitigate/reduce the consequences.
COMMENTS/ACTIONS	Notes any comments and any actions requiring resolution.

This approach was used for all of the process system hazard identifications. The "Fire" and "External Events" guidewords were handled as a facility-wide assessment and were not explicitly covered in each system hazard evaluation.

The results of the HAZOP are used directly as input to the risk matrix development.

3.1.3 Risk Matrix Development

3.1.3.1 Consequence Analysis Method

10 CFR 70.61 (CFR, 2008c) specifies two categories for accident sequence consequences: "high consequences" and "intermediate consequences." Implicitly there is a third category for accidents that produce consequences less than "intermediate." These are referred to as "low consequence" accident sequences. The primary purpose of PHA is to identify all uncontrolled and unmitigated accident sequences. These accident sequences are then categorized into one of the three consequence categories (high, intermediate, low) based on their analyzed radiological, chemical, and/or environmental impacts.

For evaluating the magnitude of the accident consequences, calculations were performed using the methodology described in the ISA documentation. Because the consequences of concern are the chemotoxic exposure to hydrogen fluoride (HF) and UO_2F_2, the dispersion methodology discussed in SAR Section 6.3.2 was used. The dose consequences for all of the accident sequences were evaluated and compared to the criteria for "high" and "intermediate" consequences. The inventory of uranic material for each accident considered was dependent on the specific accident sequence. For criticality accidents, the consequences were conservatively assumed to be high for both the public and workers.

Table 3.1-3, Consequence Severity Categories Based on 10 CFR 70.61, presents the radiological and chemical consequence severity limits of 10 CFR 70.61 (CFR, 2008c) for each of the three accident consequence categories. Table 3.1-4, Definition of Consequence Severity Category for Chemical Exposure, provides information on the chemical quantitative consequence category limits specific to the EREF.

3.1.3.2 Likelihood Evaluation Method

10 CFR 70.61 (CFR, 2008c) also specifies the permissible likelihood of occurrence of accident sequences of different consequences. "High consequence" accident sequences must be "highly unlikely" and "intermediate consequence" accident sequences must be "unlikely." Implicitly, accidents in the "low consequence" category can have a likelihood of occurrence greater than "unlikely" or simply "not unlikely." Table 3.1-5, Likelihood Categories Based on 10 CFR 70.61,

shows the likelihood of occurrence limits of 10 CFR 70.61 (CFR, 2008c) for each of the three likelihood categories.

The definitions of "not unlikely" and "unlikely" are taken from NUREG-1520 (NRC, 2002a). The definition of "highly unlikely" is taken from NUREG-1520 (NRC, 2002a). Additionally, a qualitative determination of "highly unlikely" can apply to passive design component attributes (e.g., tanks, piping, cylinders, etc.) of the facility that do not rely on human interface to perform the criticality safety function (i.e., termed "safe-by-design"). Passive IROFS that contain a safe-by-design component attribute are those components that by their physical size or arrangement have been shown to have a $k_{eff} < 0.95$. The definition of passive IROFS that contain a safe-by-design component attribute encompasses two different categories of components. The first category includes those components that are safe-by-volume, safe-by-diameter or safe-by-slab thickness. A set of generic conservative criticality calculations has determined the maximum volume, diameter, or slab thickness (i.e., safe value) that would result in a $k_{eff} < 0.95$. A component in this category has a volume, diameter or slab thickness that is less than the associated safe value resulting from the generic conservative criticality calculations and therefore the k_{eff} associated with this component is < 0.95. The components in the second category require a more detailed criticality analysis (i.e., a criticality analysis of the physical arrangement of the component's design configuration) to show that k_{eff} is < 0.95. In the second category of components, the design configuration is not bounded by the results of the generic conservative criticality calculations for maximum volume, diameter, or slab thickness that would result in a $k_{eff} < 0.95$. Examples of components in this second category are the product pumps that have volumes greater than the safe-by-volume value, but are shown by specific criticality analysis to have a $k_{eff} < 0.95$.

For failure of passive IROFS that contain a safe-by-design component attribute to be considered "highly unlikely," these components must also meet the criterion that the only potential means to effect a change that might result in a failure to function, would be to implement a design change (i.e., geometry deformation as a result of a credible process deviation or event does not adversely impact the performance of the safety function). The evaluation of the potential to adversely impact the safety function of these passive design features includes consideration of potential mechanisms to cause bulging, corrosion, and breach of confinement/leakage and subsequent accumulation of material. The evaluation further includes consideration of adequate controls to ensure that the double contingency principle is met. For each of these passive design components, it must be concluded, that there is no credible means to effect a geometry change that might result in a failure of the safety function and that significant margin exists. For components that are safe-by-volume, safe-by-diameter, or safe-by-slab thickness (i.e., first category of passive IROFS that contain a safe-by-design component attribute), significant margin is defined as a margin of at least 10%, during both normal and upset conditions, between the actual design parameter value of the component and the value of the corresponding critical design attribute. For components that require a more detailed criticality analysis (i.e., second category of passive IROFS that contain a safe-by-design component attribute), significant margin is defined as $k_{eff} < 0.95$, where $k_{eff} = k_{calc} + 3\sigma_{calc}$. This margin is considered acceptable since the calculation of k_{eff} also conservatively assumes the components are full of uranic breakdown material at maximum enrichment, the worst credible moderation conditions exist, and the worst credible reflection conditions exist. In addition, the configuration management system required by 10 CFR 70.72 (CFR, 2008f) (implemented by the EREF Configuration Management Program) ensures the maintenance of the safety function of these features and assures compliance with the double contingency principle, as well as the defense-in-depth criterion of 10 CFR 70.64(b) (CFR, 2008h).

The definition of "not credible" is also taken from NUREG-1520 (NRC, 2002a). If an event is not credible, IROFS are not required to prevent or mitigate the event. The fact that an event is not "credible" must not depend on any facility feature that could credibly fail to function. One cannot claim that a process does not need IROFS because it is "not credible" due to characteristics provided by IROFS. The implication of "credible" in 10 CFR 70.61 (CFR, 2008c) is that events that are not "credible" may be neglected.

Any one of the following independent acceptable sets of qualities could define an event as not credible:

a. An external event for which the frequency of occurrence can conservatively be estimated as less than once in a million years

b. A process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive (In determining that there is no reason for such actions, a wide range of possible motives, short of intent to cause harm, must be considered. Necessarily, no such sequence of events can ever have actually happened in any fuel cycle facility.)

c. Process deviations for which there is a convincing argument, given physical laws that they are not possible, or are unquestionably extremely unlikely.

3.1.3.3 Risk Matrix

The three categories of consequence and likelihood can be displayed as a 3 x 3 risk index matrix. By assigning a number to each category of consequence and likelihood, a qualitative risk index can be calculated for each combination of consequence and likelihood. The risk index equals the product of the integers assigned to the respective consequence and likelihood categories. The risk index matrix, along with computed risk index values, is illustrated in Table 3.1-6, Risk Matrix with Risk Index Values. The shaded blocks identify accidents of which the consequences and likelihoods yield an unacceptable risk index and for which IROFS must be applied.

The risk indices can initially be used to examine whether the consequences of an uncontrolled and unmitigated accident sequence (i.e., without any IROFS) could exceed the performance requirements of 10 CFR 70.61 (CFR, 2008c). If the performance requirements could be exceeded, IROFS are designated to prevent the accident or to mitigate its consequences to an acceptable level. A risk index value less than or equal to four means the accident sequence is acceptably protected and/or mitigated. If the risk index of an uncontrolled and unmitigated accident sequence exceeds four, the likelihood of the accident must be reduced through designation of IROFS. In this risk index method, the likelihood index for the uncontrolled and unmitigated accident sequence is adjusted by adding a score corresponding to the type and number of IROFS that have been designated.

3.1.4 Risk Index Evaluation Summary

The results of the ISA are summarized in tabular form. This table includes the accident sequences identified for this facility. The accident sequences were not grouped as a single accident type but instead were listed individually in the table. The table has columns for the initiating event and for IROFS. IROFS may be mitigative or preventive. Mitigative IROFS are measures that reduce the consequences of an accident. The phrase "uncontrolled, and/or unmitigated consequences" describes the results when the system of existing preventive IROFS fails and existing mitigation also fails. Mitigated consequences result when the preventive

IROFS fail, but mitigative measures succeed. Index numbers are assigned to initiating events, IROFS failure events, and mitigation failure events, based on the reliability characteristics of these items.

With redundant IROFS and in certain other cases, there are sequences in which an initiating event places the system in a vulnerable state. While the system is in this vulnerable, state, an IROFS must fail for the accident to result. Thus, the frequency of the accident depends on the frequency of the first event, the duration of vulnerability, and the frequency of the second IROFS failure. For this reason, the duration of the vulnerable state is considered, and a duration index is assigned. The values of all index numbers for a sequence, depending on the number of events involved, are added to obtain a total likelihood index, T. Accident sequences are then assigned to one of the three likelihood categories of the risk matrix, depending on the value of this index in accordance with Table 3.1-8, Determination of Likelihood Category.

The values of index numbers in accident sequences are assigned considering the criteria in Table 3.1-9 through Table 3.1-11. Each table applies to a different type of event. Table 3.1-9, Failure Frequency Index Numbers, applies to events that have frequencies of occurrence, such as initiating events and certain IROFS failures. In addition to further support the failure frequency index numbers used in the ISA for accident initiators that are the same as the NEF ISA accident initiators (i.e., when ISA Summary accident descriptions state “This failure frequency index was selected based on evidence from history of a similarly designed European plant . . .”), operating data from similar systems, components, and safety functions at the Urenco Almelo SP5 facility, which is similar to the NEF and EREF design, was reviewed for NEF. This review was conducted by Urenco using searches of computer-based databases at the Urenco Almelo facility for the NEF. A list of ISA Summary initiating events caused by component failures or human events was developed. Using this list of initiating events, keyword searches of computer based databases for plant control systems, operational logs, and maintenance records was performed by Urenco for NEF. The resulting information relevant to the Almelo SP5 facility was extracted for further review, evaluation, and comparison to the failure frequency index number(s) used in the applicable NEF ISA Summary accident sequences. Due to the similarity in designs, these failure frequency index numbers have also been applied to the applicable EREF ISA Summary accident sequences.

