GASEOUS DIFFUSION PLANT DECOMMISSIONING

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ABSTRACT

This paper describes the challenges and lessons learned of the decontamination and decommissioning of the first three gaseous diffusion facilities decommissioned in the United States.

BNFL BACKGROUND

BNFL Inc. is an American environmental services company whose expertise is providing technical solutions to clean up nuclear waste. The focus is on providing innovative solutions for the nation's most difficult environmental and nuclear challenges. An industry leader in safe operations, they offer a full array of decontamination and decommissioning management and

Fig. 1 BNFL-ETTP gaseous diffusion facilities

operations services within the United States and internationally. In addition to 10 years experience in the United States, the BNFL-ETTP team—senior management, project managers, supervisors—have extensive experience in the nuclear utility, waste management, project safety, and construction industries.

BNFL HISTORY

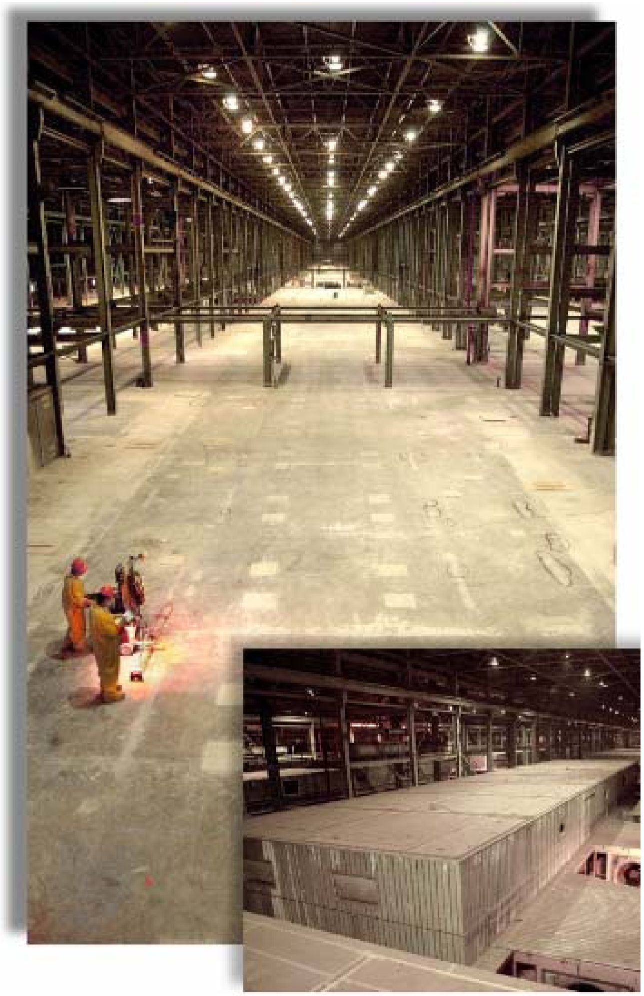


Fig. 2 Before and after pictures of gaseous diffusion building.

In August 1997, the Department of Energy awarded BNFL Inc. a six-year, fixed-price contract. The purpose of the project includes the decontamination and decommissioning of three gaseous diffusion plants (GDP)—K-33, K-31 and K-29—at the East Tennessee Technology Park (ETTP), formerly known as the K-25 site, in Oak Ridge, Tennessee. This project includes the removal and dismantlement of over 1,500 converters—some over 32,000 pounds—decontamination of over 5 million square feet of facilities, and disposition of 328 million pounds of contaminated materials. The massive size of the facilities, in addition to the cost of the project, makes this one of the largest nuclear decommissioning projects in the world.

This large D&D project employs over 1,400 workers to perform the heavy construction dismantling, removal, and disposal of process equipment, support materials, and waste. To accomplish this project, BNFL Inc. established and operates one of the most sophisticated D&D workshops in the nuclear industry and the largest nuclear Supercompactor in the world.

All three facilities were built during the beginning of the Cold War era and were used primarily for uranium enrichment processes. Production of enriched uranium ended in 1985, and the gaseous diffusion facilities were permanently shut down in 1987. Contaminates that were found in the buildings consisted of polychloride biphenyls (PCBs), friable and nonfriable asbestos, chlorofluorocarbons (CFCs), chromates, lubricant oils, miscellaneous materials regulated under the Resource Conservation and Recovery Act, uranium, and other radionuclides.

