

TRANSPORT OF DUF₆ CYLINDERS

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ABSTRACT

In the 2002 timeframe, the United States Department of Energy (US-DOE) embarked upon a plan for the accelerated cleanup of the K-25 site, the former gaseous diffusion plant located in Oak Ridge TN. Renamed, The East Tennessee Technology Park (ETTP), K-25 was slated for a full remediation and reindustrialization program originally estimated to cost \$1.6B (USD). The project required the demolition of buildings, associated remediation projects, legacy waste management and the removal of over 5,000 depleted uranium hexafluoride (DUF₆) cylinders from the former weapons material site. This accelerated closure plan was developed to remove long standing environmental hazards, reclaim significant portions of valuable industrial land and reducing the risk associated with long term management of the acres of contaminated land.

In February of 1999, the US-DOE entered into a Consent Order with the Department of Environment and Conservation (TDEC) of the State of Tennessee for the management and disposition of UF₆ stored at the ETTP site. This paper describes the transportation of 5,952 depleted uranium hexafluoride (DUF₆) cylinders from the ETTP site in Oak Ridge to the Portsmouth Gaseous Diffusion Plant (PGDP) in Portsmouth OH. Visionary Solutions LLC, (VS), under a transportation tender with the US-DOE supported the remediation contractor, Bechtel Jacobs Company (BJC), with all aspects of transportation necessary to prepare the cylinders and make the shipments.

Visionary Solutions, an 8(a) certified small disadvantaged business, was responsible for marshalling the necessary transportation assets including motor carriers, Government approved drivers, and transportation equipment to effect the transport via the accelerated schedule. In addition, VS developed the transportation route, interfaced with law enforcement, first responder and regulatory personnel and scheduled all shipments according to federal, state and local requirements.

INTRODUCTION

Uranium hexafluoride (UF₆) is the chemical form of uranium commonly used during the uranium enrichment process. Within a reasonable range of temperature and pressure, UF₆ can be either a liquid, solid or gas. Solid UF₆ is a white, dense, crystalline material closely resembling rock salt. While UF₆ does not react with oxygen, nitrogen, carbon dioxide or dry air, it does react with water or water vapor to produce uranyl fluoride (UO₂F₂) and hydrogen fluoride (HF) a potentially deadly fluorine gas. It is therefore always handled in leak tight containers and processing equipment. ETTP, formerly known as the K-25 Gaseous Diffusion Plant (GDP), was

a uranium enrichment production facility built in the 1940s and 1950s. Some operations have been shut down for nearly 3 decades, and the entire production mission was ended more than 20 years ago. At the beginning of the transportation campaign, there were approximately 4,700 cylinders of DUF₆, approximately 1,150 empty cylinders and approximately 980 cylinder heels in storage at ETTP. The cylinder storage yards were a Nuclear Category 2 facility. The cylinders were in a deteriorated condition as production operations at the GDP had been terminated at least 15 years previous to the project. In this condition, the cylinders had a constant potential for an environmental release from a breach while presenting other radiological hazard and exposure concerns.

In June of 2004, Visionary Solutions LLC (VS) contracted with the US-DOE to provide transportation services in support of the DUF₆ cylinder removal scope of the ETTP site closure plan. The closure plan included a requirement to accelerate the removal of the compliant and potentially non-compliant DUF₆ cylinders to meet the requirements of the Consent Order signed between the DOE and TDEC (State of TN). The decree obligated the Department of Energy to remove all of the DUF₆ cylinders from Oak Ridge by Dec. 31, 2009.

UF₆, in various forms, has been transported safely for more than 40 years. Specific requirements exist for the shipment of UF₆ cylinders which must be designed, fabricated, inspected and tested and marked in accordance with approved standards per the American National Standard Institute N14.1 (ANSI 14.1). Three specific requirements are especially important relative to depleted UF₆ cylinder shipments:

1. cylinders must be filled to less than 62% of the certified volumetric capacity
2. pressure within cylinders must be less than 14.8 psia
3. cylinders must be free of cracks, excessive distortion, bent or broken valves or plugs, and broken or torn stiffening rings or skirts and must not have shell thickness that have decreased below a specified minimum value

