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LICENSEE: Louisiana Energy Services
National Enrichment Facility
Lea County, New Mexico

SUBJECT: SAFETY EVALUATION REPORT OF LOUISIANA ENERGY SERVICES AMENDMENT REQUEST FOR THE NATIONAL ENRICHMENT FACILITY TO PROVIDE AN ALTERNATE SOLE ITEM RELIED ON FOR SAFETY FOR MINIMIZING URANIUM HEXAFLUORIDE (UF_6) RELEASES AFTER A DESIGN BASIS EARTHQUAKE (LAR-08-07)

PROPOSED CHANGES

On May 28, 2008, Louisiana Energy Services (LES) submitted a License Amendment Request (LAR) to authorize changes in the applicability of Items Relied On For Safety (IROFS) for the Separations Building Modules (SBM) and the use of an alternate sole IROFS for minimizing Uranium Hexafluoride (UF_6) releases after a Design Basis Event (DBE). A revision to the Quality Assurance Program Description (QAPD) was submitted to apply QAPD Quality Level 1 (QL-1) program requirements to "items that are essential to the functions of IROFS" rather than to "items that affect the functions of IROFS." On September 30, 2008, the U. S. Nuclear Regulatory Commission (NRC) sent a Request for Additional Information (RAI), for clarification from LES on the approach to evaluating the impact on IROFS or other Structures, Systems and Components (SSCs). Additionally, a written commitment was provided by LES in the LAR specifying the management measures established to ensure compliance with the performance requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Section 70.61. LES responded to RAIs on October 21, 2008. This was followed by a revised LAR from LES to modify certain IROFS as well as apply a new IROFS (IROFS27e) with a graded Quality Level (QL-1G) to the SBMs.

BACKGROUND

The National Enrichment Facility (NEF) includes 3 SBMs, which each consists of two cascade halls, each hall housing a number of cascades connected in parallel producing a single product assay at any one time. Additionally, each SBM houses a UF_6 Handling Area and a Process Services Corridor. Process systems of the SBMs include:

- Centrifuge cascades and associated cascade piping in the cascade halls;
- Header piping and UF_6 system in the Process Services Corridor;
- Feed, product, and tails stations and associated UF_6 cold and chemical traps, piping, and valves in the UF_6 Handling Area; and
- Autoclaves and related equipment in the Blending and Liquid Sampling Area (BLSA).

ENCLOSURE

LES completed an evaluation of the design basis for the SBMs against credible UF_6 radiological and chemical hazards for external events. The design basis for the SBMs is to withstand natural phenomena events (e.g. seismic, tornadoes, high winds, etc.) that would result in high consequences to both the worker and the public. The original design basis of the SBMs to meet the 10 CFR 70.61 performance requirements was to withstand uncontrolled external events of magnitudes up to a highly unlikely event category of 10^{-5} per year. To achieve an acceptable risk category, SBM IROFS were established and detailed in the original Integrated Safety Analysis Summary for the NEF.

Consequence modeling was conducted by LES, which considered evaluation and credit of associated piping to retain gaseous UF_6 (and associated reaction products), to demonstrate an acceptable and achievable risk category. In responding to RAIs from NRC, LES proposed a revision in the October 23, 2008, LAR identifying the following changes:

- IROFS41 – Replace this IROFS with a new sole IROFS that credits the ability of piping systems to maintain integrity after a DBE. A revised consequence model using the Radiological Assessment System for Consequence Analysis (RASCAL) tool, demonstrating low public consequence, is the basis of this IROFS and was submitted for consideration. The RAI response further defined the role of IROFS41, stating the SBM structure was not integral to preventing the release of material during an earthquake. The requirement for SBMs is that they withstand the loading associated with a seismic event and do not collapse into the process systems and cause a release in excess of 10 CFR 70.61 performance requirements.
- IROFS26 – Eliminate this IROFS on the basis that post seismic leakage integrity function is transferred to piping.
- IROFS27a/b – Eliminate these IROFS based on criticality analyses demonstrating that criticality events in SBMs due to roof ponding or site flooding due to intense local precipitation are not credible.
- IROFS27c – Eliminate this IROFS and replace with IROFS 27e.
- IROFS27e – This IROFS is introduced for SBMs for seismic, tornado, high wind, roof snow load, roof ponding, and site flooding due to local intense precipitation. Design features of the SBMs are to withstand loadings from seismic, tornado, roof snow load, roof ponding, and site flooding from local intense precipitation. The IROFS ensures the SBMs withstand the loading associated with these events and prevents collapse. This IROFS is necessary to 1) preclude a release in excess of 10 CFR 70.61 limits if the building were to collapse and, 2) ensures that personnel can evacuate the SBMs during a seismic event under IROFS39a. This IROFS does not prevent water intrusion into the building, nor does it ensure tornado missiles do not penetrate the building.
- Revised IROFS28 – This IROFS requires the autoclaves be designed to withstand a DBE, including tornado missiles or that the autoclaves be protected from tornado missiles by shields or hardened structure.
- IROFS39a – This IROFS requires evacuation of workers from the SBMs during a seismic event to limit potential exposure of personnel to potential chemical hazards inside the building should process systems fail during the event.
- IROFS39d – This IROFS requires worker evacuation from the Centrifuge Test Facility (CTF) in the event of severe weather to protect workers from a chemical release associated with a severe weather event. This IROFS also applies to the SBMs for tornado conditions.