LARGEST SINGLE NUCLEAR DECOMMISSIONING PROJECT IN HISTORY

K-29 was built in 1951 and encompasses almost 600,000 square feet of space. K-31 was built in 1952 and covers 1.5 million square feet of space, and K-33—built in 1954—covers over 2.8 million square feet. The area in K-33 covers 64 acres, or 64 football fields. All three facilities have similar construction consisting of steel frame structures with reinforced, non-combustible concrete floors. The first level is supported concrete/steel columns sustaining concrete beams.

The roof support structure, consisting of exposed steel beams, girders, and trusses, is connected to exposed structural steel columns extending from the second floor. The roof is a steel deck assembly and the walls are constructed of concrete block or Transite.

The K-29, K-31 and K-33 process buildings were originally designed and built to house the low enrichment (<20% U235 by weight) part of the Oak Ridge Gaseous Diffusion Plant cascade. The plant enriched uranium in the U235 isotope by the gaseous diffusion process that utilized uranium hexafluoride (UF6) as the process gas. During the operation to support highly enriched uranium (HEU) production, peak enrichment level in the cascade was 12.65% for K-29, 6.2% for K-31 and 2.5% for K-33. With the termination of HEU production in the K-25 and K-27 process buildings, the K-29, K-31 and K33 process buildings continued to produce low enriched uranium (LEU) with an average enrichment of 3.2% (peak enrichment of 4.9% for K-29, 2.9% for K-31 and 1.7% for K-33).

All three GDPs operated in a similar manner. The UF6 gasses were introduced into the piping systems at a high temperature. The gasses then traveled into the diffusion equipment stages. One stage contained a motor, a compressor and a converter. The UF6 gasses would flow from the compressor into the converter through the barrier material in the converter where small amounts of U235 diffuse through the barrier material. This splits the gasses into to streams—one with slightly enriched uranium and one with slightly depleted uranium. The two streams of gasses produced would then be sent to multiple stages thousands of times so that certain enrichment levels could be met.

Project Closure

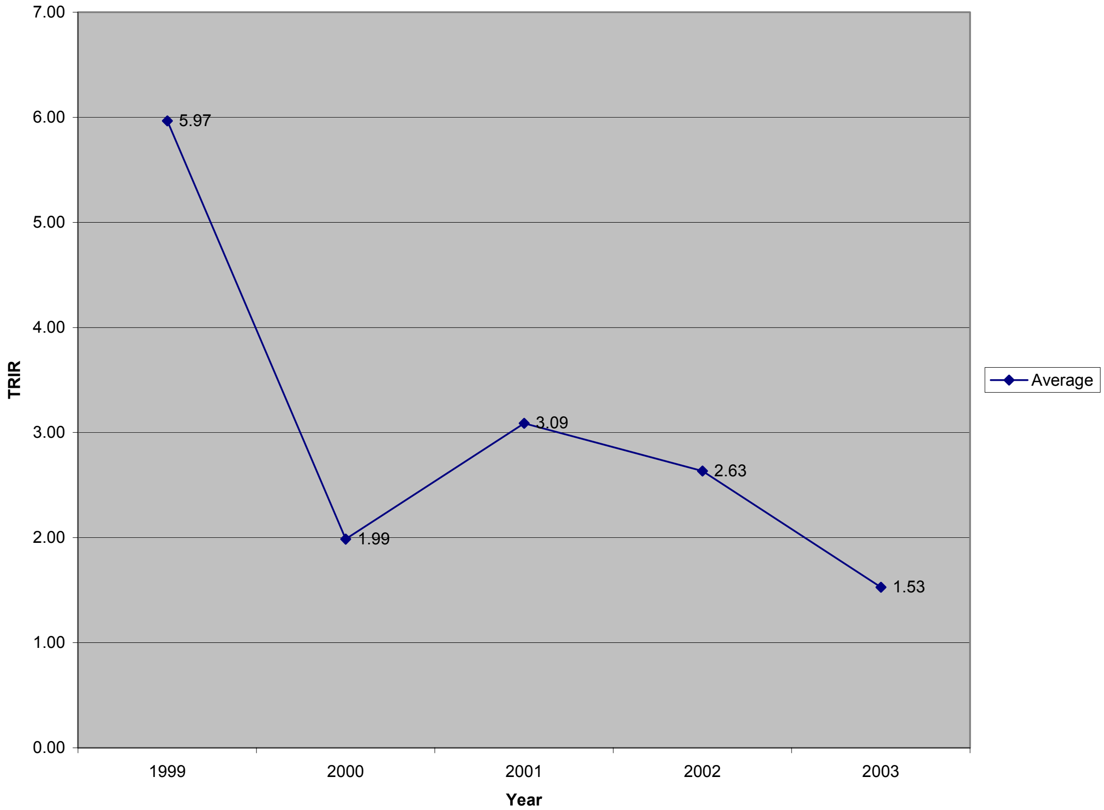
The project is currently 85% complete. All of the process components including piping, support, electrical systems, and all of the concrete pedestals have been removed from K-33 and two of the eight units have been decontaminated (356,000 square feet). In K-31, 95% of the process components and support systems have been removed, and in K-29, 75% of the process components and support systems have been removed. While completing this work, numerous activities had to occur. Over 260 million pounds of low level, TOSCA, hazardous, mixed and sanitary waste had to be removed Characterized, packaged, shipped and dispositioned. This equates to over 8,900 waste shipments. There are still another 4,300 shipments left to go. There have been over 700,000 lifts on the project and there is still another 200,000 left.

