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A REVIEW OF UF_6 CYLINDER PRACTICES AND CRITERIA

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CONTENTS

ABSTRACT

Information is presented on UF_6 cylinders and cylinder handling practices to show changes in these areas with time. These changes have provided for improved safety and efficiency in the UF_6 industry as a whole. Some of the notable changes are in cylinder life evaluations, fill limits, materials of construction, and transportation regulations.

Due to the usage life cycle of some UF_6 cylinders, especially tails long-term storage, a heterogenous system has evolved which must be controlled administratively to assure that containers in storage are handled properly to meet current requirements for safety. This administrative system is in place and functioning well to insure safety at the GDP sites.

The enrichment plant personnel are active in all facets of the emphasis toward improving the safety in UF_6 handling. This includes committee memberships, review of regulations, design and procurement of cylinders and overpacks, and interfaces with international organizations such as International Atomic Energy Agency (IAEA) and International Standards Organization (ISO).

The present criteria in the subject area is not fixed and will continue to change. The personnel from uranium enrichment will continue to be a key ingredient in improvements brought about in this important area which relates to the safety of employees in the industry, as well as the public at large.

I. INTRODUCTION

The history of UF_6 cylinders used in the gaseous diffusion complex reveals a scenario of changes with time up to the present. These changes were driven by two predominant factors--safety in handling and economics of storage for the large quantity of tails material produced by the plants. This document recounts much of this history to explain how and why the current practices relating to UF_6 handling are in existence.

Cylinders used for UF_6 handling and storage are extremely durable and their life spans many changes of rules and regulations. Therefore, cylinders used for long-term storage may be in accord with guidelines at the time of filling only to be outside the guidelines at the time of next use, requiring special handling provisions. Cylinders in use now, in some cases, exceed 30 years of service with a remaining acceptable service life of at least another 30 years. A cylinder life study project is currently in place to monitor this remaining life. This is to assure that timely action can be taken prior to life depletion through normal wear and tear experienced in long-term storage. This service is of the utmost concern since these cylinders do not undergo the rigorous inspections of those in repetitive flow service.

Purchase of new UF_6 cylinders is a continuing action. While these purchases are primarily for tails storage and involve 14-ton capacity thin-wall (5/16-inch-thick) units, occasionally purchases of other type containers are required. Currently there are some 20 container types ranging in capacity from 1 kg to 19 ton. The total inventory presently is in excess of 57,000 cylinders and growing at a rate of over 2,000 cylinders per year.

As would be expected, based on handling and safety system improvements, changes in cylinder design, manufacturing requirements, fill limits, and handling practices have occurred over the past years. Examples of key items of change are listed below:

- Change in design to improve safety--30B cylinder versus 30A cylinder. The 30A cylinder has been removed from service.

- Change in cylinder stiffening ring and lifting lug design.

- Actual cylinder volume determination by water weight measurement.

- Change in steel from A-285 to A-516 to improve brittle fracture resistance at cold temperatures in large capacity cylinders.

- Use of containment autoclaves with safety systems for cylinder feeding.

- Adjustment of cylinder fill limits to avoid failure from inadvertent actions.

While there are many more specific changes, it is important to note actions taken to improve the administrative controls which have been implemented by cooperative effort. These include formation of oversite and advice groups which, in fact, have been responsible for many of the changes mentioned above. Several of these action committees are listed:

- Multisite UF_6 Handling Committee. The activities and scope of committee membership have been expanded over the years.

- ORO 651 Committee. Responsible for updating a document covering UF_6 cylinders and UF_6 handling. Document is titled, *Uranium Hexafluoride: Handling Procedures and Container Descriptions*.

- ANSI N-14.1 Committee on UF_6 Handling.

- IAEA Committees on International UF_6 Handling and Transportation.

- Department of Transportation (DOT), Department of Energy (DOE), and Nuclear Regulatory Commission (NRC) Regulation Input. No actual membership--this action is limited to review and comment on proposed regulations.

Basically this report will cover five areas:

- Studies associated with remaining cylinder life.

- History of cylinder fill limits by cylinder type.

- Cylinder code status as it relates to cylinder inventory.

- History and reliability of cylinder valves.

- Status of transportation regulations

II. STUDIES RELATING TO REMAINING CYLINDER LIFE

Studies to evaluate remaining life of in-service UF_6 cylinders were initiated in the mid-1970s. The first report on this subject, *Uranium Hexafluoride Tails Storage Cylinders*, KY-657 was issued in June 1974. In April 1988, report KY/L-1482, *Remaining Life of Uranium Hexafluoride Tails Cylinders* was issued updating the expected life from the previous report. At this time there was an elevated concern and a study group involving personnel from Portsmouth Gaseous Diffusion Plant (PORTS), Oak Ridge Gaseous Diffusion Plant (ORGDP), Oak Ridge National Laboratory (ORNL) and Paducah Gaseous Diffusion Plant (PGDP) was formed to assure that all factors in cylinder life studies were fully addressed. The charter for this team is as follows.

> "To provide a study of UF_6 cylinders, all types, which supplies sufficiently accurate data to predict 'end of life' for these cylinders. 'End of life' is defined as a condition where the cylinder no longer will meet the code criteria of its original design. At this point the cylinder will remain capable of preventing the release of stored UF_6 and can be used under reduced criteria to remove its contents."

The group has developed a detailed action plan (see Appendix I) which provides a study scope which meets the intent of the charter. The original studies involved cylinders at PGDP only. All enrichment sites are now involved to assure storage factors at all sites are considered. Sample coupons from decommissioned cylinders are being prepared for scoping tests. Cylinders of different steels are being included. New cylinders are being entered into the data base. All these actions are designed to reduce uncertainty in the study results.

As a part of this study, a UF_6 cylinder data base (Appendix II) has been developed. This data base provides factual information on all types of cylinders currently in use. The scope involves approximately 20 cylinder types, over 57,000 cylinders, and will be updated on a yearly basis.

Due to the very low corrosion rates being experienced, the study time frame is long range. A minimum time period of five years between data sets is estimated to see measurable differences in wall thicknesses of test cylinders. Therefore, accurate records must be maintained to assure program continuity. Periodic reports are included in the action plan to assure communication of this life study status.

Based on current evaluations, a paint formulation which could stand the rigors of cylinder usage and storage would greatly enhance cycle life. A new paint formulation is being used on the current Phase XI cylinder order which is designed to increase coating life. This paint system will be included in the cylinder life evaluation program.

In summary, a proactive program is in place to systematically assure evaluation of remaining life of all UF_6 cylinder types in order to establish information for a scheduled timely removal of UF_6 cylinders from service by the end of their safe useful life.

