Uranium Hexafluoride
Packaging Tiedown Systems
Overview at Portsmouth
Gaseous Diffusion Plant,
Piketon, Ohio

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URANIUM HEXAFLUORIDE PACKAGING TIEDOWN SYSTEMS OVERVIEW
AT PORTSMOUTH GASEOUS DIFFUSION PLANT, PIKETON, OHIO

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ABSTRACT

The Portsmouth Gaseous Diffusion Plant (PORTS) in Piketon, Ohio, is operated by Martin Marietta Energy Systems, Inc., through the U.S. Department of Energy-Oak Ridge Operations Office (DOE-ORO) for the U.S. Department of Energy-Headquarters, Office of Nuclear Energy. The PORTS conducts those operations that are necessary for the production, packaging, and shipment of enriched uranium hexafluoride (UF₆). Uranium hexafluoride enriched greater than 1.0 wt percent ²³⁵U shall be packaged in accordance with the U.S. Department of Transportation (DOT) regulations of Title 49 CFR Parts 173 (Reference 1) and 178 (Reference 2), or in U.S. Nuclear Regulatory Commission (NRC) or U.S. Department of Energy (DOE) certified package designs.

Concerns have been expressed regarding the various tiedown methods and condition of the trailers being used by some shippers/carriers for international transport of the UF₆ cylinders/overpacks (Reference 3). The generally accepted method for securing the overpack during shipment is to bolt its base to the trailer bed. International shipments typically are not made using dedicated trailers, and numerous trailers have been received at PORTS with improperly and potentially dangerously secured overpacks. Also, many trailers have not been loaded at PORTS for international shipment because of mechanical problems, rotten flooring, bald tires, no brakes or brake lights, or broken springs. Because domestic shipments of UF₆ are made using dedicated trailers that are properly maintained, the domestic shipments are generally conducted in the desired manner.

Because of the concerns about international shipments, the U.S. Department of Energy-Headquarters (DOE-HQ) Office of Nuclear Energy, through DOE-HQ Transportation Management Division, requested Westinghouse Hanford Company (Westinghouse Hanford) to review UF₆ packaging tiedown and shipping practices used by PORTS, and where possible and appropriate, provide recommendations for enhancing these practices. Consequently, a team of two individuals from Westinghouse Hanford visited PORTS on March 5 and 6, 1990, for the purpose of conducting this review. The paper provides a brief discussion of the review activities and a summary of the resulting findings and recommendations. A detailed reporting of the review is documented in Reference 4.

BACKGROUND

Tiedown Concerns at Portsmouth

The PORTS has in the past identified concerns about the tiedown systems used for securing UF₆ packaging during shipment and about the general condition of the transporting vehicles (Reference 3). These concerns include the following items:

- Tiedowns used to secure empty 30-in. cylinders (Model 30B) being returned to PORTS on 40-ft domestic trailers

- Tiedowns being used for shipping 21PF-1 Overpacks on intermodal containers

- International Organization for Standardization (ISO) containers being used for international shipments, which are not inspected and/or properly maintained.

Application of a system concept for assessing the integrity of the tiedown/transportation system would suggest that all phases of the system be evaluated in accordance with consistent levels of criteria.
Summary of Regulatory Requirements for Tiedowns

Tiedown regulations that currently control the securing of UF₆ packaging for shipment are those that apply for shipping of radioactive materials. Within the United States, three federal organizations regulate the certification of radioactive materials packages: the DOE, the DOT, and the NRC. The DOE has the authority to certify packages used within and between DOE facilities. The DOT and NRC require that specific guidelines and requirements be satisfied to certify a package for transport in the U.S. For control of international shipments, the International Atomic Energy Agency (IAEA) has established guidelines for transporting radioactive materials packages. Although the IAEA has no regulatory authority within the U.S., member states have adopted the IAEA guidelines. In addition, the American National Standards Institute (ANSI) has recognized the need for nuclear material packaging tiedown criteria and has assigned a committee to prepare a standard for control of tiedowns for truck transport of radioactive materials. Specific tiedown criteria for conducting the review at FORTS was obtained from Reference 5. These criteria, as noted in Reference 5, are summarized below.

The U.S. Department of Energy. The requirements for tiedowns as specified by the DOE are provided in DOE Order 1540.1, Chapter II, Section 4, (3) Tiedown Assemblies (Reference 6). With respect to the review effort, the most significant of these regulations are as follows.

- The principal tiedown forces should be transmitted to the vehicle frame and not to the wood or metal deck.

- The strength of the tiedown attachment points on the conveyance should be greater than or equal to the strength of the tiedowns themselves. In the case when the strength of the tiedowns exceeds or equals the structural design limits of the conveyance itself, the strength of the tiedown attachment points on the conveyance is limited to the structural design strength of the conveyance.

