June 21, 2011

Mr. Steven A. Toelle, Director
Nuclear Regulatory Affairs
U. S. Enrichment Corporation
2 Democracy Center
6903 Rockledge Drive
Bethesda, MD 20817

SUBJECT: APPROVAL OF CERTIFICATE AMENDMENT REQUEST RELATED TO REVISION TO TECHNICAL SAFETY REQUIREMENTS 2.6.4.1, CRITICALITY ACCIDENT ALARM SYSTEM (NON-CASCADE FACILITIES), SAFETY ANALYSIS REPORT SECTIONS 4.2 AND 4.3.2.6, TO ALLOW USE OF C-745-X FOR STORAGE OF PROCESS EQUIPMENT CONTAINING POTENTIALLY FISSILE MATERIAL, PADUCAH GASEOUS DIFFUSION PLANT (TAC NO. L32769)

Dear Mr. Toelle:

By letter dated February 14, 2011 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML110530055), the United States Enrichment Corporation (USEC) submitted a Certificate Amendment Request (CAR) requesting a modification to the Certificate of Compliance for the Paducah Gaseous Diffusion Plant (PGDP). The proposed change would revise PGDP's Technical Safety Requirements 2.6.4.1, and Safety Analysis Report Sections 4.2 and 4.3.2.6 by allowing the use of C-745-X yard as an outdoor storage area for process equipment containing potentially fissile material. Currently, C-745-X yard is in the detection radius of the Criticality Accident Alarm System (CAAS) supporting non-cascade facilities. The proposed revision would extend the requirements for CAAS detectability and auditability to C-745-X.

On March 23, 2011 (ADAMS Accession No. ML110960603), the staff notified you that the information USEC provided in its February 14, 2011, submittal was insufficient for the staff to conduct a detailed review, and outlined the type of information which must be supplemented in order to continue with the acceptance review process. On April 4, 2011, USEC submitted the supplemental information as requested by the staff. The U.S. Nuclear Regulatory Commission's (NRC's) staff provided USEC a set of draft Requests for Additional Information (RAIs) and held a teleconference with USEC on May 2, 2011 (ADAMS Accession No. ML111260573), to clarify the draft RAI. On May 6, 2011 (ADAMS Accession No. ML111240371), the staff issued an RAI letter regarding this review. By letter dated May 12, 2011 (ADAMS Accession No. ML11146A027), USEC responded to the staff's RAI request.

The staff completed the review of the CAR and found the proposed revision to be acceptable. The staff's Compliance Evaluation Report is contained in Enclosure 1. Enclosure 2 contains Revision 9 to the PGDP's Certificate of Compliance, reflecting the revision approved for this request. The approval of this CAR is documented in the PGDP's Certificate of Compliance, GDP-1, by adding a reference to the February 14, 2011, letter from USEC.

Neither an environmental assessment nor an environmental impact statement is required for the proposed action because the requested amendment is subject to the categorical exclusion provided in Title 10 of the *Code of Federal Regulations* (10 CFR) 51.22(c)(19) and will not have a significant impact on the human environment.

In accordance with 10 CFR, Section 2.390 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System component of the NRC's ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

If you have any questions regarding this action, please contact Ms. Tilda Liu at 301-492-3217, or via e-mail to Tilda.Liu@nrc.gov.

Sincerely,

**/RA/**

Dennis C. Morey, Acting Branch Chief
Conversion, Deconversion
and Enrichment Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Docket No. 70-7001
Certificate No. GDP-1

Enclosures:
As stated

cc:
Mr. Vernon Shanks, USEC-Paducah
Paducah Gaseous Diffusion Plant
PO Box 1410
Paducah, KY 42001

Mr. Randall M. DeVault
U.S. Department of Energy – Oak Ridge
PO Box 2001
Oak Ridge, TN 37832