III. UF_6 CYLINDER FILL LIMITS FOR TYPE-48 CYLINDERS

Fill limits have been established for all models of UF_6 cylinders in service. These fill limits have required revision from time to time as conditions involving cylinder safety during use have been changed for many reasons as explained in this section. The model-48 cylinders have been used as an example. The same concerns are given to cylinders of other sizes.

The determination of a maximum fill limit involves concern for system safety and efficiency. During much of the past 40 years of filling model-48 cylinders, a uniform safety factor was not established and even today discussions and changes are being made as concerns are raised and evaluated.

The physical property of UF_6 to expand in volume by as much as 40 percent when heated from a solid state at ambient temperature to a liquid at working temperature can create substantial containment problems. Most UF_6 cylinders are filled with liquid at approximately 175°F and later heated to an excess of 200°F to liquify and empty. A cylinder, when completely filled with liquid at 175°F and then heated above that temperature, will rupture due to the hydraulic forces generated by the expanding liquid, thereby spilling the contents of the cylinder. To avoid hydraulic rupture of the cylinder, the UF_6 fill limit must be reduced such that the cylinder can be heated to the desired maximum operating temperature without overpressurizing. The calculation of the maximum fill limit to avoid overpressurization of the cylinder requires UF_6 densities at various temperatures, the actual cylinder volume, and the maximum temperature to which the cylinder will be heated. Unfortunately, the UF_6 densities are affected to some extent by the impurities, the actual cylinder volume is not always known nor what the maximum heating temperature will be, especially if shipped to another facility such as a licensee. The maximum heating temperature is the single item which shows the most diversification and has created, so called, multiple standards. The 14-ton, thin-wall cylinder, along with many other cylinders, was originally designed for 300°F design temperature. The maximum temperature on these 14-ton, thin-wall cylinders has been reduced to 250°F and further reduced down to 235°F in recent standards. The difference in fill limits when considering 300°F versus 235°F is nearly 10 percent, which is significant when considering the number and cost of cylinder purchases. The amount of control on the maximum heating temperature is the key factor in determining the temperature to use when calculating fill limits. The fill limit for "in-house use" is higher because of known safety controls over the maximum temperature used to heat the cylinder. Also, safety systems are used to prevent overheating. However, when shipping the cylinder to another group or licensee, we do not have full control and, therefore, must provide for an additional margin of safety. This double standard is necessary to maintain efficiency yet provide an adequate margin of safety to other users where full control is no longer under our control.

The philosophy in establishing fill limits and margins of safety had changed with time. Initially UF_6 cylinders were filled to a weight where they would be 100 percent full when heated to the maximum temperature with the only margin of safety being a reduced normal heating mode. In 1959 an in-depth study was completed at Paducah and reported in KY-313, *Review of Safety Maximum UF_6 Fill Limits on Cylinders Employed in Paducah Plant Operations*. This report reviewed fill limits and recommended new fill limits based on calculated minimum volumes, estimates of maximum impurities at the various fill stations, where the cylinder was to be sent, the method of heating for discharge of the UF_6 contents, and assuming 100 percent fill at a maximum heating temperature. These philosophies basically remained until about 1970 when the issue of fill limits and shipping were again reviewed in-depth in preparation of ANSI N14.1 and ORO 651 standards. At that time a safety factor of 5 percent free volume when heated was applied to all cylinders for shipment. Also actual cylinder measurements were taken showing many of the cylinder volumes could be less than the previously considered minimums, thereby reestablishing new minimum volumes. This cylinder volume issue caused a change in specifications resulting in all future cylinders having actual volumes measured and certified to be greater than the specified minimum. A maximum heating temperature of 250°F was specified as the maximum permissible operating temperature for cylinders. These items established the basic shipping criteria of 5 percent free volume at 250°F based on the minimum cylinder volume. During 1974 the 5 percent free volume for depleted cascade tails was reduced to 3 percent because of the high purity of depleted diffusion plant tails and in-house use where known controls exist. Also at this time the maximum design temperature and maximum heating temperature for thin-wall cylinders was reduced to 235°F.

A new philosophy in establishing shipping limits came about in 1986 with the use of "percent fill" at ambient temperature (70°F). DOT proposed the maximum shipping limit be "the volume of solid uranium hexafluoride at 70°F must not exceed 61 percent of the volumetric capacity of the packaging." This final rule became effective January 1, 1987 and replaced the minimum volume number for the certified volume cylinders used for shipping. The 61 percent at 70°F is essentially equal to 5 percent free volume at 250°F (60.77 percent solid at 70°F), except for the use of the individual cylinder certified volume instead of minimum volume. ANSI N14.1-1987 defines the shipping limit at 5 percent free volume at 250°F of the minimum volume. This difference is significant in some type cylinders. The average volume of the 14-ton, thin-wall, model-48 cylinders is approximately 144 cubic feet versus the established minimum of 139 cubic feet. In May 1988, DOT issued an exemption, DOT-E9924, permitting depleted cascade tails to be shipped with percentages of solid UF_6 up to 62 percent of the certified volumetric capacity of the cylinder volume.

The use of fill percentages in shipping limits has set another standard in defining fill limits. Normally fill limits are established on minimum volumes to avoid having a different fill capacity for each cylinder being filled, whereas shipping limits are calculated on actual volumes. The use of actual or certified volumes is a more realistic approach, but more difficult due to variability in cylinder volumes to verify whether a cylinder may have been filled in excess of the fill limit.

The establishment of fill limit values as shown above, even though varied with time, have been designed to avoid overpressurization during heating cycles with an acceptable safety factor. In addition to this philosophy, individual fill limits have been adjusted downward for operational concerns such as individual area preferences, standardization of fill limits for various types of cylinders, etc. However, there are cylinders in storage yards that are filled to earlier fill limits which assumed greater minimum volumes than presently assumed and based on 100 percent fill. These cylinders cannot be shipped unless the excess material is removed and the cylinder meets the current shipping limit. The maximum temperature to which these cylinders can be heated must be calculated to assure that a minimum of 5 percent free volume will be available as a safety factor.

The fill limits for model-48 series UF_6 cylinders at PGDP are shown in the following tables indicating some of the chronological changes that have occurred during the near 40 years of cylinder usage. The fill limits for other sites will be different based on site preferences and conditions such as UF_6 purity, but should not exceed the maximum fill criteria being used at that time. The following data also indicates an increasing regard for safety with time.