SAFETY – THE NUMBER ONE CONCERN

Although safety is discussed further in the "challenges" section contained below, it is a huge challenge on these complex-decommissioning projects and is, therefore, worthy of a section all its own.

Without an outstanding safety program, companies in the nuclear industry will not be allowed to conduct these projects. A number of unique programs have been developed on this project to address this issue. These programs have allowed the project to reach one million man-hours without a lost time accident twice in two years and maintain the Total Recordable Incident Rate 80% to 90% less than the national average.

Table I The total recordable incident rate from 1999 to 2003.



In order to maintain these numbers, employees and management have relied on experience attained throughout the project, Lessons Learned, and the implementation of the Behavior Based Safety (BBS) program. Workers are involved in the full spectrum of project activities. Each employee is held accountable for safety from the first day of the project to the last. The attitude toward safety, quality, and continuous improvement will be interwoven through every aspect of this project.

BNFL has implemented several programs to make sure that safety is the first priority. The Behavioral Based Safety (BBS) program was implemented in an effort to better involve the employees with safety concerns. The program focuses on employees observing the behaviors and work practices of fellow workers. When a correct or incorrect action is observed by an employee, discussions are instantaneous. Providing timely feedback allows for immediate attention to a potential problem. Through behavioral learning, it is the expectation that employees will also take these safety practices home. Training is also provided through skits and videos, but it all boils down to the employees being committed to safety.

The BBS Steering Committee is comprised of BNFL's Tennessee Labor Job-Stewards, i.e., laborers, pipefitters, boilermakers, etc., who observe and review safety issues. The goal is to train as many employees as possible to become observers and implement behavioral-based safety. To date, the BBS has currently trained almost 200 employees to be BBS observers.

BNFL’s BBS group submitted an entry for the yearly Award for Excellence through the Tennessee Labor-Management Center. This award is based on an "outstanding employee-employer partnership in the state of Tennessee that has demonstrated a commitment to cooperative labor-management relations and work force excellence.” The judging criteria for this award is based on an application with the program fulfilling requirements in: Leadership, Employee Involvement, Employee Training and Empowerment, and Employee Diversity and Morale. The BBS Program and application made the finals for this award. Two members of the Tennessee Labor-Management judging panel visited the BNFL site prior to choosing the award winner to discuss the application and process with members of the BBS. The BBS program was designated as a Finalist for the Award for Excellence.

