SAFETY ANALYSIS REPORT
FOR THE
MODEL ESP-30X PROTECTIVE SHIPPING PACKAGE
FOR 30-INCH UF_6 CYLINDERS

(Revision 2, March 2000)

Submitted by:

Eco-Pak Specialty Packaging
Division of The Columbiana Boiler Company
Columbiana, Ohio 44408

with DOT-21PF-1A and DOT-21PF-1B overpacks. The package is lifted by four (4) shackles attached to the lower half of the PSP. The package may also be lifted by fork truck tines under the angle-reinforced bottom of the package.

The closure joint of the package is stepped down to the outside to minimize water in-leakage into the cylinder cavity and provides a metal-to-metal seat on the outboard side such that compression of the inboard gasket is controlled. The gasket is a 5/8-inch thick medium density, closed-cell silicone sponge rubber with a minimum continuous temperature rating of 400°F.

1.2.3 Contents of Packaging

The ESP-30X package is used for the safe transport of uranium hexafluoride enriched in the U^{235} isotope; the UF_6 must be packaged in Model 30B UF_6 cylinders which have been fabricated, inspected, tested and maintained in accordance with the requirements of ANSI N14.1, The package contents are limited to a maximum of 5,020 pounds UF_6 enriched to not more than 5 wt% U^{235}. The UF_6 , which may container either virgin or recycled uranium, must not contain more than the following maximum quantities of radionuclides[1] and impurities:

U^{232}	5.0E-09 g/gU
U^{234}	2.0E-03 g/gU
U^{235}	5.0E-02 g/gU
U^{236}	2.5E-02 g/gU
U^{238}	balance of total uranium content
Pu + Np	Alpha activity not exceeding 3.3 Bq/gU
Tc-99	5.0E-06 g/gU
Th^{228}	1.17E-09 g/gU (other U-232 daughters are ignored because of very short half-lives)

[1] The maximum quantities of radionuclides and impurities listed here represent the maximum concentrations specified in either ASTM C787 or ASTM C996.

Fission Products	4.4×10^5 Mev Bq/d kgU (total contribution from gamma emitting fission products); this results in the following individual maximum activities:

Ru^{106}/Rh^{106}	2095 Bq/gU
Ru^{103}/Rh^{103}	885 Bq/gU
$Ce^{144}/Pr^{144}/Pr^{144}$*	8349 Bq/gU
Sb^{125}	1030 Bq/gU
Cs^{134}	283 Bq/gU
Cs^{137}/Ba^{137}*	778 Bq/gU
Zr^{95}	598 Bq/gU
Nb^{95}	574 Bq/gU

From ASTM C-787, the total concentration of elements that form non-volatile fluorides (including Al, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Pb, Li, Mg, Mn, Ni, K, Ag, Na, Sr, Th, Sn, Zn, and Zr) must no exceed 3.0E-03 g/gU.

Also, from ASTM C-787, the content of other elements must not exceed the following concentrations in g/gU:

Sb < 1	As < 3	B < 1	Bi < 5	Cl < 100
Cr < 10	Nb < 1	P < 50	Ru < 1	Si < 100
Ta < 1	Ti < 1	Mo < 1.4	W < 1.4	V < 1.4

Additionally, for reprocessed UF_6, the maximum total activity present in the package is limited to 957 mixture A_2 values (See Section 4).

1.3 Appendices

1.3.1 Eco-Pak Specialty Packaging Drawing No. ESP-30X, Model ESP-30X Protective Shipping Package

1.3.2 UF_6 30B Cylinder

GENERAL NOTES

1. GROSS WEIGHTS
THE GROSS WEIGHTS OF A LOADED ESP-30X ARE AS FOLLOWS:

COMPONENT	WEIGHT (KGS)	WEIGHT (LBS)
ESP-30X OVERPACK	1,340	2,955
30B CYLINDER	631	1,390
MAXIMUM LOAD PER 30B	2,277	5,020
MAXIMUM GROSS WEIGHT OF LOADED PACKAGE	4,248	9,365

2. MATERIALS OF CONSTRUCTION
THE MATERIALS OF CONSTRUCTION FOR THE ESP-30X ARE AS FOLLOWS:

SKIN	ASTM A569 CARBON STEEL
PLATES/ CHANNEL	ASTM A572-50 CARBON STEEL
FLAT BAR AND ANGLES	ASTM A36 CARBON STEEL
BOLTS AND NUTS	ASTM A193 B7 AND A194 2H
FOAM	ESP SPECIFICATION ESP-PF-1 CLOSED CELL PHENOLIC FOAM
GASKET	SILICON, CLOSED CELL MED. DENSITY TEMP. RATED TO 400°F
LIFTING SHACKLES	FORGED CARBON STEEL WITH A SAFETY FACTOR OF 5

THE 30B CYLINDER AND VALVE ARE CONSTRUCTED IN ACCORDANCE WITH ANSI N14.1

3. FINISH
PAINT ALL EXTERNAL SURFACES AND ALL SURFACES IN CONTACT WITH FOAM USING THE MILAGE AS REQUIRED BY THE MANUFACTURE'S SPECIFICATION FOR SHERWIN WILLIAMS CATALYZED EPOXY PRIMER (PART A RED OXIDE E61RC22, PART B CATALYST V66TC1) OR EQUIVALENT. ALL PAINTING SHALL BE IN ACCORDANCE WITH WRITTEN PROCEDURES IN ACCORDANCE WITH MANUFACTURE'S REQUIREMENTS. PAINT ALL EXTERNAL SURFACES WITH AN ADDITIONAL (2 MIL MIN.) TOP COAT OF A CATALYZED URETHANE ACRYLIC ENAMEL IN ACCORDANCE WITH MANUFACTURE'S SPECIFICATIONS

4. PLACARD AND LABEL EACH END

5. ALL WELDING PROCEDURES AND PERSONNEL SHALL BE QUALIFIED IN ACCORDANCE WITH AWS D1.1 OR ASME SECTION IX

6. NDT PERSONNEL SHALL BE CERTIFIED IN ACCORDANCE WITH ASNT-TC-1A. VISUAL INSPECTORS MAY BE CERTIFIED IN ADDITION TO OR IN LIEU OF ASNT-TC-1A AS AN AWS-CWI OR CAWI.

7. NAMEPLATE SHALL BE ATTACHED AFTER PAINTING BY SPOT WELDING AND PAINT RETOUCHED.

8. DIMENSION TOLERANCES UNLESS OTHERWISE NOTED: 12" AND OVER ±3/8"
1" UP TO 12" ±1/8"
0" UP TO 1" ±1/16"
ANGLES ±1°
MATERIAL THICKNESS SHALL BE WITHIN MILL TOLERANCE UNDER APPROPRIATE MATERIAL SPECIFICATION.

9. MAGNETIC PARTICLE ALL FINAL WELDS UNLESS OTHERWISE SPECIFIED 10% OF LINEAR LENGTH OF WELDS.

10. STENCILING SHALL BE OF A CONTRASTING COLOR AND BE A MINIMUM OF 1" IN HEIGHT UNLESS NOTED. THE FOLLOWING SHALL BE ON THE NEAR SIDE/BOTTOM SECTION AND THE FAR SIDE/TOP SECTION. AT A MINIMUM THE FOLLOWING SHALL BE SHOWN:

DESIGN ID NUMBER:	USA/---/-- TYPE - (2" LETTERS)
MODEL NUMBER:	ESP-30X
OWNERS NAME	----------
OWNERS ADDRESS:	CITY AND/OR COUNTRY
	URANIUM HEXAFLUORIDE FISSILE
	GROSS WEIGHT LBS
	KGS

11. ALL CLOSURE BOLTS SHALL BE TORQUED PRIOR TO SHIPMENT TO 150 FT. LBS. + 10 - 0

12. PACKAGE ID PLATE
A. PLATE SHALL BE A MIN. OF 11" WIDE x 15" LONG x 20 GAUGE SHEET, ASTM A-240 TYPE 304/304L STAINLESS STEEL.
B. AT A MINIMUM THE FOLLOWING INFORMATION SHALL BE ENGRAVED/ETCHED ON TO THE ID PLATE IN LETTER HEIGHTS AS FOLLOWS:

USA/----/--				1/2"
RADIOACTIVE MTL. TYPE --				3/8"
MFG. BY: ECO-PAK SPECIALTY PACKAGING				3/8"
A DIVISION OF CBC				3/8"
QA APPROVAL NO:				3/8"
OWNER SERIAL NO.				3/8"
MODEL NO. ESP-30X ESP S/N:				3/8"
PKG. TARE WGTS IN LBS AND KGS				3/8"
DATE	COVER	BOTTOM	PACKAGE	3/8"
MM/YR	---LB	---LB	---LB	3/8"
	---KG	---KG	---KG	3/8"
MAX. GROSS WEIGHT 9365 LBS				3/8"
4248 KGS				3/8"

C. LOWER (BOTTOM HALF) SHALL BE WEIGHED WITH ALL HARDWARE AND NAMEPLATE.
COVER (TOP HALF) SHALL BE WEIGHED WITH NAMEPLATE.
D. WEIGHT TOLERANCE IS ±2 LBS OR ±1 KG. ALL WEIGHTS SHALL BE ROUNDED UP TO THE NEXT WHOLE NUMBER.

13. SEAL ACETATE PLUGS USING RTV SILICONE CAULKING.

14. GASKETS SHALL BE INSTALLED USING AN APPROPRIATE MATERIAL AS DESCRIBED IN STANDARD OPERATING PROCEDURES.

15. CERTIFICATIONS, TEST REPORTS AND QA RECORDS FOR THIS PACKAGE SHALL BE STORED AND MAINTAINED AS REQUIRED BY THE QUALITY ASSURANCE PROGRAM.

