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Investigation and Deactivation of B Plant HEPA Filters

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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INVESTIGATION AND DEACTIVATION OF B PLANT HEPA FILTERS

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ABSTRACT

This paper describes the integrated approach used to manage environmental, safety, and health considerations related to the B Plant canyon exhaust air filters at the U.S. Department of Energy (DOE) Hanford Site. The narrative illustrates the development and implementation of integrated safety management as applied to a facility and its systems undergoing deactivation.

During their lifetime, the high efficiency particulate air (HEPA) filters prevented the release of significant quantities of radioactive materials into the air. As the material accumulated on the filters, it created an unusual situation. Over long periods of time, the radiation dose from the filter loading, combined with aging and chemical exposure, could actually degrade those filters which were intended to protect against any release to the environment.

The filter configuration, high internal dose rates and material disposal requirements combined to make any conceivable remediation methods a challenge. B Plant has balanced considerations of risk, cost and available technologies in a way that protects the public and plant workers, while minimizing environmental impacts.

I. BACKGROUND

B Plant was the second facility (after T-Plant) built at the Hanford Site during World War II to separate Plutonium 239 from irradiated reactor fuel using a bismuth phosphate process. The main building, 221-B, is divided into 40 cells, each surrounded by heavy concrete walls. Cell #3 (near the east end of the building) is actually a railroad tunnel for material transfer; cells 1, 2 and 4 are used for waste and other storage. The other 36 cells contain chemical processing equipment. The cells are closed on top by heavy concrete "cover blocks", above which, a long "canyon", runs the entire length of the building (over 800 ft long).

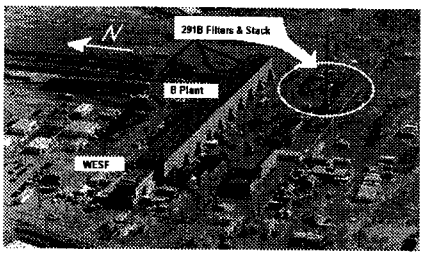

Figure 1 - B Plant/WESF

In the early 1950s, the plant was shut down and replaced by other facilities employing more efficient plutonium separation processes; first, the Reduction-Oxidation (REDOX) plant, followed by the PUREX (plutonium-uranium reduction extraction) plant. An effort to retrofit B Plant for the REDOX process was abandoned after PUREX was successfully started up in 1956.

During the period 1962-67, B Plant was decontaminated and modified to separate cesium 137 (Cs-137) and strontium 90 (Sr-90) from the wastes associated with REDOX and PUREX. These fission products are highly radioactive and, considering their decay chains, are associated with high energy beta and gamma radiation. The cesium/strontium separation campaign begun in 1968 was intended to remove a significant source of heat from the waste, thus reducing the hazards associated with tank storage.

In 1970-71, the Waste Encapsulation and Storage Facility (WESF) was constructed adjacent to the west end of B-Plant. As the separation process continued at B Plant, both cesium and strontium salts were transferred to WESF, where they were sealed inside double stainless steel capsules. Today, six hundred and one Sr-90 (strontium fluoride)

capsules and 1,315 Cs-137 (cesium chloride) capsules are stored at the bottom of water pools inside WESF. With a total radioactivity of over 140 million curies (including radioactive decay progeny), this represents over 30% of the radioactivity on the Hanford site.

After the separation mission ended in 1971, B Plant was considered as a candidate to perform a pilot process for pre-treatment of Hanford Site tank wastes. However, questions continued to arise regarding the aging plant's compliance with current engineering, safety and environmental criteria. In 1990, DOE made the decision to eliminate B Plant from consideration for the pre-treatment mission.

B Plant continued to operate, providing utilities and waste handling in support of WESF capsule storage. At the same time, plant systems, such as confinement ventilation and fire protection, were operated and maintained as necessary to safeguard remaining facility hazards. In 1995, DOE issued an order to deactivate B Plant; eliminate significant environmental and safety hazards; and prepare the facility for an as yet undetermined period of unmanned surveillance and maintenance (S&M) pending ultimate disposition.