Table 1. Fill limits for 10-ton, thick-wall, model-48 A/X (Model P)

In-house Limits Pounds/Temperature, °F	Shipping Limits Pounds/Temperature, °F	Min. Vol. (ft^3)	Date	Bases
22,000	21,500	111.0	11/51	Unknown
22,500/250	21,900/250 (C) 21,000/300 (L)	111.0 111.0	9/59	KY-313 assumes 100% full with pure tails, R-114 in top product and 250°, HF in side product and 300° for shipment out of complex. These were recommendations only.
21,700/250	21,500/250 (C) 21,000/300 (L)	111.0	7/61	Reduced to match fill limits on 10-ton thin walls for tails and reduced to 21,500 at Portsmouth's request.
21,700/250	22,500/250 (C) 21,000/250 (C) 20,400/300 (L)	111.0 111.0 111.0	2/65	Shipment of storage tails permitted up to 22,500, 21,000 for product within complex (C) and to licensee (L) reduced to 20,400.
21,700/250	21,700/250 (C) 21,000/300 (L)	111.0 111.0	8/68	Standardized at 21,700, but limited to 21,000 for licensee (L) at 300°.
21,700/250	21,030/250 (C/L)	108.7	8/71	Minimum volume reevaluated.
21,870/250	21/030/250 (C/L)	108.7	12/81	Tails fill increased to 3% free volume.

(C) Complex Usage
(L) Licensee Usage

Table 2. Fill limits for 10-ton, thin-wall, model-48T

In-house Limits Pounds/Temperature °F	Shipping Limits Pounds/Temperature °F	Min. Vol. (ft³)	Date	Bases
22,000/?	Not shippable	?	1/56	Unknown
21,700/250	Not shippable	107.1	9/59	KY-313 assumed 100% full for pure tails.
21,700/250	21,700/250 (T)	107.1	2/65	Shipment permitted per Bureau of Explosives
21,700/250	21,000/250 (P) 21,700/250 (T)	107.1	8/68	Thin walls permitted for product and fill reduced.
21,700/250	20,700/250 (P) 21,700/250 (T)	107.2	1/71	Minimum volume reevaluated and product fill reduced.
21,700/225	20,700/250 (P) 21,700/225 (T)	107.2	8/71	Maximum temperature reduced on tails.
21,530/235	20,700/235 (P)	107.2	12/81	235° maximum for thin-wall cylinders utilized.
21,530/210	20,700/235 (P)	107.2	10/86	210° maximum temperature for noncertified volume.

(P) Product
(T) Tails

Table 3. Fill limits for 14-ton, thin-wall, model-48 O/OM/G

In-house Limits Pounds/Temperature, °F	Shipping Limits Pounds/Temperature, °F	Min. Vol. (ft^3)	Date	Bases
28,200/250	Not permitted	139.0	6/58	100% full at 250° with heating limited to hot water/atmos steam.
28,200/250	27,400/250	139.0	12/67	Approved for shipment.
28,000/250	27,400/250	139.0	8/68	Lowered to be consistent with limits on 14-ton thick wall.
28,000/250	26,000/250	135.0	10/70	Minimum volume reevaluated for uncertified volume cylinders.
28,000/225	26,000/250	135.0	8/71	Maximum temperature reduced for tails.
28,000/220	26,000/250	135.0	2/72	Maximum temperature reduced for feed.
28,000/220 28,000/235	26,000/235	135.0 139.0	3/75	Cylinders below 111061 use 135 ft^3 and 220°; cylinders 111061 and above have certified volume of 139 ft^3 and use 235° maximum.
28,000/220 28,000/235	26,070/235 26,840/235	135.0 139.0	12/81	Fill recalculated at 5% free volume at 250°F and cylinder split for certified volume upped to 111821 where volume is stamped on name plate.
28,000/210 28,000/235	26,070/235 26,840/235	135.0 139.0	12/83	Reduced maximum temperature on cylinders below 111822 to 210° for additional safety.
28,000/210 28,000/235	26,070/210 26,840/235	135.0 139.0	10/86	Reduced maximum temperature on all uncertified volume cylinders to 210°F.
28,000/210 28,000/235	26,070/210 26,840/235 28,000/235	135.0 139.0 142.4	5/88	Shipment of up to 28,000 pounds permitted if certified water capacity is 8880 lb or greater giving 5% free volume.

Table 4. Fill limits for 14-ton, thin-wall, model-48 H/HX[a]

In-house Limits Pounds/Temperature, °F	Shipping Limits Pounds/Temperature, °F	Min. Vol. (ft^3)	Date	Bases
28,000/235	26,840/235	139.0	1/79	In-house tails 3% free volume at 235° and shipping is 5 percent free volume at 250°.
28,000/235	27,030/235	140.0	1/83	Minimum volume spec increased and all cylinders certified to have volumes greater than 140 ft^3.
28,120/235	27,030/235	140.0	10/86	Increased tails to reflect 3% free volume at 235°.

a. Tails only

Table 5. Fill limits for 14-ton, thin-wall, model-48 OH/OHI (48 F)[a]

In-house Limits Pounds/Temperature °F	Shipping Limits Pounds/Temperature °F	Min. Vol. (ft^3)	Date	Bases
28,000/250	28,000/250	142.7	10/61	Based on criticality approval, but filled to 27,700 at the request of ORGDP until 8/68.
28,000/250	27,030/250	140.0	?/71	Volume reestablished.
28,120/235	27,030/250	140.0	12/81	Maximum temperature reduced on in-house tails to 235° because of uncertified volumes.

a. Tails only

Table 6. Fill limits for 14-ton, thin-wall, model-48 Y[a]

In-house Limits Pounds/Temperature, °F	Shipping Limits Pounds/Temperature, °F	Min. Vol. (ft^3)	Date	Bases
	27,560/250	142.7	?/71	Shipping limit 5% free volume at 250°.
28,660/250	27,560/250	142.7	12/81	Fill limit established for tails at 3%.

a. Tails only

IV. CYLINDER CODE STATUS AS IT RELATES TO CYLINDER INVENTORY

During the past 35 years, many various types and models of UF_6 cylinders have been procured for the many facets of production at the gaseous diffusion complexes. As the need for various types of cylinders have changed, the codes and standards have affected the design, operation, and handling requirements. At the DOE gaseous diffusion plants, the largest majority of cylinders in use are large capacity cylinders. These are 10- and 14-ton cylinders that are 48 inches in diameter and approximately 12 feet in length. The first large capacity (48-inch) cylinders were procured by ORGDP in 1951. These first 1,000 cylinders, model "P" (Product) were 10-ton, thick-wall (0.625-inch-thick) and specified to be fabricated in accordance with ASME code for unfired pressure vessels, paragraph U-69, but not specified to be code-stamped. In 1953 PGDP began procuring 1500 model "P" cylinders with code-stamping as an effort to improve the quality. The cylinder model "P" designation at that time was changed to 48X for cylinders that were code-stamped and 48A for cylinder not code-stamped. Since 1953 PGDP has been responsible for the design and procurement of all large capacity UF_6 cylinders.

A large majority of these cylinders were fabricated from A-285 steel which when subjected to temperatures in the -40° range have inadequate embrittlement properties, which places restrictions on shipments under today's regulations. These cylinders are listed in Appendix III as type, manufacturing date, cylinder model, code-stamped, and total number. Recent purchases have been of A-516 steel which has acceptable embrittlement properties at lower temperatures. Planned actions are under way to remove cylinders fabricated from A-285 steel from routine shipment service.