16. SHACKLES ARE RATED AT 1300 LBS. AND HAVE A SAFETY FACTOR OF 5

17. GASKET MATERIAL: SILICONE SPONGE MED. DENSITY CLOSED CELL RATED FOR CONTINUOUS USE AT 400°F

18. UPPER NEOPRENE SPONGE MED. DENSITY CLOSED CELL: LOWER NEOPRENE 50-60 DUROMETER A

19. ESP-PF-1 CLOSED CELL PHENOLIC FOAM LOW CHLORIDE 200 PPM OR LESS WITH A DENSITY OF 9.5 TO 12.5 LBS PER CUBIC FOOT

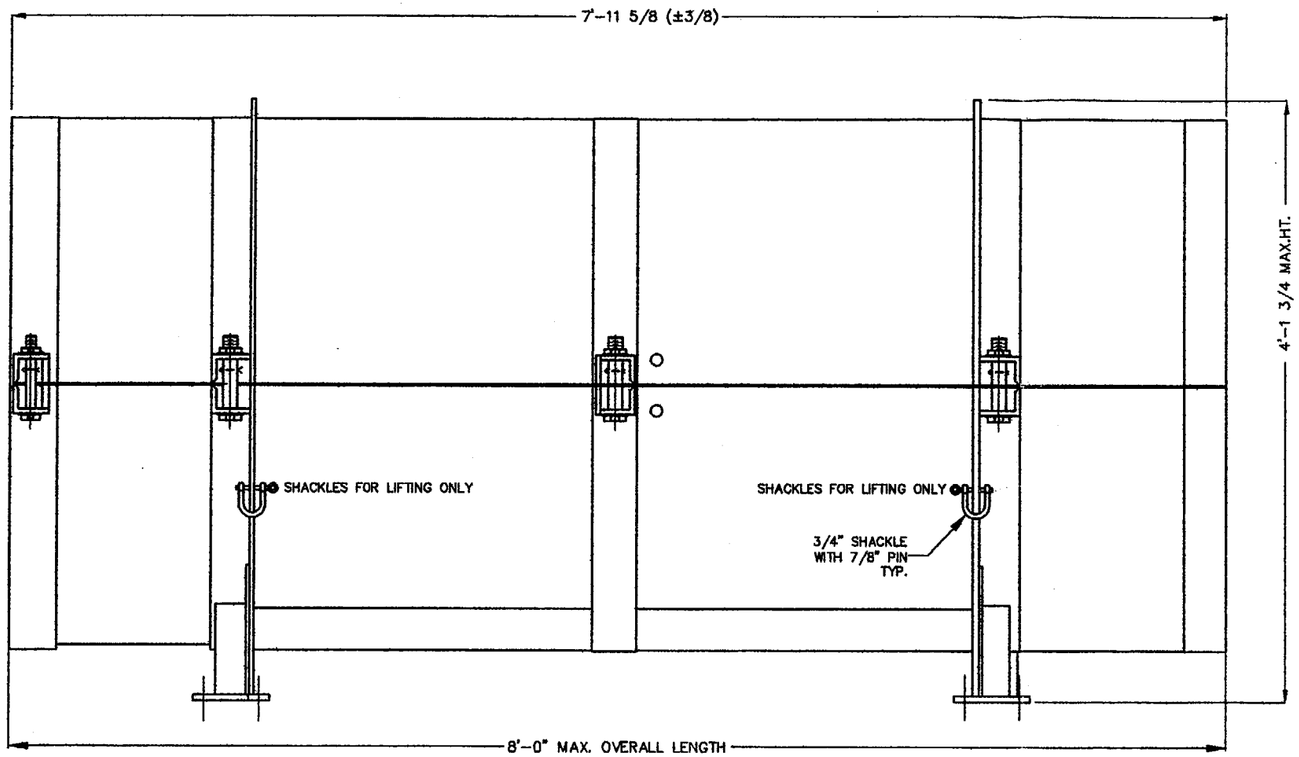
20. FASTENERS: BOLTS-ANSI B16.2.1; A193; GRADE B7(MARKED)
NUTS: ANSI B18.2.2 SF; A194; GRADE 2H (MARKED)
WASHERS: CARBON STEEL

Rev. No.	Change	Date	By
⑨			
⑧			
⑦			
⑥			
⑤			
④			
③			
②	CLARIFIED SHEETS 2, 3, & 4	03/27/00	JLR
①	MODIFIED NOTES 1, 2, 3, 4, 8, 9 & 17	03/14/00	ARM
	REVISIONS		

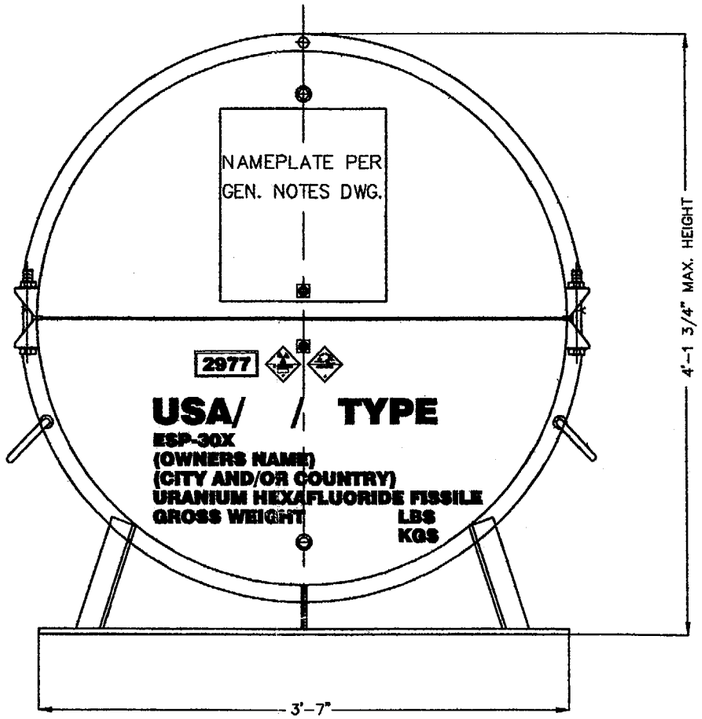
Eco-Pak Specialty Packaging Division of CBC

30X
PROTECTIVE SHIPPING PACKAGE

Checked: TR
Drawn: 8/99
Dr'n By: GAC
Appr'd By:
Scale: NONE
DRAWING NUMBER 30X-1 SAR
REV. 2 SHEET 1 OF 4



SIDE VIEW



END VIEW

NOTES:

NAMEPLATE NEARSIDE ON TOP HALF
NAMEPLATE FARSIDE ON BOTTOM HALF
STENCIL NEARSIDE ON BOTTOM HALF
STENCIL FARSIDE ON TOP HALF
TOLERANCES: SEE NOTE 8 ON SHEET 1

Rev. No.	Change	Date	By
⑨			
⑧			
⑦			
⑥			
⑤			
④			
③			
②	CLARIFIED DIM. & SHACKLES	03/27/00	JLR
①	ADDED TOLERANCE NOTE	03/14/00	ARM

REVISIONS

Eco-Pak Specialty Packaging Division of cdc

GENERAL ARRANGEMENT OF
30X PROTECTIVE SHIPPING CONTAINER

Checked:	Date: 8/99	DRAWING NUMBER	
App'd By: TR	Dr'n By: GAC	30X-2 SAR	
App'd By:	Scale: NONE	REV. 2	SHEET 2 OF 4

FIGURE WITHHELD UNDER 10 CFR 2.390

Rev. No.	Change	Date	By
⑨			
⑧			
⑦			
⑥			
⑤			
④			
③			
②	CLARIFIED MATERIAL LABELS	03/27/00	JLR
①	ADDED TOLERANCE NOTE	03/14/00	ARM

• REVISIONS •

Eco-Pak Specialty Packaging Division of dlc

30X
PROTECTIVE SHIPPING CONTAINER

Checked: [illegible]
App'd By: [illegible]
App'd By:

Date: 8/99
Dr'n By: GAC
Sheet: NONE

DRAWING NUMBER
30X-3 SAR

REV. 2 | SHEET 3 OF 4

FIGURE WITHHELD UNDER 10 CFR 2.390

Rev. No.	Change	Date	By
⑨			
⑧			
⑦			
⑥			
⑤			
④			
③			
②	ADDED MATERIAL LABELS	03/27/00	JLR
①	ENLARGED MAIN SECT. VIEW & ADDED NOTES	03/14/00	ARM

• REVISIONS •

Eco-Pak Specialty Packaging Division of CBC

30X
PROTECTIVE SHIPPING CONTAINER

Checked [illegible]
Appr'd By [illegible]
Appr'd By

Date 8/99
Dr'n By GAC
Scale NONE

DRAWING NUMBER 30X-4 SAR
REV. 2
SHEET 4 OF 4

SHERWIN WILLIAMS CHEMICAL COATINGS

PRODUCT DATA CC-A12

CATALYZED EPOXY PRIMER

PART A - RED OXIDE E61 R C22
PART B - CATALYST V66 T C1

PRODUCT DESCRIPTION

Catalyzed Epoxy Primer E61 R C22/V66 T C1 is a two-component epoxy primer system offering excellent adhesion and corrosion resistance. Its' fast dry makes it ideal for production line application. It is especially suitable for use under POLANE® Polyurethane topcoats where superior corrosion resistance is needed.

Advantages:

- Very fast drying for a catalyzed epoxy.
- Excellent corrosion resistance.
- No "sweat-in" time required - can be applied immediately after mixing.
- Long working pot life.
- Free of lead hazards.
- Recommended primer under POLANE® Polyurethanes for best corrosion resistance on metal.
- Meets transformer specifications when topcoated with POLANE HS.
- Ideal primer for structural steel, farm and construction equipment, railroad equipment, machinery, transformers, castings, etc. when topcoated with POLANE Polyurethanes.
- Excellent chemical resistance.
- Ideal for application to untreated steel.

CHARACTERISTICS

Color:	Red Oxide
Gloss:	Under 30 units
Mix Ratio:	4 parts E61 R C22 1 part V66 T C1 2 parts R7 K 54
Volume Solids:	E 61 R C22 - 44% ± 2% V66 T C1 - 39% ± 2%
Catalyzed and Reduced:	30.7%
Viscosity:	
	E61 R C22 - 30 to 50 seconds Zahn #5 V66 T C1 - 10 to 20 seconds Zahn #5
Spreading Rate:	
Catalyzed and Reduced:	480 sq.ft./gal. at 1 mil (dry film, no application loss)
Working Pot Life:	8 hours
Package Life:	1 year
Drying:	Air dry 77°F, (25°C) 50% RH, 1.5 mils dry film
To Touch:	20-30 minutes
Tack Free:	1-2 hours
To Recoat:	1-2 hours
Force Dry:	20' at 140°F
Flash Point:	Under 100°F

Air Quality Data:

Photochemically Reactive. Volatile Organic Compounds (VOC) - E61 R C22 as packaged (maximum) 4.0 lb/gal (480 gms/ltr) V66 T C1 as packaged (maximum) 4.15 lb/gal (490 gms/ltr). Catalyzed 4:1 and reduced 50% (maximum) with R7 K 54 - 5.60 lb/gal (672 gms/ltr). Free of lead hazards. Contains chromates.