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DOCKET NUMBER: 70-7001

CERTIFICATE NUMBER: GDP-1

CERTIFICATE HOLDER: United States Enrichment Corporation
Paducah Gaseous Diffusion Plant
Paducah, Kentucky

SUBJECT: COMPLIANCE EVALUATION REPORT FOR CERTIFICATE AMENDMENT REQUEST REGARDING REVISION TECHNICAL SAFETY REQUIREMENTS 2.6.4.1, CRITICALITY ACCIDENT ALARM SYSTEM (NON-CASCADE FACILITIES), SAFETY ANALYSIS REPORT (SAR) SECTIONS 4.2 AND 4.3.2.6, TO ALLOW USE OF C-745-X FOR STORAGE OF PROCESS EQUIPMENT CONTAINING POTENTIALLY FISSILE MATERIAL, PADUCAH GASEOUS DIFFUSION PLANT (TAC NO. L32769)

## 1.0 PROPOSED CHANGES

By letter, dated February 14, 2011 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML110530055), the United States Enrichment Corporation (USEC) submitted a certificate amendment request (CAR) requesting a modification to the Certificate of Compliance for the Paducah Gaseous Diffusion Plant (PGDP). The proposed change would revise PGDP's Technical Safety Requirements (TSR) 2.6.4.1, and Safety Analysis Report (SAR), Sections 4.2 and 4.3.2.6, by allowing the use of C-745-X yard as an outdoor storage area for process equipment containing potentially fissile material. Currently, C-745-X yard is in the detection radius of the criticality accident alarm system (CAAS) supporting non-cascade facilities. The proposed revision would extend the requirements for CAAS detectability and auditability to C-745-X.

## 2.0 BACKGROUND

On February 14, 2011, USEC submitted a CAR to extend coverage of its existing CAAS to cover the storage of removed process equipment potentially containing fissile material in the C-745-X outdoor storage yard. USEC submitted proposed change pages to the PGDP SAR and TSR. The changes included updating several references in SAR Section 4.2 and TSR 2.6.4.1 to discuss the storage of these components on the C-745-X pad, and updating the discussion of the criticality consequence evaluation in SAR Section 4.3, including updating several values of the first pulse and accumulated radiation dose in SAR Tables 4.3-17 and 4.3-18. Changes to the calculated radiation doses were partly the result of errors discovered in the SAR tables, and partly because a new bounding dose had to be determined due to the proximity of the C-745-X pad to the property boundary. Material to be stored on the pad is closer to the property boundary than any other fissile material operation, resulting in a higher bounding dose.

On March 23, 2011 (ADAMS Accession No. ML110960603), the staff notified you that the information USEC provided in its February 14, 2011, submittal was insufficient for the staff to conduct a detailed review, and outlined the type of information which must be supplemented in order to continue with the acceptance review process. On April 4, 2011, USEC submitted the supplemental information as requested by the staff. This information included calculations of the doses associated with a criticality event on the C-745-X storage pad, a demonstration of

adequate CAAS coverage over this area, and the applicable nuclear criticality safety approval (NCSA) and nuclear criticality safety evaluation (NCSE) governing the storage of removed process equipment. The NRC staff provided USEC a set of draft requests for information (RAI) and held a teleconference with USEC on May 2, 2011 (ADAMS Accession No. ML111260573), to clarify the draft RAI. On May 6, 2011 (ADAMS Accession No. ML111240371), the staff issued a RAI letter regarding this review. By letter, dated May 12, 2011 (ADAMS Accession No. ML11146A027), USEC responded to the staff's RAI request.

## 3.0 DISCUSSION

The aspects of the CAR that the staff reviewed consisted of: (1) evaluation of the calculated dose at the property boundary, and at other distances as stated in SAR Table 4.3-17, and Table 4.3-18; (2) evaluation of whether the existing CAAS system adequately covers, in terms of detector sensitivity and annunciator audibility, planned operations on the C-745-X pad; and (3) the nuclear criticality safety basis as discussed in the NCSA and NCSE. The staff's review of these aspects of the CAR is discussed below.