- The load shall be inspected thoroughly by the shipper and carrier prior to release of the shipment. The shipper should ensure that the carrier recognizes his or her responsibility to check the tiedowns periodically during transit, and tighten them as necessary.

U.S. Department of Transportation. On the tiedown of packages onto motor vehicles for truck transport, the DOT requirements are quite explicit and the tiedown of packages or cargo onto a motor vehicle is discussed in 49 CFR 393 (Reference 7). This regulation states specifically that the tiedowns must withstand a loading of 1.5 times the cargo weight in any one direction and still remain under the force required to cause the tiedown system to fail under static loading conditions. This requirement provides a design standard that clearly uses failure rather than yield criteria to judge the adequacy of the system.

U.S. Nuclear Regulatory Commission. The NRC certifies Type B and fissile radioactive materials shipping packages. Specific guidelines are given in 10 CFR 71; the NRC tiedown regulations are detailed in 10 CFR 71.45b (Reference 8) and state that if there is a system of tiedown devices which is a structural part of the package, the system must be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of the package having a vertical component of two times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of five times the weight of the package with its contents.

International Atomic Energy Agency. The IAEA Safety Series No. 6 (Reference 9) addresses the tiedown of radioactive material packages and requires that any tiedown attachments on the package shall be so designed that under both normal and accident conditions, the forces in those attachments shall not impair the ability of the package to meet requirement of the regulation. This requirement does not refer to the tiedowns that fasten the package to a transport vehicle, but to the structural attachment point on the package itself. The IAEA recommends that, regardless of the loading on the cask attachment points, including failure, the package's ability to perform its safety function must not be impaired. The IAEA does not suggest a minimum or maximum loading requirement for the cask attachment points and neglects to mention the tiedowns themselves.

Paragraph 536 of IAEA Safety Series No. 37 (Reference 10) refers specifically to tiedowns. Safety Series No. 37 states that tiedowns may be necessary to secure the package of radioactive materials to the transport conveyance. Tiedown equipment and instructions will sometimes be provided by the consignor and, in such cases, such equipment and instructions are provided, it is the carrier's responsibility to secure the package to the conveyance. Hence, the IAEA places on the carrier the burden of adequately fastening the package to the transport vehicle.

American National Standards Institute. Although the DOT is responsible for baseline requirements governing tiedown regulations, other organizations may establish requirements or guidelines that are more stringent than the standards set by the DOT. Hence, the ANSI produces a series of guidelines for the nuclear industry. Use of the ANSI standards and guidelines is strictly voluntary; however, many ANSI standards have been adopted as regulatory requirements by different governing groups. For truck transport of packages weighing 1 ton (0.9 metric ton) or more, the ANSI Proposal Standard N-14.2 (Reference 11) requires that tiedown systems should survive an acceleration load applied to the package center-of-gravity as follows.

<table>
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These loadings are to be treated as static loads and are not to be combined. The tiedown shall be designed to resist design loads without exceeding the yield strength of any component of the system.

The ANSI members have expressed the opinion that because media and public attention traditionally focuses on potential accidents involving shipments of radioactive materials, additional safety measures are called for in the area of cask tiedowns. Thus, the ANSI draft standard requires that, in addition to surviving normal conditions of transport, tiedowns also survive minor accidents. Retaining the package on the trailer in a minor accident avoids the need to involve all of the required personnel and equipment should a radioactive materials package fall from its transport vehicle.

**OBSERVATIONS**

The Westinghouse Hanford team reviewed the following specific PORTS shipment configurations:

- 48-in. cylinders (Models 48X and 48Y) containing UF₆ loaded on dedicated trailers for domestic shipment
- 30-in. cylinders (Model 3ca) containing UF₆ with 21PF-1 overpacks loaded on 20-ft intermodal containers for international shipment
- 30-in. cylinders (Model 30B) containing UF₆ with 21PF-1 overpacks loaded on a 40-ft dedicated trailer for domestic shipment
- Empty 30-in. cylinders (Model 30B) loaded (stacked three on the bottom, two on top) on a 40-ft domestic flatbed trailer returned to PORTS.

The following are observations resulting from the above-noted reviews.

**48-Inch Cylinders Containing UF₆ Loaded on Dedicated Trailers for Domestic Shipment**

This shipping configuration consists of 48-in. cylinders (Models 48X and 48Y) containing UF₆ loaded on dedicated trailers that are designed specifically for this use. This configuration is often referred to as the "Davis Transport" system. The tiedowns used for this configuration consist of 4-in. nylon strands with welded winch/hoist attachment points. Each strap has a 20,000 lb minimum braking strength. The cylinders rest in cradles welded to the main frame of the trailer. The Models 48X and 48Y loaded cylinders weigh approximately 25,530 lb and 32,760 lb, respectively.