Product Limitations:

1. Topcoat only with POLANE Polyurethanes and catalyzed epoxy topcoats.
2. If primed parts are stored outside for long periods before topcoating, the chalk must be removed before painting or reprime with a thin coat of catalyzed epoxy primer.
3. On sand blasted surfaces, primer thickness must be 1 mil greater than the profile to insure best corrosion resistance. Multiple coats may be required.

SPECIFICATIONS

Surface Preparation:

Metal:
Apply to properly cleaned and/or treated metal surface. Treatment may consist of a proprietary surface chemical treatment (Zinc or Iron Phosphate). See also Metal Preparation Brochure CC-T1.

Aluminum:
Prime with Industrial Wash Primer P60 G 2.

Galvanized Iron:
Apply E61 R C22/V66 T C1 directly to aged weathered galvanize. If new galvanize, prime with Industrial Wash Primer P60 G 2.

Blasted Surfaces:
Dry film thickness must be 1 mil greater than depth of profile for best corrosion resistance.

Application:

Recommended Film Thickness:
Wet: 4-6 mils
Dry: 1.2-1.8 mils

Conventional Spray: Reduce 30-40% with R7 K 54 to 30-45 seconds Zahn #2.

Airless Spray: Reduce 0-10% with R7 K 54. For smooth appearance and good film build operate at 1800-2200 PSI with a .013 tip.

Clean Up:
Use R7 K 54

MSDS:
If a Material Safety Data Sheet is required, contact your local Sherwin-Williams Representative.

Safety Cautions:

DANGER! Contents are FLAMMABLE. Vapors may cause flash fires. Keep away from heat, sparks, and open flame. During use and until all vapors are gone: Keep area ventilated — Do not smoke — Extinguish all flames, pilot lights, and heaters — Turn off stoves, electric tools and appliances, and any other sources of ignition.

CONTAINS: VOLATILE ORGANIC COMPOUNDS
ALCOHOLS, EPOXY RESIN
POLYAMIDE RESIN, STRONTIUM CHROMATE

HARMFUL IF INHALED — MAY AFFECT THE BRAIN OR NERVOUS SYSTEM, CAUSING DIZZINESS, HEADACHE OR NAUSEA. IRRITATES EYES, SKIN AND RESPIRATORY TRACT. MAY CAUSE ALLERGIC SKIN REACTION. CAN BE ABSORBED THROUGH THE SKIN.

Use only with adequate ventilation. Wear an appropriate properly fitted vapor/particulate respirator

(continued on back)

CC-A12 7/94 2001485

(continued from column 3)

(NIOSH/MSHA approved) during and after application, unless air monitoring demonstrates vapor/mist levels are below applicable limits. Follow respirator manufacturer's directions for respirator use.

Do not permit contact with skin and eyes. Components and mixed product can be absorbed through the skin and may cause allergic skin reaction. Wear neoprene gloves and goggles. Wash hands after using. Keep container closed when not in use. Do not transfer contents to other containers for storage.

FIRST AID:

If INHALED: If affected, remove from exposure. Restore breathing. Keep warm and quiet.

If on SKIN: Wash affected area thoroughly with soap and water. Remove contaminated clothing. Launder before re-use.

If in EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention.

If SWALLOWED: Get medical attention immediately.

SPILL AND WASTE

Remove all sources of ignition. Ventilate and remove with inert absorbent. Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State, and Local regulation regarding pollution.

DELAYED EFFECTS FROM LONG TERM OVEREXPOSURE: Contains solvents which can cause permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

Contains Strontium Chromate which can cause cancer.

This product must be mixed before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.

DO NOT TAKE INTERNALLY
KEEP OUT OF THE REACH OF CHILDREN
FOR INDUSTRIAL USE ONLY

NOTE:

The information, rating and opinions stated here pertain to the material currently offered and represent the results of tests believed to be reliable. However, due to variations in customer handling and methods of application which are not known or under our control, The Sherwin-Williams Company cannot make any warranties or guarantees as to the end result.

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Advantages:

- Very fast drying for a catalyzed epoxy.
- Excellent corrosion resistance.
- No "sweat-in" time required - can be applied immediately after mixing.
- Long working pot life.
- Free of lead hazards.
- Recommended primer under POLANE® Polyurethanes for best corrosion resistance on metal.
- Meets transformer specifications when topcoated with POLANE HS.
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Viscosity:	E61 R C22 - 30 to 50 seconds Zahn #5 V66 T C1 - 10 to 20 seconds Zahn #5
Spreading Rate:	
Catalyzed and Reduced:	480 sq.ft./gal. at 1 mil (dry film, no application loss)
Working Pot Life:	8 hours
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Drying:	Air dry 77°F, (25°C) 50% RH, 1.5 mils dry film
To Touch:	20-30 minutes
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Clean Up:
Use R7 K 54

MSDS:
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Safety Cautions:
DANGER! Contents are FLAMMABLE. Vapors may cause flash fires. Keep away from heat, sparks, and open flame. During use and until all vapors are gone: Keep area ventilated — Do not smoke — Extinguish all flames, pilot lights, and heaters — Turn off stoves, electric tools and appliances, and any other sources of ignition.

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HARMFUL IF INHALED — MAY AFFECT THE BRAIN OR NERVOUS SYSTEM, CAUSING DIZZINESS, HEADACHE OR NAUSEA. IRRITATES EYES, SKIN AND RESPIRATORY TRACT. MAY CAUSE ALLERGIC SKIN REACTION. CAN BE ABSORBED THROUGH THE SKIN.

Use only with adequate ventilation, Wear an appropriate properly fitted vapor/particulate respirator

(continued on back)

CC-A12 7/94 2001485

(continued from column 3)

(NIOSH/MSHA approved) during and after application, unless air monitoring demonstrates vapor/mist levels are below applicable limits. Follow respirator manufacturer's directions for respirator use.

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SOUTHWEST RESEARCH INSTITUTE™

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION
DEPARTMENT OF FIRE TECHNOLOGY
FAX (210) 522-3377

March 13, 2000

Ms. Rose Montgomery
Columbiana Boiler Company
Eco-Pak Specialty Packaging Division
200 West Railroad Street
Columbiana, OH 44408

Reference: SwRI Project No. 01-1680a **ERRATA**

Dear Ms. Montgomery:

Enclosed please find an Errata for the above-referenced report. The Errata is to be stapled to each report and is considered part of the final report. Any distribution of the reports shall include a copy of the Errata.

Per our meeting conducted March 8 - 9, 2000, attached please find our response to the Nuclear Regulatory Commission's letter dated February 11, 2000 requesting additional information (RAI).

If I can be of further assistance, please feel free to contact me at (210) 522-3716 or by fax at (210) 522-3377.

Sincerely,

James R. Griffith, Jr., P.E., FPE
Assistant Manager
Fire Resistance Section

Approved by:

Alex B. Wenzel
Director
Department of Fire Technology

JRG/jgm

Enclosures: (1)

cc: Record Copy A - Dept. Copy
Record Copy B - Contracts
C:\wpdata\griffith\1680err.ltr

ATTACHMENT A

CONSISTING OF 1 PAGE

Explanation for Change in Pressure During the Post-Drop/Post-Fire Hydrostatic Leakage Testing of Cylinder S/N001.

The cylinder to be tested was filled with water containing a fluorescent dye and pressurized to 20 ± 1 psig using shop air. Following pressurization, the cylinder was allowed to sit for a minimum of 8 hours. The pass/fail criteria set for the test was the absence (pass) or presence (fail) of fluorescent dye traces on the exterior surface of the cylinder and valving. No dye was present on the exterior surface or valving of the cylinder tested; therefore, it was concluded that the cylinder and valving did not leak. However, a drop in pressure was noted. In the opinion of SwRI, this pressure drop was not an indication of leakage for the following reasons:

1) The soap bubble test subjected the entire containment boundary to 100 ± 1 psig and no leakage was detected. It would not have been possible to maintain 100 psig had a leak been present in the cylinder or valving.
2) The helium leakage test subjected the entire containment boundary to an internal pressure of 1.0E-03 atm. The vacuum was stabilized and maintained during the helium test procedure. It would not have been possible to stabilize the vacuum if a leak had been present in the cylinder or valving.
3) No fluorescence was detected on any exterior surface of the cylinder or valving.

There are several possible explanations for the pressure drop that was observed. The most likely are:

1) While internal temperature measurements were not made after the fire test was completed, the content temperature was likely 20°F higher at the initial pressure reading than the final pressure reading. Using the ideal gas law and 20°F differential temperature, the resulting decrease in pressure would have been 2.5 psig.
2) The initial measurement was made after changing the orientation of the cylinder from vertical to horizontal. The pressure transducer diaphragm may have had water against it during the initial measurement, causing an artificially high reading, due to the elevated temperature of the water. The final measurement was taken many hours later, after the heated water was no longer in contact with the diaphragm, allowing it to return to ambient temperature.
3) Instrumentation drift or failure may have caused an artificially high or low reading. A 1% drift of the transducer's full scale would correspond to 1.5 psig.

It is important to note that the pressure was not being monitored as a quality test, merely as a guide. The presence or absence of the fluorescent dye provided the pass/fail criteria for the test. In order for the cylinder to leak and not produce an exterior fluorescence from the dye, it would have had to leak at the location of an air bubble (estimated half-liter in volume) trapped in the cylinder during the test. Because of the orientation of the cylinder, the air bubble would not have been located at a weld seam. There was no observed damage on the exterior skin of the cylinder that would have indicated a leak at a location other than a weld or valve. Thus, there was no avenue available for leakage from the air pocket, and no water leakage was detected. Therefore, it is the opinion of SwRI that the cylinder did not leak, and that the observed pressure drop was caused by unknown experimental circumstances and in no way affected the outcome of the test.

