FERNALD VACUUM TRANSFER SYSTEM FOR URANIUM MATERIALS REPACKAGING

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ABSTRACT

The Fernald Environmental Management Project (FEMP) is the site of a former Department of Energy (DOE) uranium processing plant. When production was halted, many materials were left in an intermediate state. Some of this product material included enriched uranium compounds that had to be repackaged for shipment to off-site storage.
This paper provides an overview, technical description, and status of a new application of existing technology, a vacuum transfer system, to repackage the uranium bearing compounds for shipment. The vacuum transfer system provides a method of transferring compounds from their current storage configuration into packages that meet the Department of Transportation (DOT) shipping requirements for fissile materials. This is a necessary activity, supporting removal of nuclear materials prior to site decontamination and decommissioning, key to the Fernald site's closure process.

INTRODUCTION

The Fernald DOE site is a former uranium processing facility. Production began at the site in 1951 and continued until 1989. (1) During this time, the site produced over 900 million pounds (4.08×10^8 kilograms) of purified uranium compounds and metals. (2) These materials were used as feed materials for other government sites, mainly for use in defense programs. In 1989, production at the site was halted and the site was placed on the National Priorities List. The abrupt cessation of production activities left the site with approximately 10 million pounds (4.54×10^6 kilograms) of product compounds needing disposition. This inventory included compounds with greater than 1.0% U^{235} enrichment, i.e., low-enriched uranium (LEU). These compounds had to be repackaged in quantities containing less than 350 grams of U^{235} in order to meet DOT shipping requirements. (3)

PRIOR TECHNOLOGY

Initial Repackaging Efforts, the C-13 Project

Initial repackaging using vacuum transfer of the enriched compounds occurred between 1996 and 1997 in the C-13 area of Plant 6 at the Fernald site. The project was dubbed the *C-13 Project* for the area in which the activity occurred. This repackaging activity involved repackaging 1.25% enriched uranium trioxide (UO_3) into 350 gram quantities of U^{235} to meet the DOT requirements for an authorized fissile material package. The equipment utilized in this activity was assembled primarily from existing equipment on site and occupied approximately 3600 square feet (334 square meters). The system utilized a modified drumming station for vacuuming material into a hopper. The hopper was supported by a 10-foot (3.05 meter) high platform that was stabilized by attachment to the ceiling support structure. The material discharged through a rotary valve into the fill drum located in a second drumming station. The vacuum system was powered by two HEPA vacuums operating in parallel. General area ventilation was provided by a 4,000 cfm (1,888 L/s) HEPA unit in series with a separate

cartridge prefilter. The gulping and drumming stations were ventilated by a 1,000 cfm (472 L/s) HEPA unit. Both HEPA units discharged into a separate room to reduce the noise impact in C-13.
The flow diagram for the C-13 Project is included as Figure 1.

