Department of Energy
Brookhaven Site Office
P.O. Box 5000
Upton, New York 11973

MAY 1 7 2005

Mr. Leslie Hill
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, New York 11973

Dear Mr. Hill:

SUBJECT: BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

The final revision of the BGRR Completion Report for Below Grade Ducts Outlet Air Coolers, Filters, and Primary Liner Removal is considered approved by the regulators. Minor editorial comments on the draft version have been incorporated and the regulators have expressed no interest in further reviews. Please enter the Completion Report into the Administrative Record.

The action taken herein is considered to be within the scope of work of the existing contract (DE-AC02-98CH10886), as modified, and does not authorize the Contractor to incur any additional costs (either direct or indirect) or delay delivery to the Government. If the Contractor considers that carrying out this action is not within the contract scope of work, will increase contract costs, or delay any delivery, the Contractor must promptly notify the Contracting Officer orally and then confirm and explain the notification in writing within five (5) working days. Following submission of the written notice of impacts, the Contractor must await further direction from the Contracting Officer.

If you have any questions, please contact Mark Parsons at extension 7978.

Sincerely,

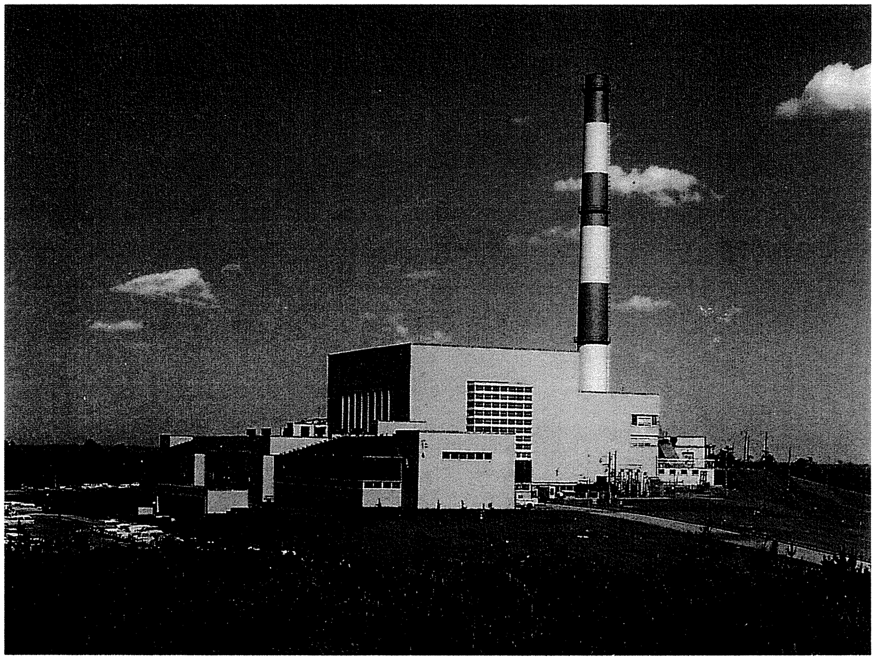
Rodrigo V. Rimando, Jr.
Brookhaven Project Director
Office of Environmental Management

cc: J. Clodius, BSA
J. D'Ascoli, BSA
T. Jernigan, BSA
F. Petschauer, BSA
J. Carter, BHSO
M. Parsons, BHSO

BNL/BGRR/11.4/1565-1652

BGRR-067

Brookhaven Graphite Research Reactor Decommissioning Project



BELOW-GROUND DUCT OUTLET AIR COOLERS, FILTERS, AND PRIMARY LINER REMOVAL COMPLETION REPORT

April 29, 2005

BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
Under Contract No. DE-AC02-98CH01886 with the
UNITED STATES DEPARTMENT OF ENERGY

EXECUTIVE SUMMARY

This report documents the completion of removal actions authorized by the U.S. Department of Energy (DOE) at Brookhaven National Laboratory (BNL) on the Brookhaven Graphite Research Reactor (BGRR). Specifically, this completion report describes work activities performed, the dispositioning of generated waste, project costs, and as-left conditions as part of the Time-Critical Removal Actions of the BGRR below-ground duct outlet air coolers and filters and the primary liner.

Work described herein was performed in accordance with the *Comprehensive Environmental Recovery, Liability, and Compensation Act* of 1980 (CERCLA) through the Interagency Agreement between the DOE, the U. S. Environmental Protection Agency, and the New York State Department of Environmental Conservation. The outlet air coolers and filters were removed through an approved CERCLA Time-Critical Removal Action Memorandum dated December 27, 2001. The below-ground duct primary liner was removed through an approved CERCLA Time-Critical Removal Action Memorandum dated September 29, 2003 and as amended through the Below-Ground Duct Descoping Document placed in the Administrative Record on June 11, 2004.

In summary, all removal activities delineated in the referenced Action Memoranda have been completed. The BGRR outlet air coolers, filters, and primary liner were removed from the below-ground duct containing approximately 50 Curies of radioactivity. All associated waste from these actions was packaged, transported and disposed at authorized radioactive, hazardous, and clean waste disposal facilities.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASUREMENT

BAO	Brookhaven Area Office
BGRR	Brookhaven Graphite Research Reactor
BHG	Brookhaven Group
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act* of 1980
DOE	Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
HEPA	High Efficiency Particulate Air
IAG	Interagency Agreement
mCi	milliCuries
mrem/hr	millirem per hour
NESHAP	National Emission Standards of Hazard Air Pollutants
NYSDEC	New York State Department of Environmental Conservation

1.0 INTRODUCTION

1.1 Purpose

This completion report documents the work conducted to complete the time-critical removal action of the Brookhaven Graphite Research Reactor (BGRR) below-ground duct outlet air coolers, filters, and the primary liner. This report becomes part of the Administrative Record and satisfies the Interagency Agreement (IAG) between the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and the New York State Department of Environmental Conservation (NYSDEC) [1,2].

2.0 SITE DESCRIPTION AND HISTORY

2.1 Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) is located in Upton, Long Island, New York, near the geographic center of Suffolk County, approximately 60 miles east of New York City (Figure 1). The Laboratory encompasses 5,265 acres (8.23 square miles). With a few exceptions, the principal facilities are located near the site's geographic center. The facilities cover an area of approximately 900 acres, of which about 500 acres were originally developed by the U.S. Army. The remaining 400 acres are occupied, for the most part, by various large research facilities.

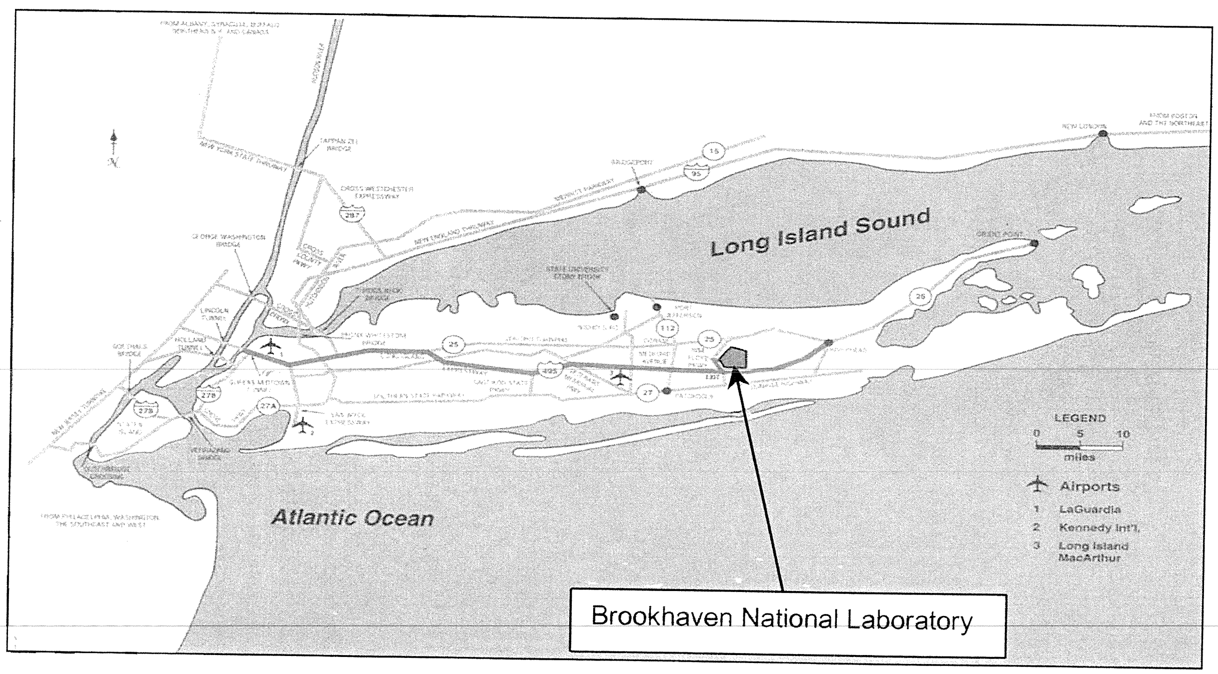


Figure 1. Location of Brookhaven National Laboratory

Brookhaven National Laboratory carries out basic and applied research in the fields of high-energy nuclear- and solid-state physics, fundamental material and structure properties and the interactions of matter, nuclear medicine, biomedical, and environmental sciences, and selected energy technologies.

2.2 Brookhaven Graphite Research Reactor

The BGRR was the world's first reactor built for the sole purpose of providing neutrons for research. During its years of operation, it was one of the principal research reactors in the United States. Its construction was completed in August 1950, and the reactor reached initial criticality in the same month. The BGRR operated until June 10, 1968, when its operation was terminated and deactivation of the facility started. In June 1972, defueling and shipment of the fuel to the DOE's Savannah River site was completed. The U.S. Atomic Energy Commission described the BGRR complex as being in a safe shutdown condition and it became a surplus facility within the DOE complex. From 1977 until 1997, portions of the facility were used as the BNL Science Museum.

The BGRR was an air-cooled, graphite-moderated reactor located in Building 701. Reinforced concrete exhaust ducting, which included a primary and secondary liner, ran in two separate below-ground ducts from the reactor's exhaust plenums to the filters and coolers. Downstream of the coolers, the duct rose above the ground and combined into one large duct, which was located on, and supported by, the Fan House (Bldg. 704). The primary air-cooling system included cooling fans that were located in Building 704.

During reactor operations, the fans drew filtered outside cooling air across the reactor pile through this ductwork. The air then moved through the ductwork, where it was filtered and cooled, through exhaust fans, and discharged to the atmosphere through a 320-foot-tall exhaust stack. Figure 2 is a picture of the BGRR site looking north.

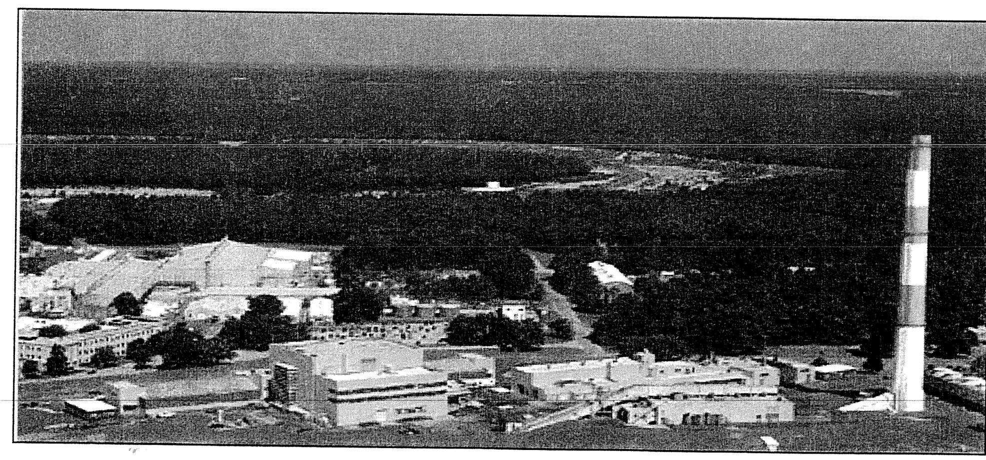


Figure 2. BGRR Site Looking North

2.3 BGRR Below-Ground Ducts

The BGRR's below-ground ducts broadly include the north and south below-ground ducts. These ducts run from the pile outlet air plenums to the point where the duct rises above grade just east of the Instrument House (708). The ducts are rectangular in cross section and are made of concrete. From the pile outlet air plenums to the exhaust air coolers, the interior surface of the concrete was protected by a secondary air-cooling system. This system consisted of a 3-inch air passage lining the duct, in which a separate stream of air flowed between a steel plate lining the concrete and an insulating partition made of crimped aluminum sheets between two steel plates. Beyond the coolers the ducts are unlined concrete. The ducts under the Reactor Building, 701 (grade elevation is 110 feet), are 14.5 feet high and 10.5 feet inches wide with a centerline at 88 feet 7 inches. The north and south duct extend south from the Reactor Building for approximately 65 feet, during which distance they rise to a duct center line 98 feet 9 inches. The ducts then make a 70-degree turn to the east, and expand into ducts 14 .5 feet by 20 feet wide. The outlet filters were located at this point. Immediately beyond the filters, the ducts decrease in height to 10 feet but remain 20 feet wide. The duct centerline at this point is 101 feet. The ducts continue another 35 feet at which point the coolers were located. Specific actions addressed in this completion report includes the removal of the following equipment:

1. below-ground ductwork primary liner
2. outlet air filters, including filter elements and framework
3. outlet air coolers

2.4 Stakeholder Participation

Stakeholders – including the public, regulators, legislators, and Laboratory employees – were informed of and involved in the below-ground duct removal actions through several scheduled events and media releases. From the beginning, DOE has communicated with stakeholders about its plans for decommissioning of the BGRR and has solicited community input on the path forward for decommissioning.

3.0 REMOVAL ACTIVITY

3.1 Objectives

The removal activities had the following objectives:

- Remove the below-ground duct primary liner from its termination point at the coolers to the pile plenum area.
- Remove the below-ground duct outlet air filters.

- Remove the below-ground duct outlet air coolers.
- Transport and dispose of the waste at an approved facility.

3.2 Activities

3.2.1 Time-Critical Removal Actions

Activities performed as time-critical removal actions included the removal of the below-ground duct primary liner, outlet air filters, and coolers. All waste generated from these removal actions was placed into containers for disposal at a licensed radioactive waste disposal facility. Figure 3 is an isometric view of the BGRR below-ground duct.

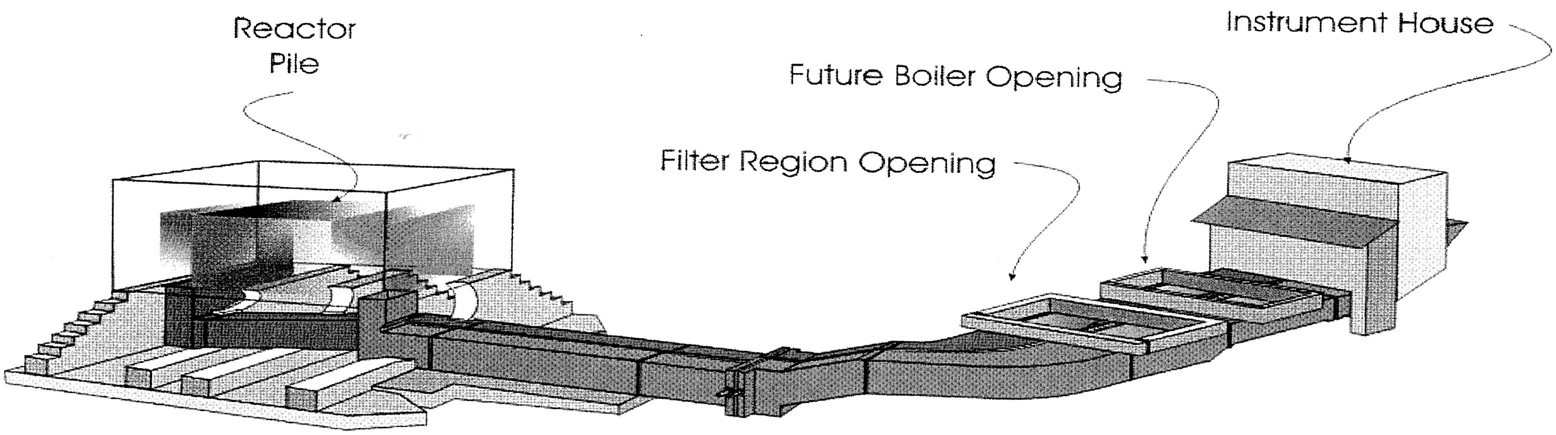


Figure 3. - Isometric View of Below Ground Duct Layout

3.2.1.1 Outlet Air Coolers

The outlet coolers were removed through an approved CERCLA Time-Critical Removal Action Memorandum dated December 27, 2001 [3]. Physical work to remove the outlet coolers began on November 20, 2001 and work was completed on January 14, 2002.

The coolers were located in the underground part of the north and south ducts, downstream of the outlet air filters. There were a total of twelve cooler banks with each duct containing six cooler banks. Each cooler bank was approximately 3 feet wide, 2 feet deep, and about 10 feet high. Each cooler bank was connected by two 4-inch-diameter carbon steel lines (supply and return) and one 1-inch-diameter carbon steel drain line. The finned tube coolers were primarily constructed of copper tube, 0.5 inches in diameter and 0.049 inches wall thickness with finned material that was tinned with lead. The overall finned material outside diameter is 1.5 inches. Each duct section at the cooler banks location was about 18.75 feet wide and about 10.5 feet high. The cooler are shown in Figure 4 below as part of the general arrangement of below ground duct.