Campaign Start-up

At the outset, the task of removing the nearly 6,000 cylinders seemed daunting at best. The cylinders were in all stages of disrepair with some requiring “in-situ” repair, while others were determined to need special overpacks for compliant transport. The cylinders were typically type 48-B steel containers having been fabricated to applicable standards at the time of manufacture. However, most of the cylinders were over 40 years old and in their current condition many could not have been proven to be DOT compliant for the trip between Oak Ridge TN and Portsmouth OH. There were only three options for the shipment of non compliant cylinders:

1. The depleted UF₆ material could be transferred into compliant containers
2. Non-compliant containers could be shipped in “overpacks” made to current regulations
3. Special exemptions could be obtained from DOT with sufficient justification to prove that the appropriate level of safety exist

Most of the DUF₆ cylinders were deemed to be compliant and shipped “as is” or if determined to be non-compliant, shipped in specially developed overpacks. Visionary Solutions worked closely with the Department of Energy’s Oak Ridge Operations Office (DOE-ORO) to ensure that transportation routes were developed that met all of the requirements of the effected states, Kentucky, Ohio and Tennessee. In conjunction with DOE-ORO and the States of Tennessee, Kentucky and Ohio, VS route transportation specialists worked to develop:

- ◆ Safe routes that avoided residential neighborhoods, schools, population centers
- ◆ Effective transport times to reduce transport during high traffic periods
- ◆ Emergency response protocols for law enforcement/ first responder personnel
- ◆ Tracking and communication plans to alert interested parties of all shipments

The number of projected shipments, the type of material to be transported and the stringent driver selection requirements imposed by the Dept. of Energy and the States effectively ruled out the possibility of selecting a single motor carrier for the entire campaign. The likelihood of a single carrier being able to provide sufficient transportation assets including drivers with the required certifications, endorsements and equipment necessary to meet the stringent regulatory requirements of the campaign necessitated the use of multiple carriers. Visionary Solutions, LLC was responsible for screening potential firms, interviewing and selecting qualified drivers, obtaining extensive background checks and approvals through the State of Kentucky, and assuring that all equipment met all project requirements for each shipment.



Figure 1. V-TOC monitored and tracked all shipments

has been using the TRANSCOM system as well as commercial systems to monitor all VS shipments including DOE-Oak Ridge Operations (DOE-ORO) shipments out of Oak Ridge, TN. During normal transportation campaigns, V-TOC is staffed 24-hours per day, 7 days per week in a secure environment. It maintains tracking operations in 4 systems including TRANSCOM and QUALCOMM, and has five fully functional workstations and emergency power back up capabilities.

The requirement to maintain constant contact and communication with all shipments was achieved using the proprietary Visionary Solutions Transportation Operations Center (V-TOC) which utilized the DOE Transportation and Tracking Communications (TRANSCOM) satellite tracking and communication system for all shipments. VS is familiar with en-route monitoring having established V-TOC as a fully functional call and transportation center for emergency response and dispatch support in 2004. Since that time, VS

Regulatory Interfaces

The DUF₆ Transportation Campaign required close interaction with federal, state and local law enforcement and regulatory officials. UF₆ is a potentially dangerous material that can have significant impact on the public or the environment in the event of a transportation related breach or related incident. These uranium compounds are a toxic mix of hazardous and radiological agents that pose a serious environmental challenge along with the potential to expose personnel performing remediation activities to low level radiation if not properly controlled. Negotiations between the Department of Energy and regulatory authorities from Ohio, Kentucky and Tennessee were on-going long before the first DUF₆ shipment was made in March of 2004.

Visionary Solutions played an important role in those discussions supporting route development, communication protocols and emergency response procedures. VS was instrumental in developing motor carrier and driver procedures that adhered to the stringent requirements imposed by regulatory agencies. Special transportation requirements included:

- ◆ Strict CDL driver requirements
- ◆ Restricted access to loading and egress sites
- ◆ Special CVSA Level VI inspection requirements at the point of departure, with additional CVSA Level I inspections at each state port of entry and final delivery site
- ◆ Restricted departure times to minimize disruptions to population centers, school zones and transportation routes
- ◆ Highway Route Controlled Quantity (HRCQ) like routes/procedures (no escorts)
- ◆ Special communication interfaces with Law Enforcement personnel to ensure shipments were not stopped or stranded during transport