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION
DEPARTMENT OF FIRE TECHNOLOGY
FAX (210) 522-3377

ERRATA

SwRI Final Report No. 01-1680a

entitled

PERFORMANCE EVALUATION OF UF_6 SHIPPING CONTAINERS
UNDER HYPOTHETICAL ACCIDENT CONDITIONS
SPECIFIED IN TITLE 10 CFR PART 71.73

By

James R. Griffith, Jr., P.E., FPE

The following corrections are applicable to the above cited report which was issued under SwRI Project No. 01-1680a, dated May 1998.

Page iii

Paragraph 3, now reads as follows:

> The maximum single point temperature recorded on the surface of the 30B cylinder during the 11-hr cool down period was **177°F** (TC 3 at 3 hr 52 min), and the average of the maximum TC readings was 152°F.

This is changed to read:

> The maximum single point temperature recorded on the surface of the 30B cylinder during the 11-hr cool down period was **187°F** (TC 3 at 3 hr 52 min), and the average of the maximum TC readings was 152°F.

Page 15

Paragraph 1, Line 4, now reads as follows:

> The plug end was replaced with a port allowing for pressurization of the 30B cylinder to **19** psig.

This is changed to read:

> The plug end was replaced with a port allowing for pressurization of the 30B cylinder to **20 ± 1** psig.

Page 42

Paragraph 3, now reads as follows:

> The maximum single point temperature recorded on the surface of the 30B cylinder during the 11-hr cool down period was **177°F** (TC3 at 3 hr 52 min), and the average of the maximum TC readings was 152°F.

This is changed to read:

> The maximum single point temperature recorded on the surface of the 30B cylinder during the 11-hr cool down period was **187°F** (TC3 at 3 hr 52 min), and the average of the maximum TC readings was 152°F.

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July 20, 1999

Ms. Heather Little
Eco-Pak Specialty Packaging
Division of Columbiana Boiler Company
200 West Railroad Street
Columbiana, OH 44408
Phone: (423)543-4211
Fax: (423)543-6007

RE: ESP letter dated May 4, 1999 and SwRI Final Report No. 01-1680a

Dear Ms. Little:

This letter is provided in response to the U.S. Nuclear Regulatory Commission (NRC) questions regarding ESP's license application for the ESP-30X over pack. Each of the items listed in your letter is addressed and supporting documentation is attached to this letter.

STRUCTURAL No. 1:

The initial air pressure soap bubble leakage test performed on the ESP-30X, SN 002 (30B cylinder identified as CB-1871-7) on March 11, 1999 resulted in a leak being detected at the valve. Inspection of the valve found the torque to be 110 ft-lb instead of 200-400 ft-lb recommended in the installation procedure. A custom made valve tool was used to turn the valve one full turn tighter with a maximum torque of 215 ft-lb, just slightly above the minimum torque requirement. The air pressure soap bubble leakage test was repeated and no leaks were detected. Subsequent helium and hydrostatic leakage tests were successful. See QA Surveillance Report 98-SR-050 for Project No. 01-1680-101(attached).

Page D-1 of Appendix D of the referenced report records leakage test results for a completely different package, identified as OPM-1, SN 002, which was tested with the ESP-30X but is not part of the application for ESP-30X package design. ESP-30X, SN 002 (30B cylinder, CB-1871-7) was not fire tested.

STRUCTURAL No. 5:

Item a:

Following the successful post-fire helium leakage test on the 30B cylinder (identified as CB-1871-2, ESP-30X SN001), the hydrostatic test was initiated. As stated on pages 16 and D1 of the referenced report, at 10:40 a.m. on March 24, 1999, the 30B cylinder was completely filled with water containing a flourescent dye and pressurized to 20 psig. At 8:47 a.m. on March 25, 1999 the internal pressure was noted to be 13 psig and the 30B cylinder was inspected for leaks. There were no visible traces of leaks from any of the openings, which would have been evident from the flourescent dye. The drop in pressure was attributed to the drop in temperature of the cylinder and contents.

The drop in pressure is directly proportional to the change in temperature. Assume the initial condition was that the 30B cylinder was filled with steel short at 150°F. Cold water (containing a flourescent dye) was poured into the 30B cylinder and the pressure was set to 20 psig. The 30B cylinder and contents cooled to 70°F. This alone would account for a pressure drop of about 4 psig.

Item b:

The over pack marked as ESP-30X SN002 with 30B cylinder marked CB-1871-7 was subjected to leakage and drop tests only (refer to Attachment 2). Following all drop tests each over pack was inspected for damage and ESP-30X SN 001 was selected for the pool fire tests.

Item c:

Table 9-3 of *Southwest Research Institute Performance Evaluation Of UF6 Shipping Containers Under Hypothetical Accident Conditions Specified In Title 10 CFR Part 71.73* (Appendix 2.10.9) stated at 30 min, "Flames subsiding. Residual burning allowed to self extinguish." This statement was not meant to imply that the package was not fully engulfed at 30 min. Review of the video tape and test data indicates that the package was fully engulfed for 30 min.

Item d:

Refer to Figure 2 for calibration certificate for Veeco Mass Spectrometer Leak Detector Model 7MS40.

Item e:

SwRI received preliminary drawings of the test articles for test item preparation purposes prior to conducting the test program and completing the final report. ESP can provide the final detail drawings and comments concerning any differences between the test article and the final package design.

Item f:

Following the successful fire test, the 30B cylinder (CB-1871-2) was removed from the over pack, pressurized with shop air at 100± 1 psig and the soap bubble leak test was performed. The soap bubble leak test was repeated several times over the next 22 min and no leakage was detected. At the conclusion of the soap bubble leak test the internal pressure reading was 99 psig. Furthermore, subsequent helium leakage test results determined no leakage at any connections on the cylinder.

Item g:

Appendix D, page D-1 refers to a different design package (OPM-1, SN.002) which was tested but is not part of the application for ESP-30X package design. The ESP-30X SN 002 with 30B cylinder CB-1871-7 was not subjected to the fire test.

Item h:

The initial air pressure and soap bubble leak test on the ESP-30X, SN 002 was performed on March 11, 1998 and resulted in a leak being detected at the valve. Inspection of the valve found the torque to be 110 ft-lb, well below the recommended value of 200-400 ft-lb. A custom made valve tool was used to turn the valve 1 full turn tighter with a maximum torque of 215 ft-lb. The air pressure and soap bubble leak test was repeated and no leaks were detected. See QA Surveillance Report 98-SR-050 for Project No. 01-1680-101(attached). Subsequent leakage tests resulted in no leakage.

leak test was repeated and no leaks were detected. See QA Surveillance Report 98-SR-050 for Project No. 01-1680-101(attached). Subsequent leakage tests resulted in no leakage.

THERMAL No. 2:

Table 9 - 4 on page 28 of the report shows the maximum temperature reading recorded by the thermocouples during the 30-min fire exposure period and during the cool down period following the pool fire. Figure 9-11 on page 34 shows the maximum temperature readings indicated by the temperature tags for the duration of the 30-min fire exposure and cool down period. Temperature tags and post test thermocouple measurements are in agreement. Some of the labels delaminated from the cylinder and no temperature measurements were available.

CONTAINMENT No. 1:

a. The initial air pressure soap bubble leakage test performed on the 30B cylinder involved pressurizing the cylinder to 100 psig using shop air via a fitting installed at the plug connection. All connections were then checked with a soap solution.

b. The helium leak test was performed by evacuating the 30B cylinder with a ruffing vacuum pump via a fitting installed at the plug connection. The Veeco 7MS40 was connected to the 30B cylinder via the plug fitting. A plastic bag was placed over the plug fitting and flooded with helium to confirm that the fitting did not leak and establish the background helium leakage rate. The bag was then placed over the valve and flooded with helium. Following a minimum 10-min period the helium leakage rate was recorded.

c. The 30B cylinder was completely filled with water containing a flourescent dye and pressurized to 100 psig using shop air via a fitting installed at the plug connection.

CONTAINMENT No. 6:

The complete 30B cylinder and all fittings, including the valve and plug connection, remained leaktight after the initial leakage tests and after post-fire helium and hydrostatic leak tests.

GENERAL:

Section 4.0 of *Southwest Research Institute Performance Evaluation Of UF6 Shipping Containers Under Hypothetical Accident Conditions Specified In Title 10 CFR Part 71.73* (Appendix 2.10.9) should be revised as follows:

> All test and quality assurance procedures were written under Southwest Research Institute's Nuclear Quality Assurance Program Manual (NQAPM) and/or the Department of Fire Technology Quality Assurance Manual (DFTQAM). All test procedures and activities were approved under ESP's NRC Approved Quality Assurance Program (Certificate No. 0179), which meets the requirements of Title 10 CFR 71, Subpart H, and monitored by ESP personnel. The NQAPM and DFTQAM meet the requirements of Title 10 CFR 50, Appendix B. SwRI prepared a Project Quality Plan (PQP) Document No. NPQP-98-01-1680, which identified the specific sections of the NQAPM or DFTQAM which apply, and addressed specific requirements identified in the contract. SwRI Quality Assurance/Quality Control (QA/QC) personnel provided independent surveillance, quality checks, and inspections during the course of this program.

I trust that this information will be sufficient. Please feel free to contact me at (210)522-3716 or reach me by fax at (210)522-3377, or e-mail at jgriffith@swri.org if I can be of further assistance.

It has been my pleasure to work with you and I am looking forward to our next project.