Credits assumed by these changes do not affect other hazards analyzed in the SBMs. While there is not significant difference between qualified piping as a part of IROFS41 and unqualified piping in the SBM (both are seismically analyzed), the qualified portion is (sole IROFS portion) credited to maintain "low" public consequence. Although other piping would survive a DBE, it is conservatively assumed to fail, which would result in an instantaneous release of Hydrogen Fluoride (HF) from the non-qualified portion of the system.

The original license commitment for the LES QAPD required all SSCs that affect IROFS to be QL-1. The May 28, 2008, LAR revised the QAPD to require QL-1 for IROFS and items that are "essential" to IROFS functions. The revision submitted October 23, 2008, retained these specifications, but established a "QL-1 Graded" quality level specifically for IROFS 27e. Design is performed under a QL-1 program. Construction activities, such as procurement of materials, fabrication, and erection, will use a QL-1 Graded program in which processes and controls are applied to the critical elements. Critical elements relate exclusively to the IROFS27e function of the building, i.e. withstand loading associated with external events.

REGULATORY REQUIREMENTS

Under 10 CFR 70.61, a licensee is required to evaluate in the Integrated Safety Analysis (ISA) compliance that the risk of high consequence events are highly unlikely, that the risk of intermediate consequence events are unlikely, and that the risk of nuclear criticality accidents be limited by assuring that under normal and credible abnormal conditions, all nuclear processes are subcritical.

Under 10 CFR 70.62, a licensee is required to establish and maintain a safety program including management measures that demonstrates compliance with the performance requirements of § 70.61.

Under 10 CFR 70.64, an applicant or licensee is required to apply baseline design criteria including quality standards and records to the design of new facilities and new processes, and to develop and implement the design in accordance with management measures.

Under 10 CFR Part 70.65, each application must include a description of the applicant's safety program and an Integrated Safety Analysis (ISA) summary including a description of the management measures

Under 10 CFR Part 70.4, management measures include configuration management, maintenance, training and qualifications, procedures, audits and assessments, incident investigations, records management, and other quality assurance elements.

GUIDANCE

The NRC staff conducted its safety review in accordance with NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility."

TECHNICAL DISCUSSION

Codes and Standards

LES proposes to eliminate IROFS27c from the SBMs and replace it with a new IROFS called IROFS27e for the SBMs. The new IROFS27e ensures that the SBMs withstand the loading associated with design basis external events and prevents collapse to: 1) preclude a release in excess of 10 CFR 70.61 limits if the SBM buildings were to collapse; and 2) ensure that workers can evacuate to limit potential exposure of personnel to chemical hazards inside the SBM buildings should UF6 process systems fail during the event. The IROFS27e will be designed to withstand the loading associated with seismic, tornado, high wind, roof snow load, roof ponding, and site flooding. The IRFOS27e requirement is only that the SBM buildings withstand the loads; i.e., the building does not collapse. It does not require that water ingress be prevented during local intense precipitation events or that tornado missiles be prevented from entering the building. LES has proposed IROFS27e to replace existing IROFS27c so that acceptable consequences for potential chemical releases, from SBMs, associated with the design basis events of seismic, high wind, roof snow load, roof ponding, and site flooding can be demonstrated with the new IROFS; several amended IROFS, such as IROFS28; and management measures.

The primary function for the new SBM IROFS27e is to ensure that SBMs will be able to withstand the loads associated with seismicity, tornado, high wind, roof snow, roof ponding, and site flooding without collapse. Collapse of the SBM structures may damage the IROFS process systems and consequently affect these systems' ability to meet the 10 CFR 70.61 requirements. To fulfill this function, LES is proposing changes to the SBM structural design requirements which provide greater flexibility in SBM building design but maintain sufficient conservatism such that the SBM buildings can withstand the specified design basis external events without collapse onto the UF6 process systems. The design and construction of the future SBM building structures will be in accordance with the New Mexico Building Code, International Building code, and accepted industry standards including American Institute of Steel Construction (AISC) Manual for Steel Construction and American Concrete Institute (ACI) 318. In addition, LES also proposes the following:

- Use the current American Society of Civil Engineers (ASCE) 43–05 design basis earthquake originally used for SBM IROFS27c for all SBMs;

- Design SBMs to remain elastic for loads associated with seismic, tornado, high wind, roof snow load, roof ponding and site flooding from intense local precipitation;

- Adopt load combinations for seismic and extreme wind loads in accordance with AISC N690 and ACI 349, as appropriate (the same as those used for the original SBM IROFS27c); and

- Follow the ASCE 4 and ASCE 7 guidelines to perform seismic and structural analyses of SBM buildings and use conservative design inputs in conducting the analyses

LES also proposes to keep the option of using ACSE 43–05 to design future SBMs and SBM-1001 expansion.