For failure frequency index numbers used in the ISA associated with accident initiators resulting from component failures that are not the same as the NEF ISA accident initiators (i.e., when ISA Summary accident descriptions state, “This failure frequency index was selected based on evidence from the nuclear industry..."), operating data from similar systems, components, and safety functions at Department of Energy, commercial nuclear industry facilities, and research facilities is reviewed. This review is conducted using the Savannah River Site Hazard Analysis Generic Initiator Database (SRP, 1998) and Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs (EGG, 1983). The Savannah River Site Hazard Analysis Generic Initiator Database is a set of generic frequencies for various common accident initiators within the Savannah River Site compiled from accident information, Hazards Analysis Checklists, Safety Analysis Reports, and other relevant data sources from the Savannah River Site. The Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs is a comprehensive generic component failure database that was developed from available plant data obtained from the Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), the Centralized Reliability Data Organization (CREDO) data programs, and other sources. The information resulting from a review of these two industry data sources is compared to similar events in the Urenco Almelo facility database and the more conservative data for the failure event is used.

For failure frequency index numbers used in the ISA associated with accident initiators resulting from operator errors that are not the same as the NEF ISA accident initiators (i.e., when ISA Summary accident descriptions state, “This failure frequency index was selected based on the Technique for Human Error Rate Prediction (THERP) Methodology"), the THERP Methodology is described in the Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications (NRC, 1983). THERP is a methodology to predict human error probabilities and to evaluate the degradation of a man-machine system likely to be caused by human errors alone, or in connection with equipment functioning, operational procedures and practices, or other systems and human characteristics that influence systems behavior. The method uses conventional reliability technology with modifications appropriate to the greater variability, unpredictability, and interdependence of human performance as compared with that of equipment performance. The steps in THERP are similar to those in conventional reliability analysis, except that human activities are substituted for equipment outputs.

When failure probabilities are required for an event, Table 3.1-10, Failure Probability Index Numbers, provides the index values. Table 3.1-11, Failure Duration Index Numbers, provides index values for durations of failures.

These are used in certain accident sequences where two IROFS must simultaneously be in a failed state. In this case, one of the two controlled parameters will fail first. It is then necessary to consider the duration that the system remains vulnerable to failure of the second. This period of vulnerability can be terminated in several ways. The first failure may be "fail-safe" or be continuously monitored, thus alerting the operator when it fails so that the system may be quickly placed in a safe state. Or the IROFS may be subject to periodic surveillance tests for hidden failures. When hidden failures are possible, these surveillance intervals limit the duration that the system is in a vulnerable state. The reverse sequences, where the second IROFS fails first, should be considered as a separate accident sequence. This is necessary because the failure frequency and the duration of outage of the first and the second IROFS may differ. The values of these duration indices are not merely judgmental. They are directly related to the time intervals used for surveillance and the time needed to render the system safe.

The duration of failure is accounted for in establishing the overall likelihood that an accident sequence will continue to the defined consequence. Thus, the time to discover and repair the failure is accounted for in establishing the risk of the postulated accident.

The total likelihood index is the sum of the indices for all the events in the sequence, including those for duration. Consequences are assigned to one of the three consequence categories of the risk matrix, based on calculations or estimates of the actual consequences of the accident sequence. The consequence categories are based on the levels identified in 10 CFR 70.61 (CFR, 2008c). Multiple types of consequences can result from the same event. The consequence category is chosen for the most severe consequence.

In summarizing the ISA results, Table 3.7-1, Accident Sequence and Risk Index, provides two risk indices for each accident sequence to permit evaluation of the risk significance of the IROFS involved. To measure whether an IROFS has high risk significance, the table provides an "uncontrolled risk index," determined by modeling the sequence with all IROFS as failed (i.e., not contributing to a lower likelihood). In addition, a “controlled risk index” is also calculated, taking credit for the low likelihood and duration of IROFS failures. When an accident sequence has an uncontrolled risk index exceeding four but a controlled risk index of less than four, the IROFS involved have high risk significance because they are relied on to achieve acceptable safety performance. Thus, use of these indices permits evaluation of the possible benefit of improving IROFS and also whether a relaxation may be acceptable.

3.2 INTEGRATED SAFETY ANALYSIS TEAM

The EREF subject matter discussed in this section is essentially identical to the National Enrichment Facility (NEF) SAR (LES, 2005) with the exception that for the non-core process systems, process expertise was provided by SGN rather than ETC.

There were two ISA Teams that were employed in the ISA. The first team worked on the non-classified portions of the facility and is referred to in the text as the ISA Team. The second team, referred to as the Classified ISA Team, performed the ISA on the classified elements of the facility. Both teams were selected with credentials consistent with the requirements in 10 CFR 70.65 (CFR, 2008a) and the guidance provided in NUREG-1520 (NRC, 2002a). To facilitate consistency of results, common membership was dictated as demonstrated below (i.e., some members of the Non-Classified Team for the core process systems participated on the Classified Team. One of the members of the Classified Team has had formal ISA Team Leader Training. In addition, the Classified ISA Team Leader participated in some of the non-classified ISA Team meetings.)

The ISA was performed by a team with expertise in engineering, safety analysis and enrichment process operations. The team included personnel with experience and knowledge specific to each process or system being evaluated. The team was comprised of individuals who have experience, individually or collectively, in:

- Nuclear criticality safety
- Radiological safety
- Fire safety
- Chemical process safety
- Operations and maintenance
- ISA methods.

The ISA team leaders are trained, experienced, and knowledgeable in the ISA method(s) chosen for the hazard and accidents evaluations. Collectively, the team had an understanding of all process operations and hazards under evaluation.

The ISA Manager was responsible for the overall direction of the ISA. The process expertise for the core process systems was provided by the ETC personnel on the team. In addition, the team leader had an adequate understanding of the process operations and hazards evaluated in the ISA, but is not the responsible cognizant engineer or enrichment process expert.

Process expertise for the non-core process systems was provided by the SGN personnel on the ISA Team. SGN, AREVA's engineering subsidiary, is the engineer for the Georges Besse II gas centrifuge enrichment facility currently under construction in France.

3.3 COMPLIANCE ITEM COMMITMENTS

The subject matter discussed in this section is extracted from the EREF ISA Summary. While EREF utilized methods that were similar to those utilized by NEF to develop the information, there are substantial differences in the material.

3.3.1 IROFS

- For accident sequences PT2-3, PT2-6, PT2-9 DS1-2, DS1-3, DS1-4, DS2-1, DS2-2, DS2-3, DS2-4, DS2-5, DS8-1, DS8-2, SW1-1, SW1-2, CL1-1, CL1-2, CL1-3, LW1-1, LW1-2, LW1-3, LW4-3, LW4-4, LW4-5, CM5-1, CM6-1, CP1-1, CP5-7, CP5-8, VR1-2, VR1-3, VR2-1, VR2-2, PB2-6, PB3-2, PB3-3, and PB3-4, an Initiating Event Frequency (IEF) index number of "-2" may be assigned based on evidence from the operating history of similar designed Urenco European plants. Detailed justifications for the IEF index numbers of “2" will be developed during detailed design. If the detailed justification does not support the IEF index number of "-2," then the IEF index number assigned and the associated accident sequence(s) will be re-evaluated and revised, as necessary, consistent with overall ISA methodology.
- For Administrative Control IROFS that involve "use of "a component or device, a Failure Probability Index Number (FPIN) of "-2" may be assigned provided the IROFS is a routine, simple, action that either: (1) involves only one or two decision points or (2) is highly detailed in the associated implementing procedure. Alternately, an FPIN of "-3" may be assigned for this type of IROFS provided the criteria specified above for an FPIN of "-2" are met and the IROFS is enhanced by requiring independent verification of the safety function. This enhancement shall meet the requirements for independent verification identified below. If these criteria cannot be met, then the FPIN assigned to the IROFS and the associated accident sequence(s) will be re-evaluated and revised, as necessary, consistent with the overall ISA methodology.
- For Administrative Control IROFS that involve "verification of a state or condition, an FPIN of "-2" may be assigned provided the IROFS is a routine action performed by one person, with proceduralized, objective, acceptance criteria. Alternately, an FPIN of "-3" may be assigned for this type of IROFS provided the criteria specified above for an FPIN of "-2" are met and the IROFS is enhanced by requiring independent verification of the safety function. This enhancement shall meet the requirements for independent verification identified below. If these criteria cannot be met, then the FPIN assigned to the IROFS and the associated accident sequence(s) will be re-evaluated and revised, as necessary, consistent with the overall ISA methodology.
- For Administrative Control IROFS that involve “independent sampling," different samples are obtained and an FPIN of "-2" may be assigned provided at least three of the following four criteria are met.
    1. Different methods/techniques are used for sample analysis.
    2. Samples are obtained from different locations.
    3. Samples are obtained at different times. The time period between collections of the different samples shall be sufficient to ensure results are meaningful and representative of the material sampled.
    4. Samples are obtained by different personnel.

If at least three of the above criteria cannot be met, then the FPIN assigned to the IROFS and the associated accident sequence(s) will be re-evaluated and revised, as necessary, consistent with the overall ISA methodology.