<p>DUF₆ directive for loads under Highway Route Controlled Quantity (HRCQ) restrictions:</p> <ul style="list-style-type: none"> ◆ Drivers required to meet stringent criteria. Drivers were subject to personal background checks in addition to government background check. ◆ Drivers received additional training on cargo hazards and measures to be taken in the event of incident or emergency ◆ Routing Restrictions Applied Such As: <ul style="list-style-type: none"> ● No Route through Highly Concentrated Population Areas ● No Major Events planned near the area ● Safest and Quickest Route Planning ● Special Scheduling Restrictions Met ● Daily Level 6 inspections 1st six months. <p>Note: Material was not an actual HRCQ.</p>	<p>VS Management Criteria for the DUF₆ Campaign:</p> <ul style="list-style-type: none"> ◆ 0 Incident 0 Tolerance Driver Campaign. For example; <ul style="list-style-type: none"> ● 1st Time Speeding/Moving Violation: <ul style="list-style-type: none"> ■ Driver Removed from Campaign on the Spot ■ Carrier Received Suspension of Loads by 1/2 Next Day for 30 days ■ Open Driver and Tractor Filled Next Day and Deliveries Kept On Schedule. ● Daily pre-trip and post-trip driver inspections with follow-up reports ● 200+ Drivers subject to qualification process for the DUF₆ Campaign Driver Pool ● Drivers were placed by VS onto a waiting list to be used if approved and position became available.
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In conjunction with DOE and its contractor, Bechtel Jacobs Company, a transportation management plan complete with a comprehensive emergency response and incident mitigation capability was developed and implemented. Visionary worked with DOE approved motor carriers to ensure that all transportation and emergency response protocols were maintained at all times. Our staff is experienced at managing drivers and equipment to ensure that only the highest quality drivers and equipment are dispatched. Five motor carriers with the required certifications, licenses and endorsements were selected for the campaign. Each firm was required to place their employees and equipment under direct Visionary Solutions' direct management and control to ensure that all procedures and protocols were maintained. Under VS direction, qualified hazardous materials drivers were hired / contracted to transport the DUF₆ cylinders. All drivers were required to undergo background checks by State law enforcement and meet strict performance requirements throughout the life of the project.

Carriers Used for DUF₆ Campaign:

- Interstate Ventures***
- A.J. Metler Specialty Transport***
- Southern Freight Logistics***
- Tag Transport***
- Hubbard Trucking***



Figure 2. VS provided Emergency Management training along DUF₆ routes

Prior to the start of transport operations, Visionary Solutions provided emergency response training to over 450 first responders, law enforcement and emergency management personnel. Emergency management personnel including, first responders, law enforcement personnel and volunteer fire departments along DUF₆ transportation routes were instructed by VS through the Department of Energy's Transportation Emergency Preparedness Program (TEPP). Training included instruction in basic radiation awareness, DUF₆ cylinder handling, and hazardous/radioactive spill response procedures and communication protocols.