To assess the potential effects of tornado-generated missiles and water ingress after external events, LES proposes an after-event assessment management measure. The new SBM

IROFS27e will not protect the IROFS process systems from water ingress and tornado-generated missiles. In addition, the IROFS process systems and attached equipment will not be designed for impact of tornado-generated missiles either. Even though, the electrical equipment and panels associated with the IROFS process systems are located in National Electrical Manufacturers Association (NEMA) Type 4 enclosures to prevent water damage, the sensors mounted on the IROFS process systems and cabling may not be waterproof. To address these concerns, LES proposes an after-event walkdown measure to assess whether the functionality of the IROFS process systems is impaired. Appropriate actions will be taken based on the walkdown results.

Because SBM IROFS27e does not include protection of water ingress resulting from intense local precipitation and tornado-generated missiles, LES is proposing an after-event walkdown management measure to assess damage of the IROFS process systems in the SBMs with respect to the conditions of the related safe-by-design attributes. Based on the walkdown findings, LES will take appropriate action accordingly. The staff finds that an after-event walkdown management measure will be acceptable to assess IROFS process system damage if appropriate plans and procedures including sufficient specific measure details such as safe-by-design attributes to be examined along with damage threshold criteria are developed. LES consequence analyses assessing process IROFS damage caused by water ingress and tornado-generated missiles are reviewed elsewhere.

On the basis of the NRC staff's above review, the licensee has demonstrated: 1) the proposed codes and standards coupled with the proposed design approach provide sufficient design margin making collapse of SBMs highly unlikely; and 2) implementing an adequate walkdown management measure to assess functionality of the IROFS process systems after water ingress and tornado-generated missile impact should be sufficient to ensure safety. The staff reviewed design and construction codes and standards and design approaches LES proposes for the new SBM IROFS27e, for future SBMs, and potential expansion of SBM-1001. The NRC staff finds that the proposal is acceptable because design of SBMs in accordance with the proposed codes and standards and design approaches would ensure sufficient capacity to resist structural collapse. The NRC staff finds the licensee provides reasonable assurance that amended IROFS will ensure compliance with the performance requirements of 10 CFR 70.61 from a structural compliance perspective.

Radiation Protection

The amendment request seeks to modify IROFS used to mitigate the consequences of an event caused by a Design Basis Event (DBE) such as an earthquake, tornado, or strong winds. The licensee's amendment seeks to move the safety function of the IROFS from the building structure of the SBMs to the internal piping, The amendment states the cascades and piping in this portion of the facility will retain sufficient material to ensure a DBE remains low consequence. LES modified IROFS41 to ensure the process equipment in the Cascade Halls is seismically qualified not to fail during a DBE. Assumptions include: 1) piping in the building fails resulting in a corresponding release of material and 2) estimated to remain intact, but release a percentage of material through leaks at the IROFS boundary. No credit is taken for the building or the HVAC system.

Licensee calculations indicate of the UF_6 in the Cascade Halls will escape from leaks in the first 30 minutes. The combination of this material with of the UF_6 released throughout the rest of the SBMs is not sufficient to exceed the low consequence event threshold for workers or a member of the public. The licensee's

calculations demonstrate that of the material in the Cascade Halls could be released before an intermediate consequence would occur. This was confirmed by the NRC staff using RASCAL (software version v3.0.5). These calculations assumed conservative meteorological conditions of 0.6 meter/second (m/s) wind speed and stability class F. Exposures which occurred during strong winds or a tornado would be reduced due to rapid dispersion of material.

The modified IROFS41 limits the risk to workers more than the previously approved IROFS. The original IROFS41 indicated a low consequence to workers when all the UF_6 was released into the SBM. Under the revision, of the UF_6 would remain in the cascade equipment, further reducing potential consequences to workers.

Removal of IROFS26 allows the HVAC system in the SBMs to operate in recirculation mode rather than be shut down after a DBE. Buildup of material in the HVAC system further limits the release of material to the environment. The licensee removes IROFS27a/b because criticality events in SBMs, due to roof ponding and site flooding due to local intense precipitation are not considered credible. This change does not affect radiation protection.

The NRC staff reviewed the licensee's submittal for modifying IROFS 26, 27, and 41. Based on the evaluation, the staff finds that for Radiation Protection, the modified IROFS make all credible intermediate consequence accidents unlikely, and all credible high consequence accidents highly unlikely. The NRC finds the licensee provides reasonable assurance that amended IROFS will ensure compliance with the performance requirements of 10 CFR 70.61 and are consistent with the radiation protection program requirements of 10 CFR 19, 20, 30, 40, and 70.

Chemical Safety

LES's calculation of the size of a UF_6 release that would result in a low consequence at the site boundary was reviewed. The calculation was performed using an iterative approach and the RASCAL software. Assumptions include: 1) loss of the entire inventory of UF_6 in the Centrifuge Assembly Building (CAB), , the Blending and Liquid Sampling Areas (BLSA); and 2) no loss of liquid UF_6 from the autoclaves based on IROFS28, a design feature to ensure the integrity of the autoclaves for a tornado missile or seismic event. LES determined a site-wide release of 336 kilograms (kg) of UF_6, under conservative meteorological conditions of 0.6 meter/second (m/s) wind speed, stability class F, and no precipitation results in a low consequence at the site boundary. For purposes of evaluating potential consequences to the public, LES uses the terms "site boundary," "controlled area boundary," and "fence line" interchangeably. The RASCAL calculation using the source term to dose model was independently verified by NRC staff . Table 2-1 of the LAR provides a summary of the site-wide release by building location and shows, for a low consequence event at the site boundary, the contribution from the must be to meet the regulatory requirements. Staff review found the modeling approach LES used in estimating the quantity equivalent to a low consequence event is reasonable and conservative.