The cooler banks in each duct were accessible via (a) the ten concrete cover plugs located on top of the cooler housing, and via the air-cooling duct openings (above ground) downstream of the coolers, and (b) from the east end of the below-ground duct opening, which was connected to the above-ground duct sections which were removed in early 2001.

Removal of the coolers was accomplished by workers entering the below-ground ducts through the east end of the system, where the ducts exited to above grade. An enclosure was constructed to envelop the open duct ends and provide a means to control the entry and egress of personnel, equipment and waste from the below-ground ducts. Workers entered the ducts and, using both manual and electric-powered hand tools, cut and removed the coolers from the ducts.

The cooler waste material was place in metal boxes, transferred to BNL's Waste Management Facility, and volume reduced in a super-compactor. After volume reduction the cooler waste was re-packaged in metal boxes and transported to a commercial low-level burial facility located in Clive, Utah for disposal. The material was disposed of as mixed waste due to lead contained in soldered cooler joints.

3.2.1.2 Outlet Air Filters

The outlet filters were removed through an approved CERCLA Time-Critical Removal Action Memorandum dated December 27, 2001 [3]. Physical work to remove the outlet filters began on October 31, 2003 and work was completed on January 12, 2004.

The exhaust air filters were located in the below-ground duct upstream of the cooler housing. Each filter cell consisted of a box-like frame with a removal cover and was normally two feet square by four inches deep. This frame contained about 30 square feet of filter media arranged in four-inch deep narrow "Vs" formed by wire mesh screens, which confine the filter media on both sides. The filter cells were permanently welded together to form panels of ten filter cells each, two cells high by 10 feet wide by 4 inches deep. Each filter panel weighed about 450 pounds. A total of 32 panels composing 320 filters were placed in each duct. The filters are shown in Figure 4 below as part of the general arrangement of below ground duct.
At the filter housing location, the ducts are about 18.75 feet wide and 16 feet high. The filters were designed to be accessible through the removable concrete slabs, which form the roof of the filter well. However, after removal of the coolers, the filters were accessible from the east end via the openings in the ends of the below-ground ducts where they rise above ground.

The filters were removed in two stages. During the first stage of the work, the filter media from the 640 filter elements was removed using the specially designed tools described in the following paragraphs. After all of the filter media was removed and the waste containers were transported from the BGRR site, the remote manipulator was fitted with demolition tools to remove the steel filter frame in a manner similar to that used in the primary liner removal described in 3.2.1.3 herein.

With the exception of the remote-controlled Brokk Manipulator with the filter removal tool, all equipment necessary for the filter removal was located inside of a specially constructed steel building: the Duct Service Building. This building is 30 feet wide, 76 feet long and 30 feet high at the center. The building is erected on a 10-inch thick concrete slab, centered east-to-west over the filter access openings. The filter access plugs were not removed until all of the filter media was removed and transported from the BGRR facility. Access into the below-ground duct for loading and unloading large tools and equipment was through the "Future Boiler Openings"; these openings were fitted with special removable covers.

During filter removal operations, the Duct Service Building was maintained at a negative pressure with respect to the outside environment with a separate HEPA-filtered ventilation system. In addition to maintaining building negative pressure, this ventilation system also ventilated the below-ground ducts during the filter removal process to minimize airborne contamination and remove the exhaust gases generated by the diesel-powered manipulator. This prevented the possible release of contamination to the environment. The ventilation system had two separate units: one operated during normal operations and the other served as a backup. Each of the ventilation units was powered from a separate 460V electrical service. The HEPA-filtered ventilation system included an auto-shutdown capability and exhausted to the environment via a single exhaust, which was continuously monitored during all operations. This exhaust was the only pathway to the environment from the below-ground ducts.

The filter elements were removed with a specially designed filter removal tool that was attached to a diesel powered, remote-controlled Brokk 330 Manipulator. The filter removal tool removed the filter elements from the filter frame. The removed filter elements were reduced in size through a commercial hammermill from which a vacuum hose pulled reduced filter media to a cyclone separator that was situated atop, and connected directly to, a shielded burial liner. This process was used to remove and dispose of all 640 below-ground duct filter elements. In all, four burial liners were filled with filter media, sealed closed, and transported in shielded casks from BNL to the DOE low-level burial facility located in Hanford, Washington for disposal.

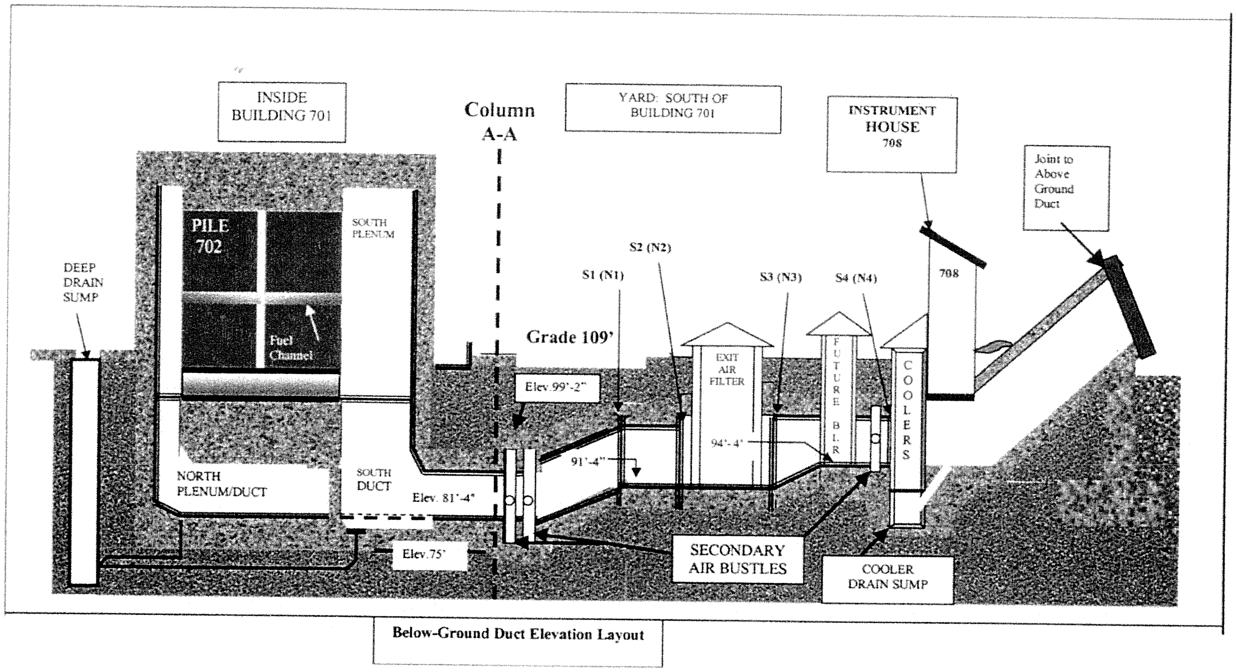


Figure 4. General Arrangement of Below Ground Duct Components & Structures

3.2.1.3 Primary Liner

The below-ground duct primary liner was removed through an approved CERCLA Time-Critical Removal Action Memorandum dated September 29, 2003 and as amended through the Below-Ground Duct Descoping Document placed in the Administrative Record on June 11, 2004 [4,5]. Physical work to remove the primary liner began on February 19, 2004 and work was completed on January 14, 2005.

Portions of the primary liner (see Figure 5) were removed using the same Brokk 330 Manipulator that was used for filter removal. The liner removal process entailed removal of the inner binding plate, then the multi-sheet thermal aluminum barrier, and finally the "wetted" portions of the outer binding plate. The manipulator was fitted with different tools such as impact hammer/chisel, metal-cutting shear, or clamshell bucket depending on the task being performed. The majority of the removal work was accomplished using the impact hammer/chisel. This tool was used for cutting the nuts and bolts, which held the inner binding plates in place, peeling sheets of aluminum from between primary liner surfaces, and cutting the outer binding plate into small, manageable sections.

Debris and loose contamination that settled on the remaining (unwetted) outer binding plate or secondary liner (which was exposed after removal of the outer binding plate) was removed from by vacuuming or other mechanical means. Subsequently, a light-colored industrial rust-inhibitive was applied to fix in place any minute, incidental contamination and to enhance lighting and visibility for future activities and inspections. Upon completion of all removal work, UL-approved commercial-grade string lighting was installed in the ductwork.

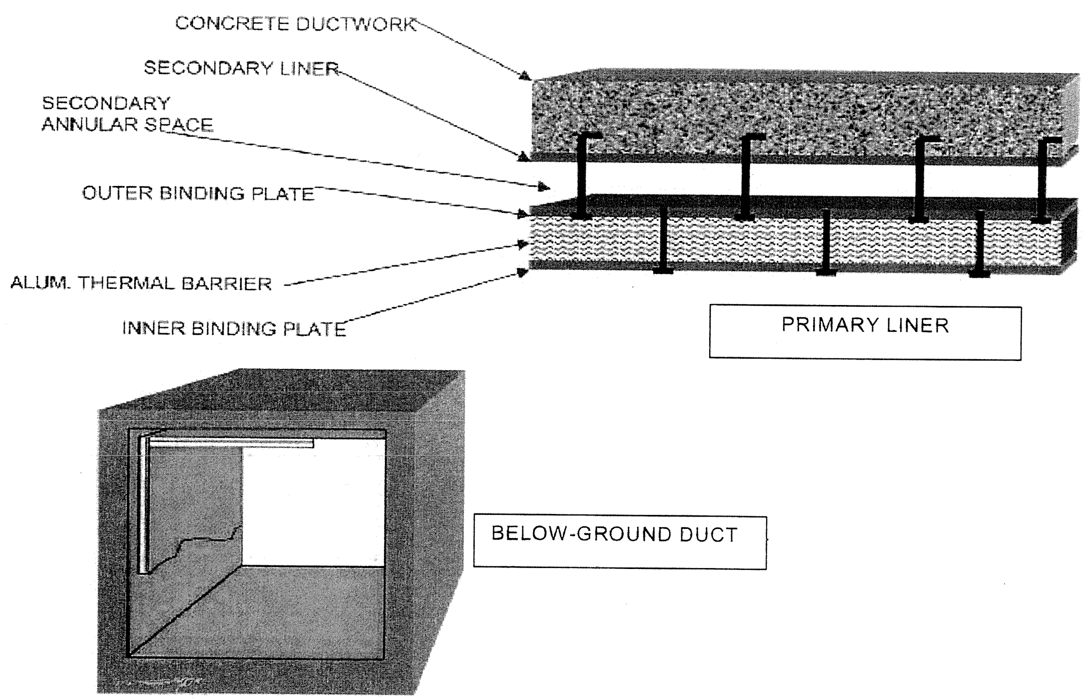


Figure 5. Primary Liner Configuration

3.3 As-left Condition

Overall, approximately 50 Curies were removed from the below-ground ducts through removal of the coolers, filters, and primary liner. The estimated remaining radioactivity in the below-ground duct is less than one Curie (0.867 Curies). This remaining radioactivity is located in inaccessible areas and is bound in the metal and concrete of the remaining below-ground duct structure. As stated in the Brookhaven Graphite Research Reactor Below Ground Duct Liner Descoping Report [5], approximately 8,400 sq. ft. of unwetted outer binding plate remains in place. A fixative was applied to this remaining surface to ensure that residual radioactivity is fixed in place. Additionally, an engineering evaluation was performed of the as-left outer binding plate to ensure that there were no industrial safety issues. This evaluation concluded that the remaining outer binding plates may be left in place (Appendix 6).

An "as-left" radiation survey was performed of the below-ground duct. In general, radiation dose rates throughout the below-ground duct average 1.4 mrem/hr. A summary of this survey is documented in Appendix 5 that includes radiation dose rates before and after removal activities. Overall, the radiation levels in the below-ground ducts were reduced by a factor of 50 and by a factor of 250 where the outlet exhaust filters were located. Dispersible radioactivity is essentially negligible. Additionally, sample "coupons" were cut out of the remaining outer binding plates in the north and south ducts. These coupons were surveyed to confirm that only incidental radioactivity remained in the annular space between the remaining outer binding plate and the secondary liner of the below-ground duct. In summary, it was confirmed that only a trace quantity (0.318 mCi) resides in this area. A summary of the radioactivity found on these samples is documented in Appendix 5.

3.4 Cost of Work

The total cost to remove the below-ground duct coolers, filters and primary liner was $7,126,000. A breakdown of these costs is presented below.

Component	Cost
Cooler Removal and Waste Disposal	$718,000
Filter Removal and Waste Disposal	$1,828,000
Primary Liner Removal and Waste Disposal	$4,580,000

4.0 WASTE MANAGEMENT

4.1 Outlet Air Coolers

Removal of the coolers resulted in 672 cubic feet of waste, which was sent to BNL Waste Management Division for volume reduction by compaction. After compaction, a net volume of 288 cubic feet of waste was shipped to Envirocare's facility in Clive, Utah on March 21, 2002. On March 25, 2002 the waste was received at Envirocare for disposal.

4.2 Outlet Air Filters

Approximately 640 cubic feet of filter media was packed in four 170-cubic-foot waste containers and shipped to DOE's facility at Hanford, Washington for disposal. The first shipment took place on April 19, 2004. The last shipment left BNL on June 1, 2004 and the certification of disposal for all filter waste was received on June 11, 2004.

4.3 Primary liner

Approximately 23,700 cubic feet (670,000 pounds) of steel and aluminum, from the primary liner was removed and packaged in twenty-five Department of Transportation-certified "strong-tight" containers and shipped via truck to Envirocare's facility in Clive, Utah. The first shipment of waste took place on April 30, 2004. The last shipment of waste was received at Envirocare's facility on February 17, 2005.

5.0 LESSONS LEARNED

The following were lessons learned during the removal of the below-ground duct coolers, filters and primary liner:

- When performing a first of a kind project, adequate planning becomes a critical key to a successful project. Planning for the removal of the below-ground duct coolers, filters and primary liner began a year in advance of actual physical work. This period certainly allowed for deliberate budgeting, scheduling, contract development, training, procedural development, hiring and other activities in preparing for physical work execution.

- Training Brokk Manipulator operators on mock-ups for the removal of the below-ground duct filter elements and primary liner was invaluable. If the resources were not expended on training and in building mock-ups of the below-ground duct filter banks and the primary liner, operators of the Brokk Manipulator would have been on a very steep learning curve while working on highly radioactive components. In fact this project would have failed without mock-ups and the training of operators.

- The testing of facsimile filters on size reducing the below-ground duct filter elements in the industrial hammer mill provided a tremendous benefit in identifying that the hammer mill required a stronger motor for the application at hand. Specifically, testing the hammer mill on clean filter elements, that included the application of a fixative that was to be applied to the radioactive filter elements in the below-ground duct, demonstrated that a motor of 25 horsepower was required as a replacement to the original 15 horsepower motor. Had this test not been performed, the hammer mill would undoubtedly have clogged during operations with highly radioactive filter elements.

- The use of fixative on high radioactive contaminated components, such as the filter elements and the primary liner, substantially reduced airborne levels during component removal and waste processing. Calculations performed on an event scenario involving the drop of filter elements estimated that radioactive airborne concentrations would exceed 1,000,000 derived air concentration hours. Although no event conditions were encountered during removal activities, the maximum airborne concentrations measured were well less than 100 derived air concentration hours. This experience was greatly attributed to the use of fixative such as the application of paint to filter elements and inner binding plates.

- Continued vigilance on pursuing project completion that included disposition of the waste streams was critical in completing the project. Specifically, project personnel continuously tracked availability of waste disposal facilities to ensure that waste would ultimately be buried at designated waste facilities. If this effort were not made, the below-ground duct filter media would possibly have missed a window for disposal at the DOE Hanford facility. Soon after the last of four filter burial liners was disposed at Hanford, the State of Washington passed an amendment denying access for out of state waste.

- Communications on a daily basis that included safety tailgate, pre-job planning, and plan-of-the-day meetings were integral to the successful completion of the project. These communications involved all key personnel involved in the project from working labor force to senior managers.

- Lessons learned from removing the primary liner in the north duct were applied in the south duct. These lessons learned resulted in removal operations running more smoothly and remotely in the south duct. From a personnel radiation exposure standpoint, lessons learned in the north duct helped reduce expected radiation exposures to individuals in the south duct from a goal of 7 person-rem to 5.8 person-rem.

6.0 REFERENCES

1. CERCLA-FFA, 1992, Federal Facility Agreement under CERCLA Section 120, Administrative Docket Number II-CERCLA-FFA-00201, *IAG Agreement*, United States Environmental Protection Agency, Region II, United States Department of Energy, and the New York State Department of Environmental Conservation. In the matter of the U.S. Department of Energy's Brookhaven National Laboratory, 1992.

2. Federal Facility Agreement under CERCLA Section 120, Administrative Docket Number II-CERCLA-FFA-00201, United States Environmental Protection Agency, Region II, United States Department of Energy, and the New York State Department of Environmental Conservation. In the matter of the U.S. Department of Energy's Brookhaven National Laboratory, 1992.

3. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor Coolers and Filters Removal Action," Report BGRR-046, Rev. 0, December 27, 2001.

4. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor Primary Liner Removal Action," Report BGRR-057, Rev. 0, September 29, 2003.

5. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor Below Ground Duct Liner Descoping," April 1, 2004.

APPENDIX 1

DO/BAO AUTHORIZATION TO PROCEED WITH THE REMOVAL ACTIONS

1. Letter dated November 19, 2001 from R. Desmarais (DOE/Brookhaven Area Office [BAO]) to L. Hill (Brookhaven Science Associates [BSA]), Subject: Approval of the Unreviewed Safety Issue Determination/Safety Evaluation (USID) for the Brookhaven Graphite Research Reactor (BGRR) for Below Ground Duct Coolers Removal (BGRR-SE-01-03)

2. Letter dated August 14, 2003 from M. Holland (DOE/Brookhaven Area Office [BAO]) to T. Sheridan (Brookhaven Science Associates [BSA]), Subject: Authorization to Start Removal of Brookhaven Graphite Research Reactor - Decommissioning Project (BGRR DP) Below Ground Duct Filters

3. Letter dated October 2, 2003 from Y. Collazo (DOE/Brookhaven Area Office[BAO] to L. Hill (Brookhaven Science Associates [BSA], Subject: Brookhaven Graphite Research Reactor (BGRR)

Department of Energy
Brookhaven Area Office
P.O. Box 5000
Upton, New York 11973

NOV 19 2001

RECEIVED
NOV 19 2001
BGRR PROJECT

Mr. Leslie Hill
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, New York 11973

Dear Mr. Hill:

SUBJECT: APPROVAL OF UNREVIEWED SAFETY ISSUE DETERMINATION/ SAFETY EVALUATION (USID) FOR THE BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR) FOR BELOW GRADE DUCT COOLERS REMOVAL (BGRR-SE-01-03)

The Brookhaven Area Office (BAO) has reviewed your request to begin work on Below Ground Duct Coolers Removal. BAO has determined that the actions referenced in USID/SE BGRR-SE-01-03 (Rev.0) comply with the requirements of DOE-EM-STD-5502-94, Hazard Baseline Documentation and DOE-EM-STD-5503-94, EM Health and Safety Plan Guidelines. Therefore, Below Ground Duct Cooler Removal work is authorized.

If you have any questions regarding this matter, please contact Mark Parsons of my staff at extension 7978.

Sincerely,

Robert L. Desmarais, Director
Project Management Division

cc: M. Parsons, BAO
G. Penny, BAO
H. Taylor, BAO
C. Adey, BNL

38287/435.20.1.3

A component of the DOE Chicago Operations Office

(1)

Department of Energy
Brookhaven Area Office
P. O. Box 5000
Upton, New York 11973

AUG 1 4 2003

Mr. Thomas R. Sheridan
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, NY 11973

Dear Mr. Sheridan:

SUBJECT: AUTHORIZATION TO START REMOVAL OF BROOKHAVEN GRAPHITE RESEARCH REACTOR – DECOMMISSIONING PROJECT (BGRR DP) BELOW GROUND DUCT FILTERS

Reference: Letter, from L. M. Hill, BNL to R. Desmarais, BAO, Subject: Brookhaven Graphite Research Reactor (BGRR) Unreviewed Safety Issue Determination/Safety Evaluation (USID/SE); Removal of BGRR-DP Below Ground Duct (BGD) Filters, dated August 8, 2003

The Department of Energy (DOE) Brookhaven Area Office (BAO) has reviewed and approved the referenced request for authorization to proceed with initiation of the BGRR BGD Filter Removal. A team of DOE subject matter experts reviewed the USID/SE and prepared the attached DOE Approval Basis. BNL is required to comply with the requirements of the USID/SE and the DOE Approval Basis during the removal of the filters.

If you have any questions, please contact Mark Parsons at extensions 2488 or 7978 or contact Harold Taylor at extension 2924.

Sincerely,

Michael D. Holland
Area Manager

Enclosure
As stated

cc: P. Jones, BAO
H. Taylor, BAO
M. Parsons, BAO
C. Adey, BNL

DOE Approval Basis for the:
BGRR USID/SE for the Removal of BGRR-DP Below Ground Duct Filters

The Operations Management Division has performed a review of the Brookhaven Graphite Research Reactor (BGRR) Unreviewed Safety Issue Determination/Safety Evaluation (USID/SE) for the removal of the Below Ground Duct (BGD) filters. The safety evaluation was determined to be adequate, allowing the filter work to proceed. The following criteria serve as a basis for that approval:

Base Information: The USID/SE and attachments provide sufficient background information to support the review of the more technical aspects of the USID. The BGRR-DP project will commit to providing adequate detail in their Technical Work Documents (TWDs) for the implementation of USID/SE commitments that will ensure category 3 thresholds are not reached or exceeded during the filter removal.

Hazard/Accident Analyses: The hazard and accident analysis (abnormal operations assessment) is presented in Appendix B to the USID/SE. Seven potential events are analyzed. With the administrative controls and mitigating factors considered, "LOW" risks are associated with the BGD Filters Removal Scope.

Four conditions for operation are highlighted in the introductory section of the Abnormal Operations Assessment. These are: (1) pre-treatment of fiber mesh, media and fines with 'FIBERTACK', a non-toxic fixative barrier; (2) serial removal operation, beginning with the North Duct and not to proceed to the South Duct until the North Filter removals are completed and waste containers relocated away from the BGRR-DP Complex footprint; (3) no more than half the gross inventory of either duct in any waste container; (4) relocation of each waste container away from BGRR-DP complex as soon as it is filled and prior to additional filter removal activities within the same duct.

Hazard mitigation, as described in the risk assessment tables of the Abnormal Operations Assesment, also includes:

- Limitation on duct filter inventory available within reach of the tool arm of the Brokk machine
- Use of Strong Tight Containers
- Installation and use of both Explosive Gas and Carbon Monoxide monitors
- Use of approved Work Control Permit, Radiological Work Permit, task-specific Environment, Health and Safety Plan and TWDs.
- Specialized training, as described in USID and attachments

Safety Management Program: BNL's institutional safety management programs are adequate and shall be adhered to.

Records:

1. BGRR-SE-02-03, "Removal of BGRR-DP Below Ground Duct Filters," Rev. 0, 8/6/2003 (with appendices and attachments).
2. E-mail Moss to Dikeakos, Jones, Parsons, Taylor, "Planning of work associated with BGD Filters Removal," 8/12/2003.

Department of Energy
Brookhaven Area Office
P. O. Box 5000
Upton, New York 11973

OCT - 2 2003

Mr. Les Hill
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, New York 11973

Dear Mr. Hill:

SUBJECT: BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

Reference: Letter, M. Holland, DOE to J. Lister, NYSDEC, and M. Logan, EPA, Dated: June 4, 2003, Subject: "Brookhaven National Laboratory (BNL) Interagency Agreement (IAG) Brookhaven Graphite Research Reactor"

The final Action Memorandum for the BGRR Below Grade Duct Primary Liner Removal Action was submitted to the regulators via the referenced letter. This document is considered approved and there are no outstanding issues.

Please enter the Action Memorandum into the Administrative Record by the end of this month and prepare the appropriate public notices. Please coordinate drafts of any public notices with this office.

If you have any questions, please call Mark Parsons at extension 7978.

Sincerely,

for Yvette T. Collazo, Acting
Environmental Team Leader

cc: J. Carter, BAO
M. Parsons, BAO
C. Adey, BNL
J. Clodius, BNL
F. Petschauer, BNL

APPENDIX 2

BGRR BELOW-GROUND DUCT DESCOPING DOCUMENT

Department of Energy
Washington, DC 20585

MAY 2 7 2004

Mr. Leslie Hill
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, New York 11973

Dear Mr. Hill:

SUBJECT: BROOKHAVEN GRAPHITE RESEARCH REACTOR (BGRR)

Reference: Below Ground Duct Liner Descoping, dated April 1, 2004

The referenced paper discusses the impacts of a plan to not remove portions of the Below Ground Ducts liner that remained dry when the ducts contained water. This document has been reviewed by the Department of Energy and the regulators with no resultant comments.

Please enter the document into the Administrative Record so that it may supplement the BGRR Below Grade Duct Primary Liner Removal Action Memorandum that was entered into the Administrative Record in October 2003.

If you have any questions, please call Mark Parsons at extension 7978.

Sincerely,

Rodrigo V. Rimando, Jr.
Brookhaven Project Director
Office of Environmental Management

cc: J. Carter, BHSO
M. Parsons, BHSO
J. Clodius, BSA
F. Petschauer, BSA

file copy

Environmental Management Directorate

BROOKHAVEN
NATIONAL LABORATORY

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lhill@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

APR 0 9 2004

Mr. Robert Desmarais, Director
Project Management Division
U.S. Department of Energy
Brookhaven Site Office
Upton, New York 11973-5000

Dear Mr. Desmarais:

SUBJECT: SUBMITTAL OF BGRR BELOW-GROUND DUCT (BGD) LINER DESCOPING

Enclosed is the BGRR BGD Descoping Paper. This paper justifies the reduction in scope of the removal of BGD primary liner resulting in a cost savings of $1M. The paper has been reviewed by Mark Parsons of your staff and it is necessary to forward the report to NYSDEC and EPA for their review. Subsequent to regulatory review, it will be placed into the Administrative Record.

If you have any questions, please contact Fred Petschauer, of my staff, at ext. 7498.

Sincerely,

L. M. Hill, Director
Environmental Management

FP/add

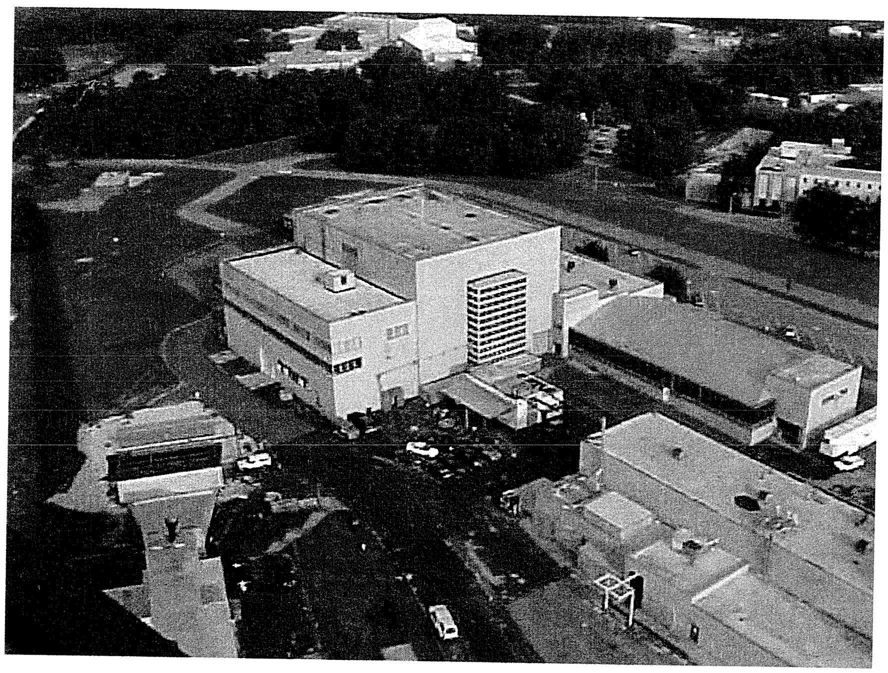
Enclosure:
As stated

cc: J. Clodius, w/o encl.
T. Jernigan, w/o encl.
S. Kumar, w/o encl.
M. Parsons, BHSO, w/encl.
F. Petschauer, w/o encl.
WP 123

Below Ground Duct Liner Descoping

Brookhaven Graphite Research Reactor (BGRR)

Decommissioning Project



April 1, 2004

Purpose

The purpose of this report is to delineate a reduction in the scope of below-ground duct (BGD) primary liner removal. The proposed reduction entails leaving behind those sections of the primary liner's outer binding plate that were not saturated in contaminated water and contain a very small amount of residual radioactivity.

Justification

The current scope of removal activity for the BGD primary liner delineated in the Action Memorandum (BGRR 057, September 29, 2003), approved by the Regulators and in the Administrative Record, includes removal of the entire primary liner including the outer binding plate. The total radioactivity associated with this removal is 4,170 milliCuries at a cost of $4.3M. As a result of leaving behind a portion of the outer binding plate a reduction in cost of $978,000 (23%) will be realized while only a small quantity, maximum 17.4 milliCuries (<0.5%), would remain above the existing Action Memorandum scope of remediation.

In addition to the rationale presented above, it should be noted that the BGRR Project baseline assumes that the BGD secondary liner and concrete will remain in place. This structure has 850 milliCuries. Such a quantity of radioactivity outweighs, by a large margin, the radioactivity (max. 17 milliCuries) that is proposed to remain in the outer binding plate, which is part of the same BGD structure.

Description of Primary Liner

The primary liner is located inside the below-ground ducts. There are two ducts, north and south, each containing a primary liner. To protect the concrete of the below-ground duct from the high exhaust air temperatures during reactor operations, the duct section upstream of the air coolers had a three-part thermal liner (primary liner) and a secondary liner. The secondary liner forms the inner wall of the concrete duct and is bonded to the concrete pour with steel J-bolts. Between the primary and secondary liners is a three-inch space that forms the secondary air duct; the inner duct is the primary air duct. Attachment 1 provides a sectional view of this arrangement. During reactor operations, the primary reactor cooling exhaust air (radioactive) flowed through the primary air duct, and secondary cooling air (non-radioactive) flowed through the three-inch secondary air duct to cool the concrete duct structure.

The primary liner is constructed of four inches of crimped aluminum sheets sandwiched between two-carbon steel binding plates, the outer (rear) and the inner (front) binding plates. The outer binding plate is attached to the steel secondary liner with steel nuts and studs. The inner binding plate is likewise attached to the outer binding plate in a similar manner, with steel spacers to maintain the four-inch space for the crimped aluminum sheets. The outer binding plate is a continuous weldment of smaller plates, which is interrupted only at several expansion joints. The inner binding plate is an assembly of smaller steel plates (nominally five feet by six feet) bolted together with steel strapping to seal the seams.

BGD History

The BGRR operated from 1950 until 1968. During this period there were twenty-eight reported ruptured fuel cartridges. While normal reactor operations would have contaminated the cooling system, these fuel failures contributed to the contamination of the cooling system and its components, including the BGD primary liner.

In 1997, approximately 57,500 gals of water was found in the BGD. The contaminated water was removed in 1998. In addition, the BGD exhaust filters (56 Curies) were removed in 2003.

In 2001 and 2002 the BGD was characterized. The majority of contamination found within the primary liner is located in those areas that were saturated with radioactive water. Although primary air contaminated the entire primary liner, i.e., the four-inch sandwich of crimped aluminum sheets and carbon steel binding plates, only a small percentage of the total radioactivity in the primary liner is located in the unwetted portions of the primary liner. Furthermore, contamination located on the inside of the outer binding plate that was unwetted, represents an even smaller percentage of the overall inventory. Additionally, radiological surveys of the outside surface of the unwetted outer binding plate have indicated no contamination above background readings.

Description of Reduced Scope

A modified approach to remediating the primary liner would entail removing all inner binding plates, all aluminum and 3,205 sq. ft. of wetted outer binding plate. Approximately 8,379 sq. ft. of unwetted outer binding plate would remain in place. Attachment 2 highlights those sections of the primary liner wetted outer binding plate that would be removed. Additionally, Attachment 2 provides a detailed breakdown on the specific quantities of the outer binding plate that will be removed.

Approximately 4,170 milliCuries associated with the primary liner will be removed. Based on empirical samples from the outer binding plate, a calculated inventory of between 5.3 and 17.4 millicuries (Attachments 3 and 4) would exist in the remaining outer binding plate.

Through past characterization efforts and video inspections, the wetted portion of the outer binding plate was estimated at three feet on the vertical sides. However, during actual removal, all wetted portions of the outer binding plate will be bounded and removed based on radiological data and physical inspection.

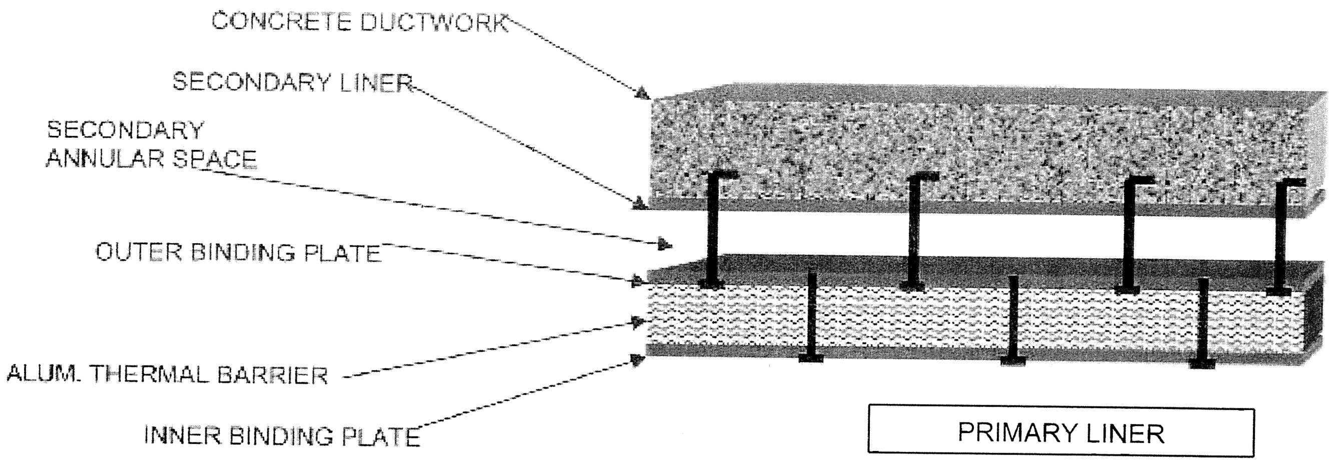
Upon completion, a fixative will be applied to the remaining outer binding plate.