As a result from the visit to the ETTP site, the Tennessee Center for Labor-Management Relations gave BNFL special recognition for its outstanding accomplishment in designing and implementing a Behavioral Based Safety (BBS) program. Tennessee Center for Labor-Management Relations Dr. Barbara Haskew was very impressed with BNFL’s accomplishments and is encouraging other companies to use BNFL’s BBS program as a catalyst for their own safety issues.

In addition, BNFL has implemented other ways to keep people focused as the project comes to a close. The most recent is the Safety Break. This provides employees with the chance to discuss safety issues and complete a safety questionnaire. The program highlights issues that may occur during this transition time, such as losing focus from anxiety and uncertainty. By focusing on the future, and the prospect of future work, safety will be maintained.

CHALLENGES

Decommissioning GDP’s entail a number of large challenges. They are all Category 2 nuclear facilities, contain significant quantities of fissile material, encompass significant hazards from industrial safety,and contain numerous unknowns. Because of this, it is required to be creative and foresighted to continually address the challenges on this type of project. A few of these challenges are discussed below.

Facility Size

One of the first challenges that must be addressed in this type of decommissioning environment is the tremendous size of the facilities. K-33 covers 64 acres and the main room on the cell floor of K-33 covers 32 acres. This makes it extremely difficult to isolate areas for different radiological control permits. How does one isolate an area where respirators are needed? Do you post all 32 acres? The answer is no. It was necessary to develop respiratory protection zones that cover certain work activities. Therefore, as the work moves, the respirator zone moves with it.

Facility Condition

We are also faced with antiquated facilities that have not been kept up to code. A loss of power in the facilities would cause total darkness, leaving 400 workers stranded and unable to monitor announcements. Since this was unacceptable, it was necessary to develop different schemes to meet the Life Safety Code. Steps were implemented to provide all employees in the facilities with flashlights and radios in order to maintain the code.

Work Force

Another issue to be conquered was the hiring of over 900 building trades craft, and indoctrinating them into a nuclear environment. One advantage to this workforce is their requisite knowledge for conducting the construction portion of the work: i.e. rigging and lifting, equipment operation, material movement, etc. However, these workers were not experienced in a radiological and nuclear rigor environment making it necessary to develop a rigorous training regime to begin the process. In addition, we have required a large management presence on the floor. That process requires that Foremen be on the floor over 90% of the time, supervisors are on the floor over 75% of the time, and managers are on the floor 30 to 50% of the time. Reinforcement of the appropriate practices and knowledge from training, while addressing the numerous problems and unknowns, will now occur on a real-time basis.

Additionally, the work control systems and control requirements need to be designed so they are usable for the work force. These systems will be different whether a nuclear work force is used or whether a construction work force is used. Choosing the correct system of controls is the most important factor to ensure the requirements are implemented appropriately.

Safety Programs

Another challenge is the safety programs that were implemented at the commencement of the project. These programs were developed over 40 years ago and do not adapt themselves very well to decommissioning. Criticality Safety is one such program. The normal set of controls and analysis used do not apply and, therefore, there is a necessity to develop new types of analysis and new sets of controls. The old paradigms cannot be relied upon. In addition, the controls must be devised so workforces with very little experience—if any—with criticality safety, can easily understand the controls.

Criticality Safety

Criticality safety programs have been developed over the past 50 years to support the operation of nuclear processing facilities. During this time, standards of practice, lessons-learned, training, and general rules have been developed to ensure safe operation of such facilities. This approach has resulted in an excellent safety record for the industry, but applying these same techniques to D&D projects has led to several tribulations.

Typically, safety at processing facilities is based on passive and active engineered controls, mostly relying on favorable geometry for primary criticality control. Processing plants also have well defined operations that can be readily analyzed for credible upset conditions, followed by the establishment of adequate limits and controls. D&D operations typically deal more with distributed uranium mass over a large range of equipment and waste streams. This material is usually in low quantities and concentration, but there is usually no opportunity for passive control. The difficulty in handling such situations is typically how to bound both normal and credible abnormal operating conditions. In most D&D activities, parameters are not specifically controlled, they are verified and then acted upon.

Another issue for NCS programs in D&D activities is when to release fissile systems from fissile controls. Eventually the fissile portion of the waste will require removal and collection. Clearly, all of this material can not be removed. The questions faced here are, "When have we done enough to release the item? What is our method of verification? What are the failures that could occur during such activities and how do we bound them?"