LES's calculation of the fraction of HF released from the cascade piping after a seismic event was reviewed. The release was modeled using from Chapter 25, "Ventilation and Infiltration," of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 1997 Handbook-Fundamentals. Assumptions include: 1) the portion of the piping within the cascade halls, as well as the centrifuges, would remain intact because the cascade halls are designed to withstand a DBE, thereby

retaining gaseous UF_6 and UF_6 reaction products; and 2) leakage occurs at the , where the piping would potentially be severed during a seismic event. LES estimated the fraction of UF_6 and its reaction products that can leak out of the piping at the interface defined by the , within 30 minutes, is . The fraction released during a seismic event is less than the fraction equivalent to a low consequence event . NRC staff concludes this is an adequate margin of safety to account for uncertainty in the modeling, and that releases from the seismic event would result in a low consequence to the public.[1]

Facility operations at SBM 1001 will begin while construction continues on other portions of the site. LES performed an analysis of the potential for consequences during a seismic event to workers, including construction workers, who may be working outside the SBM or inside other buildings. Construction workers are considered to be facility workers and are provided training and are included in event notification and emergency evacuation. IROFS41 credits the ability of piping systems in the to maintain integrity after a DBE. IROFS28 requires that the autoclaves be protected from tornado missiles by shields or hardened structure, and IROFS27e ensures the SBMs withstand the loading associated with these events and prevents collapse. LES found that a mitigated release of of UF_6, under standard meteorological conditions of 4 m/s wind speed and stability Class D would result in low consequences to workers outside the SBM. RASCAL software was used and the analysis credited IROFS27e, IROFS28, and IROFS41. NRC staff independently verified the RASCAL calculation using the source term to dose model.

LES evaluated the consequences to the public from a UF_6 release offsite due to a tornado event. The calculation was performed using RASCAL software and was independently verified by NRC staff. The source term included all gaseous UF_6 from the handling area and cascade halls, any gas that pours out of breached vessels containing solid UF_6, and any liquid UF_6 that flashes to gas from unprotected autoclaves. The licensee determined a release of of UF_6, under two sets of meteorological conditions (6.7 m/s wind speed and stability Class B, and 0.6 m/s wind speed and stability class F) would result in intermediate consequences at the site boundary. A calculation for a mitigated release was also completed by the licensee and verified by NRC staff finding that a release of 0.514 kg/s would result in low consequences at the site boundary.

To reduce consequences to the public to low from a seismic event, the passive engineering controls of IROFS27e, IROFS28, and IROFS41 are applied. The systems to be seismically qualified for IROFS41 are based on previously described consequence analysis and are identified as the , and associated supports.

In evaluating consequences to workers from a seismic event, LES assumed that consequences to workers will be high and identified an existing administrative control, IROFS39a, to be applied to the SBM to reduce the consequences to low. IROFS39a requires evacuation of workers from the SBMs during a seismic event to limit potential exposure of personnel to potential chemical hazards inside the building should process systems fail during the event. IROFS27e, IROFS28, and IROFS41 are credited for assessing consequences to construction workers and other workers located outside of the SBM, as well as for public assessment.

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[1] Atmospheric transport and dispersion models generally perform within an uncertainty factor of 2-3 (U.S. NRC, Nuclear Fuel Cycle Facility Accident Analysis Handbook, NUREG/CR-6410, 1998, pp. 5-80 to 5-82).

To reduce the consequences to the public to low from a chemical release due to a tornado or high wind event, IROFS28 is identified as a passive control. A combination of IROFS28 and an administrative control, IROFS39d, are applied to reduce consequences to workers to low. IROFS39d requires worker evacuation from the Centrifuge Test Facility (CTF) in the event of severe weather to protect workers from a chemical release associated with a severe weather event.

The NRC staff reviewed the licensee's submittal for modifying IROFS 26, 27, and 41. Based on the evaluation, the staff finds that for Chemical Process Safety, the modified IROFS make all credible intermediate consequence accidents unlikely, and all credible high consequence accidents highly unlikely. The NRC finds the licensee provides reasonable assurance that amended IROFS will ensure compliance with the performance requirements of 10 CFR 70.61 for chemical consequences to workers and the public.

Criticality Events

IROFS26 and IROFS41 consisted of building dampers and building design credited to mitigate the release of UF_6 from the SBMs following a seismic event. Modification of these IROFS removes the requirement to trip the fan and damper on the building HVAC system, such that the system will continue to operate in recirculation mode after a release. LES provided the following analyses to support its assertion that criticality following a seismic event is not credible:

- "Risk of Nuclear Criticality Induced by a Seismic Event Affecting the NEF Cascade System," and
- "Risk of Criticality Induced by a Seismic Event Affecting NEF."