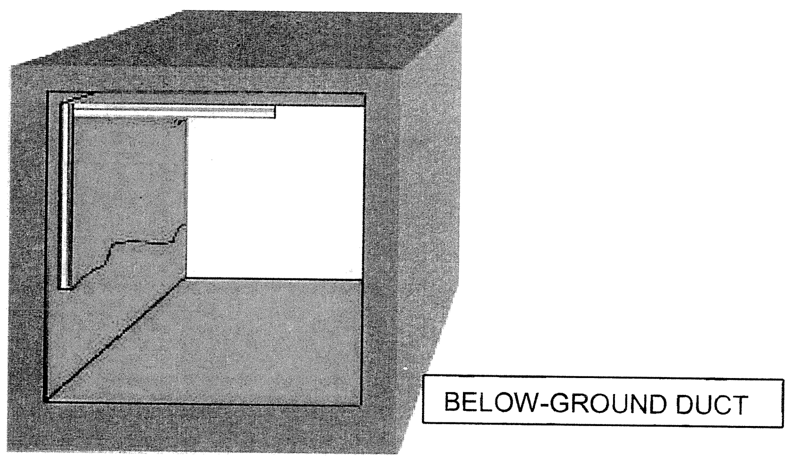
Conclusion

The proposed reduction in scope will leave greater than half the outer binding plate in place. Although this condition will restrict access to the annulus space between the remaining outer binding plate and secondary liner, no major impact to the cost of performing a final status survey is anticipated. As part of the final survey, it is planned to cut out a one foot section of the remaining outer binding plate at ten foot intervals to assess the annulus space.

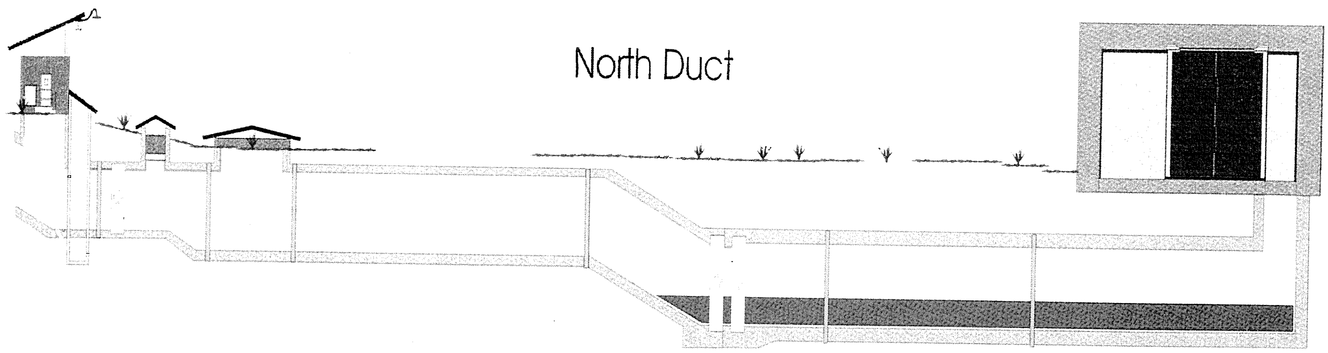
In consideration of any industrial safety issues that may be created as a result of the partial segmentation of the outer binding plate, an engineering evaluation of the "as left condition" of the BGD will be performed and documented. In addition, a physical inspection of the BGD will be performed at the end of the project. Any unsafe conditions identified in the engineering evaluation or the physical inspection will be addressed and corrected to ensure that BGD is left in a safe condition.

Attachment 1



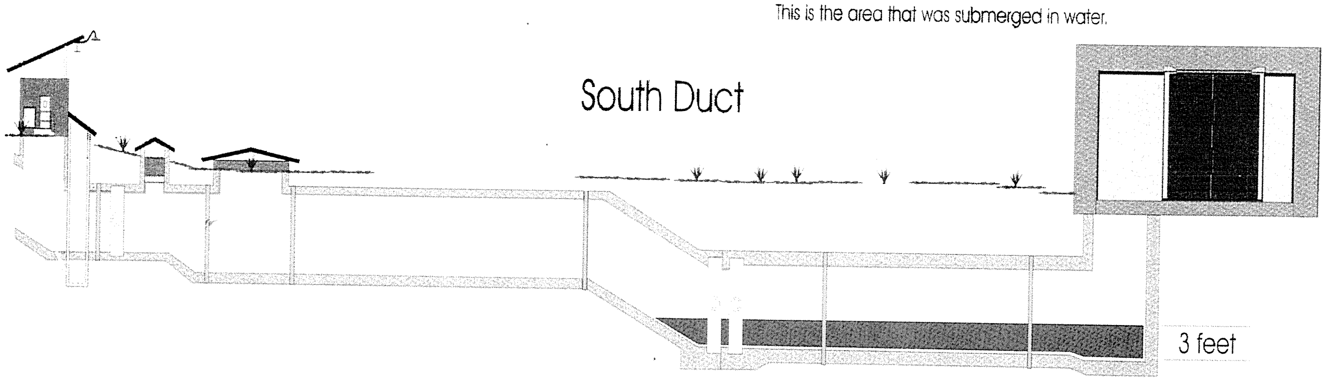


BELOW GROUND DUCT OUTER BINDING PLATE REMOVAL



129 linear feet

Outer Binding Plate will be removed from floor level to approximately 3 feet vertical from floor. This is the area that was submerged in water.



98 linear feet

BGD Liner - Outer Binding Plate Sample Analysis - 12" X 12" Coupon

(1) Based upon an analysis of a 12" by 12" square of outer steel liner removed for survey, from the North Duct, the following radiological contamination levels were detected:

Average activity found on tape after removal @		89000 dpm/100 cm^2
(Based on results of Survey 02/12/04)	=	890 dpm/cm^2
Average activity on front of steel plate via direct frisk @		19250 dpm/100 cm^2
(Based on results of Survey 02/12/04)	=	192.5 dpm/cm^2
Combined liner surface activity concentration	=	1082.5 dpm/cm^2

(2) Estimated area of liner proposed to be left behind :

= 11508 sq. ft.
= 10691281.84 cm^2

Estimated surface activity of liner proposed to be left behind :

= 1.16E+10 dpm
= 5.21E-03 Ci
= 5.21E+00 mCi

(3) The activity calculated above in Step 2 was based on observations made with a Beta-Gamma frisker and so reflect only the activity given off by the strong Beta and Gamma emitters; namely the isotopes Co-60, Sr-90 and Cs-137 as listed below:

Steel Liner Isotopic Abundances

NUCLIDE	ACT. CONC. [pCi/gr]	ABUND. [%]
Co-60	4.13E+00	0.11%
Sr-90	7.50E+02	19.20%
Cs-137	3.09E+03	79.11%
U-234	1.07E+01	0.27%
U-235	1.23E+00	0.03%
U-238	3.62E+01	0.93%
Pu-239	6.05E+00	0.15%
Pu-240	6.05E+00	0.15%
Am-241	1.38E+00	0.04%
Sum=	3.91E+03	100.00%

NUCLIDE	RESIDUAL ACTIVITY [mCi]
Co-60	5.60E-03
Sr-90	1.02E+00
Cs-137	4.19E+00
U-234	1.45E-02
U-235	1.67E-03
U-238	4.91E-02
Pu-239	8.20E-03
Pu-240	8.20E-03
Am-241	1.87E-03
Sum=	5.30E+00

The abundances of those three isotopes sum up to 98.42%
Therefore total activity (including all isotopes) = 5.30E+00 mCi

Assumptions:

(1) Activity found on 12" X 12" square steel plate is characteristic of average activity throughout 11,508 sq. ft. of outer liner to be left.
(2) Ratio of specific isotopes is as determined previously for waste profile (see BGRR-SE-03-01).
(3) No difference between North and South Duct.
(4) The effective area surveyed via direct frisk with a Ludlum 3 & 44/9 Probe is 20 cm^2.

Conclusion: Based on 12" X 12" coupon , the calculated radioactive inventory to be left in the BGD unwetted outer binding plate is 5.30 mCi.

BGD Liner - Outer Binding Plate Sample Analysis - SBE50*

1) Based upon an analysis of a sample of inner steel liner taken at SBE50 (a disc of 7 cm diameter, thickness = 3/8" and weight of 252 gm), the following radiological contamination level was detected:

   Contamination on top surface of disc = 1,177 pCi/gm of Cs-137.

2) Contamination on top surface of inner binding plate is conservatively assumed comparable to contamination on bottom surface of outer binding plate.

3) Activity concentration based on attributed thickness of contamination depth equals:

   1/16" or 1.5 mm.

4) Weight of thickness of metal/contamination used for activity concentration equals:

   1/6 of weight of total disc [1/16" = 1/6 of 3/8"] = 252/6 gms = 42 gms.

5) Total activity of top surface of inner binding plate sample equals:

   42 gms X 1,177 pCi/gm = 4.94E+04 pCi = 1.10E+05 dpm

6) Area of top surface of inner binding plate sample equals:

   Pi X r^2 = 3.14 X 3.5 X 3.5 = 38.48 cm^2

7) Cs-137 activity of disc surface equals:

   1.10E+05 dpm / 38.48 cm^2 = 2.86E+03 dpm/cm^2 or 2.86E+05 dpm/100 cm^2

8) Estimated area of unwetted outer liner proposed to be left behind equals:

   10691282.84 cm^2

9) Estimated Cs-137 surface activity of liner to be left behind equals:

   3.06E+10 dpm = 1.38E+01 mCi

10) Cs-137 activity represents 79.11 % of total activity of all isotopes to be found. Scaling other isotopes known to be present off the Cs-137 detected yields:

Steel Liner Isotopic Abundances

NUCLIDE	ACT.CONC. [pCi/gr]	ABUND. [%]
Co-60	4.13E+00	0.11%
Sr-90	7.50E+02	19.20%
Cs-137	3.09E+03	79.11%
U-234	1.07E+01	0.27%
U-235	1.23E+00	0.03%
U-238	3.62E+01	0.93%
Pu-239	6.05E+00	0.15%
Pu-240	6.05E+00	0.15%
Am-241	1.38E+00	0.04%
Sum=	3.91E+03	100.00%

NUCLIDE	RESIDUAL ACTIVITY [mCi]
Co-60	1.92E-02
Sr-90	3.35E+00
Cs-137	1.38E+01
U-234	4.71E-02
U-235	5.23E-03
U-238	1.62E-01
Pu-239	2.62E-02
Pu-240	2.62E-02
Am-241	6.98E-03
Sum=	1.74E+01

11) Total activity to be left behind equals: **17.40 mCi**

Conclusion: Based on sample SBE50, the calculated radioactive inventory to be left in the BGD unwetted outer binding plate is 17.4 mCi.

*Based on input from BGRR-049, "Characterization Report for the Below-Ground Ducts and Associated Soils" Rev. E dated January 30, 2002

APPENDIX 3

NESHAP EVALUATIONS

Environmental & Waste Services Division

81 Cornell Ave., Bldg. 120
P. O. Box 5000
Upton, NY 11973-5000
Phone 631 344-8107
Fax 631 344-6079
bhooda@bnl.gov

BROOKHAVEN
NATIONAL LABORATORY

Managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: *January 8, 2004*

To: *Steve Moss*

From: *Benny Hooda*

Subject: *NESHAPs Evaluation for BGRR- Removal of BGD Primary Liner*

A National Emission Standards for Hazardous Air Pollutants (NESHAPs) evaluation was completed for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project to remove the Below Ground Duct (BGD) Primary Liners. Attachments I, the Facility/Process Radionuclide NESHAP Evaluation reports the technical information about the source term. Attachment II, the synopsis report from CAP88-PC, version 2.0, modeling program provides a conservative estimate of the effective dose equivalent of 1.50E-05 mrem/year to the Maximally Exposed Individual (MEI) at the southeast location.

The potential effective dose equivalent was well below the 10 mrem/year annual limit as specified in the 40 CFR 61, subpart H, and below the 0.1mrem/ yr. limit, which would require a NESHAPs permit, and continuous monitoring of the source. Although continuous monitoring was not required but a isokinetic sampling probe has been installed in the HEPA filtered ventilation system of the Duct Service Building (Bldg.708-T) to ensure that people in the surrounding environment are not exposed to levels of radioactive materials exceeding the established regulatory limits. Also, the emissions monitoring would help to assess the possible consequence of non- routine incidents, and in selection of appropriate corrective action.

Please contact me at 8107, if you have any questions regarding this NESHAPs evaluation.

BH:car

Attachments

Distribution:		
	C. Adey	T. Jernigan
	P. Bergh	R. Lee
	G. Goode	R. Lykins
	L. Hill	T. Petschauer

File: EC72ER.04

REGISTERED TO ISO 14001: 1996

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ATTACHMENT I

FACILITY/ PROCESS RADIONUCLIDE NESHAPs EVALUATION

Prepared by
Benny Hooda
January 08, 2004

1. SOURCE NAME AND LOCATION

Name(s):	Removal of the Below Ground Duct (BGD) Primary Liner
Location:	Brookhaven Graphite Research Reactor (BGRR) Brookhaven National Laboratory (BNL) Upton, NY 11973
Latitude:	N 40° 52'
Longitude:	W 72° 53'

The Brookhaven Graphite Research Reactor (BGRR) has been identified as the Area Of Concern (AOC) 9B (Removal Area #3) in the interagency Agreement between Environmental Protection Agency, Department of Energy, and New York State Department of Environmental Conservation under the Federal Facility Agreement of the *Comprehensive Environmental Response Compensation, and Liability Act* (CERCLA) of 1980. The Primary Liner from the North and South Ducts removal is planned after the removal of the filters in the BGD of the BGRR. The Primary Liner is constructed of four inches of crimped aluminum sheets sandwiched between two-carbon steel binding plates. The Duct Service Building (DSB), a temporary structure, 30' wide, 76' long, and 30' high at the center has been erected on 10-inch thick concrete slab with all the applicable building codes to service the removal of contaminated filters and the liners. The DSB will be maintained at negative pressure with a separate HEPA filtered ventilation system.

Two Brokk Model 330D Remote Systems, which are diesel powered, radio-remote controlled manipulator will be used to remove nearly 500 linear feet of the Primary Liners from the North and South Ducts. These two machines are identical with the exception that one of them has a shorter arm for better maneuverability. All controls to the Brook machines are located at a video control console, which is located in the instrument room. Each Brokk machine has two forward cameras and one rear facing video camera. The Brokk machines can be fitted with various tools; such as steel plate Sawing System, Shearing tools, Clamshell Bucket, Impact Hammer, and Abrasive Cutting tool to remotely perform any of the required functions. These tools shall be used to shear the three-part Primary Liner into small enough pieces to be carried through the vacuum hose to a cyclone separator in the DSB. The liner removal process will entail removal of the inner binding plate, then the aluminum sheets, and finally the outer binding plate. The removal of the BGD Primary Liner shall be performed with ERD Operations Procedures Manual (ERD BGRR-TP-03-06).