II. MITIGATING HAZARDS

A. Hazard Identification

The cesium and strontium separation campaign of the 1960s and '70s presented a variety of hazards, particularly within the processing areas (canyon and process cells). Chemical processes employed equipment such as evaporators, pumps, agitators and centrifuges, and involved highly radioactive material driven by thermal and mechanical energy. Organic solvents and other chemicals used in the processes added potential chemical hazards, including fire or explosion. Even process and waste water represented a potential leakage path for radioactive contamination.

Even after processing ended in 1971, the legacy of radioactive contamination and chemicals posed significant safety challenges. The building and exhaust ventilation system were heavily contaminated with cesium, strontium and radioactive decay products. Chemicals left over from processing days posed fire, chemical exposure and waste disposal challenges. Operations and maintenance work within the facility was encumbered by the presence of asbestos, lead and confined spaces. Finally, aging equipment and utility systems needed maintenance and upgrading in order to ensure safe operation.

The key hazard controls in post-processing B Plant have been the confinement ventilation system and fire protection in the process cells. Fire protection requirements were dramatically reduced in February, 1997, when thousands of gallons of contaminated organic solvent were removed from tanks inside the process cells. The canyon exhaust ventilation system continues to provide confinement of loose particulate contamination remaining in the canyon and process cells.

B. Confinement Ventilation System

The canyon ventilation system maintains a slight vacuum within the canyon and cells to provide confinement of any radioactive particles released from processing. Supply fans provide fresh filtered outside air through openings high on the canyon wall. Maintaining a downward flow direction, the air passes through small openings into the cells. Exhaust air from the cells is manifolded in an exhaust duct, cleaned by HEPA filters, and exhausted out a nominal 200' high stack.

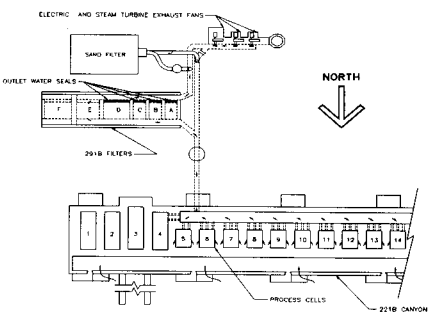

Figure 2 - B Plant Canyon Exhaust System Layout

C. Canyon Exhaust Filters

When B Plant first began its plutonium separation process, the air from processing areas was exhausted directly through the stack with no provision for filtration. In 1948, a sand filter was installed to capture airborne radioactive particles as they leaked from the process. The Plant was re-fitted with high efficiency particulate air (HEPA) filters for the cesium/strontium separation process, taking advantage of modern (1960s) technologies to provide a much higher exhaust airflow capacity.

The HEPA filters were designed to provide containment and shielding for the highly radioactive Cs-137 and Sr-90 they would collect. Cesium 137 decays by beta emission, producing Barium 137, a strong gamma emitter. Strontium 90 poses a severe biological hazard because of its affinity to collect in bone tissue. Consequently, the filters were installed in underground vaults, which provided shielding and substantial protection from environmental release.

As each filter neared the end of its service life, a replacement filter was built alongside. Exhaust air was diverted to the new filter; airflow through the retired filter was then isolated using a water-filled seal arrangement. Because water could be added or removed, the water seals allowed "on-off" control of the airflow through each filter (Figure 3). The first filter was identified as "A" Filter; the plant is currently operating the fifth, or "E" Filter.

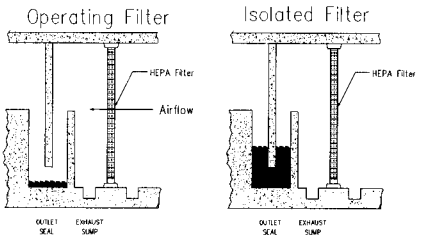

Figure 3 - Filter Water Seal Arrangement

III. EVOLUTION OF SAFETY MANAGEMENT

Safety management at B Plant has evolved from a narrow process focus to an integration of safety into all aspects of plant management. The organizational approach to managing the canyon exhaust filters illustrates this transition.