- Upon completion of the design of IROFS, the IROFS boundaries will be defined. In defining the boundaries for each IROFS, ISA Summary Appendix A, Guidelines for Development of Boundary Definitions for IROFS will be used. These guidelines require the identification of each support system and component necessary to ensure the IROFS is capable of performing its specified safety function.
- IROFS will be designed, constructed, tested and maintained to QA Levels in accordance with the QAPD. IROFS will comply with design requirements established by the ISA and the applicable codes and standards (current approved version at the time of design). IROFS components and their designs will be of proven technology for their intended application. These IROFS components and systems will be qualified to perform their required safety functions under normal and accident conditions, e.g., pressure, temperature, humidity, seismic motion, electromagnetic interference, and radio-frequency interference, as required by the ISA. IROFS components and systems will be qualified using the applicable guidance in Institute of Electrical and Electronics Engineers (IEEE) standard IEEE-323, 1983, "IEEE Standard for Qualifying Class 1 E Equipment for Nuclear Power Generating Stations" (IEEE, 1983a). Furthermore, IROFS components and systems will be designed, procured, installed, tested, and maintained using the applicable guidance in Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," Revision 1, dated October 2003 (NRC, 2003c). IROFS systems will be designed and maintained consistent with the reliability assumptions in the ISA. Redundant IROFS systems will be separate and independent from each other. IROFS systems will be designed to be fail-safe. In addition, IROFS systems will be designed such that process control system failures will not affect the ability of the IROFS systems to perform their required safety functions. Installation of IROFS systems will be in accordance with engineering specifications and manufacturer's recommendations. Required testing and calibration of IROFS will be consistent with the assumptions of the ISA and setpoint calculations, as applicable. For hardware IROFS involving instrumentation which provides automatic prevention or mitigation of events, setpoint calculations are performed in accordance with a setpoint methodology, which is consistent with the applicable guidance provided in Regulatory Guide 1.105, "Setpoints for Safety-Related Instrumentation," Revision 3, dated December 1999 (NRC, 1999).
- For IROFS that use software, firmware, microcode, programmable logic controllers, and/or any digital device, including hardware devices which implement data communication protocols (such as fieldbus devices and Local Area Network controllers), etc., design will adhere to accepted best practices in software and hardware engineering, including software quality assurance controls as discussed in the QAPD throughout the development process and the applicable guidance of the following industry standards and regulatory guides:
    a. American Society of Mechanical Engineers (ASME) NQA-1-1994, Part II, subpart Part 2.7, “Quality Assurance Requirements of Computer Software for Nuclear Facility Applications,” as revised by NQA-1a-1995 Addenda of NQA-1-1994 and ASME NQA-1-1994, Part 1, Supplement 11S-2, “Supplementary Requirements of Computer Program Testing.” (ASME, 1994a) (ASME, 1995) (ASME, 1994b)

b. Electric Power and Research Institute (EPRI) NP-5652, “Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Grade Applications,” June 1988 (EPRI, 1988).

c. EPRI Topical Report (TR) -102323, “Guidelines for Electromagnetic Interference Testing in Power Plants,” Revision 1, December 1996 (EPRI, 1996a).

d. EPRI TR-106439, “Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications,” October 1996 (EPRI, 1996b).

e. Regulatory Guide 1.152, “Criteria for Digital Computers in Safety Systems in Nuclear Power Plants,” Revision 2, January 2006 (NRC, 2006).

f. Regulatory Guide 1.168, Revision 1, “Verification, Validation, Reviews, and Audits for Digital Software Used in Safety Systems of Nuclear Power Plants,” October, 2004 (NRC, 2004b).

g. Regulatory Guide 1.169, “Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants,” September 1997 (NRC, 1997a).

h. Regulatory Guide 1.170, “Software Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants,” September 1997 (NRC, 1997b).

i. Regulatory Guide 1.172, “Software Requirements Specifications for Digital Computer Software Used in Safety Systems of Nuclear Power Plants,” September 1997 (NRC, 1997c).

j. Regulatory Guide 1.173, “Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems for Nuclear Power Plants,” September 1997 (NRC, 1997d).

- For those IROFS requiring operator actions, a human factors engineering review of the human-system interfaces shall be conducted using the applicable guidance in NUREG-0700, "Human-System Interface Design Review Guidelines," Revision 2, dated May 2002 (NRC, 2002a), and NUREG-0711, "Human Factors Engineering Program Review Model," Revision 2, dated February 2004 (NRC, 2004a).
- For IROFS and IROFS with Enhanced Failure Probability Index Numbers (i.e., enhanced IROFS) that require "independent verification" of a safety function, the independent verification shall be independent with respect to personnel and personnel interface. Specifically, a second qualified individual, operating independently (e.g., not at the same time or not at the same location) of the individual assigned the responsibility to perform the required task, shall, as applicable, verify that the required task (i.e., safety function) has been performed correctly (e.g., verify a condition), or re-perform the task (i.e., safety function), and confirm acceptable results before additional action(s) can be taken which potentially negatively impact the safety function of the IROFS. The required task and independent verification shall be implemented by procedure and documented by initials or signatures of the individuals responsible for each task. In addition, the individuals performing the tasks shall be qualified to perform, for the particular system or process (as applicable) involved, the tasks required and shall possess operating knowledge of the particular system

or process (as applicable) involved and its relationship to facility safety. The requirements for independent verification are consistent with the applicable guidance provided in ANSI/ANS-3.2-1994 (ANSI, 1994).

- The following information related to IROFS will be available on-site in the ISA documentation once final design is completed.
  - Hardware IROFS design details, such as system schematics and/or descriptive lists, sufficient to determine the structures, system, equipment or component included within the hardware IROFS' boundary
  - Identification of essential utilities and support systems on which the IROFS depends to perform the intended safety functions
  - Operating ranges and limits for measured process variables, e.g., temperature, pressure, associated with IROFS
  - Basis for establishing the average vulnerable outage time to maintain acceptable IROFS availability
  - Safety limits and safety margins, as applicable.

3.3.2 Seismic Design

- To define the design basis earthquake (DBE) for the buildings assumed to withstand seismic events in the ISA, information from ASCE 43-05, Standard Seismic Design Criteria (ASCE, 2005b) was considered along with the results of the seismic portion of the ISA and the site-specific probabilistic seismic hazard analysis performed for the EREF site.

  The ASCE standard outlines a methodology to demonstrate compliance to a target performance goal of 1.0E-05 annual probability by designing to a seismic hazard of 1.0E-04 annual probability. The difference between the design level and the performance target is accounted for in the detailed design process by confirmatory calculations.

  Based on these approaches, the DBE for the EREF buildings assumed to withstand seismic events in the ISA has been selected as the 10,000-year (1.0E-04 mean annual probability) earthquake. For the EREF, following the ASCE approach provides a risk reduction ratio of design to target performance of 10 (1.0E-04/1.0E-05). This DBE for the buildings will be used in the detailed design process to demonstrate compliance with the overall ISA performance requirements. This will be accomplished by confirmatory seismic performance calculations for the seismic Items Relied on for Safety (IROFS) during detailed design. The ASCE standard addresses design and evaluation of structures, systems, and components (SSCs). The equivalents of SSCs for the EREF are considered to be the IROFS and the items that may affect the function of IROFS. The objective of the EREF seismic design approach is to demonstrate that use of this DBE for the buildings achieves a likelihood of unacceptable performance of less than approximately 1.0E-05 per year, by introducing sufficient design safety margins, i.e., conservatism, during the design process to allow for demonstration of compliance to the target performance goal. The ASCE standard implements this objective with the end result of demonstrating compliance to the target performance goal.

  The ASCE approach is based on achieving the target performance goal annual frequencies by incorporating sufficient conservatism in the seismic demand and structural capacity evaluations to achieve both of the following:

- Less than about a 1% probability of unacceptable performance for the DBE ground motion
- Less than a 10% probability of unacceptable performance for a ground motion equal to 150% of the DBE ground motion

The ASCE method is based on achieving both of the above probability goals, which represent two points on the underlying fragility curve. Meeting these two probability goals allows the target performance probabilities to be achieved with less possibility of non-conservatism. The resulting nominal factors of safety against conditional probability of failure are 1.0 and 1.5, respectively, for the above two goals.

The actual seismic design detailed approach for EREF will be based on the ASCE method. The safety margins will be representative of those discussed above and described in more detail in the ASCE standard.

The difference between the mean annual probabilities for design (1.0E-04) and performance (1.0E-05) is achieved through conservatism in the design (factors of safety), elasticity in the structures, and conservatism in the evaluation of the design.

- To define the design basis earthquake for the UF_6 process piping and systems assumed to withstand seismic events in the ISA information from ASCE 43-05 (ASCE, 2005b) was also used to define the appropriate DBE.

  The design basis earthquake (DBE) for the process piping and systems assumed to withstand seismic events in the ISA has been selected as the 2,500-yr (4.0E-4 mean annual probability) earthquake. This DBE for the UF_6 process piping and systems will be used in the detailed design process to demonstrate compliance with the overall ISA performance requirements. This will be accomplished by confirmatory seismic performance calculations for the seismic process piping and systems IROFS during detailed process piping and system design. The objective will be to demonstrate that use of this DBE for the UF_6 process piping and systems will achieve a likelihood of unacceptable performance of less than approximately 1.0E-4 per year. The difference between the mean annual probabilities for design (4.0E-4) and performance (1.0E-4) is achieved through conservatism in the design (factors of safety), elasticity in the systems, and conservatism in the evaluation of the design. Use of this approach will result in an “unlikely” event likelihood for exceeding the seismic capacity of the UF6 process piping and systems. The design response spectra for the buildings, horizontal and vertical, are based on the 10,000-year uniform hazard response spectra described in the ISA Summary. The bedrock amplification factors described in the ISA Summary will be verified during the detailed design phase of the EREF project.

- The design response spectra for the UF_6 process piping and equipment, horizontal and vertical, are based on the 2,500-year uniform hazard response spectra. The bedrock amplification factors described in the ISA Summary will be verified during the detailed design phase of the EREF project. Complete details of the seismic evaluation are provided in Appendix F. The 2,500-year response spectra will be developed during detailed design using the same approach as the 10,000 year.

- As a result of the additional site subsurface investigation to be conducted to support the final design of the EREF, if a potential for soil liquefaction is determined to exists, an assessment of soil liquefaction potential will be performed using the applicable guidance of Regulatory Guide 1.198, Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites (NRC, 2003a).