Best regards,

James R. Griffith, Jr., P.E., FPE
Assistant Manager
Fire Resistance Section

Approved:

Alex B. Wenzel
Director
Department of Fire Technology

JRG/jrt
W:\fire\Jessica\eco-pacesp.ltr

Enclosures: Figure 1
Figure 2
Attachment 1
Attachment 2

CLIENT: ECO-PAK SPECIALTY PACKAGING
SwRI PROJECT No.: 01-1680-102
DATE: 21 MARCH 1998
FILE ID: 08030SXT.DAT

ESP-30X PACKAGE
AVERAGE FIRE TEMPERATURE

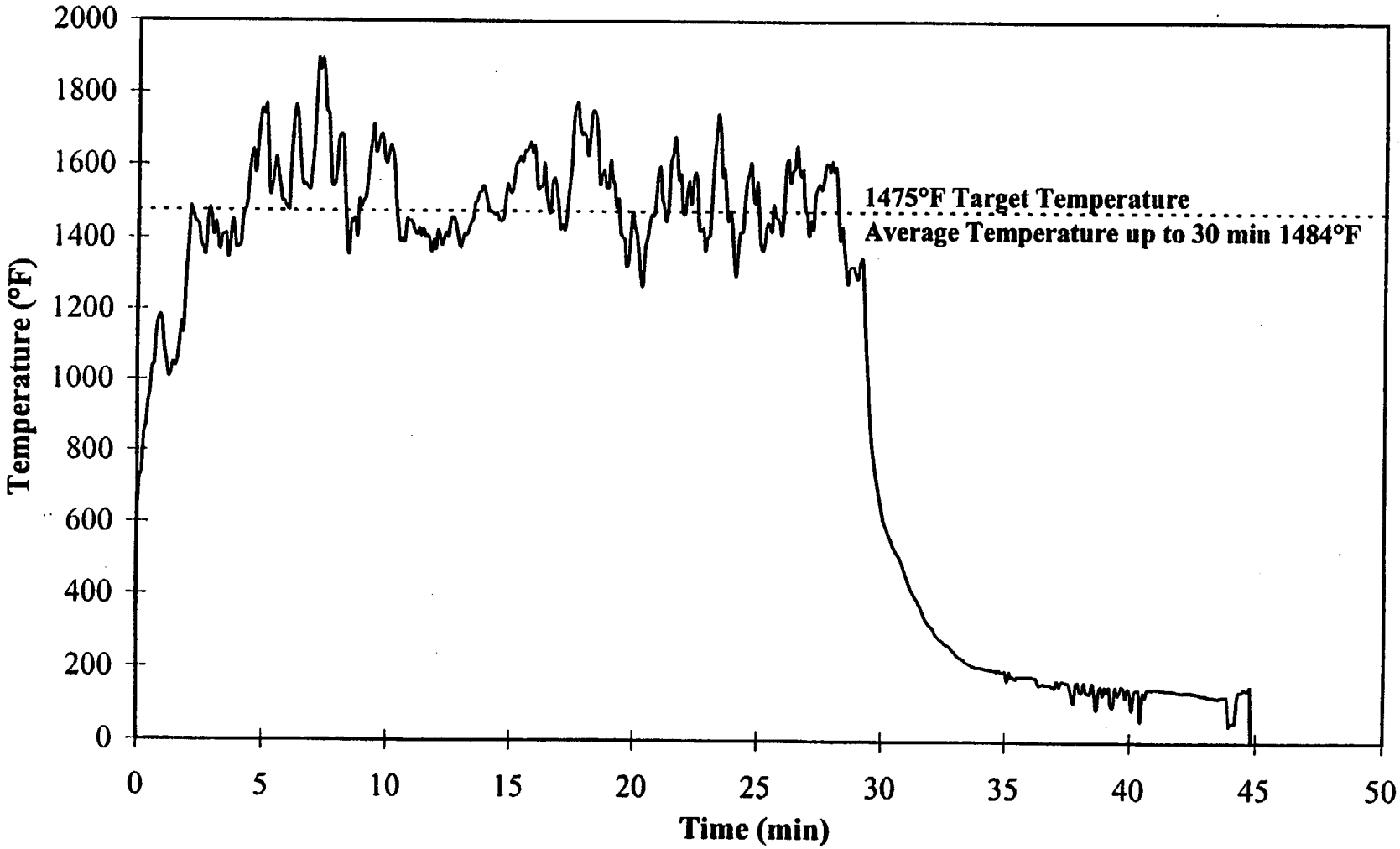

Figure 1

Terminal Drive, Plainview, NY 11803 516-349-4300 • Fax 516-349-7009

Veeco Instruments Inc.

CALIBRATION CERTIFICATE

incompliance with
ANSI/NCSL Z540-1-1994
ISO-10012-1:1992E

Veeco Instruments Inc. certifies the calibrated leak referenced below is accurate in accordance with measurement technique that compares, through the use of a Veeco Mass Spectrometer Leak Detector, each unit against a primary standard, serial number 0001* and / or 0003*. These standards are certified and calibrated by the National Institute of Standards and Technology (NIST). The reference Mass Spectrometer Leak Detector is continuously calibrated and becomes the instrument used to certify the Calibrated Leak. This instrument is maintained and calibrated in accordance with Veeco Standard Calibration Procedure for Helium Calibrators CP001-MS Rev. A.

We recommend the Calibrated Leak be returned to Veeco Instruments Inc. for recalibration annually.

NOTE: Calibrated Leaks should be stored and shipped with valve open.

MODEL: 7MS10 SERIAL NO: 0555

CAL DATE: 03/28/1997 CERTIFICATION NO: I.867607

The above sensitivity calibrator has been calibrated as of this date with the following results:

Helium Leak Rate:

0.0035 ± 10% Micron cu.ft/hr.
1.5×10^{-4} ± 10% Std. cc/sec.

Air Leak Rate Through Equivalent Leak:

0.0013 ± 10% Micron cu.ft/hr.
1.3×10^{-4} ± 10% Std. cc/sec.

Calibration Temperature: 22 °C

Temperature Coefficient = ± 3% per degree C Leak rate decreases less than 5% per year

Final Inspection By: _____
(Calibration Laboratory Technician)

This certificate shall not be reproduced except in full, without the written approval of Veeco Instruments Inc.

* NIST Test Number 251779-96R T144 ** NIST Test Number 251587-97 T160

Eco-Pak Specialty Packaging

SwRI Project No. 01-1680b

Figure 2

ATTACHMENT 1

INSTITUTE QUALITY ASSURANCE SURVEILLANCE REPORT

Project No.: 01-1680-101	Report No.: 98-SR-050	Page 1 of 5

Surveillance Scope:
Witness testing activities at SwRI and off-site for EcoPak

Reference Documents: NQAPM, Contract

Starting Date: March 11, 1998 **Ending Date:** Arpil 2, 1998

QA Representative: Kenneth R. Jones

Person(s) Conducting Test/Exam/Procedure: 01 - Jim Griffith and others, client reps
04 - Dan Pommerening and others, client reps

Satisfactory Findings:
Tests conducted in accordance with procedures using qualified personnel. Drop tests conducted on the drop pad behind building 128. Leak tests conducted in Firetech labs. Pool fires conducted off-site. At all times, qualified personnel were performing tests or handling test items. Calibrated equipment verified prior to testing. All calibrated equipment listed in test logs and test report.

Reference the attached surveillance logs.

Unsatisfactory Findings:

None

Nonconformance Report No.: None **CAR/SCAR No.:** None

Attachments: Surveillance log sheets.

Recommendations/Actions: None

Equipment Calibration: As listed in logs and test report.

Approved: R. Whitehead
Institute Quality Assurance

Date: 4/20/98

Distribution: Original - QA File
cc: Originator
Jim Griffith (01)
Dan Pommerening (04)

RECEIVED
APR 30 1998
DEPT. FIRE TECHNOLOGY

SwRI Form QA-125-1c

98-SR-50

SURVEILANCE LOG	2
	ECO-PAK 01-1680-101
3-11-98	WITNESS INITIAL PRESSURIZATION (AIR) OF ESP-30X
	S/N 001 + 002. TANK 002 LEAKED DURING
	THIS STEP.
	BEGAN VACUUM FOR HELIUM LEAK TEST
	OF TANK 001.
	ON ANALYSIS OF TANK 002 FOUND TORQUE
	OF VALVE TO BE 110 FT LBS INSTEAD OF
	200-400 FT LBS AS REQUIRED. TURNED
	VALVE ONE FULL TURN TIGHTER AND
	ACHIVED 215 FT LBS TORQUE. PRESSURIZATION
	TO 100 PSI PASSED.
	TANK 001 PASSED He TEST. TANK 002
	LEFT TO VACUUM OVER NIGHT.
3-12-98	TANK 002 PASSES He TEST. ~~tst~~
	INSPECTED THERMOCOUPLE INSTALLATION
	ON TANK 001, MONITOR INSTALLATION
	ONTO TANK 002.
	WITNESSED HELIUM LEAK TEST ON
	OPM-1 ~~TANK S/N 002~~ SYSTEM S/N 002.
	ALL FOUR TANKS REMOVED FOR He TEST.
	DATA RECORDED
3-13-98	MEASURED STRUT TO BE USED IN DROP
	TEST.

98-SR-50

SURVEILANCE LOG 3

3-13-98	MONITORED INSTALLATION OF T/C's
	ON OPM 1 S/N 002 AND REASSEMBLY.
3-16-98	WITNESS 30 FT DROP TEST + 1 METER
	PUNCTURE TEST AT 13° FROM VERTICLE ON
	ESP 30X S/N 001.
3-17-98	ESP 30X S/N 002. WITNESS DROP TEST FROM
	30' AT 30° FROM VERTICLE AND W/5° TWIST.
	ALSO 1 METER PUNCTURE TEST FROM HORIZONTAL
	ONTO SEAM.
	ESP 30X S/N 001. DROP TEST FROM 1 METER IN
	HORIZONTAL POSITION ONTO BARE SURFACE.
	(PUNCTURE TEST).
	NOTE THAT BOTH UNITS HAD BEEN PRE-
	CONDITIONED TO -30°C PRIOR TO ALL DROPS.
	OPM-1 S/N 002 REMOVED FROM CONDITIONING.
	WITNESS 30' DROP FLAT BOTTOM, 30' ONE
	TOP CORNER, 30' ONE TOP EDGE, 1 METER
	PUNCTURE.
	OPM-1 S/N 001 REMOVED FROM CONDITIONING.
	WITNESS 30' DROP ONE TOP EDGE, ONE
	1 METER PUNCTURE.