2. RELEASE POINT INFORMATION

Location:	BGRR- Below Ground Duct, Primary Liner
Release height:	2.8 + 6.10 meters above the normal grade level
Source Area:	500 Linear feet
Exhaust velocity:	2.83 meter/second per HEPA unit
Exhaust temp. (°F):	Ambient

3. TECHNICAL INFORMATION ABOUT THE SOURCE

a. Overview of the Project

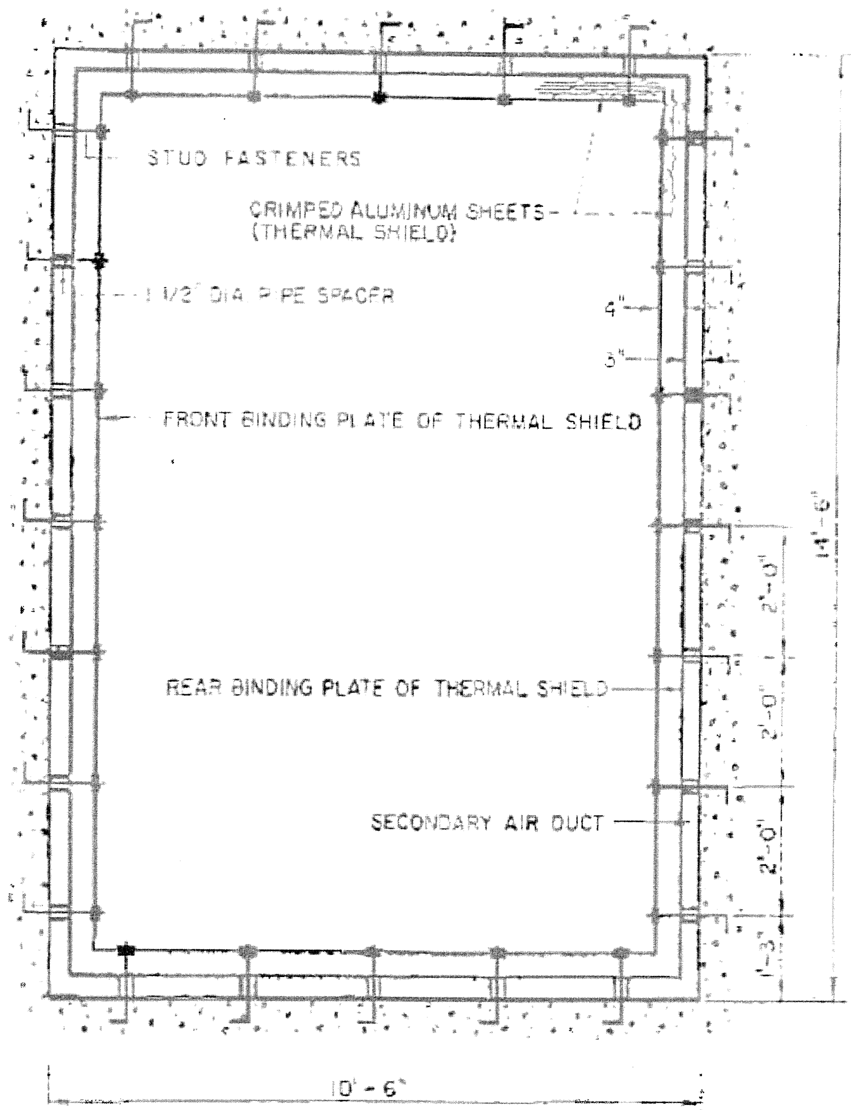
The Below Ground Duct (BGD), part of the BGRR reactors Primary Air Cooling System was constructed from steel reinforced concrete. The BGD consists of two separate North and South Ducts, which are connected to the reactor exhaust air plenums. The duct sections upstream from the air coolers have a three part thermal liner. Between the primary and secondary liners is a three-inch space that forms the secondary air duct; the inner duct is the primary duct. The Primary Liner was constructed of four inches of crimped aluminum sheets sandwiched between two-carbon steel (inner and outer) binding plates (Figure 1). The BGRR decommissioning project has collected, and analyzed the samples from the primary liner to identify radiological contamination. The following radionuclides were identified in/on the primary liner: Co-60, Cs-137, Sr-90, Am-241, U-234, U-235, U-238, Pu-238, Pu-239, and Pu-240.

b. Ventilation Systems

During the Primary Liner removal operation, the DSB and the BGD will be maintained at a slightly negative pressure with respect to outside environment. Two self contained, skid mounted 6000 cfm HEPA filtered ventilation units have been tested, and are operational. These HEPA filtered units inlet duct is connected to the BGD Primary Liner removal operation to minimize any airborne contamination. The HEPA filtration system units are situated inside the metal Duct Service Building (bldg. 708-T), and exhausts via a single 26" round duct to the outside

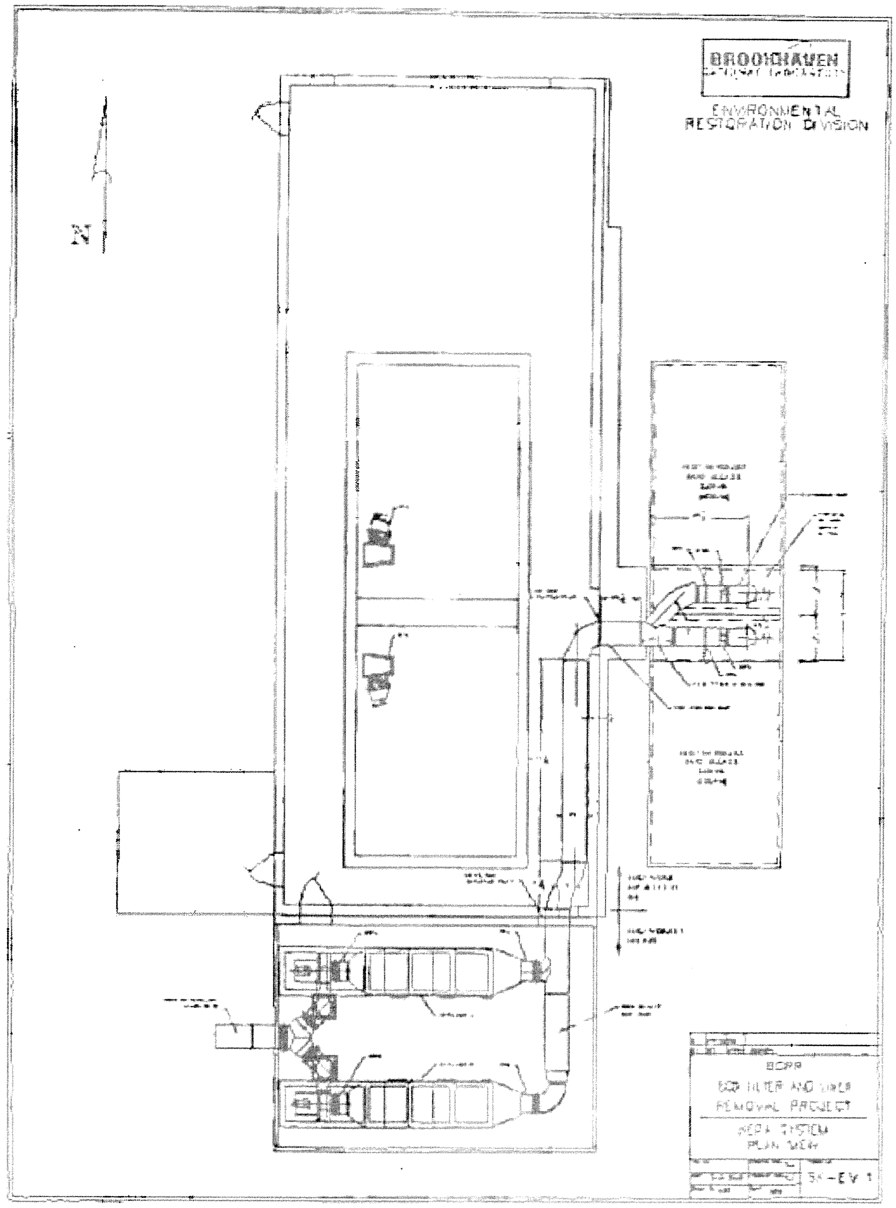
Airborne particulate and charcoal monitoring is being performed in accordance with the ANSI/HPS N13.1-1999 standard requirements, as this is the only pathway from the Below Ground Duct to the environment. The samples collected from the stack duct are routinely analyzed for gross alpha/beta, gamma, and other radiological parameters when requested. *Note:* Air filter/charcoal samples collected during the BGD Filters removal process have not shown any radionuclide activity above the minimum detectable concentrations.

Fig. 1 Cross Section of the Primary Liner



SECONDARY AIR COOLING SYSTEM IN
EXTERIOR PRIMARY AIR EXHAUST DUCT
FIGURE G06.05-1

Fig. 2 Duct Service Building



c. Source Term Development

Two remote manipulators will be used for the liner removal work. One manipulator will be fitted with standard demolition tools while the other manipulator will have a clamshell bucket loading the liner waste into a transport cart. When the transport cart is filled, it will be moved to the filter Access Opening and the liner waste shall be removed with the Gantry Crane for placement in the sealant type waste transport containers. Once the Primary Liner is removed, the Secondary Liner will be exposed which will be left in place until final disposition of BGRR is determined. Debris and loose surface contamination will be removed via vacuuming or other mechanical means. After loose surface contamination removal, a light colored industrial coating such as "Rustoleum" paint will be applied to fix any loose contamination, and will aid in better visibility during future inspections. The Primary Liner radionuclide concentrations used for development of the source term were based on Appendix A of the USID Number: BGRR SE-03-01 document. The isotopic concentrations are given in Table 1 & 2 below.

Assumptions:

1. Total activity on the surface of the Primary Liner was loose, unbound, removable particles, and no correction factor was applied in order to be conservative.
2. The characterized radionuclide activity inventories on the Primary Liners and steel plates were dispersed into the environment.
3. Activity on steel plates and aluminum liners was combined, and released simultaneously from the stack.
4. One hundred percent of the total inventory was released into the environment after adjusting for physical state of the radionuclide and effluent control methods used in accordance with Appendix D to Part 61.
5. Surface activity adhesion, gravitational settling and particle size effects were not considered in the release scenario.

Table 1. Isotopic Activity in Steel

Radionuclides	Activity (Curies)	Estimated Release (Curies)
Sr-90	2.40E-01	2.40E-06
Pu-239	1.93E-03	1.93E-08
Pu-240	1.93E-03	1.93E-08
Am-241	4.41E-04	4.41E-09
U-234	3.42E-03	3.42E-08
U-235	3.93E-04	3.93E-09
U-238	1.16E-02	1.16E-07
Co-60	1.32E-03	1.32E-08
Cs-137	9.88E-01	9.88E-06

Table 2. Isotopic Activity in Aluminum		
Radionuclides	Activity (Curies)	Estimated Release (Curies)
Ni-63	3.16E-03	3.16E-08
Sr-90	1.08	1.08E-05
Pu-239	3.28E-03	3.28E-08
Pu-240	3.28E-03	3.28E-08
Pu-238	8.48E-05	8.48E-10
Am-241	9.82E-04	9.82E-09
U-234	1.06E-03	1.06E-08
U-235	6.22E-05	6.22E-10
U-238	2.25E-04	2.25E-09
Th-228	1.12E-04	1.12E-09
Co-60	4.09E-04	4.09E-09
Cs-137	1.82	1.82E-05

d. Dose Assessment

The radiological dose and risk assessment to the maximally exposed individual (MEI) was estimated using the Clean Air Act Code CAP88-PC, version 2.0 modeling program to show compliance with 40CFR 61.93 (a) regulation. The meteorological data (temperature, precipitation, wind speed, and mixing height) used in the modeling program was site specific.

The dose estimates in CAP88-PC are applicable to low-levels of chronic exposures and not for short-term releases or acute exposures; therefore, it was assumed that the low-level emissions are continuous over the course of year. The CAP88-PC Model is based on the Gaussian plume model with its associated limitations. The Duct Service Building (bldg. 708-T) stack duct is situated on a hill by comparison to the adjacent buildings (bldg. 901& 906), and is in horizontal alignment to the ground; therefore plume behavior may be influenced by aerodynamic distortion due to chimney phenomena, surrounding building and terrain.

The agricultural assumptions were that 100 percent of vegetables were imported. Because Suffolk County does not have any dairy and cattle farms, 100 percent of milk and meat was imported from outside of the assessment area.

The total dose to the MEI resulting from the BGRR Below Ground Duct, Primary Liner removal operation was estimated to be 1.5E-05 mrem/year. The potential dose was below the 10 mrem/year annual limit as specified in the 40 CFR 61, subpart H, and below the 0.1mrem/ yr. limit, which requires the NESHAPs continuous monitoring requirements. Although continuous monitoring was not required but a sampling probe has been installed in the HEPA filtered ventilation system of the Duct Service Building (Bldg.708-T) to ensure that people in the surrounding environment are not exposed to levels of radioactive materials exceeding the established regulatory limits. Also, the emissions monitoring would help to assess the possible consequence of non- routine incidents, and in selection of appropriate corrective action.

References:

1. BGRR-SE-03-01, "Removal of BGRR-DP Below Ground Duct Primary Liner," Dated 09/30/03.
2. Clean Air Act Assessment Package, CAP88-PC Version 2.0 Dose Modeling Program. 1988.
3. ANSI/HPS N13.1-1999, "Sampling and Monitoring Releases of Airborne radioactive Substances from the Stacks and Ducts of Nuclear facilities."
4. BNL SBMS Radiological Air Emissions Subject Area, NESHAPs Assessment Form.
5. ERD-OPM No. ERD-BGRR –TP-03-06, Rev. 0, " Removal of the Below Ground Duct (BGD) Primary Liner."
6. ERD-OPM No. ERD-BGRR –TP-03-06, Rev. Draft, " Installation of the HEPA Ventilation System for the Removal of the Below Ground (BGD) Outlet Air Filters and the Primary Liner",
7. ERD-OPM 2.1, Work Planning and Control System
8. BGRR-002, Rev. 4, Hazard Classification and Auditable Safety Analysis for Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project.
9. BGRR-USQD-02-03, Removal of the BGRR-DP Below Ground Duct Filters
10. BNL Contract 69095, Portable 6000-CFM HEPA Ventilation System
11. BNL Radiological Control Manual
12. BNL-ESD-01, Quality Assurance Plan: Radiological Air Emissions at BNL.
13. ESH 1.6.0, Material Handling: Equipment & Procedures
14. Technical Environmental Health and Safety Plan (TEHASP) for the removal of the BGD Outlet Air Filters
15. BGRR WMP-04, Waste Management Plan, Below Ground Duct Liner Removal, May 8, 2003

ATTACHMENT II

C A P 8 8 - P C

Version 2.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S   R E P O R T

Non-Radon Population Assessment
Jan 7, 2004 04:45 am

Facility: BGRR- Removal of Below Ground Duct Primary Liner
Address: Brookhaven National Laboratory
P.O.Box 5000
City: Upton
State: NY   Zip: 11973

Source Category: Stack
Source Type: Stack
Emission Year: 2004

Comments: Removal of Below Ground Duct Primary Liner

Effective Dose Equivalent
(mrem/year)

1.50E-05

At This Location: 2500 Meters Southeast

Dataset Name: Primary Liner
Dataset Date: Jan 7, 2004 04:45 am
Wind File: C:\CAP88PC2\WNDFILES\BNL[illegible].WND
Population File: C:\CAP88PC2\POPFILES\BNL98A.POP

Environmental Services Division

BROOKHAVEN
NATIONAL LABORATORY

81 Cornell Ave., Bldg. 120
P. O. Box 5000
Upton, NY 11973-5000
Phone 631 344-8107
Fax 631 344-6079
bhooda@bnl.gov

Managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: *December 11, 2002*

To: *Steve Moss*

From: *Benny Hooda*

Subject: ***NESHAPs Evaluation for BGRR- Below Ground Duct Filters***

A National Emission Standards for Hazardous Air Pollutants (NESHAPs) evaluation was completed for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project to remove the Below Ground Duct-Filters. Attachments I, the Facility/Process Radionuclide NESHAP Evaluation report have the technical information about the source. Attachment II, the synopsis report from CAP88-PC, version 2.0, modeling program provides a conservative estimate of the effective dose equivalent of 3.53E-05 mrem/year to the Maximally Exposed Individual (MEI) at the southeast location.

The potential effective dose equivalent was well below the 10 mrem/year annual limit as specified in the 40 CFR 61, subpart H, and below the 0.1mrem/ yr. limit, which would require a NESHAPs permit, and continuous monitoring of the source. Even though continuous monitoring was not required but the best management practice and the preliminary plans show a separate HEPA filtered ventilation system will be installed in the Duct Service Building (Bldg.708-T) to be constructed for this project. The combination of application of the fixative on the BGD filters and HEPA filtered ventilation would further minimize emissions to the environment. Also, continuous monitoring of the duct/stack should be implemented to maintain record of actual emissions and mitigate any unplanned releases.

Please contact me at 8107, if you have any questions regarding this NESHAPs evaluation.

BH: car
Attachments

Distribution:	P. Bergh	K. Brog	T. Jernigan	R. Lee
	F. Petschauer	J. Selva	B. Zimmerman	

EC72ER.02

* * *

b. Ventilation Systems

Two self contained, skid mounted 6000 CFM HEPA ventilation units will be installed with inlet duct and discharge duct or stack. The HEPA filtration system unit(s) will be situated inside the metal building to minimize airborne contamination and maintain the Duct Service Building (bldg. 708-T) interior at a slightly negative pressure.

c. Source Term Development

The Outlet Air Filters will be removed in two stages. During the first stage of work a specially designed tool attached to remote-controlled manipulator will render the fiberglass filter media into small pieces that would be carried to a shielded burial liner via vacuum hose. During second stage the steel filter frame will be removed using the demolition tools attached to the same remote controlled device. Prior to removing 640 filter elements, a fixative will be applied to reduce airborne emissions. The radionuclide concentrations on the filters were based on the BGRR-SE-01-03 document, and are given in Table 1.