The first thin-wall (0.312-inch-thick) cylinders were 10-ton model "T" (Tails), which were fabricated in 1956 for tails storage. Of these 4,320 cylinders, only 1,000 were code-stamped with documentation available. Documentation may be available through the National Board of Boilers and Pressure Vessel Inspectors if registered when manufactured.

In 1958 PGDP fabricated cylinders from internally nickel-lined converters referred to as CVs to store tails material. There were 142 19-ton cylinders made from size 3 converter shells (0.500-inch-thick) and 150 12.8-ton cylinders made from size 1 converter shells (0.375-inch-thick). These CV cylinders were not code-stamped and built for use at PGDP only. In order to remove the contents from these cylinders, special procedures will be required.

The first 14-ton, thin-wall model "O" (Optimum) cylinders were procured in 1958 for tails storage. This cylinder was designed for increased capacity utilization. The model "O" cylinders were manufactured with boxed channel stiffening rings and code-stamped.

The model "OM" (Optimum Modified) cylinders were procured in 1962 and incorporated a design change from the model "O" cylinder. The boxed channel stiffening rings of the model "O" cylinders could collect moisture and freeze in the winter. This freezing could induce a failure of the weld between the cylinder wall and the channel. The channel design was replaced with a stiffening ring made from a 1 1/8 inch by 2 1/2-inch bar. It should also be noted that the first 4,450 cylinders of this type were not code-stamped due to the conviction that PGDP could provide the inspection with the ASME code inspector employed at PGDP; this conviction was later overturned. The next 11,521 model "OM" cylinders procured beginning in 1968 were code-stamped.

The first 14-ton, thick-wall (0.625-inch) model "OH" (Optium Heavy-Wall) cylinders were procured in 1961 for preproduction shipments between GDP sites. These cylinders were fabricated with a skirt on the valve end only. Another preproduction type cylinder model "OHI" (Optimum Heavy-Wall Interplant) was procured some 18 months later. This cylinder, also a thick wall, was fabricated with skirts on both the valve and plug ends. Neither cylinder model was code-stamped; however, the cylinders were fabricated to meet code criteria.

As a result of the initiation of the ANSI standard N14.1, "Packaging of Uranium Hexafluoride for Transport," all cylinders procured after 1961 were ASME code-stamped.

The cylinder model "O" and "OM" designation was changed to model "G" in 1977. The model "G" type cylinder was designated as a (General) purpose storage cylinder. This designation was changed because Allied-Chemical was supplying normal feed material in model "OM" cylinders which added confusion to the cylinder model identification system.

The need for a cylinder to transport normal material resulted in the design of the model "HX" cylinder in 1978. This was a basic model "G" cylinder with skirts added to both the valve and plug ends. Later that year the cylinder was changed to a model "H" when the cylinder construction material was changed from A-285 to A-516 steel. The reason for the material change was that A-516 steel has better low temperature fracture properties. From that point on all large capacity model-48 cylinders were constructed with A-516 material.

The next type of cylinder designed was the model "Y" cylinder in 1979. This is a 14-ton thick-wall cylinder with skirts on both the valve and plug ends for use of transfer of tails material between GDP sites.

A number of manufacturers have supplied UF_6 cylinders to the DOE facilities, as well as to feed converters. As stated earlier, these cylinders were consistently build to ASME standards, but were not code-stamped in many instances. With the implementation of N14.1 ANSI standards and issue of the ORO-651 document, additional control and uniformity were implemented in the industry. Still concerns existed with some of the cylinder suppliers such as poor quality workmanship and materials, along with financial problems which placed stress on the purchasing and delivery cycles sometimes forcing action to insure safety. In the early 1970s, a quality assurance system was imposed on all vendors awarded contracts, requiring that a quality assurance plan be submitted and approved prior to start of manufacture. In addition, a number of vendor audits and surveillances were made during the manufacturing cycle to assure the quality plan was adhered to.

More recently, additional actions have been taken to assure selection of qualified vendors and improved delivery schedules as well as cylinder quality. Prescreening of potential vendors has been established. A team of personnel from Purchasing, Engineering, and Quality Control visit potential suppliers to ascertain capability. From these visits a qualified vendors' list is prepared for bid proposals. NQA-1 criteria is now incorporated in bid specification, including material certification from all vendors. Increased vendor surveillance, up to and including full time, is being implemented. Receiving inspection based on a statistical plan is exercised. No cylinder is released for use until all quality related data is received and verified. Release of cylinders for use is by official letter from the Inspection Department of PGDP which is responsible for new cylinder criteria verification. Appendix II provides a tabulation of cylinders currently present at the enrichment facilities.

V. STATUS OF UF_6 CYLINDER VALVE TECHNOLOGY

The cylinder valves were developed in the early 1950s. At that time the valve in use was fabricated in two sections from an alloy that was susceptable to stress corrosion cracking. Failures occurred when the union nut between the body and bonnet cracked. The valve presently in use, which is supplied in 1-inch and 3/4-inch sizes, is now a one-piece body assembly which contains a Monel stem and a top sealing packing nut. The valve is made of a single-phase, aluminum-bronze alloy which was selected because of its resistance to corrosion by UF_6 and hydrogen fluoride, which is present in a cylinder containing UF_6. This valve technology was developed in a joint effort between the Superior Valve Company and personnel of Union Carbide Nuclear Company, an operating contractor for DOE at that time.

The single-phase alloy used, CDA 636, is a special application material. In the past its supply was limited to a single supply source, Bridgeport Brass Company. There have been several incidents in the manufacture of this material which have led to major problems in the valve supply chain. The first problem occurred in 1977 when the level of lead impurity in the alloy was allowed to exceed 0.01 percent. This allowed the lead to segregate into the grain boundary system and reduce the hot workability and room temperature ductility of the material. Several thousand valves were never placed in service causing a severe industry-wide valve shortage until new material could be produced and acceptable valves manufactured and supplied. These problems have been identified early in the manufacturing/use cycle and corrected without safety being compromised.

A second problem occurred in 1987; valve body cracking during installation into the cylinders. An extensive investigation was required to identify the problem as inadequate homogenization in the metal production process. To correct this problem, the bronze mill was required to use a master alloy, rather than pure aluminum in preparation of the metal. The bronze mill also developed detailed quality control procedures for the production of CDA 636 alloy. The forging plant revised its quality control program and initiated ultrasonic inspection of the forged body. Enhanced inspection of the final valve assembly was implemented at the valve producer's facility. These actions resulted in a valve which is acceptable. Lessons learned from this incident have been included in current valve specifications.

