USEC
A Global Energy Company

June 12, 2000
GDP 00-0098

Mr. William F. Kane
Director, Office of Nuclear Material Safety and Safeguards
Attention: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Paducah Gaseous Diffusion Plant (PGDP)
Docket No. 71-6553
Proposed Changes to the Paducah Tiger Overpack Safety Analysis Report

Dear Mr. Kane:

The United States Enrichment Corporation (USEC) herein submits for NRC review and approval a change to KY-665, Revision 1, "Safety Analysis Report on the 'Paducah Tiger' Protective Overpack for 10-Ton Cylinders of Uranium Hexafluoride." This report is incorporated by reference in Certificate of Compliance No. 6553 for the Paducah Tiger Overpack (PTO). As a result, USEC requests that the NRC issue a revision to Certificate of Compliance No. 6553.

The proposed change to the PTO Safety Analysis Report (SAR) is associated with the use of 48X cylinders manufactured by W. H. Stewart Company. Enclosure 1 to this letter provides a detailed description of the change. The actual revised PTO SAR pages are provided in Enclosure 2 with the Removal/Insertion Instructions. The technical basis that supports the change is summarized in Enclosure 3.

USEC requests NRC's expeditious review of this submittal so that the affected cylinders can be returned to service. Any questions regarding this matter should be directed to Dr. Elizabeth Darrough at (301) 564-3422. There are no new commitments contained in this submittal.

Sincerely,

S. A. Toelle

Steven A. Toelle
Director, Nuclear Regulatory Affairs

Rec'd NCD 5/3/01

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NMSS01 Public

Enclosures:
1. United States Enrichment Corporation (USEC), Detailed Description of the Changes to KY-665, "Safety Analysis Report on the "Paducah Tiger" Protective Overpack for 10-Ton Cylinders of Uranium Hexafluoride," Revision 1.

2. United States Enrichment Corporation (USEC) Certificate Amendment Request, Paducah Gaseous Diffusion Plant, Letter GDP 00-0098, Removal/Insertion Instructions.

3. Technical Basis Supporting Changes to KY-665, Revision 1, "Safety Analysis Report on the "Paducah Tiger" Protective Overpack for 10-Ton Cylinders of Uranium Hexafluoride."

cc: E. Brach, NRC HQ
R. Hall, NRC HQ
P. Hiland, NRC Region III
K. O' Brien, NRC Resident Inspector - PGDP
D. Hartland, NRC Resident Inspector - PORTS

United States Enrichment Corporation (USEC)
Detailed Description of the Changes to
KY-665, "Safety Analysis Report on the 'Paducah Tiger' Protective Overpack for 10-Ton Cylinders of Uranium Hexafluoride," Revision 1

Description of Change

This change is proposed to support the use of W. H. Stewart Co. type 48X UF_6 cylinders manufactured in the early 1980's, in accordance with ANSI N14.1-1971 after ANSI N14.1-1982 was approved. USEC has determined that a change to the Paducah Tiger Overpack (PTO) Safety Analysis Report (SAR) is needed. Specifically, changes are proposed to PTO Safety Analysis Report Revision 1 Sections 1.1, 1.2.1.9 and 2.12 "48X 10-ton UF_6 Cylinder." The proposed change addresses the use of these cylinders provided that they are inspected, tested, and recertified in accordance with ANSI N14.1-1990.

Reason for Change

W. H. Stewart Co. manufactured type 48X UF_6 cylinders in the early 1980's. These cylinders were manufactured for TVA, Kerr McGee, Eldorado-Cameco, etc. Over the years DOE purchased some of these cylinders which now belong to USEC. These cylinders were manufactured in accordance with the 1971 edition of ANSI N14.1. They were manufactured after the 1982 edition of ANSI N14.1 was approved. The 1971 edition of ANSI N14.1 required that the heads of the cylinders be a nominal 0.625 inches thick, while the 1982 edition of ANSI N14.1 required that the heads of the cylinders be a minimum 0.625 inches thick. The Certificate of Compliance (C of C) from the NRC for the Paducah Tiger Overpack (C of C No. 6553), requires, in Section 6, that the 48X cylinder be fabricated in accordance with ANSI N14.1 in effect at the time of fabrication. At the time these cylinders were fabricated, ANSI N14.1-1982 was in effect while the cylinders were built in accordance with ANSI N14.1-1971.

Justification of the Change

The technical justification for the change is included as Enclosure 3.