The basis for concluding that criticality is not credible following a seismic event is that the amount of material available is less than a minimum critical mass. LES calculated that a minimum of 20.1 kg U would be required before criticality is possible (corresponding to a $k_{eff} + 3\sigma < 0.95$), for a uniform aqueous solution at an enrichment of 6 weight percent (wt%) ^{235}U. The amount needed at 2wt% ^{235}U is 180 kg U. The NRC staff confirmed the plausibility of these mass values by comparing LES' calculated results with tables in Nuclear Criticality Safety in Operations With fissionable Materials Outside Reactors, ANSI/ANS-8.1-1998. These values assume the material consists of a sphere of optimally moderated UO_2F_2 and water, fully reflected by water, and therefore is conservative relative to realistic configurations. UF_6 reacts vigorously with water to form UO_2F_2 and HF, and the formation of UO_2F_2 would tend to spread out over a wide area, and tend to be very dry. Following a release of this amount of material, significant quantities of liquid water and a mechanism for consolidating the material into a compact geometry would be required before criticality would be achievable. While conceivable that cooling water pipes or other sources of water could breach during a seismic event, though a simultaneous local intense precipitation event is considered extremely unlikely, such a breach would have to occur near the vicinity of the UF_6 release. An unfavorable geometry accumulation point would also be required, and the solution formed would have to wash into it. The staff qualitatively considers this combination of events to be very unlikely.

Additional conservatism is noted in the assumed enrichment of 6wt% ^{235}U, as the maximum product that can be withdrawn is at 5wt% ^{235}U. The staff notes LES assumed that in a release, the average enrichment would not exceed 1.5wt% ^{235}U. Consideration that the release could occur anywhere in the cascade, from the area of highest to lowest enrichment, can not be discounted. The only area where a lower enrichment is relevant is the contingency dump

system, which is limited to less than 1.5wt% ^{235}U. Given the quantity of material that could be released at 6wt% ^{235}U, even if the minimum critical mass were present, achieving a critical configuration would be very unlikely. Geometric considerations may likely be different if significantly larger quantities of UF_6 were present.

The inventory of UF_6 that would be available following a seismic event was reviewed. The SBMs are divided into three areas: the cascade halls, the UF_6 handling area, and the BLSA. For the cascade halls, LES determined the inventory in the two SBM cascade halls is 274.7 kg UF_6 in Section 2.6 of Enclosure 2 to the NEF LAR dated October 23, 2008. Assuming an atmospheric release fraction (ARF) of , LES determined that the total amount of UF_6 that could be released would be 18.6 kg U, less than a minimum critical mass. The reviewer noted that if all of the material were released, the amount released would exceed a minimum critical mass. The ARF was used by LES in both its baseline ISA documentation (AREVA Document 32-2400503-00, "ISA Consequence Assessments for Airborne Releases") and its . The process is under negative pressure, and the expectation is that moisture will initially enter the breached equipment and react with UF_6 to form UO_2F_2 and HF. UO_2F_2 particulates are dense and would tend to settle quickly both inside and immediately outside the breached equipment. The NRC staff independently evaluated the chemical and radiological consequences from such an event, based on the document "NEF Accident Analysis Documentation" . The staff estimated the source term based on the NRC model for control room habitability as described in NUREG/CR-5659, SAIC-90/1054 1A, 1B, "Control Room Habitability System Review Models." This model does not use the ARF as a parameter, but an implied ARF can be determined through calculation. The NRC staff analysis found the value to be . The LES assumed value of , and is considered to be conservative. Additional information is supplied in Attachment 3 to the October 23, 2008, LAR that further sets forth rationale why criticality would be extremely unlikely even if more than a minimum critical mass were available for release: 1) the inventory of UF_6 is divided among a large number of centrifuges, each of which contains, only at most, a few grams of UF_6; 2) the UF_6 cascade is operated at sub-atmospheric pressure, which will (at least until the cascade pressure equalizes) limit the amount of material that can be released; and 3) the nature of the process is such that the intrusion of even a small quantity of air and water into the cascade would cause it to cease functioning, which would stop the flow of gas in the vicinity of the breach. For these reasons, the amount of material that can realistically be expected to be released is much less than the total inventory. Even if the total inventory were released, achieving a critical condition would still be very unlikely for the reasons stated above. Consequently, there is no criticality concern with such a release from the cascade.

For the UF_6 handling area and BLSA, the maximum amount of UF_6 held up in process piping is 18.8 kg, which is less than the minimum critical mass for UF_6 at 6wt% ^{235}U and even less than the minimum critical mass at 5wt% ^{235}U, which is 26.6 kg U according to the license application, Table 5.1-1. Cylinders and traps in these areas contain a much larger inventory of UF_6, and a release from them could exceed the minimum critical mass. LES states that the holdup capacity of a single filter unit is only 10 kg UF_6, per the manufacturer's specification. This limitation makes it not credible to accumulate even a single minimum critical mass on a single filter unit. Criticality from a release of UF_6 from cylinders and traps is also very unlikely due to the integrity of cylinders and to the additional conditions that would be needed for criticality following a release. The staff therefore concludes that there is a negligible criticality concern with such a release from the UF_6 handling area or BLSA.