In both cases above the entire nuclear industry was made aware of the problem and, in both cases, DOE-owned inventory valves were used to meet the industry-wide shortage. In addition, a valve restoration program was initiated to provide an additional valve inventory source. This restoration program proved to be cost-effective and is being continued. Also, steps were taken to reduce unnecessary valve usage, especially in the cylinder inspection process which had resulted in unused valves being removed and discarded.

Another failure mechanism has been cracking of the valve packing nut which is also manufactured from CDA 636 material. The problem was related to material hardness and the presence of residual stresses. The incidence of the problem was reduced by revising specifications to require a thermal stress relief of the material. A proposal has been circulated to the ANSI N14.1 committee to adopt more crack resistance alloys, such as CDA 613 or Monel, for packing nuts.

Several actions have been identified to further improve the reliability and quality of the supply of UF_6 cylinder valves in the future. The first is to expand the source of material for valve production. This action is under way. Several alternate sources of valves are available off shore which have an alternate source of CDA 636 alloy. A survey of United States metal specialty companies has developed expressions of interest from at least three sources if the quantity of material is sufficiently large. A current order for 7,500 valves is being processed.

Another action is to develop an acceptable alternate material for use in valve manufacture. This is a current project under the Process and Long Range Technical Support (P&LRTS) program. An aluminum-bronze alloy, CDA 613, has been tested for use to improve packing nut reliability and has proven acceptable in a wide-scale test program. Its use is being proposed to the ANSI N-14.1 group as an acceptable alternate for this purpose. The CDA 613 material is also undergoing tests as an alternate material for use in manufacturing valve bodies. A number of valve bodies have been received and are undergoing evaluation testing. This alloy has been extensively used for cascade equipment and for components used for the handling of liquid and high pressure UF_6.

Starting in 1976, DOE began supplying valves to other groups in the uranium industry. This supply action was started to relieve shortages brought about by the manufacturing problems previously mentioned and has continued to some extent. Because of liability to DOE which could be involved, it is considered prudent that DOE should stop providing valves to other groups, except on very special occasions or when it is a "last resort."

There is a second area which involves DOE valves in customer cylinders which should be allowed to continue. This is the replacement of a damaged valve in a customer's full cylinder. The alternative would be to return the cylinder. However, since the replacement valve would be proof-tested by a cylinder heating and emptying cycle, its integrity is proven prior to its return to the customer or their representative. These two activities, sale and exchange, have involved approximately 1,500 valves since 1976.

In summary, UF_6 valves have presented several problems since their use began in the 1950s. The problems have been in the manufacture and use of the material CDA 636. Specification changes and quality assurance programs have been strengthened to correct known and perceived problem areas. Active programs are under way to increase sources of supply and develop alternate or substitute materials.

VI. STATUS OF UF_6 CYLINDER TRANSPORTATION REGULATIONS

Transportation regulations of UF_6 cylinders have undergone change much like the changes to the cylinders themselves. These changes have evolved as the industry has grown and reflect an ongoing, increased concern for safety of the industry. Today many regulatory agencies are involved in the safe transportation of UF_6 on a national and international basis. The key to this involvement is the exchange of ideas and concerns all of which are directed to further improving the safety of the transportation as it relates to UF_6 and other radioactive materials.

From late 1940 to mid-1950, the Bureau of Explosives (B of E) regulated the transportation of radioactive materials via rail and the Interstate Commerce Commission (ICC) regulated the transportation by highway. Special permits were required from the regulator prior to the consignor shipping UF_6. The 10-ton, heavy-wall, type-P, model-48A cylinder was originally approved for transportation of UF_6 under U.S. Coast Guard Special Permit 47-52 in July 1952; then under ICC Special Permit 805 series in March 1954; and subsequently under B of E permit 844. The 14-ton, heavy-wall, type OHI, model-48F cylinder was authorized for transportation under B of E permit 1280 issued in October 1961.

DOT was established in 1966. This enactment was in the same time frame as the amendment to public law 89-645 which allowed private ownership of special source material including UF_6. Within several years the DOT revised the ICC regulations to conform more closely with international standards and established the six transport groups relative to radiotoxicity as we know them today. In addition, three further classes, namely, "special form," normal form," and "large quantity" were recognized by DOT which the IAEA and the Atomic Energy Commission (AEC) had adopted earlier.

In 1979 the NRC was given responsibility for developing performance standards for package design and review and for approving package designs for commercially-used, type-B and large quantity packages used in transporting UF_6. DOT was given resonsibility for developing safety standards governing the handling and storage of radioactive material packages (while in the carrier's possession), as well as development of type-A package standards.

The current status, as a result of these past regulatory actions, is presented below:

- DOT has primary responsibility for safety in transporting all hazardous materials, including radioactive material. DOT regulates shippers and carriers and sets design and performance specifications for packaging that will carry Type A quantities of nuclear material.

- The NRC regulates the packaging and transport of radioactive material for its licensees, which includes all commercial shippers of radioactive material. In addition, under an agreement with DOT, the NRC sets the standards for packaging of the Type B quantities of radioactive material or fissile material.

- DOE is responsible for the packaging and transport of radioactive material by its contractors. Both the NRC and DOE require that the shipments under their authority meet DOT regulations. DOE meets NRC's standards for packaging and follows DOT's regulations for shipping.

- The ICC has jurisdiction over the economic (cost) aspects of shipping radioactive material, such as regulating carrier rates.

- The shippers offering hazardous materials (including radioactive materials) are responsible for classifying and packaging the materials, labeling the packages, and preparing the proper shipping papers in accordance with DOT regulations. DOT requires the carriers who transport the materials to examine the shipper's certification papers, check packages for proper labeling, placard the vehicle, stow packages properly, comply with training and routing requirements, comply with vehicle safety requirements, and report incidents.

In addition to U.S. regulations, other international groups provide information which is accepted and becomes a part of the current regulations. For example, the International Commission on Radiation Protection (ICRP) and the United States National Council on Radiation Protection and Measurements (NCRPM) provide the primary recommendations for radiation exposure as it relates to transported radioactive items. In addition, the IAEA issues basic safety standards for radiation protection which have been adopted by U.S. regulatory groups, namely DOT and NRC for portions relevant to the safe transport of radioactive material.

In July 1985 Martin Marietta management established the Energy Systems Transportation Safety Committee. The basic objectives of the committee are to provide a forum for review of transportation safety problems among all installations; develop uniform Energy Systems policies/procedures; exchange knowledge, experience, and ideas; interpret DOE orders/policies; and conduct audits of programs at each installation. The scope of the assignment includes the transport of hazardous, radioactive, and nonhazardous materials for intraplant, interplant, and external shipments. Each site has a representative from the traffic staff which serves on this committee. Each site also has its own Transportation Safety Committee. DOE-ORO representatives are invited and attend the meetings of this committee.