Table 1. Estimated Radionuclide Emissions

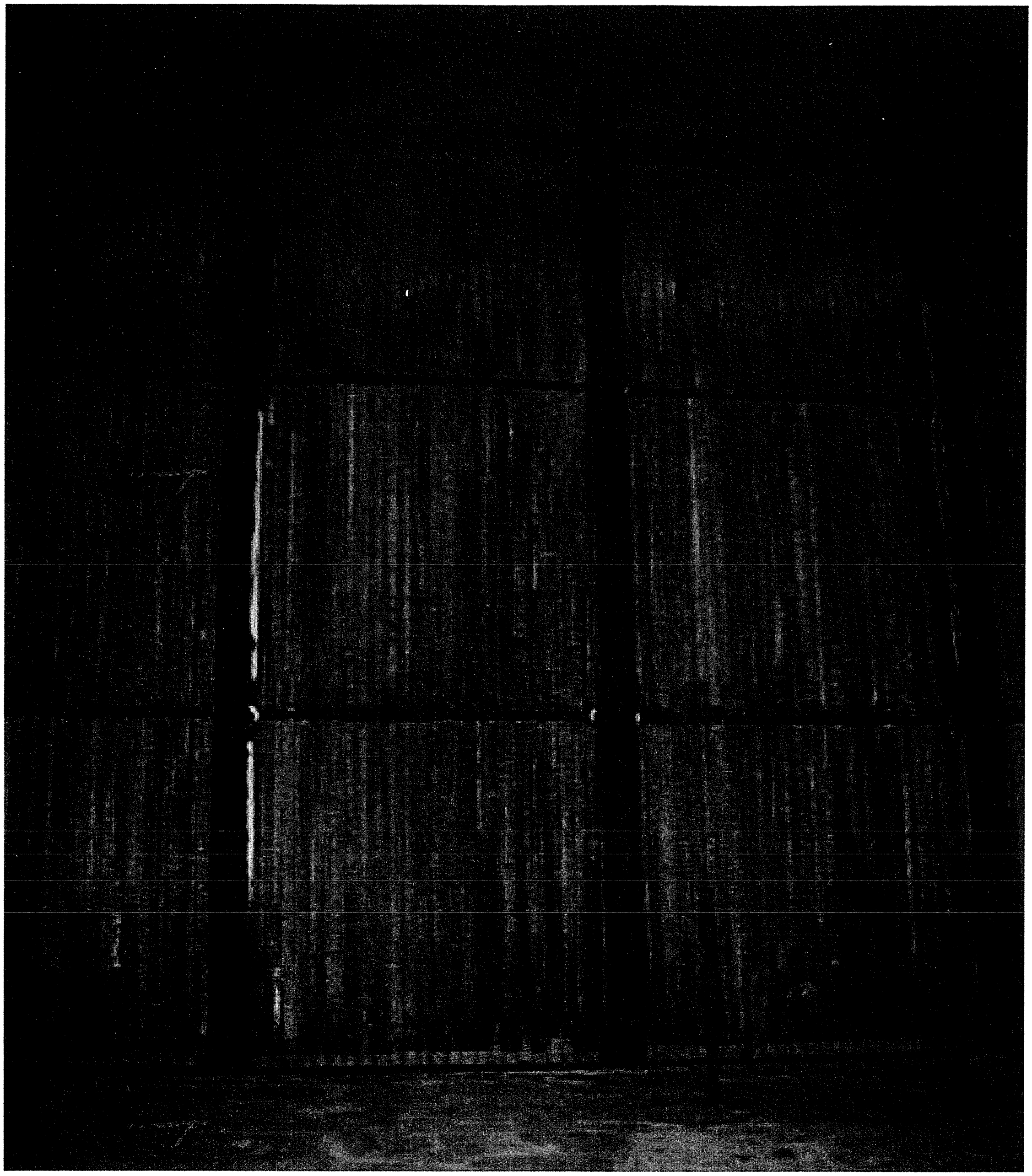
Radionuclide	Concentration (Ci)	Estimated Radionuclide emissions (Ci)
H-3	7.79E-02	7.79E-02
C-14	1.33E-02	1.33E-08
Fe-55	1.46E-02	1.46E-08
Co-60	1.27E-02	1.27E-08
Ni-63	1.42E-01	1.42E-07
Sr-90	8.63	8.63E-06
Y-90	8.63	8.63E-06
Tc-99	1.46E-03	1.46E-09
I-129	3.18E-04	3.18E-04
Cs-137	2.31E+1	2.31E-5
Eu-152	1.35E-02	1.35E-08
Eu-154	6.52E-03	6.52E-09
Eu-155	6.98E-03	6.98E-09
Ra-226	4.91E-03	4.91E-09
Th-232	4.05E-05	4.05E-11
U-234	2.30E-03	2.30E-09
U-235	1.40E-04	1.40E-10
U-238	2.32E-03	2.32E-09
Pu-238	5.05E-03	5.05E-09
Pu-239	1.81E-01	1.81E-07
Pu-240	1.81E-01	1.81E-07
Pu-241	1.90E-01	1.90E-07
Am-241	5.90E-02	5.90E-08

ATTACHMENT II

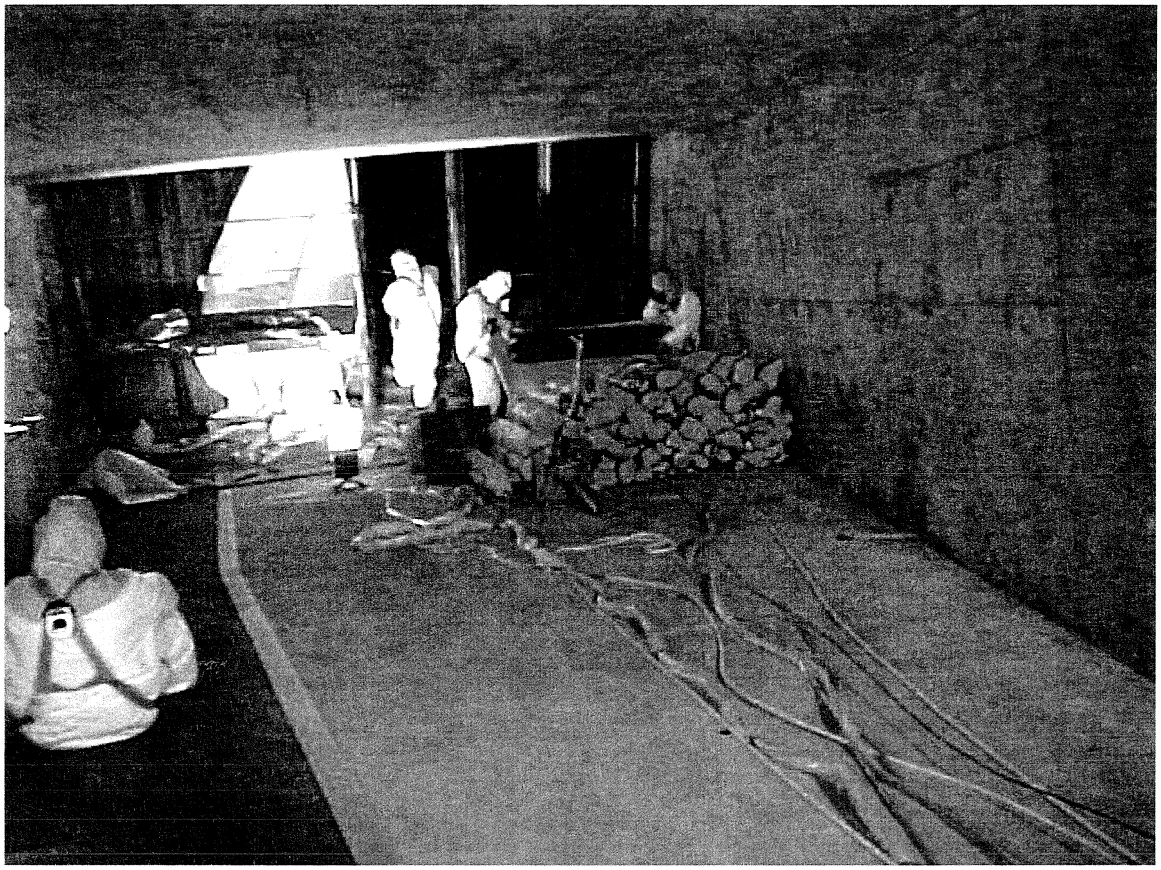
```
                    C A P 8 8 - P C

                     Version 2.00

         Clean Air Act Assessment Package - 1988


                  S Y N O P S I S   R E P O R T

                Non-Radon Population Assessment
                     Dec 10, 2002  12:25 pm


 Facility:  Brookhaven Graphite Research Reactor
  Address:  Brookhaven National Laboratory
            P.O.Box 5000
     City:  Upton
    State:  NY                  Zip:  11973


 Source Category:  Area
     Source Type:  Stack
   Emission Year:  2003

 Comments:  Removal of Below Ground Duct Filters


              Effective Dose Equivalent
                    (mrem/year)

              ___________________________

                      3.33E-05
              ___________________________


At This Location:   2500 Meters Southeast

     Dataset Name:  BGRR
     Dataset Date:  Dec  10, 2002  12:25 pm
        Wind File:  C:\CAP88PC2\WNDFILES\BNL00.WND
  Population File:  C:\CAP88PC2\POPFILES\BNL38A.POP
```

APPENDIX 4

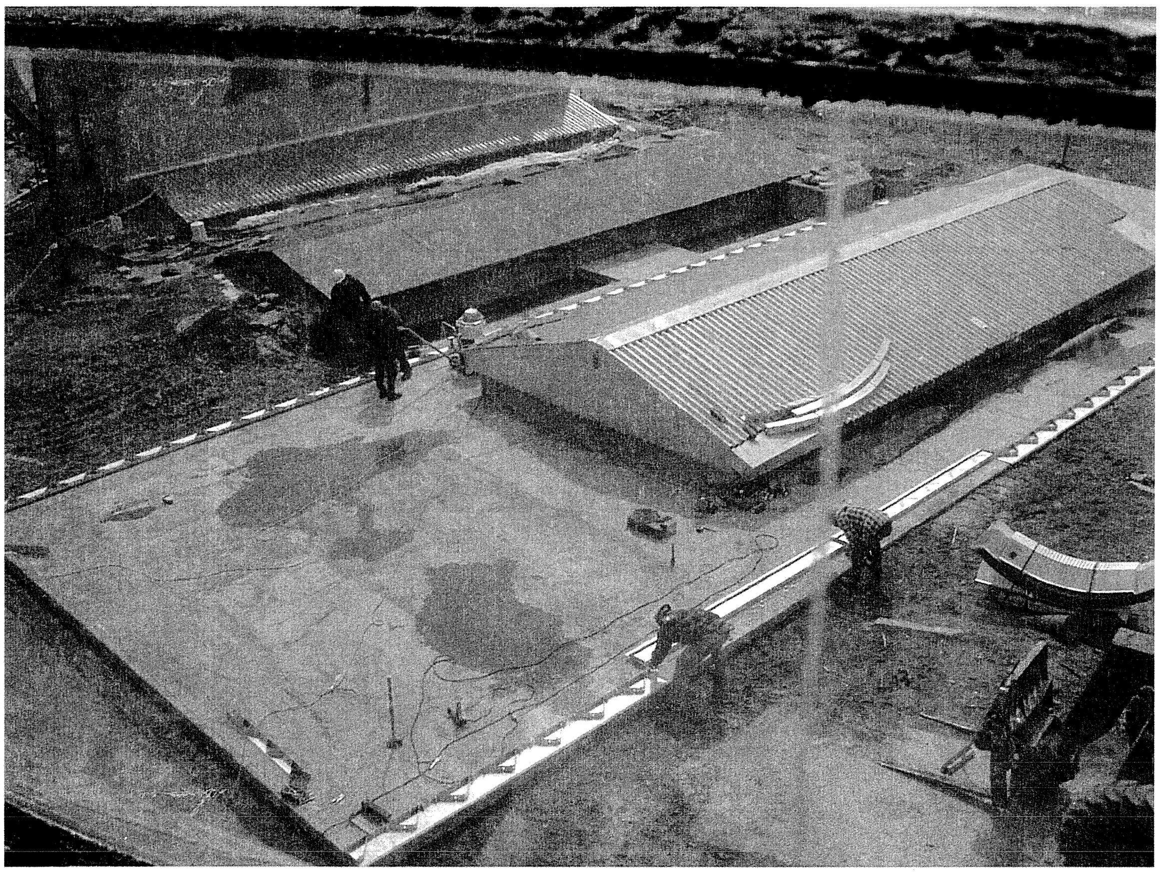
PICTORIAL REVIEW OF THE REMOVAL ACTIVITIES



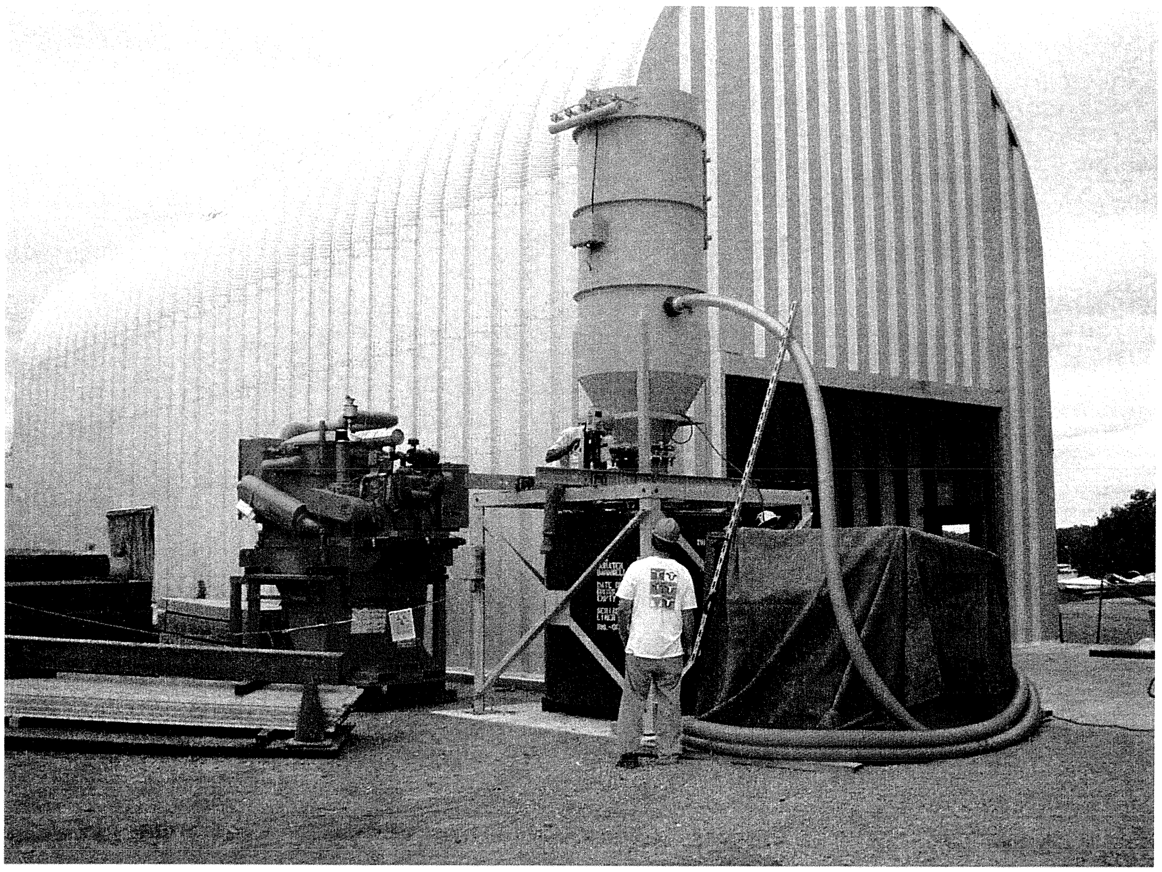
OUTLET COOLERS IN THE BELOW-GROUND DUCT PRIOR TO REMOVAL



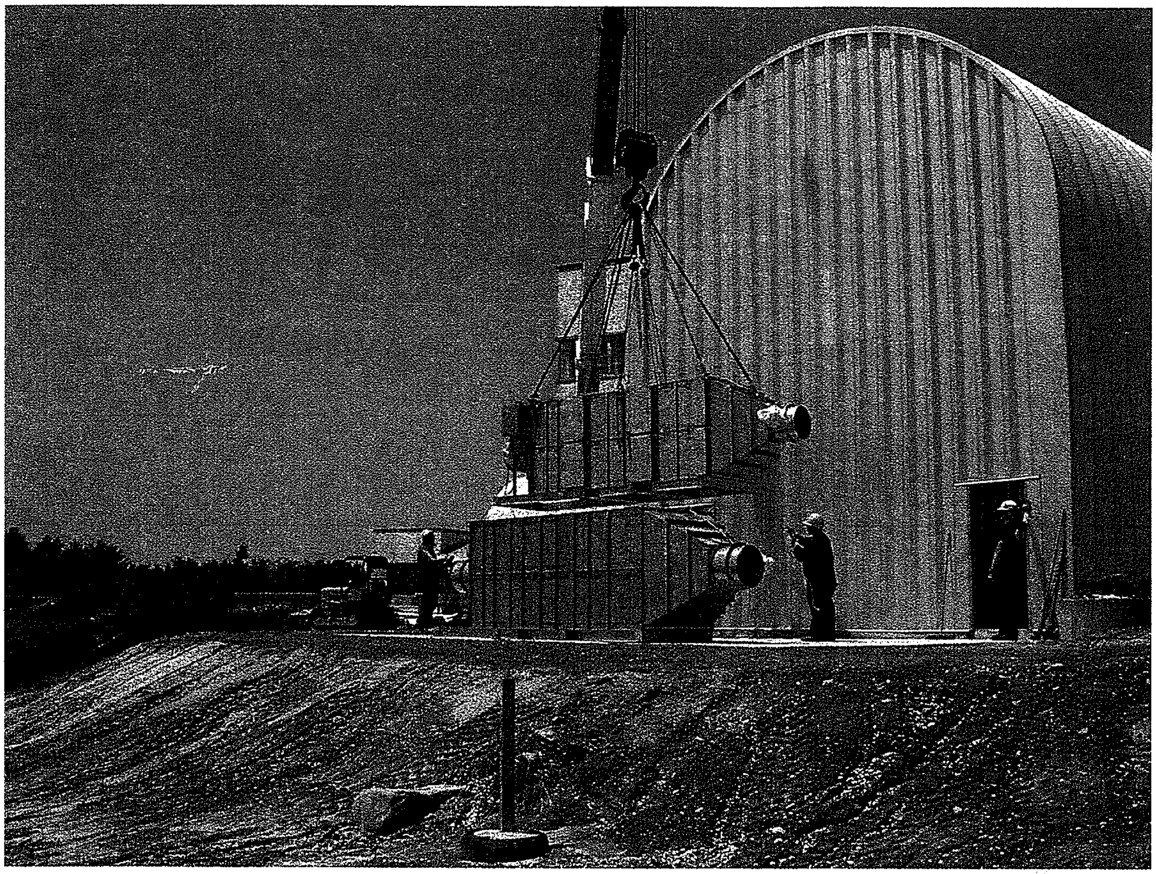
THE REMOVAL PROCESS OF THE COOLER UNITS IN THE NORTH DUCT BANK. THE COOLER TUBES WERE CUT, BUNDLED & WRAPPED FOR DISPOSAL. BUNDLES CAN BE SEEN IN THE YELLOW PLASTIC.