Transportation Routes and Schedules

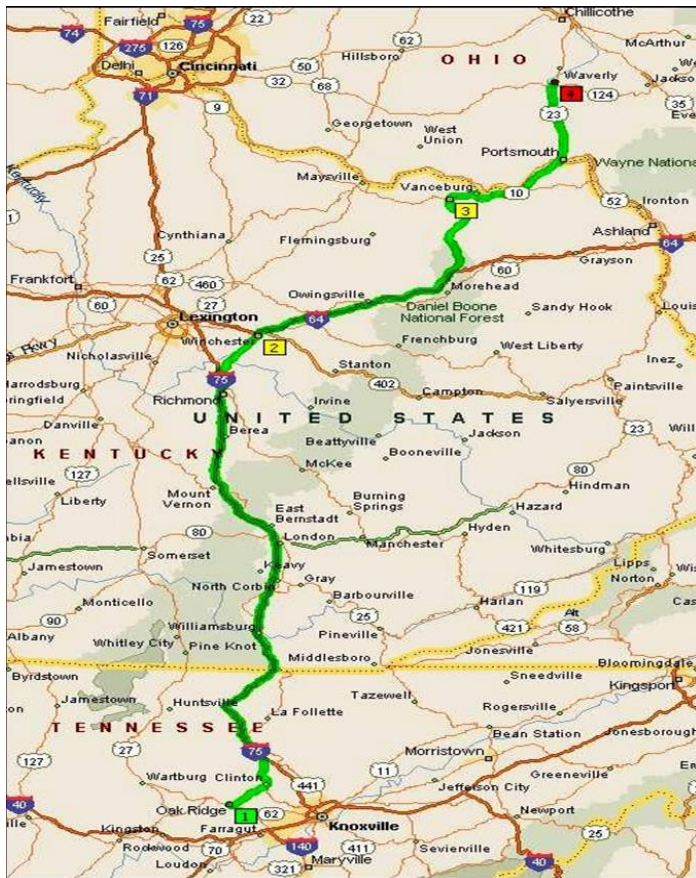


Figure 3. DUF₆ Route Map

The transportation route selected for the shipment of DUF₆ cylinders from Oak Ridge TN to Portsmouth OH was developed to meet stringent requirements from all affected stakeholders. Post 9/11/2001 concerns over the threat associated with transporting large quantities of radioactive material resulted in the decision to use HRCQ-like routing procedures even though the material did not meet HRCQ standards. In addition, certain jurisdictions did not want the materials to transverse their locales during high traffic periods including early mornings when rush hour commutes and active school bus routes.

VS assisted DOE in the negotiation with the states to select the route and shipment requirements. VS developed transportation routes and schedules designed to minimize exposure to the public while on the public thoroughways.

Consequently, routes had to be developed that either avoided high population centers or assured that DUF₆ shipments crossed those areas during low traffic periods. It was determined that all shipments should originate from the ETTP site at the same time, very early in the morning, each day to ensure that the routes met these requirements. Visionary Solutions worked with the selected motor carriers to ensure that drivers were constantly aware of projected schedules and any changes to standard operating procedures. Each driver was required to be at the ETTP site by 4:00 AM each morning to participate in pre-trip inspections, safety meetings and ensure that the loads could be properly secured for transport. Each load was required to be on the road by 6:30AM to avoid high traffic periods in the originating locale and the areas to be traversed.

The Department of Energy required that transport vehicles and cylinders be made available to State highway and radiological health inspectors during loading and transport. Each transport vehicle and load underwent radiological surveys and was subject to a complete CVSA Level VI inspection prior to departure from the loading facility. In addition, each State had the option to perform separate CVSA inspections whenever shipments were in their jurisdiction. The State of Ohio also had the opportunity to inspect each shipment upon arrival at the Portsmouth Gaseous Diffusion Plant (PGDP).



Figure 4. Pre-Trip Trailer Inspection

Visionary Solutions Performance



Figure 5. Transport of DUF₆ Cylinders

VS provided all required labor, equipment, support materials, facility, maintenance, fuel, required documentation, permits, and certificates for transporting of the nearly 6,000 depleted uranium hexafluoride cylinders (DUF₆) from the East Tennessee Technology Park (ETTP) to the DOE Portsmouth Gaseous Diffusion Plant in Ohio. This project shipped up to 18 shipments each day, shipping 5 days per week.

At project completion in December of 2006, VS had successfully transported 5,952 cylinders in 4,975 shipments without a single DOT reportable accident.

VS recruited and trained a pool of over 150 drivers and submitted each for background checks and approval by the state of KY. From this pool, a cadre of 102 drivers was selected. Thirty five drivers were dedicated to the project with the remainder available for fill in as needed. To ensure strict adherence to the schedule, driving schedules were systematically developed. Teams were capable of running five shipments each week, while single drivers could run three shipments one week and two the next. There were 12 regular teams with 31 teams consisting of different drivers (rotating partners). Up to 40 tractors were dedicated to the project and were maintained to be able to pass daily CVSA Level VI inspections at the ETTP site. Additionally, VS supplied the transportation project manager and up to 4 maintenance and support personnel. VS was required to interact in planning sessions with DOE and BJC to address scheduling issues and to assist with changing requirements. VS personnel verified that all cylinders were properly loaded and secured prior to leaving the ETTP site.