From the above information, it is clear that safety in the transport of UF_6 within the enrichment community has been upgraded with time. Review and input to existing and new regulations is a constant function of Martin Marietta Energy Systems employees. Membership on key committees such as ANSI N-14 and its various subcommittees and an ongoing review of DOT and NRC information is an continuing function. In fact, a multisite UF_6 handling committee has been in existence within the DOE-ORO sites involved with UF_6 handling for a number of years and personnel on this committee and other Energy Systems' personnel are increasing their scope to include other commercial groups, as well as establishing contact with the IAEA and ISO in matters relative to UF_6 handling and transport.

ACKNOWLEDGEMENTS

Special recognition is extended to J. H. Alderson, S. C. Blue, C. D. Ecklund, and B. K. Hook for their input to this document. Through their expertise the preparation of this report has been enhanced in a timely and professional manner.

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ACTION PLAN

UF_6 CYLINDER LIFE STUDY

		Responsibility	Sch. Compl. Date	Actual Compl. Date
1.	Appoint study team	J. H. Alderson C. W. Walter	5/13/88	5/12/88
	- Ad Hoc members from other sites			
2.	Develop scope of project	Team Members	5/31/88	6/21/88
	- Coupons from cylinders			
	- Ultrasonic thickness test - cylinders			
	- Field metallography			
3.	Develop assessment of UF_6 cylinder criteria	J. H. Alderson	8/30/88	5/20/88
4.	Establish a data base of various cylinders and cylinder yards at each individual site	C. R. Barlow R. E. Dorning J. H. Alderson	9/30/88	11/10/88
5.	Develop test plan for coatings of new cylinders	R. I. Reynolds	9/30/88	
6.	Develop test plan on coupons distribution and evaluation	J. L. Fraizer	3/15/89	
7.	Develop test plan for ultrasonic testing of existing cylinders at all sites	J. H. Alderson	9/30/88	9/22/88
8.	Develop test plan for field metallography	B. C. Leslie	2/15/89	
9.	Select cylinders for evaluation	H. M. Henson J. H. Alderson	9/30/88	8/24/88
10.	Develop test plan to determine if electrolytic potential exists between cylinder - saddle - ground	C. R. Barlow	4/15/89	

		Responsibility	Sch. Compl. Date	Actual Compl. Date
11.	Ship cylinders to Oak Ridge for preparation of coupons (cylinder selection complete)	J. H. Alderson	10/30/88	10/4/88
12.	Prepare coupons from damaged cylinders	J. L. Fraizer	4/30/89	
13.	Distribute coupons to each site for evaluation	J. L. Fraizer	6/30/89	
14.	Conduct electrolytic tests on various cylinders at each site	Team	4/30/89	
15.	Conduct ultrasonic thickness test on statistical based cylinders for life cycle data	C. R. Barlow R. E. Dorning J. C. Vandeven	6/30/89	
16.	Evaluate test data from ultrasonic thickness test of cylinder	J. T. Bracey	Continuing	
17.	Evaluate test data on coupon corrosion study per ASTM	H. M. Henson R. E. Dorning S. C. Blue	12/31/89 12/31/90 12/31/92	
18.	Issue status reports	Team	12/31/89 and Continuing	
19.	Rupture test cylinders for data base as required	Team	Continuing	

UF_6 CYLINDER RUPTURE TEST

ACTION PLAN

	Action	Responsibility	Scheduled Compl. Date	Actual Compl. Date
1.	Develop scope of cylinder rupture test	C. R. Barlow R. I. Reynolds	6/30/88	5/26/88
2.	Develop UF_6 rupture master data base for a type of cylinder 5" - 48"	C. R. Barlow	6/30/88	6/30/88
3.	Develop cylinder testing procedure	C. R. Barlow	2/28/89	
4.	Select cylinders for rupture test.	R. I. Reynolds	10/30/88	8/31/88
5.	Hydrostatic rupture cylinders(s)	C. R. Barlow	3/1/89	
6.	Evaluate ruptured cylinder(s)	C. R. Barlow R. I. Reynolds	4/1/89	
7.	Obtain coupons from ruptured cylinders	H. M. Henson	4/30/89	
8.	Strength analysis vs. rupture test computer simulated	J. L. Frazier	4/30/89	
9.	Issue status report on rupture test	C. R. Barlow	12/31/89	

Appendix II

UF_6 CYLINDER DATA

UF6 CYLINDER DATA BASE

DATA	Isotopic 1 Kg.	1 S Cyl. 1 Lb.	2 S Cyl. 4.9 Lb.	5 A Cyl. 0.284 Cu.Ft. (obsolete)
Manufacture(1)	PGDP	DOE Site	Hoke	Vendor
Material	Monel	Nickel	Nickel	Monel
Data Report	No	No	Yes	Yes
Code Stamp	No	No	DOT	Yes
Markings	Yes	Yes	Yes	Code Plate
Heat Treat	No	No	No	No
Shell	B-165	B-162	B-162	B-165
Heads	B-164	B-162	B-162	B-165
Skirt	N/A	N/A	N/A	Footring
Stiff. Rings	N/A	N/A	N/A	N/A
Lift Lugs	N/A	N/A	N/A	N/A
Coupling	N/A	B-160	B-165	B-160
Weld(long)	Seamless	Seamless	Seamless	Seamless
Dip Tube	No	No	No	Yes
Valve	Ni-Cu 3/8	Ni-Cu 3/8	Ni-Cu 3/8	CDA 636 3/4
Valve Prot.	N/A	N/A	N/A	Yes
Valve Guard	N/A	N/A	N/A	Yes
Valve Seal	N/A	Yes	Yes	Yes
Plug	N/A	N/A	N/A	N/A
Plug Seal	N/A	N/A	N/A	N/A
Valve Thd.	N/A	Yes	Yes	7-12
Plug Thd.	N/A	N/A	N/A	N/A
X-Ray	100%	No	No	Spot
Hydro	400 psig	400 psig	400 psig	400 psig
Washed	Yes	Yes	Yes	Yes
Dryed	Yes	Yes	Yes	Yes
Air Test	No	100 psig	100 psig	100 psig
Water Cap.	No	Yes	Yes	Yes
Tare Wt.	Yes	Yes	Yes	Yes
Handling	Manual	Manual	Manual	Cart
Maint.	Scrap	Scrap	Scrap	Repair
Transport	Manual	Rack	Rack	Cart
Overpack	Type 7A	N/A	Type 7A	DOT 20-PF-1
Corrosive	No	No	No	No
Thickness	0.109 Nom.	0.062 Min.	0.112 Min.	0.258 Nom.
Quanity	125 (2)	197 (3)	1,902	1,078
MAWP	200 psig	200 psig	200 psig	200 psig
Usage	Sample	Sample	Sample	VHE
Nominal Cap.	1 Kg.	1.0 lb.	4.9 lb.	55 lb.