98-SR-50

SURVEILANCE LOG 4

3-18	REMOVE COVER ON ESP 30X S/N 002.
	REMOVE TANK AND PERFORM 100 PSI PRESSURE
	TEST. BEGIN PUMP DOWN FOR HELIUM
	LEAK TEST.
	REMOVE COVERS FROM OPM 1 S/N 001.
	NOTE COVERS JAMMED FROM WARPING
	CAUSED BY DROPS. REMOVED CYLINDERS
	AND PERFORMED VISUAL INSPECTION.
3-19	PERFORM HELIUM LEAK TEST ON
	ESP 30X S/N 002
3-20	PERFORM POOL FIRE TEST ON OPM-1 S/N 002
3-21	PERFORM POOL FIRE TEST ON ESP-30X S/N 001
3-23	OPEN ESP-30X S/N 001 POST FIRE TEST. REMOVE
	CYLINDER. PERFORM PRESSURE TEST. START
	PUMP DOWN FOR HELIUM LEAK TEST.
3-24	PERFORM HELIUM LEAK TEST. START
	SOAK UNDER PRESSURE FOR HYDRO TEST.
	OPEN OPM-1 S/N 002 POST FIRE TEST.
	REMOVE CYLINDERS. HELIUM LEAK
	TEST. NOTE 2 OF 4 CYLINDERS FAIL.
3-25	VERIFY HYDRO. NO LEAKS.

SURVEILANCE LOG

3-25	DRILL + TAP LIDS ON 4 OPM CYLINDERS.
	HELIUM LEAK # 1 + 4.
	OPEN #1 TO LOOK AT O-RINGS.
3-26	HELIUM LEAK #2+3.
	VOTE #3 WOULD NOT HOLD VACUUM.
4-2	PERFORM POOL FIRE TEST OF OPM-1 S/N 001

ATTACHMENT 2

Test Results for ESP-30X SN 002/30B Cylinder CB-1871-7

ESP-30X SN 002/30B Cylinder No. CB-1871-7 Test Results

Sections 1.0 - 8.3 are equivalent to the original test report, *Southwest Research Institute Performance Evaluation Of UF6 Shipping Containers Under Hypothetical Accident Conditions Specified In Title 10 CFR Part 71.73* (Appendix 2.10.9). Section 8.4 is not applicable, since ESP-30X SN 001 was selected for the thermal test.

1.0 TEST RESULTS

1.1 Leakage and Hydrostatic Test Results

Initial soap bubble and helium leakage tests were performed on the 30B cylinder prior to conducting the drop tests and following completion of the pool fire exposure test. The preliminary soap bubble test was performed at 3:30 pm on March 11, 1998. For this test, the 30B cylinder was pressurized to 100 psi, and the soap bubble indicator fluid was directed to the region surrounding the valve assembly and monitored for signs of leakage. A leak was immediately detected. The acceptance criteria specified that any leakage greater than 1.0×10^{-7} std cc/sec of air is considered a failure. We checked the torque and found it to be low (110 ft-lbs), tightened the valve one full turn and met the minimum (215 ft-lbs) torque requirement.

The pre-drop helium leakage test was performed on March 12, 1998. At 4:37 pm on March 11, 1998 we started to evacuate the 30B cylinder with a ruffing vacuum pump to the required pressure of less than 1×10^{-3} atm (1×10^{-3} atm = .0147 psi = .761 Torr). At 8:40 am on March 12, the test port pressure was 76-81 MT. Leak rate background was 1.7×10^{-9} atm cc/sec. The helium flow into the mylar bag taped around the valve was started at 8:47 am, and at 8:50 am, the leak rate was 1.7×10^{-9} atm cc/sec.

Following completion of the drop testing on March 17, 1998, final post-drop soap bubble and helium leakage tests were performed on the 30B cylinder. The preliminary soap bubble test was performed March 18, 1998. The 30B cylinder was pressurized to 100 psi at 2:44 pm; and the soap bubble indicator fluid was directed to the valve assembly and monitored for signs of leakage. At 3:10 pm, no leakage was detected.

The post-drop helium leakage test was performed on March 19,1998. At 3:36 pm on March 18, a ruffing vacuum pump was used to evacuate the 30B cylinder to the required pressure, and the background helium leakage rate at 8:58 am on March 19 was 8.3×10.6^{-9} atm cc/sec, test port pressure 65-70MT. At 9:02 am, helium flow into the bag started. At 9:22 the rate was 8.2×10^{-9} atm cc/sec.

Following successful completion of the post-drop helium leakage test, the 30B cylinder was filled with water containing fluorescent indicator dye. The test item was placed horizontally with the valve in the 6 o'clock position. The plug opposite the valve end was replaced with a port allowing for pressurization of the 30B cylinder to approximately 20 psig. At 4:38 pm, the pressure was allowed to stabilize at 20 psi, and we started the hold period. At 8:30 am on March 20, tank pressure was 16 psi and there were no signs of leakage which would have been indicated by the dye.

Table 1.1 summarizes results for the pre-drop/post-drop preliminary soap bubble tests, pre-drop/post-drop helium leak tests, and post-drop hydrostatic leakage test. Data log sheets for all leakage and hydrostatic tests are found in Appendix D.

Table 1.1. Leakage and Hydrostatic Test Results

Test Item: ESP-30X, SN002 30B Cylinder, CB-1871-7

TEST PERFORMED	REQUIREMENT	MEASUREMENT	PASS/FAIL
Pre-Drop Soap Bubble	No Leaks	No Leaks	Pass
Pre-Drop Helium	$<1.0 \times 10^{-7}$ std cc/sec	1.7×10^{-9} std cc/sec	Pass
Post-Drop Soap Bubble	No Leaks	No Leaks	Pass
Post-Drop Helium	$< 1.0 \times 10^{-7}$ std cc/sec	8.2×10^{-9} std cc/sec	Pass
Post-Drop Hydrostatic	No Leaks	No Leaks	Pass

1.2 Drop Testing

The testing outlined in this section was designed to demonstrate the performance of the shipping configurations under hypothetical accident conditions.

The drop testing included the following major steps:

1. Conditioning to -20°F of ESP-30X SN002
2. 30 foot drop test of SN002 at 30° from horizontal on end closure bolt.
3. Physical inspections of over pack.
4. 40-in. puncture test of SN002 on center closure bolt.
5. Physical inspections of over pack.

Test facilities utilized for performance of the work under this project were adequate to accomplish the objectives of the project.

1.2.1 Assumptions

A basic assumption made for this testing was that the drops made are the worst case condition as required by 10 CFR Part 71.

1.2.2 Environmental Conditioning

The low temperature conditioning was done in a chamber to achieve the required test item temperature, -20°F (-29°C) on the over pack insulation. To measure this temperature a 2-in. deep hole was drilled in the over pack and a thermocouple installed. The thermocouple hole was sealed with RTV to prevent air infiltration. To accelerate cooling, the air temperature in the chamber was varied. A target air temperature was -40°F the minimum transportation temperature as defined in ANSI N14.1. In some cases the air temperature was set lower than this to accelerate the cooling. Because of the thermal mass and insulation of the test item, its response to changes in the air temperature was slow.

Conditioning was performed until the test item had reached the required temperature. During the testing process, which included: removal from the conditioning chamber, drop angle adjustments, drops, and physical inspection, the test item temperature rose. When not being tested, the test item was returned to the chamber to stabilize the temperature. This low temperature conditioning met the intent of the low temperature requirements of 10 CFR Part 71.

Plots of the chamber air temperature and test item temperatures are included in this report as Figure 6-1. Low temperature conditioning of the ESP-30X test items was started on March 13, 1998 at 13:28 p.m., Figure 2. During the first 24 hours of conditioning the chamber air temperature was set to a nominal

-40°C. At this time the test item temperatures were close to the required levels. To insure that they did not get too low the chamber temperature was raised to -30°C for the rest of the weekend. Sunday, March 15 at 16:30 p.m., the liquid nitrogen supply ran out. Since this occurred late in the day on Sunday it was not corrected until early Monday morning, March 16 at 6:07 a.m. During this time the chamber and test item temperatures rose. On Monday morning Dewars were connected to the chamber and the air temperature set to -40°C. These Dewars were used until the large tank was refilled and connected March 16 at 11:46 p.m. At that time the air temperature was set to -50°C, to try and drive the test item temperatures down to the required levels prior to testing.

On removal of ESP-30X SN001, which had a temperature of -31°C (-23°F) from the chamber March 16 at 13:31 p.m. the air temperature was set back to -40°C. Drop testing was performed on SN001 and it was returned to the chamber for additional conditioning over night. When placed back in the chamber the insulation temperature was -8°C (17°F). The temperature had risen 23°C during the 1 hr and 45 min of testing, about 1°C every 5 min.

Upon removal of ESP-30X SN002, with an insulation temperature of -34°C (-30°F), for drop testing March 17 at 7:39 a.m., the air temperature was reset to -30°C. At this time the two OPM-1 shipping containers were placed in the chamber and the temperature reset to -50°C. At 9:05 a.m. it was again reset to -60°C, in an attempt to quickly bring the OPM-1 containers down to the required temperature. ESP-30X SN002 was subject to two drops as required and not returned to the test chamber. ESP personnel considered testing of this item complete after the two drops.

At 9:38 a.m. ESP-30X SN001, which had an insulation temperature of -34°C (-30°F), was removed from the chamber. This was prior to the final puncture test on this test item, as specified by ESP personnel.

It was possible to keep the temperature at or below -20°F (-29°C) before the drop.

1.2.3 Drop Testing

Drop testing of the ESP-30X SN002 was performed on March 17, 1998. Immediately before opening the chamber, the test item temperature was -29°F (-34°C). Two tests were performed on ESP-30X SN002. The first was a 30-foot drop onto the fiat surface of the pad. The orientation of the test item, 30° from horizontal with a 5° rotation, with the impact at the forward closure bolt location, Figure 9. The damage to the over pack exterior was measured and recorded following this testing. The second was a 40-in. drop onto a puncture bar attached to the center of the steel plate. The orientation of the test item, horizontal with a 5° rotation, with the impact at the center closure bolt location, Figure 12. The damage to the over pack exterior was measured and recorded following this testing.

The testing performed on this test item is given in Table 1.2. All testing was completed.