3.3.3 Building Requirements

- To support the final design of the EREF, additional soil borings and rock coring will be performed at the EREF site. Laboratory testing of soil and rock samples and additional in-situ tests will be performed as necessary to determine static and dynamic soil and rock properties. This information will be used to evaluate foundation bearing capacity, estimated settlement and provide geotechnical input for soil/rock structure interaction analysis.
- Allowable bearing pressures will be determined for the proposed foundations and anticipated loading. Allowable bearing pressure for the stability of structures will be based on the strength of the underlying soil and rock. For structures founded on rock the allowable bearing capacity is expected to be much higher than the loads that will be applied. The methods used to determine allowable bearing pressure will follow applicable methods in one or more of the following publications: Naval Facilities Engineering Command Design Manual (NAVFAC) DM-7.02, Foundations and Earth Structures (NAVFAC, 1986a); Foundation Engineering Handbook (Winterkorn, 1975); Foundation Analysis and Design (Bowles, 1996); Foundation Engineering (Peck, 1974); and Rock Foundations (ASCE, 1996).
- Settlement evaluation will consider the manufacturers and or other specified allowable total and differential settlement of equipment and buildings. The methods used will follow applicable methods in one or more of the following publications: NAVFAC DM-7.01, Soil Mechanics (NAVFAC, 1986b); Foundation Engineering Handbook (Winterkorn and Fang, 1975); Foundation Analysis and Design (Bowles, 1996); and Foundation Engineering (Peck, 1974).
- The SBMs are designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- Load bearing walls, columns, floors, and roof construction of the SBMs will have a fire-resistance rating consistent with Type I-B requirements.
- The seismic isolator slab, as part of the building envelope, cannot lead to an unacceptable release of UF_6 during or after an earthquake, up to the DBE for the buildings. Therefore, the seismic isolator slab performance is included as part of the building IROFS for seismic, and the following requirements are imposed on the seismic isolator slab:
    - Maintain support for flomels, cascades and other equipment or components containing UF_6 that are supported by the seismic isolator slab during and after a seismic event.
    - Maximum displacements of the seismic isolator slab during a seismic event must not lead to adverse impacts on adjacent building walls or other equipment or components containing UF_6.
- Each Separations Building Module superstructure is structurally independent from the rest of the facility and is designed to resist the normal load conditions as defined by the IBC (ICC, 2006) and the Extreme Environmental loads as defined by the ISA Summary.
- The floors of the Cascade Halls have a floor profile quality classification of flat in accordance with ACI 117-90 (ACI, 1990) to aid in the transport of assembled centrifuges.
- The TSB is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- Load bearing walls, columns, floors, and roof construction of the TSB will have a fire-resistance rating consistent with Type I-B requirements.

- The TSB portion of the structure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006) and the Extreme Environmental loads as defined by the ISA Summary.
- The OSB is designed to meet the occupant and exiting requirements and the construction Type I-B classifications set by the IBC (ICC, 2006).
- Load bearing walls, columns, floors, and roof construction of the OSB will have a fire-resistance rating consistent with Type I-B requirements.
- The OSB portion of the structure is designed to resist normal loads conditions as defined by the IBC (ICC, 2006) and does not need to resist Extreme Environmental Loads, but it is designed such that Extreme Environmental Loads acting on the OSB will not adversely affect the TSB.
- The CRSB is a single-story structure designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- Load bearing walls, columns, and roof construction of the CRSB will have a fire-resistance rating consistent with Type I-B requirements.
- The CRSB superstructure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006) and the Extreme Environmental Loads defined by the ISA Summary.
- The CAB is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- The CAB superstructure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006). This building does not need to resist Extreme Environmental loads as defined by the ISA Summary.
- The BSPB is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- Load bearing walls, columns, floors, and roof construction of the BSPB will have a fire-resistance rating consistent with Type I-B requirements.
- The Blending, Sampling, Preparation Building superstructure is designed to resist the normal load conditions as defined by the IBC (IBC, 2006) and the Extreme Environmental Loads as defined by the ISA Summary.
- The Full Tails, Full Feed, Empty Cylinder Storage Pads, the Full Product Cylinder Storage Pad, and the Cylinder Overpack Storage Pad are designed to resist the normal load conditions as defined by the IBC (ICC, 2006).
- The Electrical Services Building is designed to meet the construction type, occupance and exiting requirements of the IBC (ICC, 2006).
- The Electrical Services Building superstructure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006), using structural steel framing.
- The Electrical Services Building for the Centrifuge Assembly Building is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- The Electrical Services Building for the Centrifuge Assembly Building superstructure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006) using structural steel framing.

- The Gasoline and Diesel Fueling Station is designed to meet the construction type, occupancy, and exiting requirements of the IBC (ICC, 2006).
- The Gasoline and Diesel Fueling Station is designed to resist the normal load conditions as defined by the IBC (ICC, 2006) using structural steel framing.
- The two Mechanical Services Buildings are designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- Each Mechanical Services Building structure is designed to resist the normal load conditions as defined by the IBC (ICC, 2006), using structural steel framing.
- The Administration Building is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- The Administration Building superstructure is designed to resist normal load conditions as defined by the IBC (ICC, 2006), using structural steel framing.
- The Security and Secure Administration Building is designed to meet the construction type, occupancy and exiting requirements of the IBC (ICC, 2006).
- The Security and Secure Administration Building structure is designed to resist normal load conditions as defined by the IBC (ICC, 2006), using structural steel framing.
- The Guard House is designed to meet the occupancy and exiting requirements set by the IBC (ICC, 2006).
- The Guard House structure is designed to resist normal load conditions as defined by the International Building Code (ICC, 2006), using structural steel framing.
- The Visitor Center will be a commercial building constructed to the provisions of the local building code.

3.3.4 Structural Design Criteria

- As part of the Integrated Safety Analysis for external events, the following structures (buildings and areas) were determined to be required to withstand the design basis natural phenomena hazards and external hazards defined in the ISA Summary:
    - Separations Building Modules (UF_6 handling area, process service corridors, and cascade halls including the link corridors, electrical support rooms and second floor mechanical rooms)
    - BSPB
    - Cylinder Receipt and Shipping Building
    - TSB
- The above structures shall be designed to withstand the effects of external events (i.e., seismic, winds, snow, and local intense precipitation).
- The determination of normal wind pressure loadings and the design for wind loads for all structures and structural components exposed to wind are based on the requirements of the IBC (ICC, 2006), Section 1609 which further refers to the wind design requirements of ASCE 7-05, Chapter 6.0 (ASCE, 2005a).
- The structures and components listed above exposed to wind are designed to withstand the Extreme Environmental wind as defined in the ISA Summary Section.

- Protection against flooding is provided by establishing the facility floor level at 0.15 m (0.5 ft) above the high point of the finished grade elevation and all roads are set below this. At roof access doors, the door threshold is set at least 0.15 m (0.5 ft) above the top of the roofing material.
- All buildings and structures, including such items as equipment supports, are designed to withstand the earthquake loads defined in Section 1613 of the IBC (ICC, 2006) which invokes the earthquake design requirements of ASCE 7-05 (ASCE, 2005a). Every structure is designed to resist the total lateral seismic forces applied in the directions which will produce the most critical load effects as delineated in Section 12.5 of ASCE 7-05 (ASCE, 2005a). The seismic analysis shall consist of one of the types permitted by Table 12.6-1 in ASCE 7-05 (ASCE, 2005a), based on the structure's seismic design category, structural system, dynamic properties, and regularity. The permitted analytical procedures include Equivalent Lateral Force Analysis, Modal Response Spectrum Analysis, and Seismic Response History Procedures.

  The provisions in AISC 341-05 (AISC, 2005b) govern the design fabrication, and erection of structural steel members and connections in the seismic load resisting system (SLRS) and splices in columns that are not a part of the SLRS, in buildings and other structures, where the seismic response modification coefficient, R, (as specified in ASCE 7-05 (ASCE, 2005a)) is taken greater than 3, regardless of the seismic design category.
- The Design Basis Earthquake (DBE) for the EREF site will be determined using the methods in ASCE 43-05 (ASCE, 2005b). The peak accelerations will be determined during detail design. The design spectra will be based on the building construction type in accordance with Limit State C of ASCE 43-05 (ASCE, 2005b). For licensing purposes, soil amplification factors are based on Soil Class C. This assumption will be verified during final design.
- Normal Snow Loads (S) on roofs and other exposed surfaces for all structures including snow drifts, sliding snow, unbalanced snow, and rain on snow loads, are determined in accordance with the IBC (ICC, 2006), Section 1603 which invokes the snow load design requirements in Chapter 7 of ASCE 7-05 (ASCE, 2005a).
- Extreme Environmental Snow Loads on roofs of buildings listed above is based on a Ground Snow Load (p_g) of 309 kg/m^2 (63.2 lb/ft^2)**.**
- The roof drainage systems (including secondary roof drainage path) will be designed such that the amount of rainfall that can collect on the roof does not exceed the design load for the roof.
- Roofs will be designed so as to not pond water to a depth during the extreme local precipitation that could exceed the Extreme Environmental Rainfall which is equivalent to the 24-hour extreme local precipitation estimate of 112 mm (4.39 in).
- The following features apply to the SBM, TSB, CRSB and BSPB:
  - Since the sloped roof design precludes any significant ponding on the roofs, any leaks into the building through the roof liner would not be significant due to small hydrostatic driving heads of any water on the roof. The layouts in the SBMs, CRSB and BSPB are very open designs which would result in significant spreading out any precipitation leaking into the buildings. The layout in the TSB provides for smaller rooms spread over three floors. The individual rooms are interconnected through many doors. Any leaks into the building through the roof liner would disperse from room to room and floor to floor without any significant ponding in any of the individual rooms.

- The facility floor levels will be set 0.15 m (6 in) above the finished outside adjacent grade. Finished grading will slope away from buildings preventing any accumulations/ponding of precipitation from roof run-off or sheet flow of storm water against the buildings. At roof access doors, the door threshold is set at least 0.15 m (6 in) above the top of the roofing material.