A. Historical Perspective

Like many other DOE facilities, B Plant was built and operated in the relative secrecy of World War II and the ensuing Cold War. Production volume was often a very high priority, and plants operated without public scrutiny or outside agency oversight. Nevertheless, the Plant was designed and operated with safety in mind.

B Plant was built in Hanford's 200 East Area; far from the nearest settlement. This location was chosen to minimize the impact to public in the event of explosion or other catastrophic accident. The canyon building has thick concrete walls intended to provide both mechanical containment and radiation shielding. Fire protection and confinement ventilation systems are among the other safety features designed into the plant, based upon sound engineering judgement, without the benefit of more modern analytical risk evaluation techniques.

In 1985, B Plant issued a nuclear Safety Analysis Report (SAR). Although the last processing mission had ended some 14 years earlier, this report was intended to implement newly issued DOE requirements for safety analysis. The SAR focused on major process hazards associated with the proposed waste preprocessing mission, and imposed "Operational Safety Requirements" intended to control those hazards. Although the preprocessing mission did not materialize, the SAR provided a basis for controlling the most significant plant hazards for over 10 years.

As the Cold War ended, the veil of secrecy began to lift from DOE facilities. Public scrutiny focused increasing attention toward environmental impacts associated with past practices at the various DOE sites. Outside regulatory agencies began to influence safety and environmental standards. Beginning in the late 1980s, the facility staff found itself learning about and implementing a confusing array of agency requirements, such as: Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and Washington State Administrative Code (WAC).

With guidance and assistance from the Defense Nuclear Facilities Safety Board (DNFSB), DOE has begun to develop ways to make sense of this daunting maze of requirements. B Plant has joined with DOE in its efforts to implement an integrated approach to safety management as described in DNFSB's Recommendation 95-2.

At the working level, this approach focuses on an understanding of the work to be accomplished, and the associated hazards (all types of hazards). Appropriate controls are then incorporated as needed from the various environmental, safety and health programs. This "seamless" approach ensures that planning focuses on the hazards involved in the work, regardless of which specific safety program applies.

B. Managing the Exhaust Filters

Historically, the B Plant Process Engineering group maintained estimates of radioactive inventory within the facility. By the end of the cesium/strontium separation mission, the canyon exhaust air filters represented a significant element within that inventory. While the inventory in the filters was substantial, the exhaust filters were considered by the SAR to be a reliable barrier against environmental release.

1. Unreviewed Safety Question. The filters suddenly drew increased attention when, in 1992, a group of engineers within the plant recognized the potential for degradation of the older HEPA filter chambers (A, B and C Filters) due to high accumulated radiation exposure.

Inventory estimates for each of these filters was on the order of 1E+04 curies of Cs-137 and 1E+03 curies of Sr-90, based upon measurements taken during the 1970s and '80s. Because the material was trapped on the filter media itself, the total exposure to various filter components was estimated to approach 1E+05 - 1E+06 rad. Studies from various sources were available to suggest that various materials, especially organics such as adhesives and sealants used in HEPA filter construction, could lose their strength under such high accumulated exposures.

Although the older filters (A, B and C Filters) had been retired from operation, they were identified in facility procedures for potential backup service. In addition, the water seals used to prevent air flow through the filters required periodic refilling to maintain positive isolation. The potential existed for the filters to come online inadvertently through neglect or improper operation (draining the water).

D Filter had been in continuous operation since the latest radiation measurements were taken; its inventory estimate was assigned a high degree of uncertainty, with an upper bound estimate of over 5E+05 curies of Cs-137. Nevertheless, D Filter was not considered suspect at the time. The filter system had several stages of filters, which would prevent any large radiation buildup on the final filter stages. D Filter was never operated during chemical processing, hence never exposed to significant concentrations of acids or other corrosive vapors. Finally, with the filter in service, its performance was monitored on a daily basis; annual aerosol challenge tests checked for even minute leakage.