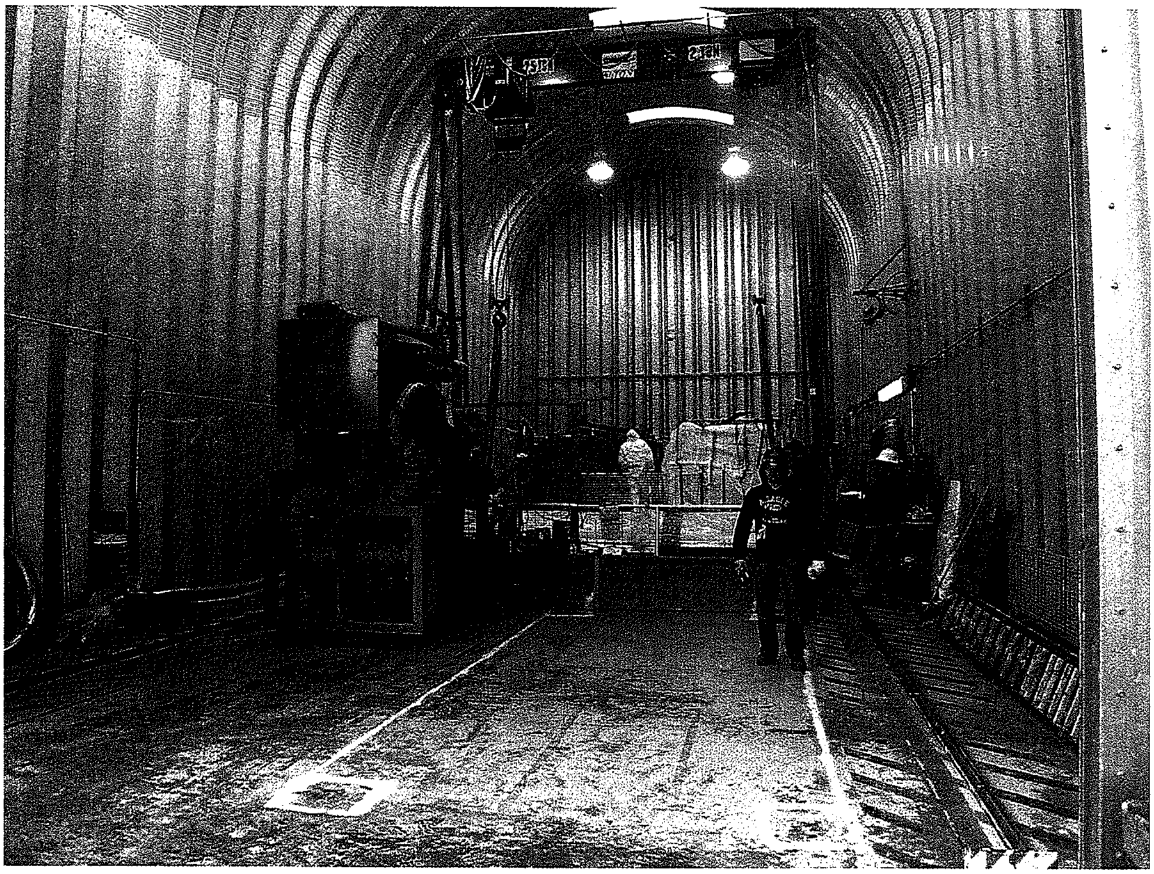
DUCT SERVICE BUILDING FOUNDATION INSTALLED AROUND BGRR FILTER OPENING. WORKERS ARE INSTALLING THE BUILDING PERIMETER SILL OVER THE NEWLY POURED REINFORCED CONCRETE SLAB. AFTER THE BUILDING WAS ERECTED, THE ROOF OVER THE FILTER PLUGS WAS REMOVED.



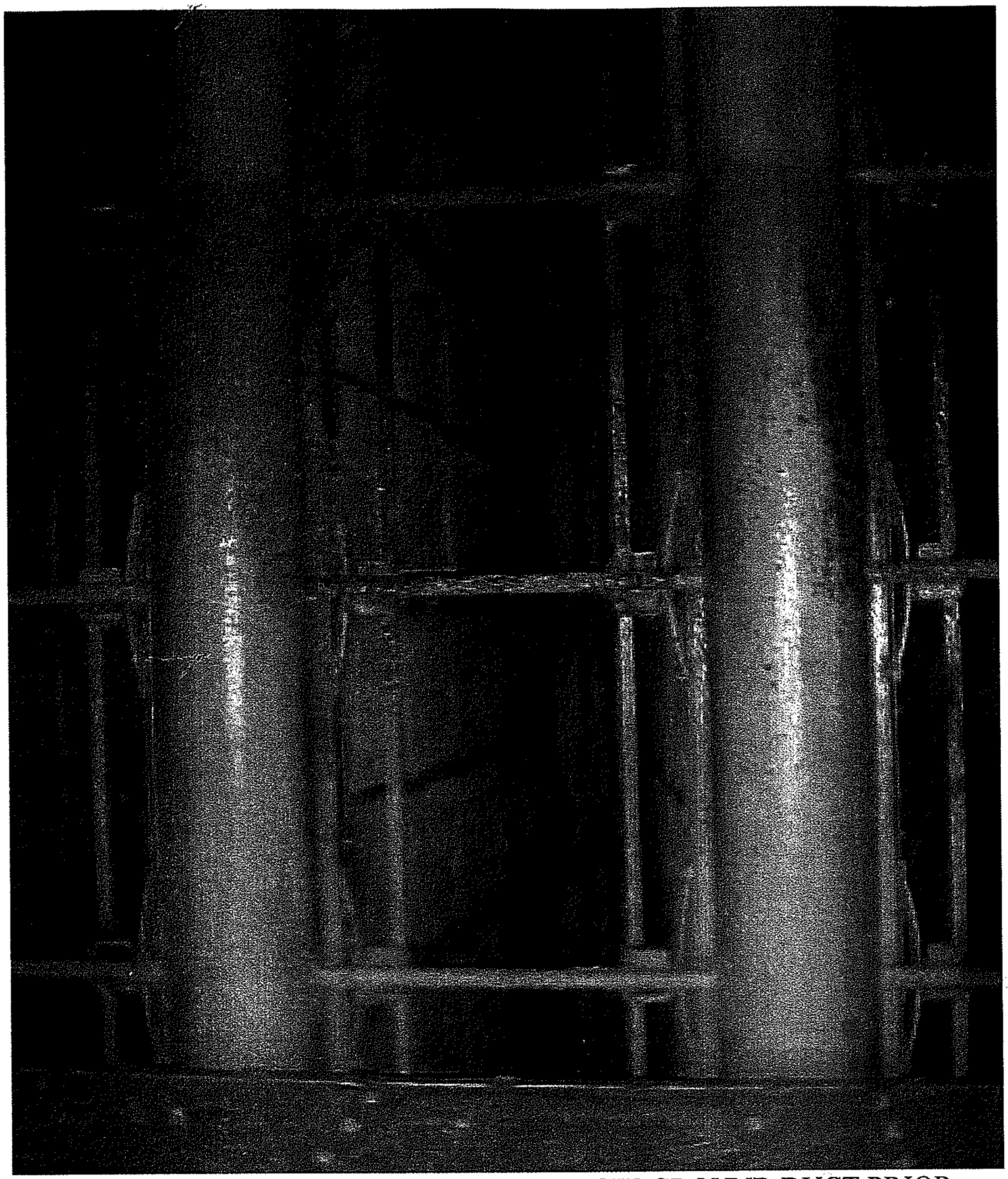
DUCT SERVICE BUILDING AFTER CONSTRUCTION. THE FILTER REMOVAL VACUUM SYSTEM CONSITING OF THE WASTE SEPARATOR (TALL GRAY UNIT), THE YELLOW HI-VAC UNIT, DURATEK WASTE LINER, AND THE BROKK HAMMERMILL (COVERED) IS SET UP OUTSIDE FOR MOCK-UP TESTING.



SECOND OF TWO HEPA UNITS BEING PLACED ON THE SLAB ADJACENT TO THE DUCT SERVICE BUILDING. INNER-CONNECTING DUCTWORK WAS INSTALLED CONNECTING THESE UNITS TO THE BELOW GROUND DUCT.

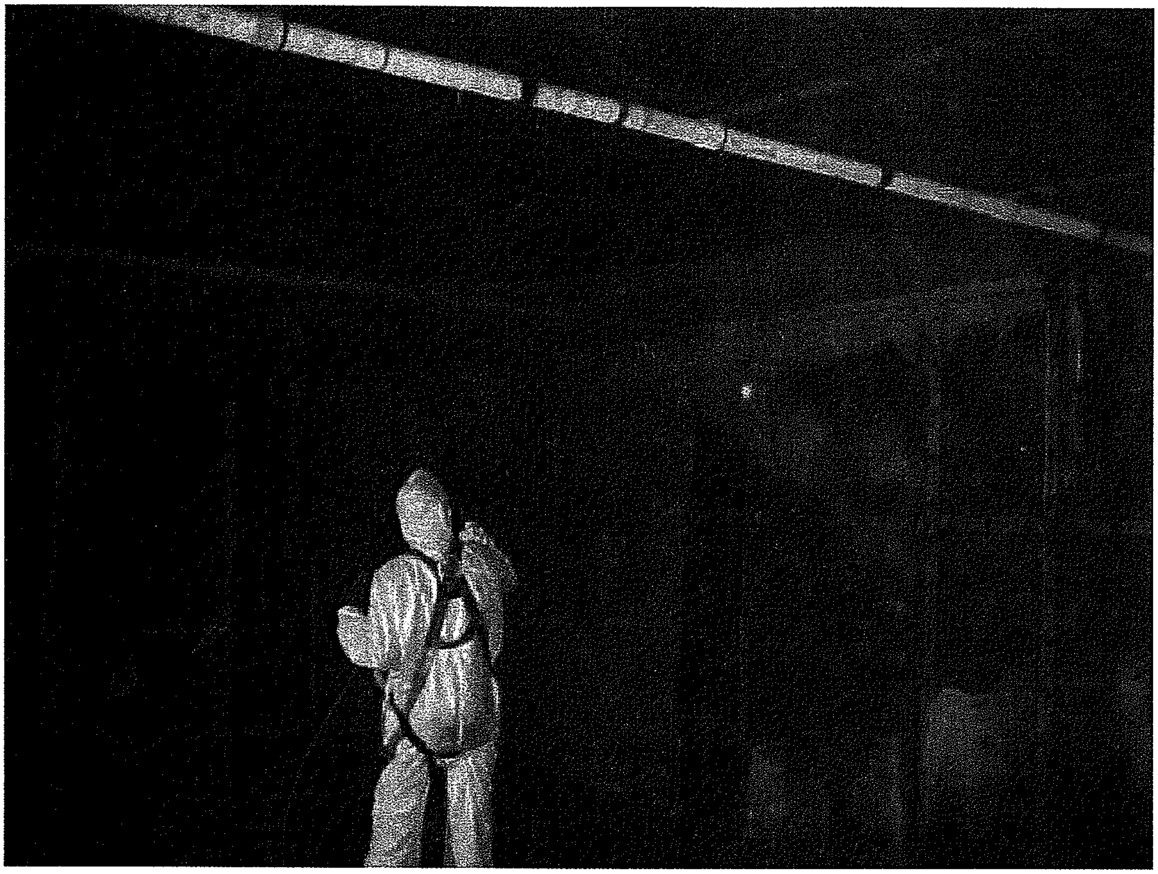


INTERIOR OF DUCT SERVICE BUILDING. THE YELLOW GANTRY CRANE CAN BE SEEN.