### Calculated First Pulse and Accumulated Doses

SAR Section 4.3.2.6 describes USEC's methodology for evaluating the consequences of a potential criticality accident. As stated in the SAR, this is based on the methodology described in NRC Regulatory Guide (RG) 3.34, "Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant." While RG-3.34 was withdrawn in 1998 (63 FR 2426), the methodology was subsequently incorporated into NUREG-6410, "Accident Analysis Handbook," Section 3.4. This methodology has as its input parameters the distance between the fissioning material and the location of interest and the total number of fissions, and then applies industry-accepted formulas and values for the components of the dose (direct neutron and gamma radiation dose, the delayed gamma dose, and the dose from the plume of volatile fission products)—as well as dose attenuation factors to account for the presence of intervening shielding.

With regard to the distance, USEC submitted engineering evaluation EV-C-815-10-022, Revision 0, "Evaluation to Determine the Minimum Distance from PGDP controlled access area (CAA) to DOE Property Boundary." This engineering evaluation concluded that the minimum distance between the PGDP CAA and property boundary is approximately 360 meters (m), based on U.S. Department of Energy's Land Boundary Survey. The C-745-X pad is contained entirely within the CAA. USEC then conservatively selected a distance of 300 m as the basis for the bounding dose referenced several times in the revised SAR, which was determined to be an unshielded dose of 8 roentgen equivalent man (rem). The staff reviewed this document and concluded that this represented a suitably conservative distance to use as the basis for bounding dose calculations.

With regard to the number of fissions, the methodology specified in the SAR is based on a solution criticality with $10^{18}$ fissions in the first pulse and a total of $10^{19}$ fissions spread over 8 hours. This model is in agreement with the methodology of RG-3.34 and NUREG-6410, and has been standard practice by NRC licensees over many years. The assumption of $10^{18}$ first pulse fissions and $10^{19}$ total fissions is widely accepted as being conservative, bounding all but one of the 22 process facility criticality accidents known to have occurred. The sole exception is the criticality accident at the Idaho Chemical Processing Plant in 1959. This took place in an extremely large volume of fissile solution that is not representative of any process at PGDP. Only 3 of the remaining 21 accidents are thought to have exceeded a total of $10^{18}$ fissions, the maximum being approximately $2.7 \times 10^{18}$ fissions. Thus, the staff considers the event evaluated

by USEC to be a conservative estimate of the total number of fissions resulting from a solution criticality accident.

With regard to the dose calculation, USEC submitted design analysis calculation DAC-832-ZA1280-0095, "Calculation of Doses for SAR 4.3.2.6 at Various Distances." For the direct neutron and gamma dose, USEC used the formulae specified in SAR Section 4.3.2.6 d, which are consistent with RG-3.34 and NUREG-6410. For the delayed gamma dose, USEC stated that it assumed a delayed-to-prompt gamma ratio of 38%, which is consistent with that used in existing SAR Tables 4.3-17 and 4.3-18. This is taken from a 1995 paper by Wilkinson, et. al., "Improved Dose Estimates for Nuclear Criticality Accidents," Nuclear Technology, Vol. 111. The contribution from the fission product plume was interpolated from the existing numbers in SAR Table 4.3-18. While this document does not describe the technical basis for the contribution from the plume, the SAR tables have been previously reviewed and approved by the NRC. The contribution from the plume is seen to be a smoothly varying function of the distance, and thus interpolation appears justified. The SAR reduces the calculated combined dose by attenuation factors corresponding to 12" of intervening concrete (a factor of 5 for gamma and 4.6 for neutron dose, taken from RG-3.34) for the shielded doses in the SAR tables. Table 4.3-17 includes only direct neutron and gamma doses, with and without shielding, for $10^{18}$ first pulse fissions. Table 4.3-18 includes, additionally, the delayed gamma dose and (for distances greater than 150 meters), the plume dose, with and without shielding for $10^{19}$ total fissions.