United States Enrichment Corporation (USEC)
Certificate Amendment Request
Paducah Gaseous Diffusion Plant
Letter GDP 00-0098

Removal/Insertion Instructions

Remove Page	Insert Page
PTO SAR	
ix, 1.1-1, 1.2-5, 1.2-6, 1.2-7, 2.1-2	ix, 1.1-1, 1.2-5, 1.2-6, 1.2-7, 2.1-2

REVISION LOG

Date	Change	Description
7/15/99	REV 1	Initial Issue. Complete Revision of all pages.
5/02/00	A	Revised Sections 3.5.1.1, 3.5.6, 4.2.2 and 7.1.2 to increase the amount of residual UF_6 allowed for shipment in the overpack.
RAC 00C056 (R0)	B	Revised Sections 1.1, 1.2.1.9, and 2.1.2 to allow for the shipment of W. H. Stewart Company cylinders in the overpack.

[Note: The Request for Application Change (RAC) number identified above for the Proposed Change B will be replaced by the approval date upon approval and issuance.]

1.1 Introduction

The Paducah Tiger overpacks are fabricated to transport 48X 10-ton UF_6 cylinders. The 48X cylinder is a DOT Specification 7A container [1], fabricated from low-carbon steel. The Paducah Tiger overpack, shown in Figure 1.1-1, provides protection for the 48X cylinders under normal conditions of transport and hypothetical accident conditions. The overpack completely envelopes the 48X cylinder using a removable lid that attaches to the body of the overpack. The overpack body supports the 48X cylinder. The overpack utilizes steel and aluminum plates and polyurethane foam to provide puncture protection, structural support, and thermal protection. The 48X cylinder, shown in Figure 1.1-2, is fabricated in accordance with ANSI N14.1 [2], or to an earlier version of ANSI N14.1 in effect at the time of fabrication, except as noted in Section 1.2.1.9, and is the package containment boundary.

The Paducah Tiger overpacks consist of an outer skin (also referred to as an "outer steel shell") and an inner liner (also referred to as an "inner steel shell") with polyurethane foam filling the space between the two shells. Both low- and high-density foams are used in the overpacks. High-density foam is used along each edge and at each corner of the lid and body. Low-density foam is used for the remainder of the overpack.

The package design incorporates rubber shock isolators for cylinder support and alignment; stainless steel breakaway plates for puncture protection; a high strength aluminum stiffening plate for both puncture protection and structural support; closure mechanisms; a tamper-indicating device; and tie-down features. These components are described in Section 1.2.1.

The 48X cylinder may contain up to 21,030 pounds of UF_6 enriched up to 4.5 wt % U-235 when filled. To be considered empty, cylinders may contain no more than 50 pounds of residual UF_6 (a heel cylinder). The isotopic content of full and heel cylinders is discussed in Section 1.2.3.

During design, a Paducah Tiger overpack prototype was built for physical testing. Results from the prototype testing were used to optimize the Paducah Tiger overpack design. To supplement the test data, computer modeling and analyses were performed. A description of the tests, and a summary of the results of the tests and analyses, are presented in Section 2.7.1. The Paducah Tiger license drawings are provided in Section 1.4. The dimensions indicated in Section 1 are generally nominal dimensions. Subsequent chapters may present dimensions that contain exact tolerances based on more detailed requirements.

engage the end skirt of the 48X cylinder. All rubber shock isolators are fabricated from ethylene-propylene diene terpolymer (EPDM).

1.2.1.7 Lifting Brackets

Four lifting brackets on the lid of the overpack are fabricated from mild steel and welded to 3/8-inch mild steel plates. These plates are in turn welded to the outer skin of the overpack.The lid lifting brackets are centered on the balance point of the overpack and inclined 10° from vertical towards the balance point. The lid lifting brackets are not intended for lifting the Paducah Tiger overpack containing a filled or empty 48X cylinder.

1.2.1.8 Tie-downs

The tie-down system consists of four ISO corner fittings on the body of the overpack and a tie-down bracket welded to each of the four ISO corners. All of the ISO corners or tie-down brackets at the base of the overpack body may be used to secure the package. These tie-down brackets also serve as a transport tie-down point as shown in Figure 1.2-5 where they are used to bolt the package to the deck of the transporter.