A safety inspection is performed and a check sheet is completed on each shipment before the loaded trailers leave PORTS. No major concerns were noted in the review of this shipping configuration, although some minor issues regarding the detailed weld designs were noted. In some cases, the tiedown strap attachment points were welded to the cylinder cradles rather than to the trailer frame. A more secure arrangement would result if tiedown attachment points were welded directly to the trailer frame. Also, because of the visual appearance of the weld metal surface, the welding specification acceptance criteria were discussed. However, no major defects in the "Davis Transport" system were observed.

**30-Inch Cylinders Containing UF₆ with 21PF-1 Overpacks Loaded on 20-Foot Intermodal Containers for International Shipment**

This shipping configuration consists of an intermodal container with ISO corners mounted to and locked into position on a conveyance trailer specifically designed for truck transport of intermodal containers to a docking location where they are loaded onto ships. As many as four 21PF-1 Overpacks containing 30-in. cylinders (Model 30B) filled with UF₆ enriched > 1% are loaded onto one 20-ft intermodal container. Each 21PF-1 Overpack is attached to the wooden floor of the intermodal container with eight 3/4-in.-diameter bolts, each torqued to a specified value. After insertion of the tiedown bolts through the drilled holes, a backing plate, a washer, and nut are installed on the underside of the decking. Because of variations in structural framing configurations used by the different intermodal container manufacturers, three different standardized sizes of 1/4-in. thick backing plates have been designed and are available for use. The installer selects the most suitable size, attempting to select a size that will overlap the flanges of the intermodal container structural steel deck framing.

In some instances, none of the standardized backing plates will adequately interlock with the flanges of the steel deck framing, and the wood decking must provide resistance to tiedown loadings. As noted above, the poor condition of the wooden decking on some intermodal containers limits its capacity to resist loading. In addition, the wooden decking is usually attached to the steel deck framing by 1/4-in.-diameter self-drilling/self-tapping bolts that in some cases are completely rusted or corroded away. For those cases where the structural adequacy of the tiedown system is suspect, the trailers are rejected and the shipments are not made until an acceptable trailer can be provided.

This shipping configuration was the primary focus of the Westinghouse Hanford reviewer team. Major issues observed and noted included rusting of the intermodal container frames, rotting and deterioration of the intermodal container wooden decking; and, because intermodal containers can be slightly different in design, inconsistencies in the basic tiedown approach. Figures 1 and 2 show the extent and severity of these issues. These photos show areas where the main longitudinal structural support members of the trailer are completely rusted through and some of the woods are cracked. Another typical problem that has been experienced at PORTS with the intermodal containers is that the floor decking is often rotten, broken, splintered, or damaged in other ways. In some cases, the plywood used has become delaminated because of age and exposure to weather.
Because intermodal containers are transported over various shipping routes, potential shipping problems cannot be predicted. Receipt of the containers after their arrival and inspection at PORTS may adversely affect U.S. production and shipping operations, loading schedules, and customer relations.

30 inch Cylinders Containing UF₆ with 21 PF 1 Overpacks Loaded on a 40 Foot Dedicated Trailer for Domestic Shipment

The shipping configuration used for domestic shipment of U.S. 30 inch cylinders is similar to that used for international shipments, except that a dedicated 40 foot trailer is used instead of the intermodal containers. This configuration is used because it allows much closer control of the shipping process and eliminates the uncertainties associated with obtaining a trailer from a transportation pool. Hence, many of the concerns associated with use of the intermodal containers, e.g., the deterioration of wood deck, rusted structural components, cracked bolts, and outdated inspection, are not an issue. At PORTS operations involving this shipping configuration appear to be well organized and controlled. It should be noted, however, that this dedicated configuration also relies upon a load resisting configuration similar to that used for the intermodal containers.

Another observation noted during the review was that the intermodal containers do not appear to be inspected and maintained on a frequent or regular basis. This observation is based on information obtained from inspection tags attached to the containers. One trailer was manufactured in June 1970 and received its first maintenance examination in June 1988. A second trailer was manufactured in October 1970 and received an inspection in 1979. There was no indication that these trailers had received subsequent inspections or maintenance. Additionally, no information was available to confirm that other trailers being loaded at the time of this review had been inspected.

Even though the wooden decking of the dedicated trailer appears to be in excellent condition and its integrity can be maintained to meet consistent and acceptable standards, the dedicated configuration does not provide a mechanism for transmitting the load to the vehicle frame without transmitting them through the wooden decking. Many variables associated with this mechanism influence its load capacity—functions such as overlap of the bolts, the distance between the bolts, and the moisture content of the wooden decking. Hence,
the qualification of this tiedown concept by analytical and/or test processes would be uncertain, costly, time consuming, and would most likely yield questionable results.