- The Full Feed Cylinder Storage Pads, Full Tails Cylinder Storage Pads, and Full Product Cylinder Storage Pad are designed to drain excess precipitation, thereby precluding any significant ponding due to extreme precipitation.
- Load combinations for concrete structures are based on ASCE 7-05 (ASCE, 2005a) and ACI 318-05 (ACI, 2005a). Additional load combinations for concrete structures listed above are based on ACI 349-06 (ACI, 2006).
- All concrete structures are designed using ACI Strength Design Methods: ACI 349-06 (ACI, 2006) for concrete structures and components listed above and ACI 318-05 (ACI, 2005a) for all other concrete structures.
- Load combinations for steel structures for all buildings are based on ASCE 7-05 (ASCE, 2005a). Additional load combinations applicable to steel structures and components listed above are based on AISC N690-06 (AISC, 2006).
- All structural steel is designed using the AISC Methods (ADS or LRFD) provided in AISC 360-05 (AISC, 2005a). Structural steel for structures listed above is designed using the AISC Methods (ADS or LRFD) provided in AISC N690-06 (AISC, 2006).
- Load combinations for masonry walls are based on ASCE 7-05 (ASCE, 2005a) and ACI 530-05 (ACI, 2005b).
- Masonry walls are designed using either the Allowable Stress Method or Strength Design Method in ACI 530-05 (ACI, 2005b).
- The allowable bearing pressure will be based on allowable settlement of equipment and building.

3.3.5 Codes and Standards for Structural Design

The following codes and standards are generally applicable to the structural design of the EREF:

- International Building Code (ICC, 2006)
- ASCE 7-05, Minimum Design Loads for Buildings and Other Structures (ASCE, 2005a)
- ASCE 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities (ASCE, 2005b)
- ACI 318-05, Building Code Requirements for Structural Concrete (ACI, 2005a)
- ACI 349-06, Code Requirements for Nuclear Safety Related Concrete Structures (ACI, 2006)
- ACI 530-05/ASCE 5-05/TMS 402-05, Building Code Requirements for Masonry Structures (ACI, 2005b)
- AISC Steel Construction Manual, Thirteenth Edition including ANSI/AISC 360-05, Specification for Structural Steel Buildings (AISC, 2005a)

- AISC Seismic Design Manual, including ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings (AISC, 2005b)
- ANSI/AISC N690-06, Specification for Safety-Related Steel Structures for Nuclear Facilities (AISC, 2006)
- PCI Design Handbook, Sixth Edition (PCI, 2004).

3.3.6 Process Systems Requirements

- The autoclave is designed to sustain seismic loading without a loss of integrity. The autoclave is held in place by anti-drop devices, the design of the "screw-nut" devices, pivots and rollers. In addition to the process components and other interior support equipment (e.g., walkways and bridges) are secured to ensure they do not become displaced and cause damage.
- The autoclave pressure vessel is designed and fabricated in accordance with the requirements of ASME, Section VIII, Division I (current edition at the time of autoclave manufacture), with the exception that the pressure relief devices specified in Section UG-125 through 137 are not provided due to the potential for release of hazardous material to the environment through a pressure relief device. Instead, two independent and diverse automatic trips of the autoclave heaters and fan motor are provided to eliminate the heat input and preclude approaching the autoclave design pressure.
- The Separations Building GEVS provides for continuous monitoring and period sampling of the gaseous effluent in the exhaust duct in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).
- The Separations Building GEVS is designed to meet all applicable NRC requirements for public and plant personnel safety and effluent control and monitoring. The system designs also comply with applicable standards of OSHA, EPA, and state and local agencies.
- The design and in-place testing of the Separations Building GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes potassium carbonate impregnated activated carbon filters for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated carbon filters for radioiodine removal are not applicable. The prefilter efficiency (65%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1 (ASME, 1997). The impregnated carbon filter efficiency (99%) for removal of HF is based on measurement of HF concentration upstream and downstream of the carbon filter. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001b). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001b). Qualification testing, to verify HF removal efficiency, of the impregnated carbon will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated carbon filter of carbon samples will be performed on an annual basis. Throughout the useful life of the impregnated carbon, the impregnate is progressively consumed. The laboratory testing will determine the impregnant content within the sample.

The amount of impregnant present in the sample is indicative of the remaining life of carbon filter for removal of HF.

- The TSB GEVS is designed to meet all applicable NRC requirements for public and plant personnel safety and effluent control and monitoring. The system design also complies with applicable standards of OSHA, EPA, and state and local agencies.
- The TSB GEVS provides for continuous monitoring and periodic sampling of the gaseous effluent in the exhaust vent in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).
- The design and in-place testing of the TSB GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes a potassium carbonate impregnated activated carbon filter for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997(ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated carbon filters for radioiodine removal are not applicable. The prefilter efficiency (65%) is based on testing in accordance with ASME AG-1-1997 (ASME. 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1 (ASME, 1997). The impregnated carbon filter efficiency (99%) for removal of HF is based on measurement of HF concentration upstream and downstream of the carbon filter. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001b). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001b). Qualification testing, to verify HF removal efficiency, of the impregnated carbon will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated carbon filter of carbon samples will be performed on an annual basis. Throughout the useful life of the impregnated carbon, the impregnate is progressively consumed. The laboratory testing will determine the impregnant content within the sample. The amount of impregnant present in the sample is indicative of the remaining life of carbon bed for removal of HF.
- The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System provides for continuous monitoring and periodic sampling of the gaseous effluent in the exhaust vent in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).
- The design and in-place testing of the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes a potassium carbonate impregnated activated carbon filter for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated carbon filters for radioiodine removal are not applicable. The prefilter efficiency (85%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1-1997 (ASME, 1997). The impregnated carbon filter efficiency (99%) for removal of HF is based on measurement of HF concentration upstream and downstream of the carbon filter. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001b). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001b). Qualification testing, to verify HF removal efficiency, of the impregnated carbon will be performed using ASTM

D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated carbon filter of carbon samples will be performed on an annual basis. Throughout the useful life of the impregnated carbon, the impregnate is progressively consumed. The laboratory testing will determine the impregnant content within the sample. The amount of impregnant present in the sample is indicative of the remaining life of carbon filter for removal of HF.

- The design and in-place testing of the Centrifuge Test and Post Mortem Facilities GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes potassium carbonate impregnated activated carbon filters for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001b), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated carbon filters for radioiodine removal are not applicable. The prefilter efficiency (65%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1-1997 (ASME, 1997). The impregnated carbon filter efficiency (99%) for removal of HF is based on measurement of HF concentration upstream and downstream of the carbon filter. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001b). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001b). Qualification testing, to verify HF removal efficiency, of the impregnated carbon will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated carbon filter of carbon samples will be performed on an annual basis. Throughout the useful life of the impregnated carbon, the impregnate is progressively consumed. The laboratory testing will determine the impregnant content within the sample. The amount of impregnant present in the sample is indicative of the remaining life of carbon filter for removal of HF.
- In response to Bulletin 2003-03 (NRC, 2003b), AES will not purchase UF_6 cylinders with the 1-in Hunt valves installed nor purchase any replacement 1-in valves from Hunt. In the unlikely event that any cylinders are received at the EREF with the 1-in Hunt valves installed, the following actions will be taken.
    - If the cylinder is empty, the valve will be replaced before the cylinder is used in the facility.
    - If the cylinder is filled, a safety justification to support continued use of the cylinder until the valve can be replaced will be developed or the valve will be replaced in accordance with EREF procedures.

  No cylinders with the 1-in Hunt valve installed will be used as depleted uranium tails cylinders.
- Cylinders are pressure tested using compressed nitrogen in accordance with ANSI N14.1-2001 (ANSI, 2001). This system is used for testing new and decontaminated empty cylinders only.
- For cylinders containing heels, the cylinder pressure and temperature complies with ASTM C-996-04 (ASTM, 2004) prior to use as a product cylinder.

3.3.7 Utility and Support Systems Requirements

- The applicable codes and standards for the Cylinder Evacuation System are reflected in Table 3.3-9.
- The applicable codes and standards for utility and support systems, except for the portions of the Cylinder Preparation Systems addressed in Table 3.3-9, are reflected in Table 3.3-10.
- Exhaust flow from the potentially contaminated rooms (i.e., Decontamination Workshop, Chemical Trap workshop, Mobile Unit Disassembly & Reassembly Workshop, Valve & Pump Dismantling Workshop and Maintenance Facility) of the TSB is filtered by a pre-filter, HEPA filter, activated carbon filter and HEPA filter and is then released through an exhaust vent. The exhaust flow is continuously monitored for alpha and HF. The exhaust air is periodically sampled. The continuous monitoring and periodic sampling is in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).
- The Electrical System design complies with the following codes and standards:
  - IEEE C2-2007, National Electrical Safety Code (IEEE, 2007a)
  - NFPA 70, National Electric Code (NFPA, 2008)
  - NFPA 70E, Standard for Electrical Safety Requirements for Employee workplaces (NFPA, 2004)
  - IEEE 80-2007, Guide for Safety in AC Substation Grounding (IEEE, 2000)
  - IEEE 81-1983, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System (IEEE, 1983b)
  - IEEE 142-2007, Grounding of Industrial and Commercial Power Systems (IEEE, 2007b)
- On a loss of electrical power, the systems associated with items relied on for safety (IROFS) will be designed such that the safety function is maintained or the feature fails-safe.
- The potential for hydrogen accumulation and explosion will be evaluated as part of final design. The number of batteries, battery type, and charge rate information is required to determine hydrogen generation potential. Once this information is known, the ability of the room or area housing the batteries to develop an ignitable mixture of hydrogen will be evaluated and will identify appropriate features required to prevent or mitigate the effects of hydrogen ignition.
- The ventilation control of hydrogen gas will be provided in accordance with National Fire Protection Association (NFPA) 70E–2004, Standard for Electrical Safety in the Workplaces, (NFPA, 2004) and the Institute of Electrical and Electronics Engineers (IEEE) C2-2007, National Electrical Safety Code (IEEE, 2007a).
- Based on the current level of design, battery control systems have been identified for use by the 13.8 kV switchgear systems. The control system requirements for the 480/440 V switchgear have not been fully developed. This system will require further definition during detailed design to determine the control power scheme to be utilized.
- The Communication and Alarm Annunciation Systems Design complies with the following Codes and Standards:
  - NFPA 70 – 2008. National Electric Code (NFPA, 2008)
  - NFPA 72 – 2007. National Fire Alarm Code (NPFA, 2007)
  - 29 CFR Part 1910.7. Occupational Safety and Health Standards (CFR, 2008e)

- IEEE C2 – 2007. National Electric Safety Code (IEEE, 2007a)

- The criticality safety for tanks that are not Items Relied on For Safety (IROFS) will utilize two independent IROFS for mass control. The two are referred to as "sampled and analyzed," e.g., tank contents are sampled and analyzed before being transferred to another tank or out of the system. The "bookkeeping measures" is a process to calculate the potential mass of uranium in the tank for any batch operation to ensure that no tank holds more than a safe mass of uranium. This calculated mass of uranium is then compared to a mass limit, which is based on the double-batching limit on mass of uranium in a vessel from the criticality safety analyses. The "bookkeeping measures" process is described in further detail below.
  - For the EREF, the "bookkeeping measures" are only applied to tanks where the mass of uranium involved, even when double batching error is considered, is far below the safe value. Bookkeeping measures are a documented running inventory estimate of the total uranium mass in a particular tank. The mass inventory for each batch operation is calculated based on the mass of material to be transferred during each batch operation and the mass inventory in the tank prior to the addition of the material from the batch operation.