Prior to program initiation, DOE negotiated with the states of OH, KY and TN regarding specific qualifications necessary for project drivers. The three states agreed to have the drivers' backgrounds checked by the State of KY. Due to the projected length and intense schedule of the project multiple carriers were required. VS contracted with reputable, DOE Motor Carrier Evaluation Program (MCEP) approved carriers, familiar with DOE requirements for the transport of hazardous and radioactive materials. The carriers were required to provide

the qualifications for drivers they proposed to use for the project to VS. VS compiled and submitted the information to the State of Kentucky. All drivers allowed to participate in this campaign received official approval. No driver could begin transport operations until official approval in writing was received by VS from the State of KY.

These drivers were dedicated to VS by their motor carriers and VS was responsible for all scheduling and equipment. The carriers were responsible for maintaining driver qualifications and performing disciplinary action as needed. Any violations involving project drivers including speeding tickets, required immediate and permanent release of the driver from the campaign. The carrier whose driver received the ticket was then reduced by half on the schedule for a period of 30 days. VS installed tracking devices on both tractors and trailers in accordance with the project requirements. VS was responsible for ensuring that maintenance of equipment was performed in a timely manner and that all inspections and records were kept up to date. All carriers were required to work closely with VS to ensure proper maintenance and required documentation.

VS developed a schedule ensuring that all loads left the ETTP by 6:30 AM each morning requiring the transportation team to begin at 4 AM each day. This was to guarantee that all loads would exit areas close to ETTP prior to morning school and rush hour traffic. Likewise, the trucks had to be routed to avoid afternoon school traffic prior to arrival at the Portsmouth site in OH. Trucks were prohibited from stopping in the State of KY unless absolutely necessary. All inspections had to be completed expeditiously according to DOT regulation. This was a high visibility campaign with considerable oversight from DOE, state regulatory officials and the receiving site.

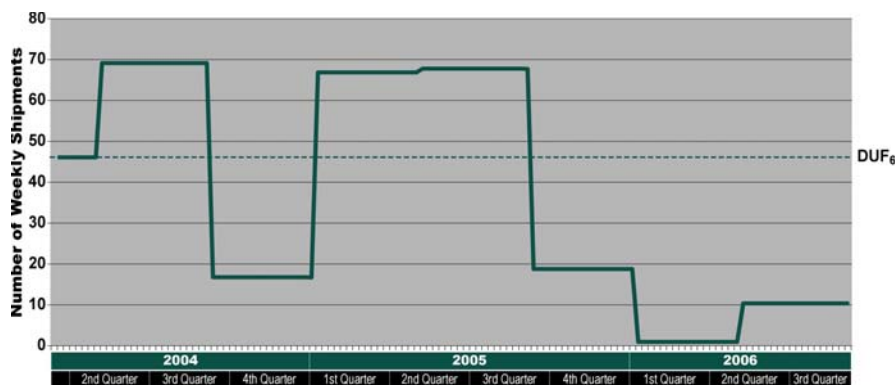


Figure 6. VS Average Weekly Shipments of DUF₆

VS provided qualified hazardous materials drivers to transport the cylinders, ensuring all transportation activities were performed in accordance with pertinent DOT regulations (Hazardous Material Regulations and Federal Motor Carrier Safety Regulations) and other applicable federal,

state and local laws and regulations. VS was responsible for the developing transportation plans, managing state negotiations, and providing first responder training, public outreach, and project-specific driver training. VS provided up to 32 specialized removable gooseneck trailers and maintained all government furnished equipment (GFE). All equipment was required to pass daily CVSA Level VI inspections conducted prior to departure and just prior to entrance to the PORTS site. KY also periodically conducted CVSA Level VI inspections at its border. Therefore, VS initiated a rigorous maintenance program approved by DOE and its contractor. Daily safety meetings were conducted with all drivers and personnel to discuss issues such as weather, road conditions, lessons learned, etc.

VS provided expertise to assist BJC in the securement of overpacks for non-compliant cylinders. VS provided tracking and monitoring of all shipments 24/7 in the VS Transportation Operations Center (V-TOC). V-TOC personnel were required to schedule all shipments into the DOE TRANSCOM system. VS was required to have a separate emergency response and recovery plan and contract in the event of an accident. VS personnel trained the state personnel to use TRANSCOM to monitor shipments in their state. During the times when TRANSCOM was inoperable either in an area or completely V-TOC personnel were required to fax the position of each shipment every 15 minutes.