The staff independently verified the calculated values in both Tables 4.3-17 and 4.3-18 at the 300 m distance, and determined that they had been calculated consistently with the approved SAR methodology. The staff examined the values that had been changed and determined that the changes were either not significant or clearly corrected an inconsistency in the tables. The staff furthermore graphed the old and new doses as a function of distance and concluded that the old and new values were consistent with one another and followed the expected shape of the curve. Based on this review, the staff concludes that the calculated dose of 8 rem at the property boundary is appropriately bounding, being based on several conservative assumptions. These conservative assumptions include conservatism in the assumed distance, conservatism in the assumed number of fissions, neglect of shielding (the 8 rem being an unshielded value), and neglect of any radioactive decay during propagation of the plume (because the analysis assumes that all $10^{19}$ fissions occur at the same instant in time).

Demonstration of CAAS Detector and Annunciator Coverage

USEC's documents included justification for why the existing CAAS system adequately covers the C-745-X pad. No changes to the existing CAAS system are being made to support this CAR. USEC submitted the report KY/S-255, "Criticality Accident Alarm Detector Placement and Coverage at the Paducah Gaseous Diffusion Plant," which establishes the basis for the 400 feet detector coverage radius that that has been used for the existing CAAS system since 1996. This report shows that the C-745-X pad is covered by clusters 24 and 25 in Building C-746-Q1. Drawing I5B-19744-L01, "CAAS for TSR Implementation Project C-746-Q: CAAS Coverage Overlays," Rev. 3, shows that the C-745-X pad is immediately across a road from Building C-746-Q1, and entirely within its 400 feet detector coverage radius. The RAI response states that C-746-Q1 is a thin-walled sheet metal building, and therefore, there is no significant shielding to reduce the radius of coverage.

USEC also submitted engineering notice EN-C-822-10-229, Rev. 0, "CAAS Audibility for C-745-X Storage Yard and Future C-746Q Southerly Expansion," to demonstrate audibility. The engineering notice contained a map of measurement locations at which the sound levels of annunciator horns were measured. The measurement locations formed a semicircular

arc centered on C-746-Q1 that entirely encompassed the outer boundaries of the C-745-X pad. According to the map, this included measurements taken between rows of cylinders where the sound could be dampened. The tests concluded that the sound level of all horns exceeded the background noise level at 500 Hertz (Hz) by at least 18 decibels (dB), with some exceeding it by 25-40 dB. The criteria approved in the certificate amendment, dated January 7, 1999, are that the broadband alarm signal must be at least 10 dB above the broadband background. If this condition cannot be met, the 1/3 octave 500 Hz alarm signal must be at least 13 dB above the 1/3 octave 500 Hz background. ANSI/ANS-8.3-1986 was the basis for the former criterion, and ISO-7731 the basis for the latter criterion. While the horns did not meet the 10 dB broadband criterion, they did all meet the 1/3 octave 500 Hz criterion. Unlike some areas at PDGP, the outdoor storage pad is unlikely to be subject to high levels of ambient noise. Based on this review, the staff has reasonable assurance that the C-745-X pad will be adequately covered by nearby detector clusters and any sounding of the horns will be clearly audible.

NCS Safety Basis for Outdoor Storage of Removed Process Equipment

The proposed SAR and TSR changes would authorize the outdoor storage of removed process equipment on the C-745-X storage pad. Therefore, the staff reviewed the applicable NCSA and NCSE to determine whether the applicant had sufficient controls in place to ensure that the risk of criticality will be reduced to an acceptable level. This is of concern to the staff because, in general, removed process equipment may be large geometry equipment potentially containing large quantities of fissionable material. Previously, such material was stored inside, whereas now it will be stored outside, where the potential for moderating the fissionable material will be significantly increased.