Table 1.2 ESP-30X SN002 Testing Performed

Procedure	Dates	Comments
Conditioning Before Drop	3/13/98 3/17/98	-30°F on Over pack Insulation at End of Conditioning
30-ft Drop	3/17/98	Good Drop; 30° with 5° Rotation
Exterior Physical Measurements	3/17/98	By Division 01 Personnel
40-in. Puncture	3/17/98	Good Drop; Horizontal with 5° Rotation
Exterior Physical Measurements	3/17/98	By Division 01 Personnel

This drop testing was performed with the cooled and undamaged ESP-30X over pack. After low temperature conditioning, the test item was removed from the chamber and a wire rope sling was attached to the over pack to orient the test item for drops. The longitudinal axis of the package was at 30° from horizontal with a 5° rotation of the seam between the upper and lower halves of the over pack, Figure 9. This drop was to impact the closure bolt at one end of the test item and then slap-down onto the closure bolt on the opposite end.

The test item was then raised to the required drop height with the crane. The drop height was determined using the calibrated plumb bob attached to the first impact point on the test item. The release of the test item was by a pneumatically actuated quick-release mechanism. No guidance of the test item was provided during the drop. Drop testing was performed under conditions that did not affect the results of the test. The average wind speed was noted, and found to be sufficiently low so that the packaging did not rotate during testing.

For this drop the pre-test conditions were:

- Drop Angle — 30° from horizontal with a 5° rotation
- Drop Height — 30 feet at impact closure bolt
- Wind Speed — Acceptable

The test item was released cleanly and impacted the pad at the desired orientation. The test item impacted the drop pad and remained on its side. Videos were taken of the drop event. The condition of the over pack can be seen in Figures 9 to 11. As a result of the drop, the exterior of the over pack was damaged. Deformation data of the over packs was measured and recorded by Division 01 personnel. Color photographs showing the extent of damage were taken. The over pack was not opened after this test. All phases of this testing were witnessed by SwRI QA/QC and ESP personnel.

The loaded ESP-30X package was then dropped 40 in. onto a cylindrical 6-in. mild steel bar mounted on the unyielding surface. For this drop, the longitudinal axis of the package was horizontal with a 5° rotation with the seam between the upper and lower halves of the over pack. Figure 12 illustrates the package orientation. This orientation was to drive the puncture bar into a specified closure bolt and try and open the two halves of the over pack.

For this drop, the pre-test conditions were:

- Drop Angle — Horizontal with a 5° rotation
- Drop Height — 40 in. to closure bolt
- Wind Speed — Acceptable

The test item was released cleanly and the drop was made, Figure 12, with the impact in the proper location. Videos were taken of the drop event. Following the drop, the over pack was on its top and half off the drop pad. Deformation of the over pack was measured and recorded by Division 01 personnel. Color photographs showing the extent of damage were taken.

There was damage to the ESP-30X over pack as a result of this testing. The seam between the upper and lower halves of the over pack did not open noticeably. ESP personnel judged the performance of the test item.

2.0 SUMMARY OF TEST RESULTS

The test items were conditioned to the required -20°F before drop testing. The temperature considered was that of the insulation in the end of the over pack.

The free fall drops were completed successfully. Drops included 30 feet onto the impact surface and 40 in. onto the puncture bar. The wind speed was such that it did not adversely affect the fall of the test item. Video of the drops was obtained. Post test inspection indicated deformation of the over pack.

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- The test item was conditioned to -20°F before drop testing.
- All drop tests were completed successfully.
- The closures on the over pack functioned properly during the drops.
- Drops resulted in deformation of the over packs.
- Damage to the closure bolts was noted.

Performance of the test items was judged by ESP personnel.

4.2 Requirements for Normal Conditions of Transport

4.2.1 Containment of Radioactive Material

The only radioactive materials in fresh UF_6 are isotopes of uranium, primarily ^{235}U and ^{238}U which have unlimited A_2 values, with traces of ^{232}U, ^{234}U, and ^{236}U. The maximum allowable leak rate for Type B shipments, assuming the maximum radioactive contents and using the 30B cylinder, is 2.2E-06 ref-cm^3/sec (see Appendix 4.4.1) per ANSI N14.5-1997. However, to preclude inleakage of moist air or water (the criticality safety of the package depends upon excluding water from the containment system), the package must be tested to leak tight conditions (leak rate less than 1 X 10^{-7} ref-cm^3/sec). The test results reported in Section 2 verify that the cylinder is capable of maintaining a leak tight condition under normal and hypothetical accident conditions. Periodic leak testing of each packaging (see Section 4.2.3, Section 7 and Section 8) assures that containment is maintained during use, and that water is excluded from the package.

4.2.2 Pressurization of Containment Vessel

During filling of the 30B cylinder with liquid UF_6, the maximum temperature inside the 30B cylinder is 180°F (USEC-651). This temperature would result in an internal UF_6 gas pressure of 60 psia. As stated in USEC-651, UF_6 is cooled and solidified and the internal pressure of a filled 30B cylinder is below atmospheric prior to shipment. At maximum normal temperature of UF_6, 136°F, the vapor pressure is less than 22 psia (Sections 3.4.4 and 3.4.6). At maximum temperature of UF_6 in a fire accident, 250°F, the vapor pressure would be 100 psia (Sections 3.5.8 and 3.5.10). All these are below the ANSI N14.1 internal design pressure of 200 psig.

4.2.3 Containment Criterion

Containment of the radioactive contents depends upon proper maintenance, periodic inspections, pre-shipment inspections of the packaging. Containment boundary leak tests are performed using a leak test with a test sensitivity of at least 5 X 10^{-8} std-cm^3/sec prior to the first use of each packaging, after maintenance, repair or replacement of components of the containment system, and periodically at intervals not to exceed 12 months. Pre-shipment leak tests are performed using a leak test with a sensitivity of at least 1 X 10^{-3} ref-cm^3/sec per ANSI N14.5-1997.

4.3 Requirements for Hypothetical Accident Conditions of Transport

4.3.1 Fission Gas Products

Neither fresh nor reprocesses UF_6 contains fission gas products.

4.3.2 Containment of Radioactive Material

Using the methodology of ANSI N14.5-1997, the maximum allowable leak rate for a Type B shipment of UF_6 in a 30B cylinder is 2.61E-04 ref-cm^3/sec (see Appendix 4.4.2).

However, to preclude inleakage of moist air or water (the criticality safety of the package depends upon excluding water from the containment system), the package must be tested to leak tight conditions (leak rate less than 1 X 10^{-7} ref-cm^3/sec).

4.3.3 Containment Criterion

Full scale compliance testing was performed on the ESP-30X package. This testing is fully described in Sections 2.10.8 and 3.5. Upon completion of tests, two leak tests were performed. A 100 psig air pressure soap bubble leak test was performed on the valve threads, seat, cap, packing nut and stem of the 30B cylinder. This method is in accordance with new cylinder and periodic inspection requirements listed in ANSI N14.1. No bubbles were found.

Following the soap bubble test, a helium mass spectrometer was used to quantify the leak rate. The test results showed that the package before and after testing has a leak rate less 10^{-7} ref-cm^3/sec.

4.4 Appendices

4.4.1 Calculation of Permissible Leak Rate for Normal Conditions
4.4.2 Calculation of Permissible Leak Rate for Hypothetical Accident Conditions (HAC)

APPENDIX 4.4.1
CALCULATION OF PERMISSIBLE LEAK RATE FOR NORMAL CONDITIONS

Leakage of Contents to Environment

The package contents, as defined in Section 1.2.3, are assumed to be completely releasable in the form of UF_6 vapor at the maximum normal temperature (136°F). The maximum total radioactivity contained in the package (assuming the maximum isotopic content for reprocessed UF_6) is 24.6 Ci (calculated in Table A). The volume of the cylinder is 7.36E05 cm^3. The radioactivity concentration (releasable activity per unit volume) of the package for both Normal and Hypothetical Accident conditions is therefore:

$$24.6 \text{ Ci} / 7.36E05 \text{ cm}^3 = \mathbf{3.35\text{-}05 \text{ Ci/cm}^3}$$

The A_2 value for the mixture in the package is 0.0257 Ci (calculated in Table B).

The maximum allowable release rate for normal conditions, per ANSI N14.5-1997, is:

$$10^{-6} A_2 \text{ per hour} = 10^{-6} (0.0257) \text{ per hour} = \mathbf{7.15E\text{-}12 \text{ Ci/sec.}}$$

The maximum allowable leakage rate for normal condition is:

$$7.15E\text{-}12 \text{ Ci/sec} / 3.35E\text{-}05 \text{Ci/cm}^3 = \mathbf{2.14E\text{-}07 \text{ cm}^3\text{/sec } UF_6}$$

The UF_6 maximum allowable leakage rate is correlated to the reference air leakage rate using the methods described in ANSI N14.5-1997 Annex B and the conditions listed in Table C. The allowable leak rate calculated for the package for the normal condition is **2.20E-6 ref-cm^3/sec.**

Inleakage of Water

Since the criticality safety of the package depends upon excluding water, it is necessary to assure that moist air (air containing water) cannot leak into the package. Therefore, the packaging must be leak tight with a maximum leakage rate of less than 1 X 10^{-7} ref-cm^3/sec.

Table A. Package Total Radioactivity

Isotope	Maximum Concentration	Total Mass in Package, g	Total Activity, Ci	Specific Activity, TBq/g[1]	Total Activity, TBq
U232	5.00E-09 g/gU	7.70E-03	1.73E-01	0.83	6.39E-03
U234	2.00E-03 g/gU	3.08E+03	1.91E+01	2.30E-04	7.08E-01
U235	5.00E-02 g/gU	7.70E+04	1.66E-01	8.00E-08	6.16E-03
U236	2.50E-02 g/gU	3.85E+04	2.50E+00	2.40E-06	9.24E-02
U238	9.23E-01 g/gU	1.42E+06	4.61E-01	1.20E-08	1.71E-02
TC99	5.00E-06 g/gU	7.70E+00	1.31E-01	6.30E-04	4.85E-03
TH228	1.17E-09 g/gU	1.80E-03	1.46E+00	30	5.40E-02
PU239	3.30E+00 Bq/gU	1.34E-06	1.37E-04	3.80E+00	5.08E-06
RU106/ RH106	2.10E+03 Bq/gU	2.69E-05	8.72E-02	1.20E+02	3.23E-03
RU103/ RH103	8.85E+02 Bq/gU	1.14E-06	3.68E-02	1.20E+03	1.36E-03
CE144/ PR144	8.35E+03 Bq/gU	1.07E-04	3.47E-01	1.20E+02	1.29E-02
SB125	1.03E+03 Bq/gU	4.07E-05	4.29E-02	3.90E+01	1.59E-03
CS134	2.83E+02 Bq/gU	9.08E-06	1.18E-02	4.80E+01	4.36E-04
CS137/ BA137	7.78E+02 Bq/gU	3.74E-04	3.24E-02	3.2	1.20E-03
ZR95	5.98E+02 Bq/gU	1.17E-06	2.49E-02	7.90E+02	9.21E-04
NB95	5.74E+02 Bq/gU	5.89E-07	2.39E-02	1.50E+03	8.84E-04
	Total	**Activity**	**24.5980 Ci**		**0.9114 TBq**

1 10CFR71, App. A.