  - There are two types of batch operations that are considered. The first type is liquid transfer between tanks based on moving a volume of liquid with uranic material present in the volume. The second is transferring a number of components into the tank with the uranic material contained within or on the components transferred in each batch operation. For both types of operations, the initial mass inventory is set after emptying, cleaning, and readying the tank for receipt of uranic material. For each batch operation, the amount of uranic material to be transferred during a particular batch operation is estimated. This quantity of material is then credited/debited to/from each tank as appropriate. A new mass inventory in each tank is calculated. The calculated receiving tank mass inventory is compared to the mass limit for the tank prior to the transfer.

  - For the second type, a transfer of a number of facility components into an open tank during a batch operation, the mass inventory on/within the components is estimated, and that mass credited to the receiving tank. The final mass inventory in the tank is calculated and the total is compared to the mass limit for the tank prior to the transfer. Open tanks associated with this system are located in the Decontamination Workshop.

- The Liquid Effluent Collection and Treatment System process piping is designed in accordance with the applicable provisions of American Society of Mechanical Engineers, ASME B31, Standards of Pressure Piping, revision in effect at time of detailed design. To provide system integrity and prevent leaks, welded construction is used everywhere practical.
- All collection tanks are designed in accordance with American Water Works Association (AWWA), American Petroleum Institute (API), or ASME Standards.
- UF_6 cylinders with faulty valves are serviced in the Ventilated Room. In the Ventilated Room, the faulty valve is removed and the threaded connection in the cylinder is inspected. A new valve is installed in accordance with the requirements of ANSI N-14.1 (ANSI, 2001).

3.4 REFERENCES

ACI, 1990. Standard Specification for Tolerances for Concrete Construction and Materials, ACI 117-90, Reapproved 2002, American Concrete Institute, 1990.

ACI, 2005a. Building Code Requirements for Structural Concrete, ACI 318-05, American Concrete Institute, 2005.

ACI, 2005b. Building Code Requirements for Masonry Structures, ACI 530-05/ASCE 5-05/TMS 402-05, American Concrete Institute, American Society of Civil Engineers, and The Masonry Society, 2005.

ACI, 2006. Code Requirements for Nuclear Safety Related Concrete Structures, ACI 349-06, American Concrete Institute, 2006.

AISC, 2005a. Steel Construction Manual, including ANSI/AISC 360.05, Specification for Structural Steel Buildings, Thirteenth Edition, American Institute of Steel Construction, 2005.

AISC, 2005b. AISC Seismic Design Manual, including ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings, American Institute of Steel Construction, 2005.

AISC, 2006. ANSI/AISC N690-06, Specification for Safety-Related Steel Structures for Nuclear Facilities, 2006.

ANSI, 1994. Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, ANSI/ANS-3.2-1994, American National Standards Institute, American Nuclear Society 1994.

ANSI, 2001. Uranium Hexafluoride - Packaging for Transport, ANSI N14.1 - 2001, American National Standards Institute, February 2001.

ASCE, 1996. U.S. Army Corps of Engineers Engineering Manual EM 1110-2-2908, Rock Foundations, Published with permission by the American Society of Civil Engineers, 1996.

ASCE, 2005a. Minimum Design Loads for Buildings and Other Structures, ASCE 7-05, American Society of Civil Engineers, 2005.

ASCE, 2005b. Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities and Commentary, ASCE 43-05, American Society of Civil Engineers, 2005.

ASME, 1989. Testing of Nuclear Air Cleaning Systems, ASME N510-1989, American Society of Mechanical Engineers, 1989.

ASME, 1994a. Quality Assurance Program Requirements for Computer Software for Nuclear Facility Applications, NQA-1 – 1994, Part II, Subpart Part 2.7, American Society of Mechanical Engineers, 1994.

ASME, 1994b. Supplementary Requirements for Computer Program Testing, NQA-1, Part I, Supplement 11S-2, American Society of Mechanical Engineers, 1994.

ASME, 1995. Quality Assurance Requirements for Nuclear Facility Applications, ASME NQA-1a-1995, American Society of Mechanical Engineers, 1995.

ASME, 1997. Code on Nuclear Air and Gas Treatment, ASME AG-1-1997, American Society of Mechanical Engineers, 1997.

ASTM, 2003. Standard Test Method for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon, ASTM D6646-03, American Society for Testing and Materials, October 2003.

ASTM, 2004. Standard Specification for Uranium Hexafluoride Enriched to Less Than 5 % ^{235}U, ASTM C-996-04,American Society for Testing and Materials, 2004.

Bowles, 1996. Foundation Analysis and Design, J.A. Bowles, 1996.

CFR, 2008a. Title 10, Code of Federal Regulations, Section 70.65, Additional content of applications, 2008.

CFR, 2008b. Title 10, Code of Federal Regulations, Part 70, Domestic Licensing of Special Nuclear Material, 2008.

CFR, 2008c. Title 10, Code of Federal Regulations, Section 70.61, Performance requirements, 2008.

CFR, 2008d. Title 10, Code of Federal Regulations, Section 70.62, Safety Program and Integrated Safety Analysis, 2008.

CFR, 2008e. Title 29, Code of Federal Regulations, Section 1910, Occupational Safety and Health Standards, 2008.

CFR, 2008f. Title 10, Code of Federal Regulations, Section 70.72, Facility Changes and Change Process, 2008.

CFR, 2008g. Title 10, Code of Federal Regulations, Section 70.4, Definitions, 2008.

CFR, 2008h. Title 10, Code of Federal Regulations, Section 70.64, Requirements for new facilities or new processes at existing facilities, 2008.

ICC, 2006. International Building Code, Internal Code Council, Inc., 2006.

EGG, 1990. Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs, EGG-SSRE-8875, EGG, February 1990.

EPRI, 1988. Electric Power Research Institute (EPRI) NP-5652, "Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Grade Applications," June 1988.

EPRI, 1996a. EPRI Topical Report (TR) -102323, "Guidelines for Electromagnetic Interference Testing in Power Plants," Revision 1, December 1996.

EPRI, 1996b. EPRI TR-106439, "Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications," October 1996.

IEEE, 1983a. Standard for Qualifying Class 1 E Equipment for Nuclear Power Generating Stations, IEEE-323, Institute of Electrical and Electronics Engineers, 2003.

IEEE, 1983b. IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System, Institute of Electrical and Electronics Engineers, 1983.

IEEE, 1989. IEEE C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus, Institute for Electrical and Electronic Engineers, 1989.

IEEE, 1992. IEEE 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, Institute for Electrical and Electronic Engineers, 1992.

IEEE, 1997. IEEE 485, Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, Institute for Electrical and Electronic Engineers, 1997.

IEEE, 2000. IEEE 80, Guide for Safety in AC Substation Grounding, Institute of Electrical and Electronics Engineers, 2000.

IEEE, 2002. IEEE C37.90.1, IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, 2002.

IEEE, 2002a. IEEE 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, Institute for Electrical and Electronic Engineers, 2002.

IEEE, 2002b. IEEE 484, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications, Institute for Electrical and Electronic Engineers, 2002.

IEEE, 2004. IEEE 946, Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations, Institute for Electrical and Electronic Engineers, 2004.

IEEE, 2007a. National Electrical Safety Code, IEEE C2-2007, Institute of Electrical and Electronics Engineers, 2007.

IEEE, 2007b. IEEE 142, Grounding of Industrial and Commercial Power Systems, Institute of Electrical and Electronics Engineers, 2007.

LES, 2005. Louisiana Energy Services (LES), National Enrichment Facility Safety Analysis Report, Revision 6, 2005.

NAVFAC, 1986a. Foundations and Earth Structures, NAVFAC DM-7.02, Naval Facilities Engineering Command Design Manual, 1986.

NAVFAC, 1986b. Soil Mechanics, NAVFAC DM-7.01, Naval Facilities Engineering Command Design Manual, 1986.

NFPA, 2004. Standard for Electrical Safety Requirements in the Workplace, NFPA 70E, National Fire Protection Association, 2004.

NFPA, 2007. National Fire Alarm Code, NFPA 72, National Fire Protection Association, 2007.

NFPA, 2008. National Electrical Code, NFPA 70, National Fire Protection Association, 2008.

NRC, 1983. Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, Final Report, NUREG/CR-1278, U.S. Nuclear Regulatory Commission, August 1983.

NRC, 1985. Monitoring and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Gaseous Effluents from Nuclear Fuel Processing and Fabrication Plants and Uranium Hexafluoride Production Plants, Regulatory Guide 4.16, Revision 1, U.S. Nuclear Regulatory Commission, December 1985.

NRC, 1997a. Regulatory Guide 1.169, "Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants," September 1997.

NRC, 1997b. Regulatory Guide 1.170, "Software Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants," September 1997.

NRC, 1997c. Regulatory Guide 1.172, "Software Requirements Specifications for Digital Computer Software Used in Safety Systems of Nuclear Power Plants," September 1997.

NRC, 1997d. Regulatory Guide 1.173, "Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants," September 1997.

NRC, 1999. Setpoints for Safety-Related Instrumentation, Regulatory Guide 1.105, U.S. Nuclear Regulatory Commission, Revision 3, December 1999.

NRC, 2001a. Integrated Safety Analysis Guidance Document, NUREG-1513, U.S. Nuclear Regulatory Commission, May 2001.