USEC submitted NCAS GEN-010, Revision 07, “Equipment Removal, Handling, and Storage,” and NCSE 120, Rev. 03, “Equipment Removal, Handling, and Storage,” which contain the controls and demonstration of subcriticality and double contingency for removed process equipment. For the purpose of criticality safety, removed equipment is categorized as either Uncomplicated Handling (UH) or Planned Expeditious Handling (PEH). Removed equipment is categorized as UH if it contains less than a safe mass or is safe geometry; otherwise, it must be considered as PEH. What constitutes a safe mass depends on enrichment, and is determined by means of the Safe Mass Curve in TSR 2.5, Appendix B. What constitutes a safe geometry is having dimensions less than those in TSR 2.5, Appendix A (e.g., piping less than 5” in diameter). Equipment categorized as UH does not require any moderation controls because either its mass or geometry is shown to be subcritical, for a given enrichment, under the worst-case moderation and reflection conditions. Equipment categorized as PEH is singly contingent on moderation control, and decontamination must be initiated within 48 hours and completed to less than a safe mass within 72 hours to minimize the potential for criticality due to moderator intrusion. Both UH and PEH are subject to administrative spacing requirements.

USEC’s RAI responses made reference to the outdoor storage of UH equipment, but made no mention of the outdoor storage of PEH equipment. The staff reviewed the NCSA and NCSE and determined that it contained no restriction on the outdoor storage of PEH equipment. USEC subsequently clarified, in an RAI response, that only UH equipment will be stored outdoors on the C-745-X pad because of the strict time limits associated with the remediation of PEH equipment in TSR 2.5.4.4 and NCSE 120. While there is no explicit prohibition on the outdoor storage of PEH equipment, this would be inconsistent with the timely remediation required by TSR 2.5.4.4 and NCSE 120.

The intrusion of liquid water into UH equipment stored outdoors is not directly a criticality concern, because these components have already been shown to be subcritical when optimally

moderated. Nevertheless, as a result of the change to store UH equipment on the C-745-X pad, USEC identified one additional accident sequence associated specifically with the outdoor storage of this equipment. Accident sequence 4.5.20 is, "What if outdoor storage of UH items leads to consolidation of fissile material from multiple items?" The concern is that solution from multiple items could flow together and collect in unfavorable geometry areas. USEC therefore established control 5.3.2.7, requiring that UH equipment openings be covered with waterproof covers whenever they are outdoors unattended, or upon the onset of inclement weather (rain or snow). The use of such waterproof covers is the first barrier for this sequence. The unlikelihood of collecting solution in an unsafe geometry and/or concentration is the second barrier. The first barrier is an administrative control, and the second is the natural and credible course of events. Besides these new barriers for sequence 4.5.20, the staff noted that UH components must be spaced two feet edge-to-edge, unless collectively the group of such components has less than a safe mass (control 5.3.2.6). While it is possible that a single UH component may have its cover left off, or improperly affixed, the staff considers it very unlikely that such an upset condition would occur for a large number of similar components. Even if this did occur, there would have to be a significant amount of material in each component, and a sufficiently large amount of liquid water would need to intrude into the components so as to allow solution to flow out of the components into the surrounding environment. Given the spacing requirement and the tendency of liquid to spread into a thin, geometrically safe layer, the staff concludes that the likelihood of any such solution collecting in an unfavorable geometry configuration to be acceptably low.

The staff noted that the covers do not have to be fireproof, so asked about the possibility of a fire as an initiating event that could cause a breach of multiple covers and subsequent pooling of solution into unfavorable geometry. In its RAI response, USEC cited spacing requirements for UH equipment and the unlikelihood of consolidating material from multiple items into the right geometry. While liquid water would likely be used to fight a large fire on the C-745-X pad, the water would tend to be directed onto the source of the fire, and not directly into the equipment openings. Even if sufficient water were used to cause solution to flow out of the components, the action of the fire water would tend to disperse, rather that consolidate, the material. The staff has therefore determined that, due to the large number of improbable events that would have to occur, criticality due to firefighting activities associated with a large fire on the C-745-X pad would be very unlikely.