Because the potential for filter degradation had not been considered in the existing safety analyses, the plant declared an Unreviewed Safety Question (USQ) and took immediate steps to ensure the filters would not be placed into operation. Facility procedures were modified to prevent operation of A, B or C Filters; valves which would drain the water seals were locked shut to prevent inadvertent operation. B Plant submitted to DOE a Justification for Continued Operation (JCO) for its ventilation system, based upon its importance in maintaining confinement of the canyon contamination.

In order to bound the risks associated with the filters, B Plant commissioned a detailed safety analysis. The study concluded that the risk of inadvertent operation of the retired filters was low. Even making the most conservative assumptions, the analysis demonstrated an insignificant risk to offsite public, and only a small impact to onsite personnel; the USQ was closed.

2. Safety Program Transformation. Although the filters did not pose an outstanding risk, questions began to arise regarding the best way to manage the radioactive material they contained. Managing the filters has required a deliberate balance between issues of public safety, environmental protection, and protection of site workers. In addition, various individuals and agencies have participated in the evaluation and planning, resulting in a balanced approach.

From 1993 through 1997, B Plant conducted an ongoing program to investigate the condition of the retired filters and manage the associated hazards. Although the safety analysis had ruled out a significant nuclear accident, B Plant recognized that the potential to reduce the risks.

During the same time period, B Plant developed a new safety authorization basis to replace its 1985 SAR. This unrelated effort was driven by the (then) new DOE Order 5480.23, *Nuclear Safety Analysis Reports*. This new "Basis for Interim Operation" (BIO), implements the essential analyses and conclusions required by the new order.

The BIO, which has since been approved and implemented, features:

- more accurate representation of current plant condition;
- better integration of existing ESH programs, such as industrial safety, fire protection, radiological control and waste management into the safety authorization basis.

Because of the brief remaining facility life, there are no current plans to develop a final SAR.

IV. INTEGRATED SAFETY MANAGEMENT

A. Overall Program Development

A number of coincident factors influenced the development of integrated safety management at B Plant. Each of the following took place within a 1 year period:

- B Plant ordered to deactivate (Oct 95)
- DNFSB issued Recommendation 95-2 (Oct 95)
- B Plant reengineered work processes and formed multi disciplinary work teams (Jun 96)
- Transition to the Project Hanford Management Contract (Oct 96)
- B Plant BIO approved (Oct 96)

The environment of change created an opportunity to redefine fundamentally the work processes in the facility. In addition, several of these events contributed new perspective to old problems.

Work processes within the plant have been reengineered. Personnel have been organized into multi-disciplinary work teams responsible for all aspects of performing assigned tasks (planning through execution). In conjunction with this re-engineered approach to work, the Plant has incorporated universal risk management into its work planning and execution processes. This enhanced approach to work planning builds upon lessons learned at PUREX and other DOE facilities.

Figure 4 - Integrating safety and work management

The B Plant BIO recognizes the contribution of the various environmental, safety and health programs toward overall safety. Consequently, the Plant took an integrated approach when implementing this new safety basis. For example, a new safety management plan was developed using OSHA and DOE guidelines for Health and Safety Plans.

B. Application to the Filters

B Plant manages the filters by developing an understanding of the hazards and selecting courses of action which minimize the overall risks. In pursuit of these objectives, the plant has performed a variety of tasks, including inspection and analysis of the filter inventory, development of an interim isolation project, and investigation of further risk reduction alternatives. All of these have been integral to planning and execution of plant programs.

1. Filter investigation. Since inventory and dose estimates were based upon 10-year old data, more radiation dose readings were taken inside A Filter (oldest), and in D Filter (greatest uncertainty). The D Filter investigation was, in itself, a successful project which relied on sophisticated computer modeling and analysis coupled with enhanced work planning to provide reliable information with minimal risk exposure.

A computer model of D Filter was developed, and radiation readings taken at various locations inside the filter housing. The field readings provided input for a Monte Carlo simulation, which provided new estimates of the cesium and strontium inventory. Because of the high degree of certainty this exercise provided, the inventory estimates for Cs-137 and Sr-90 have been reduced by factors of approximately 10 and 5, respectively.

One field work team was assigned responsibility to perform the radiation measurements, with specialized support for radiation measurement and modeling, and photography. The work team planned the work steps, identifying hazards in the process. With the aid of a recently deployed, automated hazard assessment tool, the team walked through the work process.