IROFS27a and IROFS27b consist of building passive design features to protect against SBM facility roof ponding and flooding due to local intense precipitation. LES performed analyses to

demonstrate that processes within the facilities would remain subcritical even when flooded with up to 60 cm of water, providing the basis for removal of these IROFS. LES provided the following analyses in the LAR to demonstrate these conclusions:

- ETC4040101, "Criticality Calculation for Crashed TC-12 Machines in Flood—Partial Filled Bores," Issue 1, June 26, 2008;
- ETC4039881, "Criticality Calculation for Crashed TC-12 Machines in Flood—Completely Filled Bores," Issue 1, June 18, 2008; and
- 32-9035369-000, "NEF Criticality Assessment under Flooded Conditions," September 28, 2007.

Criticality calculations ETC4040101 and ETC4039881 addressed failed centrifuge machines partially or completely filled with a mixture of uranyl fluoride and water, at a Hydrogen-to-Uranium Ratio (H/U) of 7. LES justified this H/U value based on experimental studies and stoichiometric considerations. Experimental studies showed that solid hydrates of $UO_2F_2 \cdot 1.5H_2O$ form in the presence of water vapor, for an H/U of 3. The additional hydrogen was added by assuming all the 4 moles of HF produced in converting one mole of UF_6 to UO_2F_2 were retained as water in the hydrate. The resulting solution is not optimal in terms of moderation, but contains a very large quantity of liquid water. In addition to a rising flood level up to 60 cm high, LES modeled a 2.5-cm layer of external water around the outsides of the failed machines as a "spurious" reflector. This analysis concluded that exceeding $k_{eff} + 3\sigma < 0.95$ requires 15 completely filled bores, or at least 2,000 kg of UF_6 in partially filled bores. The staff reviewed these two calculations and determined they were extremely conservative. Achieving these conditions would require the accumulation of a vast amount of fissile material and moderator simultaneously in a large number of centrifuge machines which are individually safe-by-design. Because the centrifuge machines contain at most a few grams of UF_6 under normal conditions, the process is dry, and the gas is in a strongly fluorinating environment, the staff therefore considers the likelihood of a criticality in the enrichment cascade due to such flooding to be extremely remote.

Criticality calculation 32-9035369-000 reanalyzed other fissile-bearing systems with the SBMs under conditions of a rising flood level up to 60 cm high. The systems evaluated consisted of 30B and 48Y product cylinders, networks of generic process pipes (diameter), process pipes covered by specific analyses, product vent pumps, uranic residue in 12-liter and 6-liter bottles, product traps, temporary pump storage, large pumps, product cold traps, hydraulic bench area, 14-liter pumps, Fomblin oil recovery, and 1S sample bottle arrays. Some of these are actually less reactive when flooded, depending on the importance of neutron interaction between equipment. The staff selected the case of a 6x6 array of 30B cylinders in contact with a single 48Y cylinder for confirmatory analysis (Section 5.2.2 of the third analysis above). LES performed its calculations using the MONK8A Monte Carlo criticality code. The staff independently modeled the cylinder array using the KENO-VI module of the SCALE-5.1 code. The staff determined the licensee's model included very conservative assumptions, including: 1) assuming a maximum of 8.5 kg of water inside the 30B cylinders and 9.5 kg of water inside the 48Y cylinder; 2) assuming the water was contained inside spheres of wet material placed as close as possible to the spheres in adjacent cylinders; and 3) in addition to a layer of flood water, the space between the cylinders was filled with water mists of varying densities. The staff confirmed that such an array remains subcritical if flooded with up to 60 cm of water. There is additional conservatism resulting from assuming 6wt% ^{235}U enrichment, even though plant systems are limited to a maximum of 5wt% ^{235}U. The reviewer recalculated at 5wt% ^{235}U and determined that assuming the higher enrichment resulted in a change of approximately 3.4% in k_{eff} and selected this system for confirmatory analysis because of the

relatively large quantity of UF_6, which should be sufficient to bound other plant systems. Based on this, the staff has reasonable assurance the licensee's methodology is sufficiently conservative.

LES determined that the remaining systems listed above would be subcritical under flooding up to 60 cm. In response to the staff's RAIs, LES stated that in the final design, the diameter pipework will be routed above the centrifuge machines (at least 20 feet above floor level). Therefore, the optimum moderation and full water reflection of this pipework is not credible. LES also stated that the vacuum pump/chemical trap set is subcritical ($k_{eff} + 3\sigma < 0.95$) for all conditions provided that vacuum cleaners to be used in the process have volumes limited to less than 7 liters. The configuration of these vacuums will be controlled by making them safe-by-design components, and as LES has stated, it is unlikely that they would be used for cleanup of breakdown products during severe weather that is at risk of flooding the buildings. If the vacuums are not present, these systems will remain subcritical when flooded up to 60 cm.

To justify the maximum flood level of 60 cm, LES submitted the following analyses as :

- " ;" and
- " ."

Enclosure justified selection of the probable maximum precipitation (PMP) based on the National Oceanic and Atmospheric Administration Hydrometeorological Report No. 52. The reviewer examined this report and confirmed that LES' assumptions for the PMP were consistent with known hydrometeorological data.