Table B. Mixture A_2 Calculation

Isotope	Radioactive content (Ci)	Radioactive content per total UF_6 mass (Ci/g)	10CFR71 A_2 per isotope (Ci)	Releasable Activity Fraction	A_2 Fraction
U232	1.73E-01	1.12E-07	0.00811	7.01E-03	8.64E-01
U234	1.91E+01	1.24E-05	0.027	7.77E-01	2.88E+01
U235	1.66E-01	1.08E-07	Unlimited	6.76E-03	N/A
U236	2.50E+00	1.62E-06	0.027	1.01E-01	3.75E+00
U238	4.61E-01	2.99E-07	Unlimited	1.87E-02	N/A
TC 99	1.31E-01	8.51E-08	24.3	5.32E-03	2.19E-04
TH228	1.46E+00	9.49E-07	0.0108	5.93E-02	5.49E+00
PU239	1.37E-04	8.92E-11	0.00541	5.57E-06	1.03E-03
RU106/ RH106	8.72E-02	5.66E-08	5.41	3.54E-03	6.54E-04
RU103/ RH103	3.68E-02	2.39E-08	24.3	1.49E-03	6.15E-05
CE144/ PR144	3.47E-01	2.26E-07	5.41	1.41E-02	2.61E-03
SB125	4.29E-02	2.78E-08	24.3	1.74E-03	7.16E-05
CS134	1.18E-02	7.65E-09	13.5	4.78E-04	3.54E-05
CS137/ BA137	3.24E-02	2.10E-08	13.5	1.31E-03	9.73E-05
ZR95	2.49E-02	1.62E-08	8.11	1.01E-03	1.25E-04
NB95	2.39E-02	1.55E-08	13.5	9.69E-04	7.18E-05
Total	**2.46E+01**	**1.6E-05**			**38.89**
Mixture A_2					**0.0257 Ci**

Table C. Normal Condition Fluid Properties

Property	UF_6 Normal Condition	Equivalent Reference Air
Upstream Pressure, atm	1.07 [2]	1.00
Downstream Pressure, atm	1.00	0.01
Temperature, K	331	298
Molecular Weight, g/gmol	352	29
Viscosity, cP	0.0188 [3]	0.0185
Assumed hole length, cm	1.0	1.0
Hole diameter [4], cm	3.863E-04	3.863E-04

2 Vapor pressure over solid at 331 K, NUREG/CR-4360, p.5 Vol. 1.

3 NUREG/CR-4360, p. 9, Vol. 1.

4 Calculated for UF_6 per ANSI N14.5-1997 Annex B, Section B.3, Equations B.1 through B.5.

APPENDIX 4.4.2
CALCULATION OF PERMISSBLE LEAK RATE FOR HYPOTHETICAL ACCIDENT CONDITIONS (HAC)

Leakage of Contents to Environment

The package contents, as defined in Section 1.2.3, are assumed to be completely releasable in the form of UF_6 vapor at the maximum HAC content temperature (250°F). The maximum total radioactivity contained in the package calculated in Appendix 4.4.1 is 24.6 Ci. The radioactivity concentration (releasable activity per unit volume) of the package, calculated in Appendix 4.4.1 for both Normal and Hypothetical Accident conditions, is 3.35e-05 Ci/cm^3. The mixture A_2, also calculated in Appendix 4.4.1, is 0.0257 Ci.

The maximum allowable release rate for HAC, per ANSI N14.5-1997, is:

A_2 per week = (0.0257) per week = **4.24E-8 Ci/sec.**

The maximum allowable leakage rate for HAC is:

4.24E-8 Ci/sec/ 3.35E-05 Ci/cm^3 = **1.27E-03 cm^3/sec UF_6.**

The UF_6 maximum allowable leakage rate is correlated to the reference air leakage rate using the methods described in ANSI N14.5-1997 Annex B and the conditions listed in Table D. The maximum allowable leakrate calculated for the package for HAC is 2.61E-4 ref-cm3/sec.

Table D. HAC Fluid Properties

Property	UF_6 Normal Condition	Equivalent Reference Air
Upstream Pressure, atm	6.775	1.00
Downstream Pressure, atm	1.00	0.01
Temperature, K	394	298
Molecular Weight, g/gmol	352	29
Viscosity, cP	0.02216	0.0185
Assumed hole length, cm	1.0	1.0
Hole diameter7, cm	1.36E-03	1.36E-03

Inleakage of Water

Since the criticality safety of the package depends upon excluding water, it is necessary to assure that moist air (air containing water) cannot leak into the package. Therefore, the packaging must be leak tight with a maximum leakage rate of less than 1X10^{-7} ref-cm^3/sec.

5 Vapor pressure over liquid at 394 K, NUREG/CR-4360, p.5 Vol. 1
6 NUREG/CR-4360, p.9, Vol. 1
7 Calculated for UF_6 per ANSI N14.5-1997 Annex B, Section B.3, Equations B.1 through B.5.

7. OPERATING PROCEDURES

The ESP-30X overpack is loaded and unloaded and the 30B UF_6 cylinder is filled, tested, and handled in accordance with standard, in-plant, operating procedures at various enrichment plants and at various nuclear fuel facilities. These procedures are described in USEC-651 and ANSI Standard N14.1. As a minimum, the specific procedures include steps described in the subsequent sections.

7.1 *Procedures for Loading Package*

7.1.1 Receipt and Filling of 30B Cylinder

Receipt and filling of the 30B cylinder shall be performed in accordance with USEC-651 and ANSI N14.1.

7.1.2 Cylinder Inspection

Complete inspection report verifying that the cylinder meets the guidelines of USEC-651 and the requirements of ANSI N14.1; that it has been leak-tested as required below; and that the cylinder and cylinder components are free from damage and are in working order as follows:

a. Cylinder is free from damage and is ASME "U" stamped, and has evidence that it has been cleaned and tested as required in USEC-651 and ANSI N14.1.

b. Cylinder and cylinder valve and plug free from damage and has required evidence of proper inspection and leak testing in accordance with ANSI N14.1.

7.1.3 Additional Type B Requirements for Cylinder Inspection

If the cylinder is to be used for a Type B shipment of UF_6 the following items must be completed:

a. The isotopic and radionuclide contents of each cylinder must be determined, and the UF_6 must meet the contents limits specified in Section 1.2.3.

b. Based on (a.) above, the A_2 value for the cylinder content must be established in accordance with 10CFR71, Appendix A. The cylinder must not contain more than 957 mixture A_2 values.

c. The cylinder must have been leak tested with a test that has a sensitivity of 5.0×10^{-8} std cc/sec within the past 12-month period or since valve or plug replacement, demonstrating no leakage greater than 1.0×10^{-7} std cc/sec (Appendix 4.4.1).

8.0 ACCEPTANCE AND MAINTENANCE PROGRAMS

This section describes the activities to be performed in compliance with Subpart G of 10CFR71 to assure that the ESP-30X package conforms to the requirements of this Safety Analysis Report and remains in conformance following loading.

8.1 Acceptance Tests

8.1.1 Acceptance Tests for the ESP-30X Overpack

Each completed overpack shall be inspected to document compliance with the following drawing requirements:

a. Final dimensions as described below:
   - Inner cylinder cavity dimensions.
   - Outer shell dimensions
   - Closure bolt locations.
   - Bolt center locations and hole diameters in tie down supports.
   - Flatness of gasket surface.

b. Installation of gaskets and cylinder support pads.

c. Lid to body fit.

d. Closure bolt and nut adjustments.

e. Installation of lifting shackles and security seal pads.

f. Actual weights of lid and bottom halves.

g. Final assembled weights.

h. Proper permanent marking and nameplates per 10CFR71.85(c), 49CFR172.310, and ANSI N14.1 (latest revision).

8.1.2 Acceptance Tests for the 30B Cylinder

Acceptance tests for the 30B cylinder shall be in accordance with ANSI N14.1.

8.1.3 Type B Acceptance Test for the 30B Cylinder

The 30B Cylinder shall be leak tested with equipment and tests per ANSI N14.5 that has a sensitivity of 5.0×10^{-8} std cc/sec, demonstrating no leakage greater than 1.0×10^{-7} std cc/sec (Appendix 4.4.1).

i. All repairs shall be performed by competent sources. Allowable repairs shall include repairs to welds and base metal as referenced in (h.) above. Repairs that require welding shall be made by welders who are qualified in accordance with Section IX of the ANSI/ASME Boiler and Pressure Vessel Code or Section 5 of ANSI/AWS D1.1. The repair shop shall provide certification of weld procedures and welder qualifications.

8.2.2 Maintenance Program for the 30B Cylinder

Maintenance of the 30B Cylinders shall be performed in accordance with ANSI N14.1.

8.2.3 Type B Inspection for the 30B Cylinder

8.2.3.1 Pre-shipment

a. The isotopic and radionuclide contents of each cylinder must be determined, and the UF_6 must meet the contents limits specified in Section 1.2.3.

b. Based on (a.) above, the A_2 value for the cylinder contents must be established in with 10CFR71, Appendix A. The cylinder must not contain more than 957 mixture A_2 values of activity.

c. After filling with UF_6, the cylinder and cylinder value and plug shall be leak tested with a test that has a sensitivity of 1×10^{-3} std cc/sec per ANSI N14.5, demonstrating no leakage at that rate.

8.2.3.2 Annually

The cylinder shall be leak tested with equipment and a test in accordance with ANSI N14.5 that has a sensitivity of 5.0×10^{-8} std cc/sec, demonstrating no leakage greater than 1.0×10^{-7} std cc/sec (Appendix 4.4.1).