All these questions have considerable costs. NCS standard practice is to perform very conservative analysis. NCS evaluations typically assume all uncontrolled parameters are optimized, such as assuming a sphere when not controlling geometry. This is fine when processing concentrated fissile material in safe geometry or limited batches, but it is practically impossible in a D&D operation. In order to facilitate some form of cost effective operation, NCS engineers need to apply a measured approach on credible normal and abnormal conditions. Also, due to the lack of familiarity with fissile operations, the D&D group would benefit with a limited number of simple NCS requirements.

These are challenges that will continue within the D&D operations. There is a massive learning curve for NCS engineers working a D&D project.

Authorization Basis

Another program that has similar issues is the Authorization Basis (AB). Very little has been done in the overall AB infrastructure to address decommissioning. In general, all of the guides and experiences have been written and analyzed for operational facilities. To develop an AB for a facility in decommissioning, it has been necessary to use sections from different guides and be very inventive in conducting analysis and developing controls. Again, the controls must be written so they are understandable to a workforce with no experience in AB. It will also be necessary to eventually remove safety systems. This requires the development of "Step Out" criteria so those systems can be removed.

Because removal and disposition of equipment is the major part of the project scope, the AB states these activities are not considered to be changes to the facility in the context of the AB, and equipment removal is not subject to configuration management. Evaluating removal of process equipment as facility changes and maintaining configuration control during the process would have significantly increased the workload and the duration of the project.

Programmatic key elements and nuclear safety attributes are identified for each Safety Management Program (SMPs). Nuclear safety attributes are those aspects of the program that are credited as providing accident prevention or mitigation and are, therefore, Technical Safety Requirement level controls. Identifying the nuclear safety attributes in the discussion of each SMP, improved the document flow and facilitated DOE approval.

Although the criticality hazards and radiological hazards in these facilities are real, the activities of decommissioning drive the Industrial Hazards to the top of the priority list. The number one hazard on this project is rigging and lifting. Over the life of the project, over 500,000 lifts and 5,000 critical lifts have been conducted. A lift of 40,000 to 70,000 pounds is not unusual. Therefore, an extreme system of rigging and lifting expertise is required.

Unknowns

Another challenge occurs with the continuos changing of the decommissioning operations. As new unknowns are found, lessons are learned or new enrichments are started, and the evaluations need to be changed or re-done. This puts a strain on the operations groups and the criticality safety departments to maintain the integrity of the safety program. There are many challenging unknowns in GDP's. In many cases, large deposits of UF^6 are found where none were expected. This not only complicates criticality safety issues, but also creates a tremendous industrial hygiene issue – HF gas. This must be addressed early and rapidly.

We have discovered materials in the cold recovery room that the project has classified as "Green Goo." This material is made of Miller's fluorinated oil with extremely high concentrations of UF^6 imbedded in the oil. The material comes out of the piping with a pH of less than one and releases large quantities of HF gas. It also destroys most types of PPE. There are other oils entrained in the piping systems that when heated to room temperature, become explosive. This list of unknowns would be several pages long. However, they do make the project interesting.

DECONTAMINATION AND FINAL SURVEY

Decontamination of the facilities is part of this project. This requires the decontamination of over 5,000,000 square feet of concrete and all of the structural steel. Decontamination of a floor of that extreme size has required the design of new equipment to ensure the project schedule can be met. The best production has been achieved by using a modified Bobcat using a scarifying attachment and a tag along HEPA unit mounted on a trailer. This has allowed production rates of up to 10,000 square feet per day removal of ¼ inch of material from the floor.

SECURITY

Security is one of our most frustrating challenges. Since the September 11 terrorist attack, new policies and procedures have been introduced. These changes consistently create new challenges for the project.

The majority of the work on the project requires a clearance. Initially, the clearance process took approximately six weeks, but now takes over 10 months. Because this has become such a lengthy process, additional escorts have been required for everyone, and there is now a shortage of cleared escorts. This problem can potentially create work stoppage due to the lack of escorts. Several isolation scenarios were developed to minimize the need for escorts and allow additional un-cleared workers access to different work areas.