(1) Per Markings or Plate
(2) PGDP only
(3) Portsmouth only

UF6 CYLINDER DATA BASE

DATA	5 B Cyl. 0.284 Cu. Ft.	8 A Cyl. 1.32 Cu. Ft.	12 A Cyl. 2.38 Cu. Ft. (obsolete)	12 B Cyl. 2.38 Cu. Ft.
Manufacture(1)	Vendor	Vendor	Vendor	Vendor
Material	Nickel	Monel	Nickel	Monel
Data Report	Yes	Yes	Yes	Yes
Code Stamp	Yes	Yes	No	Yes
Markings	Code Plate	Plate	Plate	Code Plate
Heat Treat	No	No	No	No
Shell	B-161	B-127	B-162	B-127
Heads	B-366	B-127	B-162	B-127
Skirt	Footring	Footring	Footring	Footring
Stiff. Rings	N/A	N/A	N/A	N/A
Lift Lugs	N/A	N/A	N/A	N/A
Coupling	B-161	B-161	B-161	B-161
Weld(long)	Seamless	Yes	Yes	Yes
Dip Tube	Yes	Yes	No	Yes
Valve	CDA 636 3/4	CDA 636 3/4	CDA 636 3/4	CDA 636 3/4
Valve Prot.	Yes	Yes	Yes	Yes
Valve Guard	Yes	Yes	Yes	Yes
Valve Seal	Yes	Yes	Yes	Yes
Plug	N/A	N/A	Yes	N/A
Plug Seal	N/A	N/A	No	N/A
Valve Thd.	7-12	7-12	7-12	7-12
Plug Thd.	N/A	N/A	5-8	N/A
X-Ray	Spot	Unknown	Unknown	Spot
Hydro	400 psig	400 psig	400 psig	400 psig
Washed	Yes	Yes	Yes	Yes
Dryed	Yes	Yes	Yes	Yes
Air Test	100 psig	100 psig	100 psig	100 psig
Water Cap.	Yes	Yes	Yes	Yes
Tare Wt.	Yes	Yes	Yes	Yes
Handling	Cart	Cart	Cart	Cart
Maint.	Repair	Repair	Repair	Repair
Transport	Cart	Cart	Cart	Cart
Overpack	DOT 20-PF-1	DOT 20-PF-2	DOT 20-PF-3	DOT 20-PF-3
Corrosive	No	No	No	No
Thickness	0.258 Nom.	0.322 Nom.	0.406 Nom.	0.406 Nom.
Quanity	400	285	852	36 (2)
MAWP	200 psig	200 psig	200 psig	200 psig
Usage	VHE	Sample	Sample	Sample
Nominal Cap.	55 lb.	255 lb.	460 lb.	460 lb.

(1) Per Markings or Plate
(2) Portsmouth only

UF6 CYLINDER DATA BASE

DATA	30 A Cyl. 2.5 Ton (obsolete)(2)	30 B Cyl. 2.5 Ton	48 A Cyl. 10 Ton	48 F Cyl. 14 Ton
Manufacture(1)	Vendor	Vendor	Vendor	Vendor
Material	Steel	Steel	Steel	Steel
Data Report	No	Yes	No	No
Code Stamp	No	Yes	No	No
Markings	Plate	Code Plate	Plate	Plate
Heat Treat	No	No	No	No
Shell	A-285	A-516	A-285	A-285
Heads	A-285	A-516	A-285	A-285
Skirt	Yes	Yes	Yes	Yes
Stiff. Rings	N/A	N/A	Yes	Yes
Lift Lugs	N/A	N/A	Yes	Yes
Coupling	A-105	A-105	N/A	N/A
Weld(long)	Yes	Yes	Yes	Yes
Dip Tube	No	No	No	No
Valve	CDA 636 1	CDA 636 1	CDA 636 1	CDA 636 1
Valve Prot.	No	Yes	Yes	Yes
Valve Guard	Yes	Yes	Yes	Yes
Valve Seal	Yes	Yes	Yes	Yes
Plug	Yes-3	Yes-3	Yes-3	Yes-3
Plug Seal	N/A	Yes	Yes	Yes
Valve Thd.	7-12	7-12	7-12	7-12
Plug Thd.	N/A	5-8	5-8	5-8
X-Ray	Unknown	Spot	Unknown	Unknown
Hydro	500 psig	400 psig	400 psig	400 psig
Washed	Yes	Yes	Yes	Yes
Dryed	Yes	Yes	Yes	Yes
Air Test	100 psig	100 psig	100 psig	100 psig
Water Cap.	No	Yes	No	No
Tare Wt.	Yes	Yes	Yes	Yes
Handling	Sling	Sling	Fixture	Fixture
Maint.	Repair	Repair	Repair	Repair
Transport	Saddle	Saddle	On Site	On Site
Overpack	DOT 21-PF-1	DOT 21-PF-1	Pad Tiger	N/A
Corrosive	Yes	Yes	Yes	Yes
Thickness	0.500 Nom.	0.500 Nom.	0.625 Nom.	0.625 Nom.
Quanity	1,663	230	1,365	90
MAWP	192 psig	200 psig	200 psig	200 psig
Usage	Product	Product	Preproduction	Preproduction
Nominal Cap.	4950 #	5020 #	21,030 #	27,030 #

(1) Per Markings or Plate
(2) 1-1-93

UF6 CYLINDER DATA BASE

DATA	48 X Cyl. 10 Ton	48 G Cyl. 14 Ton	48 Y Cyl. 14 Ton	48 H Cyl. 14 Ton
Manufacture(1)	Vendor	Vendor	Vendor	Vendor
Material	Steel	Steel	Steel	Steel
Data Report	Yes	Yes	Yes	Yes
Code Stamp	Yes	Yes	Yes	Yes
Markings	Code Plate	Code Plate	Code Plate	Code Plate
Heat Treat	No	No	No	No
Shell	A-285	A-285/516(2)	A-516	A-516
Heads	A-285	A-285/516(2)	A-516	A-516
Skirt	Yes	No	Yes	Yes
Stiff. Rings	Yes	Yes	Yes	Yes
Lift Lugs	Yes	Yes	Yes	Yes
Coupling	N/A	A-105	A-105	A-105
Weld(long)	Yes	Yes	Yes	Yes
Dip Tube	No	No	No	No
Valve	CDA 636 1	CDA 636 1	CDA 636 1	CDA 636 1
Valve Prot.	Yes	Yes	Yes	Yes
Valve Guard	Yes	Yes	Yes	Yes
Valve Seal	Yes	Yes	Yes	Yes
Plug	Yes-3	Yes	Yes	Yes
Plug Seal	Yes	No	Yes	Yes
Valve Thd.	7-12	7-12	7-12	7-12
Plug Thd.	5-8	5-8	5-8	5-8
X-Ray	Spot	Spot	Spot	Spot
Hydro	400 psig	200 psig	400 psig	200 psig
Washed	Yes	Yes	Yes	Yes
Dryed	Yes	Yes	Yes	Yes
Air Test	100 psig	100 psig	100 psig	100 psig
Water Cap.	Yes	Yes	Yes	Yes
Tare Wt.	Yes	Yes	Yes	Yes
Handling	Fixture	Fixture	Fixture	Fixture
Maint.	Repair	Repair	Repair	Repair
Transport	Sling	Sling	Sling	Sling
Overpack	Pad Tiger	N/A	N/A	N/A
Corrosive	Yes	Yes	Yes	Yes
Thickness	0.625 Nom.	0.312 Nom.	0.625 Nom.	0.312 Nom.
Quanity	1500	15,756	260	3,640
MAWP	200 psig	100 psig	200 psig	100 psig
Usage	Product	Tails & Normal	Tails Return	Normal
Nominal Cap.	21,030 #	26,840 # (3)	27,560 #	27,030 # (3)