NRC, 2001b. Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units for Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants, Regulatory Guide 1.140, Revision 2, U.S. Nuclear Regulatory Commission, June 2001.

NRC, 2002a. Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, NUREG-1520, U.S. Nuclear Regulatory Commission, March 2002.

NRC, 2003a. Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites, Regulatory Guide 1.198, U.S. Nuclear Regulatory Commission, November, 2003.

NRC, 2003b. Potentially Defective 1-Inch Valves for Uranium Hexafluoride Cylinders, NRC Bulletin 2003-03, U.S. Nuclear Regulatory Commission, August 2003.

NRC, 2003c. Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems, Regulatory Guide 1.180, U.S. Nuclear Regulatory Commission, Revision 1, October 2003.

NRC, 2004a. Human Factors Engineering Program Review Model, NUREG-0711, U.S. Nuclear Regulatory Commission, Revision 2, February 2004.

NRC, 2004b. Regulatory Guide 1.168, "Verification, Validation, Reviews, and Audits for Digital Software Used in Safety Systems of Nuclear Power Plants," Revision 1, February 2004.

NRC, 2005. Safety Evaluation Report for the National Enrichment Facility in Lea County, New Mexico, NUREG-1827, U.S. Nuclear Regulatory Commission, June 2005.

NRC, 2006. Regulatory Guide 1.152, "Criteria for Digital Computers in Safety Systems in Nuclear Power Plants," Revision 2, January 2006.

PCI, 2004. Precast Concrete Institute Design Handbook: Precast and Prestressed Concrete, Sixth Edition, Precast Concrete Institute, 2004.

Peck, 1974. Foundation Engineering, Second Edition, Ralph B. Peck, Walter E. Hanson, and Thomas H. Thornburn, Publisher John Wiley & Sons, 1974.

SRP, 1998. Savannah River Site Hazard Analysis Generic Initiator Database, WSRC-RP-95-915, June 11, 1998.

Winterkorn, 1975. Foundation Engineering Handbook, H.F. Winterkorn and H.Y. Fang, 1975.

TABLES

Table 3.1-1 HAZOP Guidewords
(Page 1 of 2)

Parameter/ Guide Word	More	Less	None	Reverse	As well as	Partly	Other Than
Flow	More Flow	Less Flow	No Flow	Reverse Flow	Deviating Concentration	Contam ination	Deviating Material
Pressure	More Pressure	Less Pressure	Vacuum		Delta-P		Explosion
Temperature	More Heat	Less Heat			Different Temperature		
Level	High Level	Low Level	No Level		Different Level		
Time	More Time/Too Late	Less Time/ Too Soon	Sequence Step Skipped		Missing Actions	Extra Actions	Wrong Time
Agitation	Fast Mixing	Slow Mixing	No Mixing				
Reaction	Fast Reaction/ runaway	Slow Reaction	No Reaction				Unwanted Reaction
Start-Up/ Shut-Down	Too Fast	Too Slow			Actions Missed		
Ruptured Pipe	Large Quantity in Pipe	Small Quantity in Pipe	Nothing in Pipe	Leakage into Ruptured Pipe			
Leaking Pipe	Fast Leak	Slow Leak		Leakage Into Pipe			
Leaking Cylinder	Fast Leak	Slow Leak		Leakage Into Cylinder			
Ruptured Cylinder	Large Quantity in Cylinder	Small Quantity in Cylinder	Nothing in Cylinder	Leakage into Ruptured Cylinder			
Geometry	More Criticality Favorable						
External Facility Fires							
Tornadoes							
Seismic Event							

Table 3.1-1 HAZOP Guidewords
(Page 2 of 2)

Parameter/ Guide Word	More	Less	None	Reverse	As well as	Partly	Other Than
Construction Activities							
Flooding							
Airplane Crash							
Snow/Ice							
Pipelines							
Local Intense Precipitation							
Volcano							
Off-Site Transportation Related (tanker on public highway)							

Table 3.1-2 ISA HAZOP Table Sample Format
(Page 1 of 1)

Date:	Location:	Drawing No.	Rev.
Node # / Description:			

Guideword	Hazard	Causes	Consequences	Preventive Factors	Mitigative Factors	Comments / Actions

Table 3.1-3 Consequence Severity Categories Based on 10 CFR 70.61
(Page 1 of 1)

	Workers	Offsite Public	Environment
Category 3 **High Consequence**	Radiation Dose: RD > 1 Sievert (Sv) (100 rem) Chemical Dose: U: CD > AEGL-3 for UF_6 HF: CD > AEGL-3 for HF	Radiation Dose: RD > 0.25 Sv (25 rem) Chemical Dose: U: 21 mg sol U intake HF: CD > AEGL-2 for HF	-
Category 2 **Intermediate Consequence**	Radiation Dose: 0.25 Sv (25 rem) <RD ≤1 SV (100) rem Chemical Dose: U: CD > AEGL-2 for UF_6 HF: HF: AEGL-2 < CD ≤ AEGL-3 for HF	Radiation Dose: 0.05 Sv (5 rem) < RD ≤ 0.25 Sv (25 rem) Chemical Dose: U: 4.06 mg sol U intake HF: HF: AEGL-1 < CD ≤ AEGL-2 for HF	Radioactive release > 5000 x Table 2 Appendix B of 10CFR Part 20
Category 1 **Low Consequence**	Accidents of lower radiological and chemical exposures than those above in this column.	Accidents of lower radiological and chemical exposures than those above in this column	Radioactive releases with lower effects than those referenced above in this column

Table 3.1-4 Definition of Consequence Severity Category for Chemical Exposure
(Page 1 of 1)

	High Consequence	Intermediate Consequence
Worker	> 147 mg U/ m^3 > 139 mg HF/m^3	> 19 mg U/m^3 > 78 mg HF/m^3
Outside Controlled Area (30-min exposure)	> 13 mg U/ m^3 > 28 mg HF/m^3	> 2.4 mg U/m^3 > 0.8 mg HF/m^3

Table 3.1-5 Likelihood Categories Based on 10 CFR 70.61
(Page 1 of 1)

	Likelihood Category	Probability of Occurrence*
Not Unlikely	3	More than 10^{-4} per-event per-year
Unlikely	2	Between 10^{-4} and 10^{-5} per-event per-year
Highly Unlikely	1	Less than 10^{-5} per-event per-year

*Based on approximate order of magnitude ranges.

Table 3.1-6 Risk Matrix with Risk Index Values
(Page 1 of 1)

Severity of Consequences	Likelihood of Occurrence		
	Likelihood Category 1 Highly Unlikely (1)	**Likelihood Category 2 Unlikely (2)**	**Likelihood Category 3 Not Unlikely (3)**
Consequence Category 3 High (3)	Acceptable Risk 3	Unacceptable Risk 6	Unacceptable Risk 9
Consequence Category 2 Intermediate (2)	Acceptable Risk 2	Acceptable Risk 4	Unacceptable Risk 6
Consequence Category 1 Low (1)	Acceptable Risk 1	Acceptable Risk 2	Acceptable Risk 3

Table 3.1-7 Accident Sequence and Risk Index
(Page 1 of 1)

Accident Identifier	Initiating Event	Preventive Safety Parameter 1 or IROFS 1 Failure Index	Preventive Safety Parameter 2 or IROFS 2 Failure/ Index	Mitigation IROFS Failure Index	Likelihood Index T Uncontrolled (U) / Controlled (C)	Likelihood Category	Consequence Category (Type of Accident)	Risk Index (h=f x g) Uncontrolled (U) / Controlled (C)	Comments & Recommendations

Table 3.1-8 Determination of Likelihood Category
(Page 1 of 1)

Likelihood Category	Likelihood Index T* (=sum of index numbers)
1	$T \leq -5$
2	$-5 \leq T \leq -4$
3	$-4 < T$
*Note: $T = a + b + c + d$	

Table 3.1-9 Failure Frequency Index Numbers
(Page 1 of 2)

Frequency Index No.	Based on Evidence	Based on Type of IROFS**	Comments
-6*	External event with freq. < 10^{-6}/yr	N/A	If initiating event, no IROFS needed.
-5	Initiating event with freq. < 10^{-5}/yr	N/A	For passive IROFS that contain a safe-by-design component attribute with freq. < 10^{-5}yr components or systems, failure is considered highly unlikely when no potential failure mode (e.g., bulging, corrosion, or leakage) exists, as discussed in Section 3.1.1.3.2, significant margin exists*** and these components and systems have been placed under configuration management.
-4*	No failures in 30 years for hundreds of similar IROFS in industry	Exceptionally robust passive IROFS (PEC), or an inherently safe process, or two independent active engineered IROFS (AECs), PECs, or enhanced admin. IROFS	Rarely can be justified by evidence. Further, most types of single IROFS have been observed to fail.
-3*	No failures in 30 years for tens of similar IROFS in industry	A single IROFS with redundant parts, each a PEC or AEC	
-2*	No failure of this type in this facility in 30 years	A single PEC	
-1*	A few failures may occur during facility lifetime	A single AEC, an enhanced admin. IROFS, and admin. IROFS with large margin, or a redundant admin. IROFS	
0	Failure occur every 1 to 3 years	A single administrative IROFS	
1	Several occurrences per year	Frequent event, inadequate IROFS	Not for IROFS, just initiating events
2	Occurs every week or more often	Very frequent event, inadequate IROFS	Not for IROFS, just initiating events

Table 3.1-9 Failure Frequency Index Numbers
(Page 2 of 2)

*Note: Indices less than (more negative than) -1 should not be assigned to IROFS unless the configuration management, auditing, and other management measures are of high quality, because, without these measures, the IROFS may be changed or not maintained.

**Note: The index value assigned to an IROFS of a given type in Column 3 may be one value higher or lower than the value given in Column 1. Criteria justifying assignment of the lower (more negative) value should be given in the narrative describing ISA methods. Exceptions require individual justification.

***Note: For components that are safe-by-volume (IROFS 98), safe-by-diameter (IROFS 96), or safe-by-slab thickness (IROFS 97), significant margin is defined as a margin of at least 10%, during both normal and upset conditions, between the actual design parameter value of the component and the value of the critical design attribute. For components that require a more detailed criticality analysis (IROFS 99), significant margin is defined as $k_{eff} < 0.95$, where $k_{eff} = k_{calc} + 3\sigma_{calc}$.