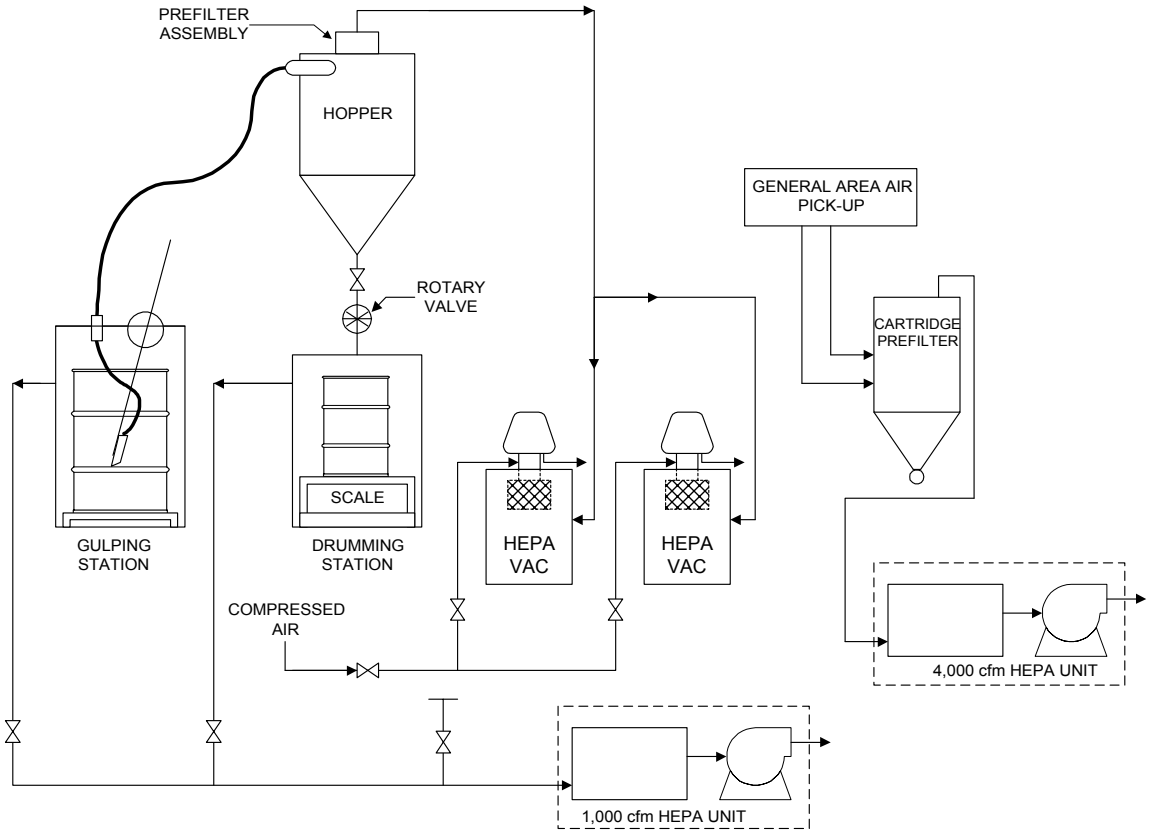

Fig. 1. Simplified flow schematic of the C-13 Project.

The major problems associated with the C-13 Project equipment were: (1) a lack of effective product dust containment, (2) a high rate of filter loading and, (3) the equipment was supposed to be portable, but was massive and difficult to move.
The prefilters for the vacuums clogged frequently, requiring continuous maintenance. This required interruption of operations approximately twice each week for several hours at a time. The lack of dust containment required all persons in the C-13 area to wear respirators. This impeded production and presented the potential for a contamination event.

CURRENT TECHNOLOGY

Drum Repackaging Station Procurement

When the C-13 Project was stopped, plans for an improved drum repackaging system were developed. A Scope of Work was prepared in 1999 and bids were solicited to design and construct a drum repackaging station for repackaging drummed, uranium bearing compounds. The repackaging station was to be deployed at the Fernald site in Building 56A. The contract was awarded on December 10, 2000 to Power Products and Services Company, of Georgetown, SC, a designer and manufacturer of radiological material handling equipment.

Each drum repackaging station, which utilizes a vacuum transfer system, performs the same function as the entire C-13 Project. The footprint of a station is approximately 204 square feet (19 square meters). The repackaging units require approximately 187 SCFM (88 L/s) of dry, compressed air at 95 psig (655 kPa). The repackaging units require approximately 20 amps of electricity at 480 volts. No other utilities are required.
A prototype station, Unit 1, was first procured in order to test the concept of the self-contained system. After successful testing of the first unit, two follow-on units were purchased, that incorporated enhancements developed during operation of the prototype. The purchase of the prototype unit, Unit 1, was funded by the Office of Science and Technology (OST) through the Nuclear Materials Focus Area (NMFA). The vacuum transfer system was eligible for funding by the OST/NMFA, because it provides confirmation of the concept using proven components with an innovative approach, and it has applicability for repackaging activities at other DOE sites. The purchase of vacuum transfer system Units 2 and 3 was funded through the site budget.