The trailer loading and unloading operations are labor intensive and time consuming. Considerable time and effort are required to remove the eight tiedown bolts for each 21PF-1 Overpack, remove the overpack from the trailer for weighing, load the overpacks back onto the trailer, reinstall the tiedown bolts, and torque the bolts. Using a convenient tiedown trailer connect/disconnect mechanism would improve the efficiency of the unloading/loading operations.

**Empty 30-Inch Cylinders Loaded on a 40-Foot Domestic Flatbed Trailer**

This shipping configuration is used for returning empty 30-in. UF₆ cylinders (Model 30B) to PORTS. It normally involves stacking ten empty cylinders in a staggered arrangement (i.e., three on the bottom and two on the top) on a 40-ft domestic flatbed trailer. The cylinders are typically chocked with a framework of 2x4 and/or 2x6 lumber attached to the trailer at the base of the stacked cylinders, with various types of cable or strap tiedowns over the top (see Figure 4).

![Figure 4. Empty 30-in. Cylinders Loaded on 40-ft Domestic Flatbed Trailer.](image)

The review of this shipping configuration noted several split boards and bent nails. Neither the quality or grade of lumber nor the size and spacing of the nails appear to be controlled. Hence, lower grades of lumber were split by the nails. In other more dense sections of lumber, the nails did not penetrate and were pounded over.

The review team suggested that acceptability of the current tiedown concept be verified by engineering analysis. However, analysis would require that certain controls be established, e.g., a grade of lumber specified and the spacing, size and number of nails specified. These controls, which would be identified as specific requirements for compliance, would enhance and supplement the current transportation configuration system. At issue would be designating the agency having the authority to impose and enforce these requirements. Other alternatives include designing and fabricating a structural steel framework for use on dedicated trailers to ship empty 30-in. cylinders.

**RECOMMENDATIONS**

**40-Inch Cylinders Containing UF₆ Loaded on Dedicated Trailers for Domestic Transport**

The review team did not identify any major concerns with respect to this shipping configuration, known as the "Davis Transport" system. However, because of the appearance of the weld metal surface, the following suggestions are offered.

- Identify the appropriate weld specification acceptance criteria and verify that the welds conform to these criteria.

- At appropriate maintenance intervals for the trailers, give consideration to removing the tiedown attachment points from the cylinder cradles and welding them onto the trailer frame.

**30-Inch Cylinders Containing UF₆ with 21PF-1 Overpacks Loaded on 20-Foot Intermodal Containers for International Shipment**

The PORTS use of the intermodal containers for international shipments of UF₆ can be facilitated in the near term by the following steps.

- Establish acceptance criteria for intermodal containers to be used for shipment of UF₆. These criteria could be very detailed and explicit or might simply require that evidence be provided that the intermodal container and trailer have recently passed the inspection of a competent independent agency. These criteria could then be provided to the shipping pools and agencies that furnish the intermodal containers with notification that after a stated date, containers or trailers not meeting the specified acceptance criteria would no longer be accepted by PORTS.

- Conduct receiving inspections at PORTS of all intermodal containers and trailers delivered from the steamship line pools and shipping agents. Any intermodal containers or trailers not passing this onsite inspection could then be rejected by PORTS and returned to the agency for replacement.

- Organize a task team of representatives from the agencies involved with the transportation of UF₆ to develop industry-acceptable transportation tiedown controls. Representatives of the team could help identify and resolve problems by promoting and implementing recommended standards and by educating participants. The result of this team effort could then be proposed to regulatory agencies to enhance existing tiedown requirements.

- A long-term plan should be developed to implement a system of dedicated intermodal containers and trailers for overseas shipments of UF₆ in 21PF-1 Overpacks. Using
this approach for domestic shipments has resulted in greater control of the shipping variables and uncertainties, and might provide similar controls to the variables associated with international shipments.

- Develop alternative tiedown schemes to ensure that the principal tiedown forces are transmitted to the vehicle frame, per the requirements of DOE Order 1540.1, and not to the wooden decking.

30-Inch Cylinders Containing UF₆ with 21PF-1 Overpacks Loaded on a 40-Foot Dedicated Trailer for Domestic Shipment

Because of the inefficiency of previously discussed loading and unloading requirements for overpacks and containers, it is recommended that a quick disconnect/connect device be designed, fabricated, and installed on the dedicated trailers to facilitate these operations. This device could be designed so that it is either bolted or welded directly to the frame of the trailer.

Empty 30-Inch Cylinders Loaded on 40-Foot Domestic Flatbed Trailer

No specific recommendation can be made that would eliminate the concerns and problems associated with these shipments. Eliminating the problems begins with controls during the loading process. The PORTS has no specific control over the loading process; however, developing several acceptable tiedown design concepts and presenting them to the shippers as acceptable and recommended methods for transporting the empty cylinders may result in some improvement.

REFERENCES


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