CONCLUSIONS



Visionary Solutions, LLC, a small transportation and logistics company headquartered in Oak Ridge TN was tasked to support the DOE ETTP Remediation project through the provision of transportation services. Our role, was to transport nearly 6,000 depleted uranium hexafluoride cylinders of varying condition from the ETTP site in Oak Ridge TN to the Portsmouth GDP in Piketon OH.

Figure 7. DUF6 Cylinder Yard Before & After

As the transportation contractor, VS was required to:

1. interface with federal, state and local customer representatives
2. determine proper shipping requirements to comply with all DOT regulatory and state transportation requirements (Code of Federal Regulations, 49 CFR)
3. enlist and manage multiple motor carriers capable of meeting stringent transportation requirements
4. provide and maintain up to 40 power units and 32 specialized trailers
5. support cylinder loading, securement, and inspection operations prior to shipment
6. monitor and track all shipments
7. provide emergency management training along transportation route

DUF₆ Transportation Summary			
DOE Campaign	Avg. Shipments Per Week	Max. Shipments Per Week	Hours Traveled
DUF₆	48	90	51,471
Total Shipments	4,975		
Total Mileage	2,786,000.00		

The Department of Energy stipulated that the transport of these cylinders from the ETTP site was a critical element of the site closure plan. An accelerated closure plan, prompted in part by a Consent Order with the State of TN, required that all of the cylinders be removed from the site prior to December 31, 2009.

Figure 8. DUF6 Shipment Summary

The project team, DOE, the Bechtel Jacobs Company and Visionary Solutions, LLC were able to complete this critical project function a full 3 years ahead of schedule. The last DUF₆ cylinder was transported from the ETTP site in December 2006. This accomplishment was the result of a committed relationship between all stakeholders coupled with strong cooperation and communication providing prompt issue resolution and timely performance. We were able to transport 5,952 cylinders over a two year period without a single DOT recordable accident.