1.2.1.9 48X 10-ton UF_6 Cylinder

The 48X 10-ton UF_6 cylinder, shown in Figure 1.1-2, forms the containment boundary for the Paducah Tiger package. Material specifications for the 48X cylinder are shown in Table 1.2-2. The 48X cylinder is a DOT Specification 7A container. The nominal diameter of the 48X cylinder is 48 inches, and the length is approximately 119 inches. The wall thickness is nominally 5/8 inch. The nominal gross loaded weight of the cylinder is 25,530 pounds. The minimum volume is 108.9 ft^3. Figure 1.1-2 also shows the valve, stiffening rings, lifting lugs, and the drain plug. Because of brittle fracture concerns as discussed in Section 2.3, all ASTM A-285 cylinders used for shipment of UF_6 have been replaced with ASTM A-516 normalized steel cylinders.

Cylinders manufactured by W. H. Stewart Company in accordance with ANSI N14.1-1971 after ANSI N14.1-1982 was approved may be used for shipment in the Paducah Tiger package provided that they are inspected, tested, and recertified in accordance with ANSI N14.1-1990.

These cylinders were manufactured with a nominal head thickness of 5/8-inch instead of the minimum 5/8-inch head thickness required by the 1982 version of ANSI N14.1.

A 1-inch angle drum (cylinder) valve, shown in Figure 1.2-6, is installed at one end of the 48X cylinder for filling and emptying the UF_6 from the cylinder.

The 48X cylinder valve stem and plug may be tinned with ASTM B32, alloy 50A or Sn50 solder material, or a mixture of alloy 50A or Sn50 with alloy 40A or Sn40A material, provided the mixture has a minimum tin content of 45 percent. Except the makeup of the tinning materials, the 48X cylinder is fabricated in accordance with ANSI N14.1.

As shown in Figure 1.1-2, three stiffening rings are welded to the 48X cylinder to provide protection during handling. Four lifting lugs are attached to the outer stiffening rings for handling of the cylinder.

A 1-inch hex head drain plug is installed on the cylinder at the end opposite the valve. This plug is used to drain cleaning solution from the cylinder during cleaning operations. It is screwed into a 1-inch half-coupling that is welded to the inside of the cylinder head.

1.2.2 Operational Features

The Paducah Tiger overpack is a simply designed and easily operated package with no active systems and few operational features. The primary operational features of the Paducah Tiger overpack pertain to loading and unloading the 48X cylinder into and out of the overpack. Many of these features are described in Section 1.2.1, and are shown in Figure 1.1-1. The lid of the overpack is designed to be removed as a single unit using four lifting points, two on either side of the lid. The lid is secured to the body of the overpack using eight ball lock pins that are manually installed and removed. No torque is applied to the pins. Drain ports at either end of the overpack allow the removal of any residual water that may inadvertently enter the overpack during periods of storage or use, and allow cleaning of the overpack inner liner when necessary. Cylinder guides are incorporated into the inner liner to facilitate the alignment of the cylinder with its cradle during loading of the cylinder into the overpack. A lid guide is used to ensure the correct orientation of the lid to the overpack body. Vent holes in the outer skin of the overpack prevent the overpack from becoming pressurized during fire accident events.

The overpack is designed so that the 48X cylinder is loaded into or unloaded from the overpack while the overpack is on the transporter, which may be either a truck flatbed or a railroad flatcar. Consequently, the overpack is not lifted or moved while it contains a 48X cylinder.

Proper operation of the package takes advantage of the physical properties of the UF_6 material. The 48X cylinder is filled with the UF_6 in a liquid state. As the UF_6 cools, it solidifies and reduces in volume. After cooldown, the vapor pressure of the solidified UF_6 is subatmospheric. A 5-day cooldown is required to assure that the UF_6 has solidified, and that there is no liquid within the cylinder. The thermal protection afforded by the polyurethane foam during the hypothetical accident event ensures that the UF_6 does not overpressurize the cylinder.

1.2.3 Contents of Packaging

The 48X cylinder is filled with liquid UF_6, which is allowed to cool and solidify inside the cylinder for at least 5 days before transport. Table 1.2-2 lists the physical properties of UF_6. Once the UF_6 solidifies in the cylinder, the cylinder pressure is below atmospheric pressure. Solid UF_6 has a density of approximately 317.8 lb/ft and occupies approximately 60% of the volume of the cylinder, because of the large density change between the solid and liquid phases. The UF_6 may not have more than 4.5 wt % U-235 isotopic enrichment and an H/U ratio of no more than 0.088. The remainder of the cylinder volume, approximately 40%, contains UF_6 vapor plus minor quantities of impurities such as HF, refrigerant gases, and air. The amount of UF_6 loaded into the cylinder is governed by weight. The weight control of UF_6 ensures that hydrostatic rupture of the cylinder will not occur even if the UF_6 is heated up to the rated temperature of the cylinder.

a design that could be transported by either truck or rail. The prime function of the overpack is to protect the 48X cylinder by providing structural and thermal protection to the 48X cylinder to ensure that it can adequately withstand both the Normal Conditions of Transport (NCT) and the Hypothetical Accident Conditions (HAC) as described in 10 CFR 71.71 and 10 CFR 71.73, respectively.