(1) Per Markings or Plate
(2) 3,000 A-285
(2) 12,756 A-516
(3) Tails shipping limit 28,000 #

UF6 CYLINDER DATA BASE

DATA	48 HX Cyl. 14 Ton	48 O Cyl. 14 Ton	48 OM Cyl. 14 Ton	48 T Cyl. 10 Ton
Manufacture(1)	Vendor	Vendor	Vendor	Vendor
Material	Steel	Steel	Steel	Steel
Data Report	Yes	Yes	Yes/No(2)	No
Code Stamp	Yes	Yes	Yes/No(2)	Yes
Markings	Code Plate	Code Plate	Code Plate	Code Plate
Heat Treat	No	No	No	No
Shell	A-285	A-285	A-285	A-285
Heads	A-285	A-285	A-285	A-285
Skirt	Yes	No	No	Yes
Stiff. Rings	Yes	Channel	Yes	Yes
Lift Lugs	Yes	Yes	Yes	Yes
Coupling	A-105	A-105	A-105	A-105
Weld(long)	Yes	Yes	Yes	Yes
Dip Tube	No	No	No	No
Valve	CDA 636 1	CDA 636 1	CDA 636 1	CMD 636 1
Valve Prot.	Yes	Yes	Yes	Yes
Valve Guard	Yes	Yes	Yes	Yes
Valve Seal	Yes	Yes	Yes	Yes
Plug	Yes	Yes	Yes	Yes
Plug Seal	Yes	Yes	Yes	Yes
Valve Thd.	7-12	7-12	7-12	7-12
Plug Thd.	5-8	5-8	5-8	5-8
X-Ray	Spot	Spot	Yes/No(2)	Spot
Hydro	200 psig	200 psig	200 psig	200 psig
Washed	Yes	Yes	Yes	Yes
Dryed	Yes	Yes	Yes	Yes
Air Test	100 psig	100 psig	100 psig	100 psig
Water Cap.	Yes	No	Yes/No(3)	No
Tare Wt.	Yes	Yes	Yes	Yes
Handling	Fixture	Fixture	Fixture	Fixture
Maint.	Repair	Repair	Repair	Repair
Transport	Sling	Sling	Sling	Sling
Overpack	N/A	N/A	N/A	N/A
Corrosive	Yes	Yes	Yes	Yes
Thickness	0.312 Nom.	0.312 Nom.	0.312 Nom.	0.312 Nom.
Quanity	1,000	6,602	16,371	4,230
MAWP	100 psig	100 psig	100 psig	100 psig
Usage	Normal	Tails	Tails & Normal	Tails
Nominal Cap.	27,030 # (4)	28,000 #	27,030 # (4)	21,530 #

(1) Per Markings or Plate
(2) Yes/Spot 11,521 cyl.
(2) No 4450 Cyl.
(3) Yes 10,701
(3) No 5,670
(4) Tails shipping limit 28,000 #

UF6 CYLINDER DATA BASE

DATA	CV (12.8 Ton)	CV (19 Ton)
Manufacture(1)	Chrysler Corp.	PGDP
Material	Ni-Clad Steel	Ni-Clad Steel
Data Report	No	No
Code Stamp	No	No
Markings	Plate	Plate
Heat Treat	No	No
Shell	A-285	A-285
Heads	A-285	A-285
Skirt	No	No
Stiff. Rings	No	No
Lift Lugs	Yes	Yes
Coupling	A-105	A-105
Weld(long)	Yes	Yes
Dip Tube	No	No
Valve	CDA 636 1	CDA 636 1
Valve Prot.	No	No
Valve Guard	No	No
Valve Seal	Yes	Yes
Plug	No	No
Plug Seal	N/A	N/A
Valve Thd.	7-12	7-12
Plug Thd.	N/A	N/A
X-Ray	No	No
Hydro	200 psig	200 psig
Washed	Yes	Yes
Dryed	Yes	Yes
Air Test	100 psig	100 psig
Water Cap.	No	No
Tare Wt.	Yes	Yes
Handling	Sling	Sling
Maint.	Repair	Repair
Transport	Sling	Sling
Overpack	N/A	N/A
Corrosive	Yes	Yes
Thickness	0.375 Nom.	0.500 Nom.
Quanity	150	142
MAWP	100 psig	100 psig
Usage	Tails	Tails
Nominal Cap.	23,800 #	34,600 #

(1) Per Markings or Plate

Total DOE Cylinder Inventory ~ 57,874

Revision date 1-3-89

Appendix III

GDP CYLINDER INVENTORY

GDP CYLINDER INVENTORY

Cylinder Model	Code Stamped	Type Steel	Manuf. Date	Type	Total
48 A	No	A-285	1951-1954	10-Ton Thick Wall	1,365
48 X	Yes	A-285	1953-1954	10-Ton Thick Wall	1,500
48 T	Yes	A-285	1956-1958	10-Ton Thin Wall	4,230
CV 12.8-Ton	No	A-285	1958-1959	12.8-Ton Nickel Clad	150
CN 19-Ton	No	A-285	1958-1959	19-Ton Nickel Clad	142
48 O	Yes	A-285	1958-1961	14-Ton Thin Wall	6,602
48 OM	Yes No	A-285	1962-1978	14-Ton Thin Wall	11,521 4,450
48 OH	No	A-285	1962	14-Ton Thick Wall	30
48 OHI	No	A-285	1962-1963	14-Ton Thick Wall	60
48 HX	Yes	A-516	1979	14-Ton Thin Wall w/skirts	1,000
48 Y	Yes	A-516	1979-1980	14-Ton Thick Wall	260
48 H	Yes	A-516	1979-1987	14-Ton Thin Wall w/skirts	3,640
48 G	Yes Yes	A-285 A-516	1978-1988	14-Ton Thin Wall	3,000 11,256

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