Some of the rules changes have made it difficult to make waste shipments, coordinate work activities, describe issues to stakeholders, and address incident responses. One particularly frustrating challenge has been in the final survey activities. Over the past 10 years, there have been significant advances in technology for conducting the final surveys. However, most of this technology cannot be used in these facilities under the normal security rules. It has been necessary to work security requirements early in the planning process. In many cases, security plan changes are required and it may take months to obtain the change. Therefore, the security group must be involved early in the process to develop the most efficient methods for conducting the work within the security requirements.

The impacts from security requirements should not be underestimated.

THE LARGEST SUPERCOMPACTOR IN THE COUNTRY

Due to the extremely large amount of material that must be processed for disposal on this project, it was necessary to develop a robust method for volume reduction. This project designed and built the world's largest supercompactor.

The largest supercompactor in the nuclear industry worldwide, is capable of processing 50 tons an hour, powered by 2,200 tons of hydraulic force. A seven 200-horsepower motors run the supercompactor and will remove 17 million pounds of stockpiled material. The Supercompactor will be utilized for those materials that cannot be practically or economically recycled. The process of supercompaction applies intense pressures, in the order of tons/sq in (tens of MPa), to achieve substantial reductions in the volume of LLW (low-level waste) routed for disposal by landfill burial. Unlike conventional supercompactors, which are single-stage presses acting on materials in sacrificial containers, this facility accepts complete components such as coolers, compressor stators, valve bodies, and converter endcaps. The supercompaction facility consists of 129,000 square feet of building area and has a dedicated truck and rail spur for receiving and dispatching material.

The fully open charging box is 26' long, 14' wide and 6' deep, so that materials can be loaded with the minimum amount of preliminary size reduction. It closes down to 5' wide by 4' deep, until the partly compacted material is within the width of the 5' shear knife, and within the open height of the clamp. A feed cylinder then pushes this material incrementally under the compaction platen and then under the shear. Successive feed and compaction cycles produce a rectangular slab having excellent density, between 60% and 80% of full metal. To maximize machine utilization, a hopper is provided onto which the next charge of material can be loaded while the compaction cycle proceeds. The hopper tips its load into the charging box within a few seconds after the feed cylinder has returned and the charging box has been fully opened. Typical throughput rates are in the range of 12 to 30 tons/hour, dependent on the feedstock.

Substantial savings will be achieved both in burial disposal costs, and in the costs of size reduction, packaging, and subsequent transportation. Project safety will be enhanced by reducing potentially hazardous processes. Supercompaction is clean and simple. The machine is industry-proven, and does not introduce any new hazards. Operations are carried out remotely, with consequent safety and ALARA benefits.

Material handling and compactor operations are carried out remotely, thus minimizing hazards and dose uptake to operators. Large components are compacted down to burial size criteria without interstage handling and labor intensive thermal cutting, thus minimizing hazards associated with these processes. The facility is provided with containment, ventilation, HEPA filtration and monitoring.

The supercompactor will reduce waste volume by up to 75%, and provide safe disposal of the following:

- 86,939 tons of low-level radioactive waste
- 13,117 tons of solid and liquid mixed waste
- Approximately 122 tons of solid and liquid RCRA waste
- 1,505 tons of solid and liquid polychlorinated biphenyl waste
- 268 tons of universal waste stream
- 71 tons of asbestos
- 20,655 tons of recyclable material
- 350 tons of triple waste
- 40,000 total tons of non-hazardous solid waste.

CLOSING

The three building decontamination and decommissioning project at East Tennessee Technology Park is not only the largest nuclear decommissioning project in the United States, but it's the only project of its kind. Because of its massive size and uniqueness, BNFL has had to be creative and inventive when solving numerous obstacles. Since there have been no other GDP decommissioning projects done within the DOE environment, there have been no previous programs or protocols from which to glean. Programs and procedures been developed particularly for this project, and equipment has been designed from scratch. In the midst of all these hurdles, BNFL maintains one of the best safety records in the industry. In April of 2003, BNFL surpassed one million work hours without a lost-time accident. During this time frame, more than 83 million pounds of material were handled. This unique project is scheduled for completion during the summer of 2004.