The only remaining hazard of concern would be if a PEH component were erroneously stored outdoors on the C-745-X pad. The characterization and the subsequent handling of removed process equipment is tightly controlled. Control 5.3.2.3 requires that the handling category (UH or PEH) must be determined prior to removal, and independently verified within 24 hours. For use of the safe mass curve to distinguish between UH and PEH equipment, enrichment must be independently verified, or else the maximum plant enrichment of 5.5 weight percent Uranium-235 must be used (Control 5.3.2.1). Independent verification of enrichment will be performed by independent sampling and analysis, or use of the maximum historical assay for the area from the Assay Tracking Program (which is an AQ-NCS software package). In addition, TSR 2.5.4.3 and NCSE 120 require that PEH equipment openings be covered by fireproof covers and gasket seals, and that these be inspected daily to verify their continued presence. The time limits and inspection requirements make it unlikely that PEH equipment would be left unattended for any significant period of time outdoors. Even if it were, the fireproof covers and gasket seals would prevent intrusion of any significant quantity of moderator over the short term. Violation of all of these administrative controls, and subsequent moderator intrusion sufficient to cause criticality, would require failure beyond what is required for double contingency. Therefore, the staff considers criticality due to the mistaken storage of PEH equipment on the C-745-X pad to be very unlikely. The staff also notes that the requirements are the same as the historical

requirements for UH and PEH equipment (apart from the new control 5.3.2.7 discussed above).

The staff therefore has reasonable assurance that the outdoor storage of UH equipment on the C-745-X pad has the appropriate controls and complies with the double contingency principle.

The staff finds that the SAR and TSR changes provide for reasonable assurance of safety and are consistent with all applicable regulatory requirements. The calculated doses in the SAR tables were calculated in accordance with previously approved methodologies and appropriately conservative assumptions. The storage of removed process equipment on the C-745-X pad will be adequately covered by the existing CAAS system, and meets the applicable requirements for ensuring subcriticality and complying with the double contingency principle.

## 4.0 ENVIRONMENTAL REVIEW

Issuance of the requested amendment to Certificate of Compliance GDP-1 is subject to the categorical exclusion provided in Title 10 of the *Code of Federal Regulations* (10 CFR) 51.22(c)(19) and will not have a significant impact on the human environment. Therefore, in accordance with 10 CFR 51.22.b, neither an environmental assessment nor an environmental impact statement is required for the proposed action.

## 5.0 CONCLUSION

Based on its review and evaluation of the information provided by USEC in its CAR, dated February 14, 2011, the staff finds that the proposed revisions to PGDP's TSR 2.6.4.1, and SAR Sections 4.2 and 4.3.2.6, by allowing the use of C-745-X yard as an outdoor storage area for process equipment containing potentially fissile material, would not have a significant increase in risk to the workers and would continue to provide adequate protection of public health, safety, safeguards, security, and the protection of the environment. Therefore, the staff concludes that the proposed revisions are acceptable and consistent with 10 CFR 76.87(c) and 10 CFR 76.89.

## 6.0 REFERENCES

U.S. NRC Regulatory Guide 3.34, "Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant," Revision 1, USNRC, July 1979.

NUREG/CR-6410, "Nuclear Fuel Cycle Facility Accident Analysis Handbook," USNRC, March 1998.

U.S. NRC, Letter from Carl J. Paperiello to James H. Miller, "Paducah Certificate Amendment Request: Criticality Alarm System Audibility Upgrades, Compliance Plan Issues 46 and 50 (TAC NO. L32103)," dated January 7, 1999.

ANSI/ANS-8.3-1986, "Criticality Accident Alarm System," American Nuclear Society, 1986.

ISO-7731: 1986, "Danger Signals for Work Places—Auditory Danger Signals," International Organization for Standardization, 1986.

## PRINCIPAL CONTRIBUTOR

Christopher Tripp