General Arrangement and Description

Each repackaging station utilizes a vacuum transfer system to transfer continuously monitored quantities of compounds of varying particle size and density, from a storage container to an approved fissile material shipping container. Each repackaging station consists of a stainless steel enclosure with two separate compartments: a vacuum-side compartment, and a fill-side compartment. The vacuum-side compartment can accommodate containers varying in size from 5 gallons to 110 gallons (19 to 420 liters). The fill-side can accommodate 30 gallon (115 liter) or 55 gallon (210 liter) drums.
Carriages, consisting of wheel mounted turntables, are used to transport drums into and out of the repackaging station. Rails, with pneumatic cylinders for lowering and raising the rails, provide a track for the carriages. The rails are lowered to close the doors to the compartments and are raised, once the door is fully open, to permit movement of the carriage into and out of the station. Negative pressure is maintained in both sides of the drum repackaging station through a HEPA ventilation system. Intake air for both the vacuum and ventilation systems enters through intake filters mounted on the top of the drum repackaging station.
Lexan viewing windows with glove ports allow removal and replacement of the drum lids, on both the vacuum and fill-side containers. The vacuum wand is operated from the top of the vacuum-side compartment. The wand penetrates a Lexan viewing window through a ball and socket joint. The vacuum operator accesses the vacuum wand from a lift platform adjacent to the vacuum-side compartment. A control panel and a pressure indicator panel are mounted on the handrails of the operator lift platform. A small, fixed height platform, provides access to the fill-side glove ports. A fill lid, fitted with air cylinders for vertical travel, provides a positive seal against the fill drum while vacuuming.
Vacuum flow is created by forcing compressed air through a vacuum head assembly. The vacuum head creates a low pressure through the venturi effect. Vacuum air enters the vacuum-side chamber through the intake filters and travels into the vacuum wand where the compound material is picked up from the vacuum-side drum. The suspended material is carried through the vacuum line to the fill lid. At the fill lid, the flow area increases causing the velocity to decrease. The majority of the material drops out into the fill-side drum. The vacuum air continues through the vacuum prefilter (NVF filter) then through the vacuum HEPA filter. After the HEPA filter, the vacuum air mixes with the compressed air and is exhausted from the vacuum head.
Vibrators on the fill lid and the vacuum prefilter housing operate automatically each time the fill lid is raised. This reduces the amount of loose material deposited in the fill-side compartment. A backflush purge of compressed air through the vacuum prefilter can be initiated by the operator, as long as the system interlocks do not detect a condition where this would be dangerous.
Interlocks prevent vacuum operation or vacuum prefilter purge when these actions might create an unsafe condition, such as when the cabinet doors are open or the ventilation fan is not operating.
A scale is mounted to the floor of the fill-side cabinet, beneath the fill drum frame and rails. The scale indicates the amount of material being transferred into the fill-side drum and can be used to automatically control the amount of material transferred. A level probe prevents grossly overfilling the fill-side drum.

Indicator lights provide status information as well as warning when a fault condition exists. An audible alarm will sound if a low differential pressure is detected across either the vacuum or ventilation HEPA filters. Pressure gauges provide continuous pressure indication for various points in the vacuum or ventilation systems.
Each drum repackaging station is equipped with fork lift pockets and can be readily decontaminated and shipped on a flat bed trailer.

Fig. 2. Drum Repackaging Station, Unit 1
(two views)

DRUM REPACKAGING STATION OPERATION

Installation of the prototype drum repackaging station, Unit 1, was completed at Fernald on March 9, 2001. After extensive testing of the equipment and training of the operators, the unit was deployed and placed into hot operation on June 28, 2001.
Approximately 410 repackaged drums of UO_3 were produced from 22 source drums when a failure of the vacuum prefilter gasket in this unit occurred. The unit was placed on standby until upgrades to the vacuum prefilter could be made.
The two follow-on units incorporate developmental upgrades based on the operation of Unit 1. Installation of these two units was completed on September 20, 2001. The units were then deployed into operation on September 26, 2001. Improvements to the new units and the final package have been implemented to eliminate the problems discovered on Unit 1. Unit 1 is currently in standby status as a backup unit.

Performance

The average number of drums produced per day during the C-13 Project was 17. The typical daily rate for each drum repackaging station is 36 drums. The actual number varies depending on the condition of the material being vacuumed, temperature and humidity in the work area, and the availability of support systems.
The major faults with the repackaging stations have been reliability related. The vacuum system typically works well. Faulty seals on the second and third units caused leaks around the vacuum prefilter and under the fill lid, impacting both the vacuum rate and the efficiency of the vacuum prefilter purge. Replacement of these seals with more resilient material was made and appears to have corrected the problem.
The electronic scale system on the prototype unit was affected by the vacuum flow. The vacuum tended to lift the fill-side drum, frame and fill lid, thereby reducing the indicated weight below the actual weight of the drum. A vacuum balance hose was installed to improve the scale performance but did not entirely remove the effects of the vacuum. The scale system for the second and third units was redesigned to remove the effects of the vacuum lift on the scale. The performance of the scale on these units is greatly improved over that of the prototype.

The rail cylinders of all three units were initially plagued with seal leaks. The cylinder manufacturer recommended replacing the seals with a type that does not require lubrication. Replacement of these seals appears to have corrected the problem.
Bolted connections tend to work loose causing leakage at various points in the system. Incorporating checks of these points in the periodic maintenance schedule appears to have corrected this problem.
Implementation of the above changes appears to have greatly improved the reliability of the equipment. The gasket material selection has made a profound difference in the equipment performance. Monitoring and improvement of the equipment will continue during the remainder of the project.