Enclosure contained the results of calculations performed using the US Army Corps of Engineers' Hydrologic Engineering Center (HEC) HEC-1 program, as well as use of the Manning Equation for the flow speed of water in an open channel. Other NRC staff knowledgeable in surface hydrology, and the Center for Nuclear Waste Regulatory Analyses, were consulted and reviewed the analysis. HEC-1 is a widely recognized program using standard hydrological modeling techniques, and was validated using the distributed test cases. The reviewer did not review the workings of this program in detail, but did confirm some of the analytical formulas used, including the Manning Equation. The staff determined that the methodology's assumptions and input parameters were sufficiently conservative. Conservative assumptions included: 1) using conservative rainfall assumptions (for total rainfall, based on the PMP, and time distribution of rainfall intervals); 2) taking a 0.4-inch allowance for any depression storage; 3) assuming overland rather than channel flow; and 4) assuming a conservative slope and Manning roughness coefficient (for floodplains with light brush in summer). LES then used the Manning Equation to conservatively determine the flow speed, which it multiplied by the channel cross-sectional area to determine a flow rate. Because flow rate is a function of the depth of the water, LES compared this flow rate to the results from the HEC-1 program, and then iteratively varied the depth until the flow rates in the two models were consistent. The criticality reviewer and the other staff determined that the assumptions were conservative and the methodology was sound. The result of LES' calculation was that it determined the maximum flood level to be 1.6 feet. Therefore, assuming a flood level of 60 cm (~2 feet) in the SBM criticality calculations is appropriately conservative.

The staff determined that the assumptions used in the hydrological model, particularly the details of the surface topography—slope, area of the drainage basin, width of the watershed

outlet, elevation of the east and west forks of the outlet, sub-surface depressions, roughness, etc., were not listed as IROFS or otherwise controlled. The staff had concerns that future changes to the surface topography, both within the controlled area and off-site (but within the drainage basin) could invalidate the assumptions in the hydrological model. To address this concern, LES committed in its letter dated December 23, 2008 (ML083640180):

> "NEF/LES will review the topography of the NEF/LES site and surrounding relevant area, out to the boundaries of the drainage basin, for any natural or manmade changes. This review will be performed every five years unless significant topography changes are identified between reviews. In the event of changes that could affect the calculation of the maximum probable flood level, NEF/LES will re-evaluate its flooding analysis to ensure that all Separation Building Modules (SBM) abnormal condition calculations are still bounding."

This commitment will be documented by LES in the SAR, which ties it to license condition 10. Given the conservative nature of the hydrological model, it appears that very gross changes would have to occur to invalidate the assumed maximum flood level. Additionally, because of the conservative nature of the assumptions and low likelihood of such a significant rainfall, the five-year review period is considered acceptable. Changes on-site that are initiated by LES would be subject to the requirements of 10 CFR 70.72, so their impact would be evaluated earlier than for those occurring off-site. Significant off-site changes would also most likely come to the attention of LES and therefore be evaluated sooner than once every five years. The staff acknowledges that some judgment must be exercised to determine what constitutes a "significant" change in topography, and considers significant changes to be those that can reasonably be expected to affect the calculation of the maximum probable flood level in a non-conservative direction. In the event that changes in topography occur such that the abnormal condition calculations are not bounding (i.e., such that the maximum flood level can exceed 60 cm), modification to the process will be required if the subcriticality requirement cannot be met (i.e., if $k_{eff} + 3\sigma > 0.95$).

The staff has reasonable assurance that the removal of IROFS26 and the modification of IROFS41 will not result in criticality following a seismic event, due to the inventory of material available and low likelihood of achieving the needed geometry, moderation, and reflection. The staff also has reasonable assurance that the removal of IROFS27a/b and IROFS27c will not result in criticality following local intense precipitation. LES has evaluated the systems in the SBM buildings and shown that they will remain subcritical (i.e., with $k_{eff} + 3\sigma < 0.95$) for flood levels up to 2 feet. LES showed that the maximum probable flood level will be no more than 1.6 feet based on a conservative hydrological model. While the topographical assumptions that go into this calculation have not been controlled as IROFS, the conservative nature of the calculations and low likelihood of a bounding rainfall provide reasonable assurance of safety, provided the topography is subject to review once every five years.

The NRC staff reviewed the licensee's submittal for modifying IROFS 26, 27, and 41. Based on the evaluation, the staff finds that for Nuclear Criticality Safety, the modified IROFS make all credible intermediate consequence accidents unlikely, and all credible high consequence accidents highly unlikely. The NRC staff finds the licensee provides reasonable assurance that amended IROFS will ensure compliance with the performance requirements of 10 CFR 70.61 from a criticality safety perspective.

Quality Assurance

The NRC staff reviewed the LAR proposed revisions to management measures and commitments using the acceptance criteria outlined in Section 11.4.3 of the Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, NUREG-1520 (NRC, 2002).

LES provided a complete description of its proposed management measures changes, focusing on changes to the application of other Quality Assurance (QA) elements as described in the QAPD and conforming changes to other management measures, including configuration management, maintenance, training and qualifications, and audits and assessments.

The QAPD is revised to include an additional Quality Level 1 Graded (QL-1G) program to apply exclusively to IROFS27e structures in a manner commensurate with the IROFS importance to safety. IROFS27e ensures that SBMs withstand loading associated with design basis external events and prevents collapse. IROFS27e structures are those structures whose failure during a seismic, tornado, or other extreme loading condition could result in consequences that exceed the 10 CFR 70.61 performance requirements.