Table 3.1-10 Failure Probability Index Numbers
(Page 1 of 1)

Probability Index No.	Probability of Failure on Demand	Based on Type of IROFS	Comments
-6*	10^{-6}	N/A	If initiating event, no IROFS needed.
-4 or -5*	$10^{-4} – 10^{-5}$	Exceptionally robust passive engineered IROFS (PEC), or an inherently safe process, or two redundant IROFS more robust than simple admin. IROFS (AEC, PEC, or enhanced admin.)	Can rarely be justified by evidence. Most types of single IROFS have been observed to fail.
-3 or -4*	$10^{-3} - 10^{-4}$	A single passive engineered IROFS (PEC) or an active engineered IROFS (AEC) with high availability	------
-2 or -3*	$10^{-2} – 10^{-3}$	A single active engineered IROFS, or an enhanced admin. IROFS, or an admin. IROFS for routine planned operations	------
-1 or -2	$10^{-1} – 10^{-2}$	An admin. IROFS that must be performed in response to a rare unplanned demand.	------
*Note: Indices less than (more negative than) -1 should not be assigned to IROFS unless the configuration management, auditing, and other management measures are of high quality, because, without these measures, the IROFS may be changed or not maintained.			

Table 3.1-11 Failure Duration Index Numbers
(Page 1 of 1)

Duration Index No.	Avg. Failure Duration	Duration in Years	Comments
1	More than 3 years	10	
0	1 year	1	
-1	1 month	0.1	Formal monitoring to justify indices less than -1
-2	A few days	0.01	
-3	8 hours	0.001	
-4	1 hour	10^{-4}	
-5	5 minutes	10^{-5}	

Table 3.3-1 UF_6 Feed System Codes and Standards
(Page 1 of 1)

The IROFS are designed, constructed, tested and maintained to QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the UF_6 Feed System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the UF_6 Feed System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the UF_6 Feed System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the UF_6 Feed System.
All process piping and mechanical components that contain UF_6 in the UF_6 Feed System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 48-in cylinders used in the UF_6 Feed System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-2 Cascade System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix B.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Cascade System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Cascade System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Cascade System.
All process piping and mechanical components that contain UF_6 in theCascade will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
The design of electrical systems and electrical components in the Cascade System will meet the applicable requirements of the National Fire Protection Association, National Electrical Code, NFPA 70 current edition in effect at detailed engineering. In addition, the electrical design will meet the appropriate industry codes and standards in effect at detailed engineering.

Table 3.3-3 Product Take-Off System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix B.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Product Take-Off System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Product Take-Off System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the Product Take-Off System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Product Take-Off System.
All process piping and mechanical components that contain UF_6 in the Product Take-Off System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 30-in and 48-in cylinders used in the Product Take-Off System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-4 Tails Take-off System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix B.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Tails Take-off System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Tails Take-off System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the Tails Take-off System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Tails Take-off System.
All process piping and mechanical components that contain UF_6 in the Tails Take-Off System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 48-in cylinders used in the Tails Take-off System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-5 Product Blending System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to the appropriate QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix C.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Product Blending System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Product Blending System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the Product Blending System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Product Blending System.
All process piping and mechanical components that contain UF_6 in the Product Blending System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 30-in and 48-in cylinders used in the Product Blending System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-6 Product Liquid Sampling System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to the appropriate QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix C.
Product Liquid Sampling Autoclaves and their supports are designed to meet the requirements of the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section VIII, Division I, current edition at the time of detail design.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Product Liquid Sampling System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Product Liquid Sampling System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the Product Liquid Sampling System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Product Liquid Sampling System.
All process piping and mechanical components that contain UF_6 in the Product Liquid Sampling System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 1.5-in, 30-in, and 48-in cylinders used in the Product Liquid Sampling System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-7 Dump System Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to the appropriate QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix B.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Dump System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Dump System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Dump System.
All process piping and mechanical components that contain UF_6 in the Dump System will meet the applicable requirements of American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.

Table 3.3-8 Gaseous Effluent Ventilation System Codes and Standards
(Page 1 of 1)

Equipment Type	Code or Standard
Filter Housings & Filters	NFPA 90A, 2002 AMC Pub. 99 – 2003 AMCA Pub. 261 – 1998 ASME AG-1-1997 DOE Handbook - 2003 ANSI/ASME N509 – 1989 ANSI/ASME N510 – 1989 ASME NQA-1 – 1994 ASTM D6646-03 ANSI/AWS-D9.1 – 2000
Fans/Motors	AMCA 210 – 1999 NEMA MG1 – 2006, Rev. 1
Dampers	ASME AG-1 - 1997

Table 3.3-9 Cylinder Evacuation Systems Codes and Standards
(Page 1 of 1)

The equipment IROFS are designed, constructed, tested and maintained to the appropriate QA Levels in accordance with the QAPD. IROFS design criteria are included in ISAS Section 3.8.1, IROFS. The design criteria for passive IROFS that contain a safe-by-design component attribute are included in ISAS Section 3.1.1.3.2 and ISAS Appendix C.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 rotating equipment in the Cylinder Evacuation System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 heat transfer equipment in the Cylinder Evacuation System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 or QA Level 2 material handling equipment in the Cylinder Evacuation System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 or QA Level 2 miscellaneous equipment in the Cylinder Evacuation System.
All process piping and mechanical components that contain UF_6 in the Cylinder Preparation Processes will meet the applicable requirements of the American Society of Mechanical Engineers, ASME B31 – Standards of Pressure Piping, revision in effect at the time of detailed design. The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for process piping and mechanical components which contain UF_6.
All 1.5-in, 30-in, and 48-in cylinders used in the Cylinder Preparation Processes comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.3-10 Codes and Standards
(Page 1 of 3)

ACI 318-05, Building Code Requirements for Structural Concrete, 2008.
ACI 349-06, Code Requirements for Nuclear Safety Related Concrete Structures, 2007.
AIChE, Guidelines for Hazard Evaluation Procedures, 2nd Edition, April, 1992.
AISC Manual of Steel Construction, Thirteenth Edition, 2005.
ANSI/AISC 360-05 – Specification for Structural Steel Buildings, 2005.
ANSI N14.1-2001, American National Standard for Nuclear Materials – Uranium Hexafluoride Packaging for Transport, 2001.
ASCE 43-05, Seismic Design Criteria for Structural Systems, and Components in Nuclear Facilities, 2005.
ASCE 7-05, Minimum Design Loads for Building and Other Structures, 2006.
ASME B31, Standards of Pressure Piping, revision in effect at the time of detailed design (The applicable provisions of ASME B31 will govern the material, design, fabrication, examination, testing and inspection for piping.)
ASME, Boiler and Pressure Vessel Code, Section VIII, Division 1, 2007.
ASTM C761-04 – Standard Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride, 2004.
ASTM E84-08a, “Standard Test Method for Surface Burning Characteristics of Building Materials,” 2008.
DOE, 2003. HDBK-1169-2003, Nuclear Air Cleaning Handbook, Department of Energy, 2003.
IEEE C2-2007, National Electrical Safety Code, 2007.
IEEE C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus, 1989.
IEEE C37.90.1, IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, 2002.
IEEE 80, Guide for Safety in AC Substation Grounding, 2000.
IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System, 1983.
IEEE 142, Grounding of Industrial and Commercial Power Systems.
IEEE 450, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, 2002.
IEEE 484, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications, 2002.
IEEE 485, IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, 1997.

Table 3.3-10 Codes and Standards

(Page 2 of 3)

IEEE 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, 1992.
IEEE 946, IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations, 2004.
ISO 668: 1995, Series 1 Freight Containers – Classification, Dimension and Ratings, 1995.
NFPA 10, Portable Fire Extinguishers, 2007.
NFPA 101, Life Safety Code, 2006.
NFPA 13, Installation of Sprinkler Systems, 2007.
NFPA 14, Standpipe, Private Hydrant and Hose Systems, 2007.
NFPA 20, Installation of Stationary Pumps, 2007.
NFPA 22, Water Tanks for Private Fire Protection 2008.
NFPA 220, Standard on Type of Building Construction, 2006
NFPA 221, Fire Walls and Fire Barrier Walls, 2006.
NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Methods, 2006.
NFPA 24, Private Fire Service Mains and Their Appurtenances, 2007.
NFPA 25, Water Based Fire Protection Systems, 2002.
NFPA 30, Flammable and Combustible Liquids Code, 2008.
NFPA 55, Compressed & Liquefied Gases in Cylinders, 2005.
NFPA 58, Liquefied Petroleum Gas Code, 2004.
NFPA 600 Industrial Fire Brigades, 2005.
NFPA 70, National Electric Code, 2008.
NFPA 704, Standard System for the Identification of the Hazards of Materials for Emergency Response, 2001.
NFPA 72, National Fire Alarm Code, 2007.
NFPA 780, Standard for the Installation of Lightning Protection Systems, 2008.
NFPA 80, Fire Doors and Fire Windows, 2007.
NFPA 801, Fire Protection for Facilities Handling Radioactive Materials, 2008.
NFPA 80A, Exterior Fire Exposures, 2007.
NFPA 90A, Installation of Air Conditioning and Ventilating Systems, 2002.

Table 3.3-10 Codes and Standards
(Page 3 of 3)

NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems, 2006.
NFPA 91, Exhaust Systems for Air Conveying of Materials, 2004.
NFPA 110, Standard for Emergency and Standby Power Systems, 2005.
NFPA 111, Standard on Stored Electrical Energy Emergency and Standby Power Systems, 2005.
NFPA 70E, Standard for Electrical Safety in the Workplace, 2004.
NFPA 1410, Standard on Training for Emergency Scene Operations, 2005
PCI Design Handbook – Precast and Prestressed Concrete, 6th Edition, 2004.
International Building Code (IBC), 2006.
International Fire Code (IFC), 2006.
International Mechanical Code (IMC), 2006.
International Fuel Gas Code (IGC), 2006.
International Energy Conservation Code (IECC), 2006.
Uniform Plumbing Code (UPC), 2003.