Radiological Protection

The prime advantage of the drum repackaging station was to be the fact that site workers would be protected from direct contact with the material and radiation exposures would be minimized. The workers would not have to wear respirators to repackage the uranium compounds due to the containment of the airborne dust in the repackaging system.
The system appears to be fairly effective at maintaining the airborne levels below the action level in typical operation of the equipment. Based on the results of area air samples and breathing zone samples, the requirement for respiratory protection was removed on July 24, 2001, after approximately one month of operating the prototype unit. Repackaging continued without respiratory protection until the vacuum prefilter lid gasket failed on August 21, 2001. Operation of Units 2 and 3 began on September 26, 2001, but with respiratory protection required. This start-up was plagued with minor equipment failures, primarily associated with failing seals. After successfully repackaging compounds for about one month, the requirement for respiratory protection was again lifted. Leaks in the vacuum prefilter housing during the filter purge cycle were noticed by the operators. Use of the purge was suspended until the leaks could be addressed. Elevated breathing zone samples caused the requirement for respiratory protection to be restored after about two weeks of operation without respirators. Replacement of gaskets and tightening of the bolted connections appears to have stopped the leaks. Use of the vacuum prefilter purge has helped reduce the amount of fugitive dust in the fill-side cabinet during removal of the filled drums. Monitoring of the air sample data continues and a decision as to whether or not the requirement for respiratory protection can be removed will be made, based on that data.
The release of uranium material outside of the repackaging station appears to be minimal except when maintenance activities preclude operation of the ventilation system or certain upset conditions occur. The placement of the intake air ports near the points where the vacuum air exits the unit helps minimize the risk of a material release, even under upset conditions. When the vacuum prefilter lid gasket failed on the prototype unit, most of the material was sucked back into the ventilation system through the intake filters. Area air monitoring confirmed that the spread of material was limited to the immediate area of the prefilter. Personal breathing zone samples and urine samples indicated no dose assigned to any of the operators in the area, even though no respiratory protective equipment was worn at that time.
Approximately 30,000 pounds of UO_3 were repackaged during the periods of July 24 to August 21, 2001 and October 23 to November 8, 2001, without respiratory protection. Personal breathing zone results averaged around 1 Derived Air Concentration (DAC) hour per shift worked. General area airborne levels averaged around 1% of the DAC for Uranium-238 (Class Y). Airborne levels near the fill side of each unit averaged around 4% DAC. The calculation of bioassay (urine) results for these periods has resulted in less than 10 mrem of collective internal exposure to the repackaging station operators.

SUMMARY AND CONCLUSIONS

The drum repackaging stations, using a vacuum transfer system, at the Fernald Environmental Management Project site have been used to repackage over 71 source drums of 1.25% enriched uranium trioxide (UO_3), producing over 1321 packages for shipping. Approximately 12 drums of 1.25% enriched uranium tetrafluoride (UF_4) have been repackaged, producing 36 packages for shipping.

The remaining product inventory to be repackaged consists of approximately 165 source drums of UO_3. If the current rate of repackaging can be maintained, this inventory will be repackaged by Spring 2002. After this, the units will be available for repackaging other compounds.
The drum repackaging stations installed at Fernald provide a method of more efficiently repackaging enriched, uranium bearing compounds into shippable quantities for off-site disposition. Site closure schedules are facilitated due to the expected repackaging efficiencies. These systems provide engineered protection that significantly limits the risk of a release of material to the environment and reduces worker exposure to airborne particles. It is expected that this will allow the workers to operate the equipment without respiratory protection. Implementation and deployment of these systems will yield an estimated cost savings of $1 million to the Fernald Environmental Management Project. An additional savings may be realized due to improved worker performance and increased stay times. Continued development of the stations will improve their reliability , durability, and maintainability.
This has been a significant, cooperative program between the Fernald Environmental Management Project, Fluor Fernald, the Department of Energy OST, and NMFA. The Drum Repackaging Stations have provided concept confirmation for nuclear materials transfer using proven, commercially available components, with an innovative approach. Possible future applications at Fernald may include the repackaging of waste compounds. After the Fernald site no longer needs the repackaging stations, they will be made available for transfer to other DOE (Environmental Management) sites for applicable nuclear or waste compounds repackaging.

REFERENCES

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