The licensee's QL-1G program identifies, during the design phase, the critical elements needed to assure the safety function of IROFS27e and ensures these critical elements are included and controlled throughout the design, procurement, and construction phases. The implementation and maintenance of the critical elements during operations will be assured by design control and configuration management, as well as other management measures. A project QA plan will be prepared to provide a documented basis for the responsibilities and requirements of the QL-1G program and will include specific provisions to assure that the critical elements, defined during the design phase, are controlled to provide reasonable assurance that the "as-built" structure will perform its safety function.

The QL-1G program commitments and description address the appropriate QA criteria in the same order as the LES QAPD. The licensee's proposed QL-1G program describes the organization and QA criteria commitments specific to the QL-1G IROFS. For the QA criteria of design control, the licensee's requirements and implementation are in accordance with the QL-1 program, applicable to all other IROFS and items essential to the safety function of IROFS, as described in Section 3 of the QAPD. Specific QL-1G program commitments are described for the QA criteria of procurement document control, instructions, procedures, drawings, control of purchased material, equipment and services, parts and components, inspections, handling and storage, and shipping. The QL-1G program will be in accordance with the QL-1 program requirements of the QAPD for the QA program criteria of control of special processes, test control, measuring and test equipment, inspection, test and operating status, nonconforming items, corrective action, QA records, audits, and provisions for change. The QL-1G program commitments adequately address QA management measures in an appropriate graded manner in proportion to the importance of the item to the achievement of safety.

Changes were also proposed to various SAR, QAPD, and related management measure commitments to apply QL-1 program requirements to "items that are essential to the functions of IROFS" rather than to "items that affect the functions of IROFS." LES commits to establish management measures to ensure compliance with the performance requirements of 10 CFR 70.61. The measures applied to a particular engineered or administrative control or control system may be graded commensurate with the reduction of the risk attributable to that control or control system. The QA management measure commitment to apply the QL-1 program

requirement to IROFS and items that are essential to the function of an IROFS would apply the management measures to IROFS in a manner commensurate with the IROFS importance to safety and its safety function.

Based on the staff review of proposed changes to management measures, commitments in the NEF SAR, QAPD, and other conforming documents, the staff concludes that the licensee has provided adequate information to ensure that the management measures applied to LES IROFS provide adequate assurance that the IROFS will be available and reliable. The staff also concludes that the licensee has provided adequate commitments for the application of baseline design criteria including quality standards and records to the design of new NEF structures, and to develop and implement the design in accordance with management measures. The NRC staff reviewed the licensee's submittal for modifying IROFS 26, 27, and 41. Based on the evaluation, the staff finds that the management measures applied make all credible intermediate consequence accidents unlikely, and all credible high consequence accidents highly unlikely. The NRC staff finds that the proposed revisions to the LES NEF SAR, QAPD, and other conforming documents are acceptable, and consistent with the performance requirements of 10 CFR Part 70.61.

Emergency Plan

The NRC staff reviewed the NEF Emergency Plan, Revision 6, dated January 28, 2008, to ensure consistency between the chemical process safety program and the emergency plan. LES clarified in response to an RAI that all workers at the NEF are trained in the characteristics and potential hazards of facility processes and materials. All workers onsite (i.e., inside the site boundary), including LES employees and construction workers, will be trained regarding chemical and radiological hazards during operations. Based on the review, the NRC staff finds reasonable assurance is provided that measures to mitigate the consequences of accident sequences identified in the ISA Summary are consistent with actions described in the emergency plan.

FINDINGS

On the basis of the NRC staff's review, the licensee has demonstrated that the proposed additions, modifications, and deletions to IROFS make all credible intermediate consequence accidents unlikely, and all credible high consequence accidents highly unlikely. The amendment request provides reasonable assurance that all credible intermediate consequences, from radiological or chemical releases, are unlikely; and all credible high consequence accidents are highly unlikely. The NRC finds the licensee provides reasonable assurance that amended IROFS will ensure compliance with the performance requirements of 10 CFR 70.61. The staff also concludes that the licensee has provided adequate commitments for the application of baseline design criteria including quality standards and records to the design of new structures, and to develop and implement the design in accordance with management measures.

The Licensee will add the commitment to evaluate site changes every five years to ensure that flooding assumptions remain acceptable to the SAR.

ENVIRONMENTAL REVIEW

There are no significant environmental impacts associated with the changes proposed in this License Amendment Request. The proposed changes do not meet the criteria specified in

10 CFR 51.60(b)(2), since they do not involve a significant expansion of the site, a significant change in the types of effluents, a significant increase in the amounts of effluents, a significant increase in individual or cumulative occupational radiation exposure, or a significant increase in the potential for or consequences from radiological accidents. Issuance of the requested amendment to the LES license is subject to the categorical exclusion provided in 10 CFR 51.22(c)(11) and will not have a significant impact on the human environment. Therefore, neither an environmental assessment nor an environmental impact statement is required for the proposed action.

CONCLUSIONS

Based on its review and evaluation provided by LES in its LAR May 28, 2008, and amended with the October 23, 2008 LAR, the NRC staff finds that the proposed revisions to the LES license are acceptable, consistent with the requirements of 10 CFR Parts 20, 30, 40, and 70, and should be approved.

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