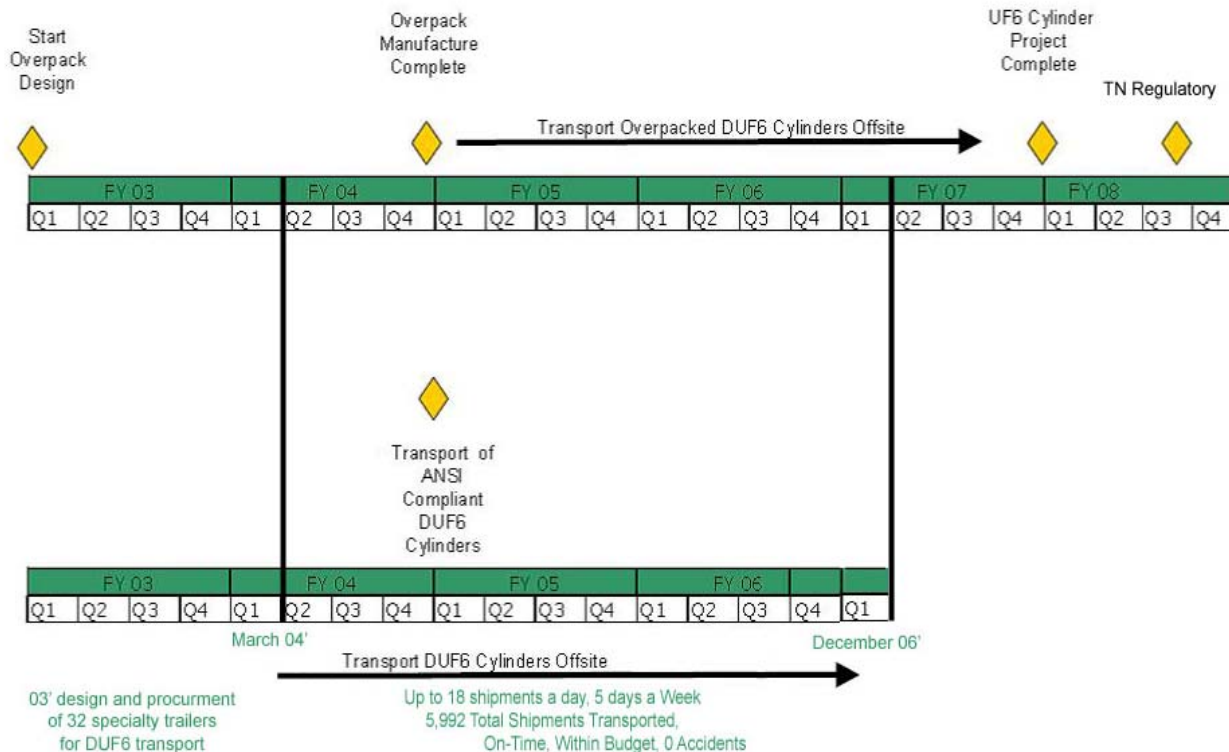


Figure 9. DOE to VS Milestone Timeline

The lessons learned from this critical transportation campaign were numerous and contributed to the continued growth and maturation of Visionary Solutions, LLC as a premier transportation and logistics firm. Bolstered by the success of this critical project, Visionary Solutions has progressed to perform additional transportation projects of increasing scope and complexity. Visionary Solutions, LLC was recently awarded a contract by the Department of Energy to provide transportation services for the Waste Isolation Pilot Plant (WIPP) project in Carlsbad NM. Visionary Solutions will perform this complicated transportation scope to retrieve and deliver U.S. Government Transuranic Waste (TRU) from Government sites to the facility in Carlsbad NM.

“Because this activity is a prerequisite for the successful remedial action to achieve closure, the cylinders must be relocated. The closure plan will accelerate movement of these cylinders to another site by at least 3 years, thus ensuring that requirements from the State of Tennessee consent order are met.”
 Source: Oak Ridge Comprehensive Closure Plan, ETTP Closure Plan, US Department of Energy
 – Oak Ridge Operations –

Visionary Solutions is a full-service transportation and logistics company with the capability to perform complicated material transportation and disposition projects in the United States and internationally. We support U.S. Government and commercial transportation projects through the provision of full-service transportation professionals and equipment to meet any customer need.

Table 1. UF6 Data Summary

Cylinder Model	Nominal Diam. (in.)	Material of Construction	Minimum Volume		Approximate Tare Weight Without Valve Protector		Maximum Enrichment Uranium-235	Shipping Limit Maximum, a UF ₆	
			ft ³	liters	lb	kg	Weight %	lb	kg
1S	1.5	Nickel	0.0053	0.15	1.75	0.79	100.00	1.0	0.45
2S	.5	Nickel	0.026	0.74	4.2	1.91	100.00	4.9	2.22
5A	5	Monel	0.284	8.04	55	25	100.00	55	24.95
5B	5	Nickel	0.284	8.04	55	25	100.00	55	24.95
8A	8	Monel	1.319	37.35	120	54	12.5	255	115.67
12A	12	Nickel	2.38	67.4	185	84	5.0	460	208.7
12B	12	Monel	2.38	67.4	185	84	5.0	460	208.7
308 ^c	30	Steel	26.0	736.0	1,400	635	5.0 ^b	5,020	2,277
48A	48	Steel	108.9	3,84	4,500	2,041	4.5 ^b	21,030	9,539
48X ^d	48	Steel	108.9	3,084	4,500	2,041	4.5 ^{b,g}	21,030	9,539
48F	48	Steel	140.0	3,964	5,200	2,356	4.5 ^b	27,030	12,261
48G	48	Steel	139.0	3,936	2,600	1,179	1.0 ^f	26,840 ^e	12,174 ^e
48Y ^d	48	Steel	142.7	4,041	5,200	2,359	4.5 ^b	27,560	12,501
48H	48	Steel	140.0	3,964	3,170	1,438	1.0 ^f	27,030	12,261
48HX	48	Steel	140.0	3,964	3,170	1,438	1.0 ^f	27,030	12,261
480M	48	Steel	140.0	3,964	3,050	1,386	1.0	27,030	12,261

ACKNOWLEDGMENTS

Mr. Brady Lester, DOT Transportation Manager, U.S. Department of Energy
 Mr. Douglas Stancell U.S. Department of Energy (ret)

REFERENCES

- 1) UF6 Management - US Department of Energy – <http://web.ead.anl.gov/uranium/guide/UF6>
- 2.) DOE ETP Closure Plan
- 3.) “Transporting DOE UF6 Cylinders from Oak Ridge, TN to Portsmouth OH”: USDOE Oak Ridge Operations Office, Oak Ridge TN