As various hazards were identified (anything from pinch points to high radiation doses), the team found ways to eliminate or control the hazards. These control measures were incorporated into the work procedure. Before performing the actual investigation, the team ran several mock-ups until it had developed a complete procedure. As a result of this approach, this difficult job was performed with minimal delays, no injuries and radiation doses well below those predicted in the pre-job planning.

2. Filter Isolation. Various consultants and outside agencies have contributed to discussions regarding filter disposition. In particular, the Plant has conducted several engineering and value engineering studies; DOE and DNFSB staff have participated in discussions and provided suggestions. Finally, B Plant employed independent technical experts to evaluate measures which could be taken to reduce the potential risks related to the filters.

As a result, B Plant has begun final design on a congressional line item project to isolate the filters. The new isolation barriers will further reduce the risk of releasing radioactive materials from the filters, and will eliminate the need to monitor and refill the existing water seals because of evaporation. The project will provide an entirely new exhaust system with reduced airflow capacity and changeable filters; this system provide confinement ventilation within the facility after deactivation.

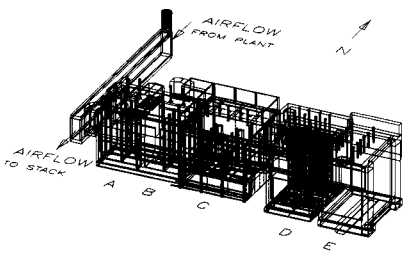

Figure 5 - 3-D Model of B Plant Filters

The project design itself integrates safety management from the conceptual phase. The original concept was to install isolation barriers immediately adjacent to the filters. However, the design team, which included plant representatives and construction experts, recognized the risks to construction workers. They moved the isolation barriers further from the filters; they developed innovative construction techniques which would reduce the risk exposure to the workers.

The design team continued to find ways to reduce exposures through design reviews and value engineering sessions. The final design looks substantially different from the original; isolation barriers will involve a remotely placed mass of concrete upstream of the filters, and steel plates where the filter outlet duct emerges above ground.

The filter isolation project resulted directly from the hazard-based approach associated with integrated safety managment. The condition of the filters does not violate requirements of any of the established safety programs. Nevertheless, the DOE/contractor team recognized and acted upon an opportunity to reduce risks associated with the potential for accidental release from the filters.

V. DEACTIVATION AND THE FUTURE

The B&W Hanford Company (BWHC) is managing an aggressive deactivation project at B Plant. In 1998, responsibility for the facility will be turned over from DOE's Office of Nuclear Material and Facility Stabilization to the Office of Environmental Restoration. Concurrently, custody will be transferred from BWHC to an environmental restoration (ER) contractor, currently Bechtel Hanford Incorporated (BHI). The ER Contractor will manage the facility in an unmanned surveillance and maintenance (S&M) condition until the final plant disposition, such as decontamination and decommissioning (D&D).

Deactivation is an interim measure to reduce risks and operating costs associated with the facility. Because there is no established level of "acceptable" risk, B Plant continues to investigate potential risk reduction measures. Proposals for incremental risk reduction are identified and analyzed. This facilitates DOE's overall task of managing hazards by allowing an evaluation of costs and benefits compared to other concerns, both at Hanford and throughout the DOE complex.

Recognizing the upcoming transfer of responsibility, BWHC is working with the ER contractor (BHI) and DOE to provide a "seamless" transition in custody. Taking advantage of this partnering arrangement, as well as insight from various outside consultants, including the DNFSB staff, the team provides a head start to plan any follow-on risk reduction measures which might be appropriate. Alternatives for further risk reduction are already being considered. Study alternatives ranging from in situ stabilization to complete remediation using remote methods have been conducted.

The B Plant canyon exhaust filters present a significant risk management challenge. Using principles of integrated safety management, DOE and its contractors are teaming together to meet that challenge.

ACKNOWLEDGMENTS

This report was prepared in conjunction with B Plant facility stabilization, performed for the U. S. Department of Energy by the B&W Hanford Company.

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