The impact of the transportation environment on the overpack design has been successfully demonstrated in the field during more than 25 years of service. All of the Paducah Tiger overpacks in service have performed satisfactorily.

The 48X cylinders are DOT Specification 7A containers (49 CFR 178.350 [2]). Cylinders are fabricated using A-516 steel subject to the requirements of ANSI N14.1 [3], or to an earlier version of ANSI N14.1 in effect at the time of fabrication, except as noted in Section 1.2.1.9.

Material specifications are presented in Table 1.2-1 for the Paducah Tiger overpack and in Table 1.2-2 for the 48X cylinder. Allowable stresses for these materials are from the ASME Boiler and Pressure Vessel Code where applicable. NRC Regulatory Guide 7.6 outlines a procedure for identifying and combining loads, classifying stresses, and comparing the stress results with the acceptance criteria. These criteria were used for normal and accident loadings to determine the acceptable stress intensities. The effects of brittle fracture, fatigue, and vibration on the 48X cylinder (i.e., the containment boundary) are addressed in the following sections. Material properties for the polyurethane foam and the various steels used in the overpack are described in Section 2.3.

The qualification of the Paducah Tiger overpack is demonstrated by analysis together with actual testing of a prototype model. Stress limits were obtained from the ASM International Metals Handbook [4] and were followed wherever appropriate and possible for all load cases except free drops, the penetration test, and the fire test, which use stress limits developed in the evaluations as described in Sections 2.6 and 2.7. The maximum calculated stress intensity, which combines general shear and general bending stress from sustained loads, is limited to the specified minimum yield stress of the material.

Technical Basis
Supporting Changes to KY-665, Revision 1
"Safety Analysis Report on the Paducah Tiger Protective Overpack for 10-Ton Cylinders of Uranium Hexafluoride"

Introduction

ANSI N14.1 – 1982 edition requires that type 48X and 48Y cylinders be fabricated with a 2 to 1 ellipsoidal head with a minimum thickness of 0.625 inches. ANSI N14.1 requires 0.500 inches minimum thickness for the head for re-certification. This is approximately 40% above that required for a 48-inch diameter, 200 psig design, ASME Boiler and Pressure Vessel Section VIII pressure vessel. The extra 0.125 inches are for corrosion allowance and are not required for the design or strength of the cylinder. The 1971 edition of ANSI N14.1 only requires that the cylinder heads be a nominal 0.625 inches thick. When specified this way, the cylinder head can be less than 0.625 inches thick in places due to the fact that the cylinder fabricator forms the head out of 0.625 inches thick plate and the forming process will cause thinning in places on the head during forming. The 1982 edition of ANSI N14.1 changed the required thickness from a nominal to a minimum thickness of 0.625 inches for the head. This would allow the whole cylinder to have a corrosion allowance of 0.125 inches before the minimum thickness for re-certification, 0.500 inches, was reached. W. H. Stewart applied for and received an exception from the DOT for this anomaly. The DOT realizing that the required thickness was only 0.500 inches for these cylinders, stated, in granting the exemption, that the cylinder no longer required an exemption after completing its first re-certification testing. USEC, in an effort to show that there were no problem with these cylinders, inspected and obtained ultrasonic thickness readings of 10 different points on each head of each cylinder in service, for a total of 102 cylinders both at Paducah and at the Portsmouth plant. The thickness measurement did not indicate any readings below 0.590 inches. As a general rule, most of the readings were above 0.610 inches.

Conclusion

Since all of the W. H. Stuart 48X cylinders in use have been inspected and found to have a head thickness above 0.500 inches and have been re-certified, use will begin once the C of C is amended to reflect the discrepancy. The 48Y cylinders are not shipped under the NRC C of C and are only regulated by the DOT. The DOT has already stated that once the cylinder has been re-certified, the exemption is no longer required and the cylinders are approved to ship as they are. The cylinders in use at both USEC plant sites have all been re-certified and meet the requirement for re-certification, therefore are safe to use. Any cylinder that has not been re-certified for use will be re-certified before it is filled again. As long as the cylinder passes all of the requirements for re-certification as required by ANSI N14.1-1990, it will be approved for use. The cylinders manufactured by W. H. Stewart before July 1, 1981 comply with the regulations and the exemption does not apply.