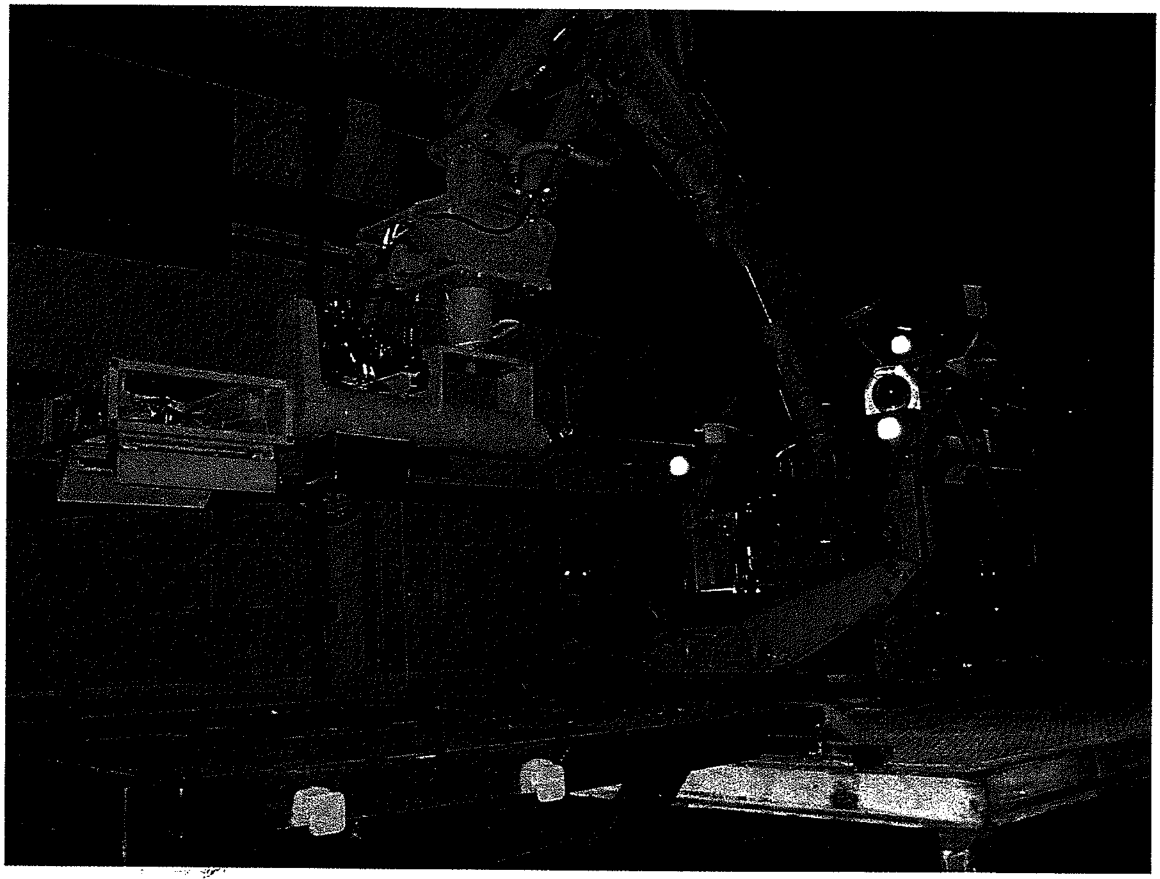


OUTLET FILTER BANK IN THE BELOW-GROUND DUCT PRIOR TO REMOVAL

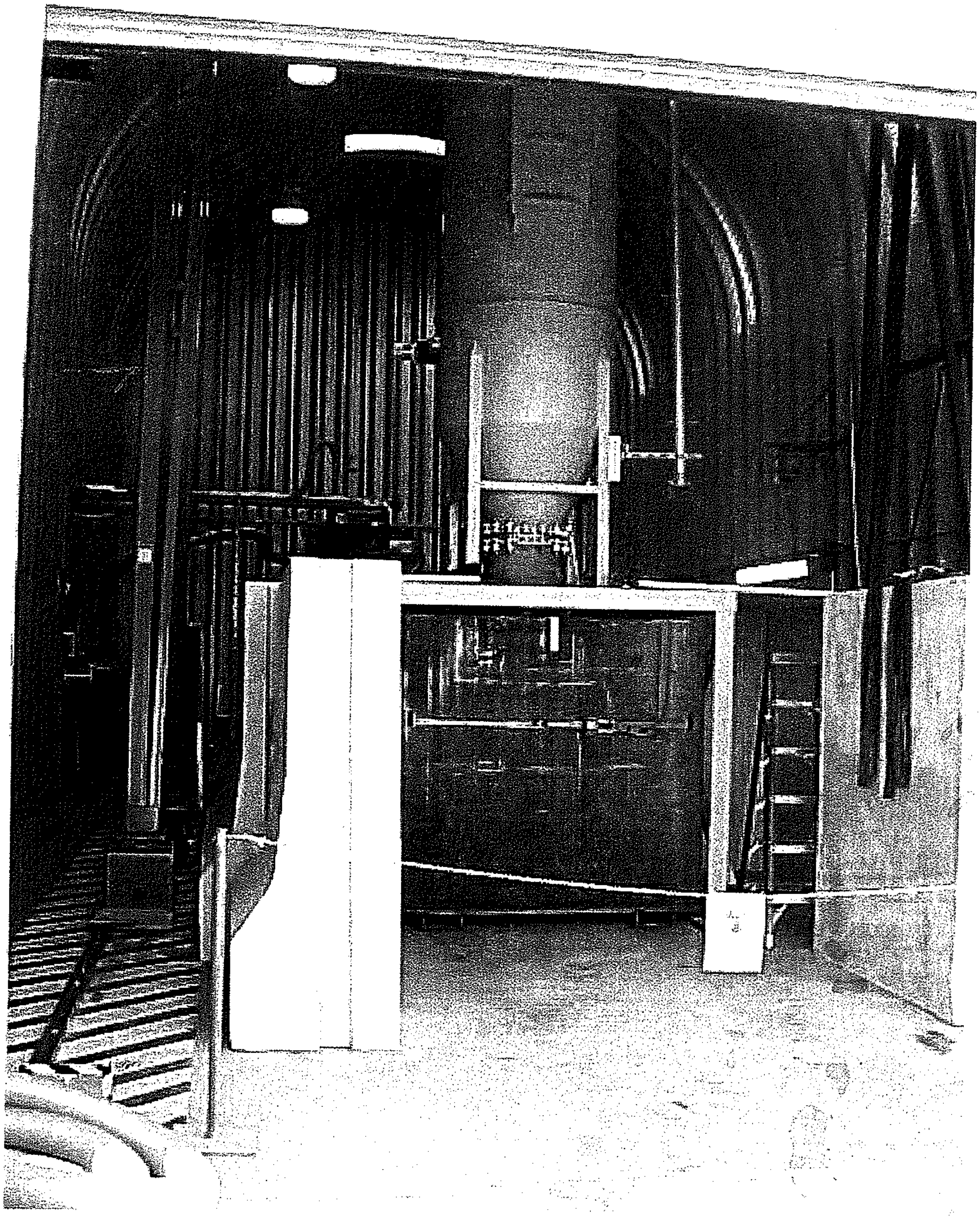
BGRR FILTERS LOOKING FROM COOLER AREA BEFORE COMMENCEMENT OF REMOVAL ACTIVITIES.



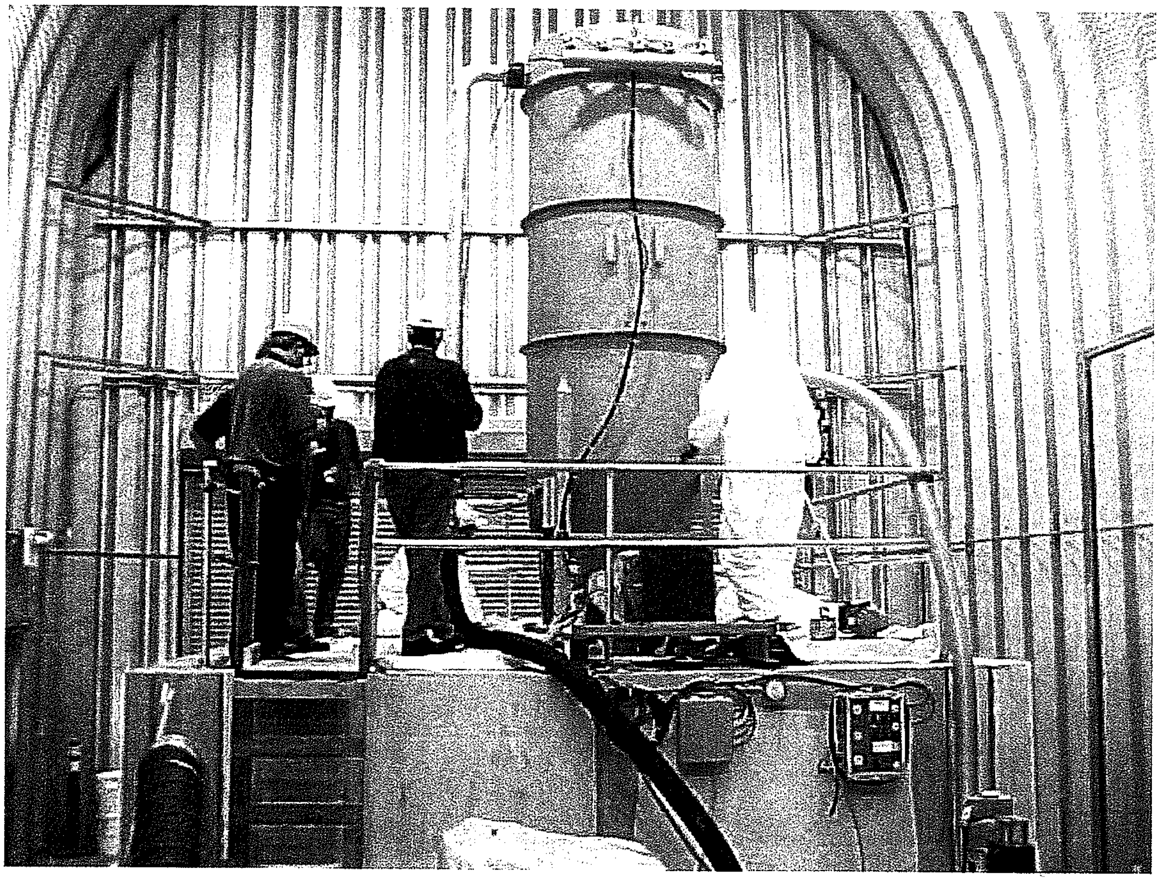
BGRR WORKER APPLYING FIXATIVE TO FILTER AREA TO MITIGATE AIRBORNE CONTAMINATION.



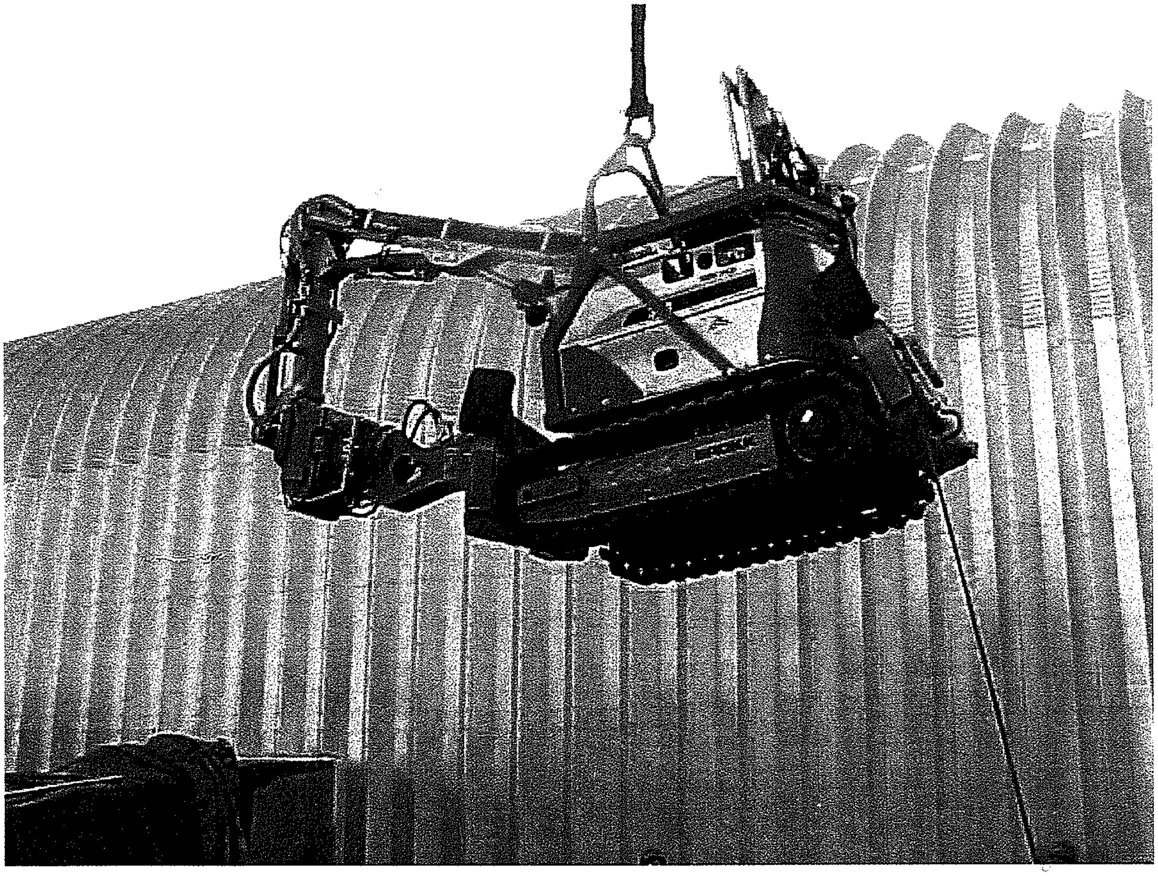
BROKK FILTER REMOVAL TOOL MOUNTED ON THE 330 REMOTE MANIPULATOR. AT THE LEFT CENTER OF THE PHOTO THE YELLOW CLAMPING JAWS ARE SEEN. THIS PHOTO WAS TAKEN AT BROKK'S FACILITY IN SWEDEN DURING ACCEPTANCE TESTING.



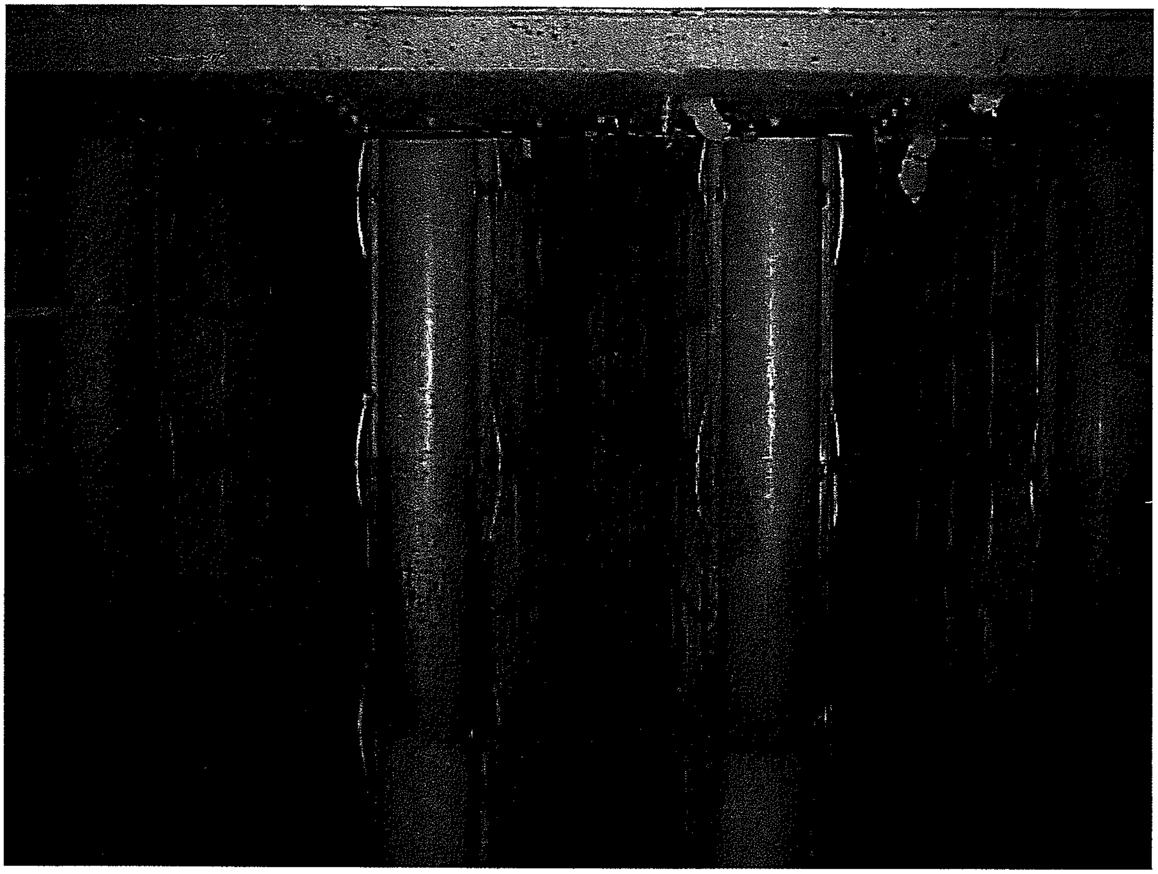
THE FILTER SEPARATOR/DURATEK LINER INSTALLED IN ITS FINAL LOCATION IN THE DSB. THE YELLOW SHEILD BLOCKS WERE SET IN FRONT OF THE DURATEK LINER PRIOR TO FILTER REMOVAL OPERATIONS.



BGRR WORKERS DURING ONE OF SEVERAL "FULL DRESS" REHEARSALS HELD FOR CHANGEOUT OF THE FILTER WASTE LINERS.

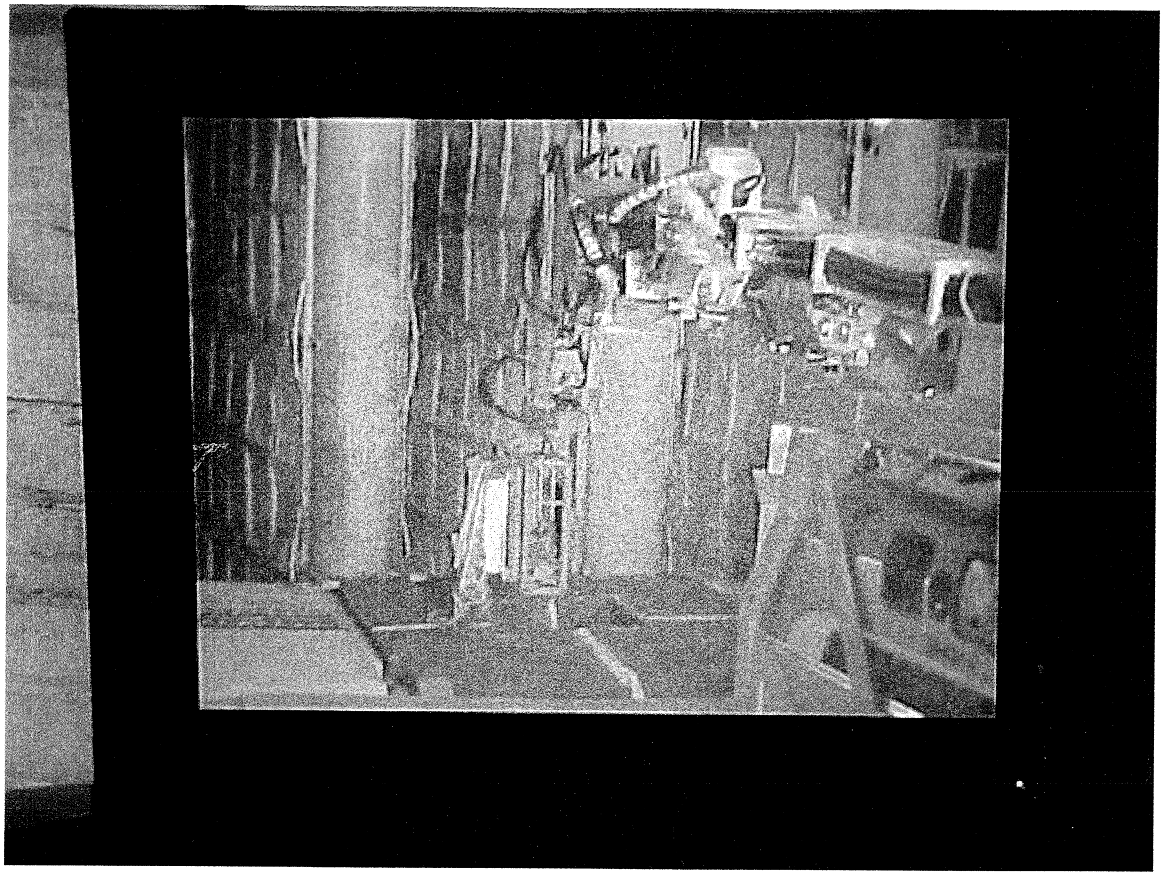


THE BROKK MANIPULATOR BEING LOWERED INTO THE NORTH BGD



VIEW OF NORTH OUTLET AIR FILTERS LOOKING WEST FROM DOWNSTREAM SIDE AFTER LOCKING DEVICES WERE REMOVED. NOTE THAT THE ENTIRE FILTER BANK IS COATED WITH A LIGHT-COLORED FIXATIVE TO MITIGATE THE AIRBORNE CONTAMINATION.

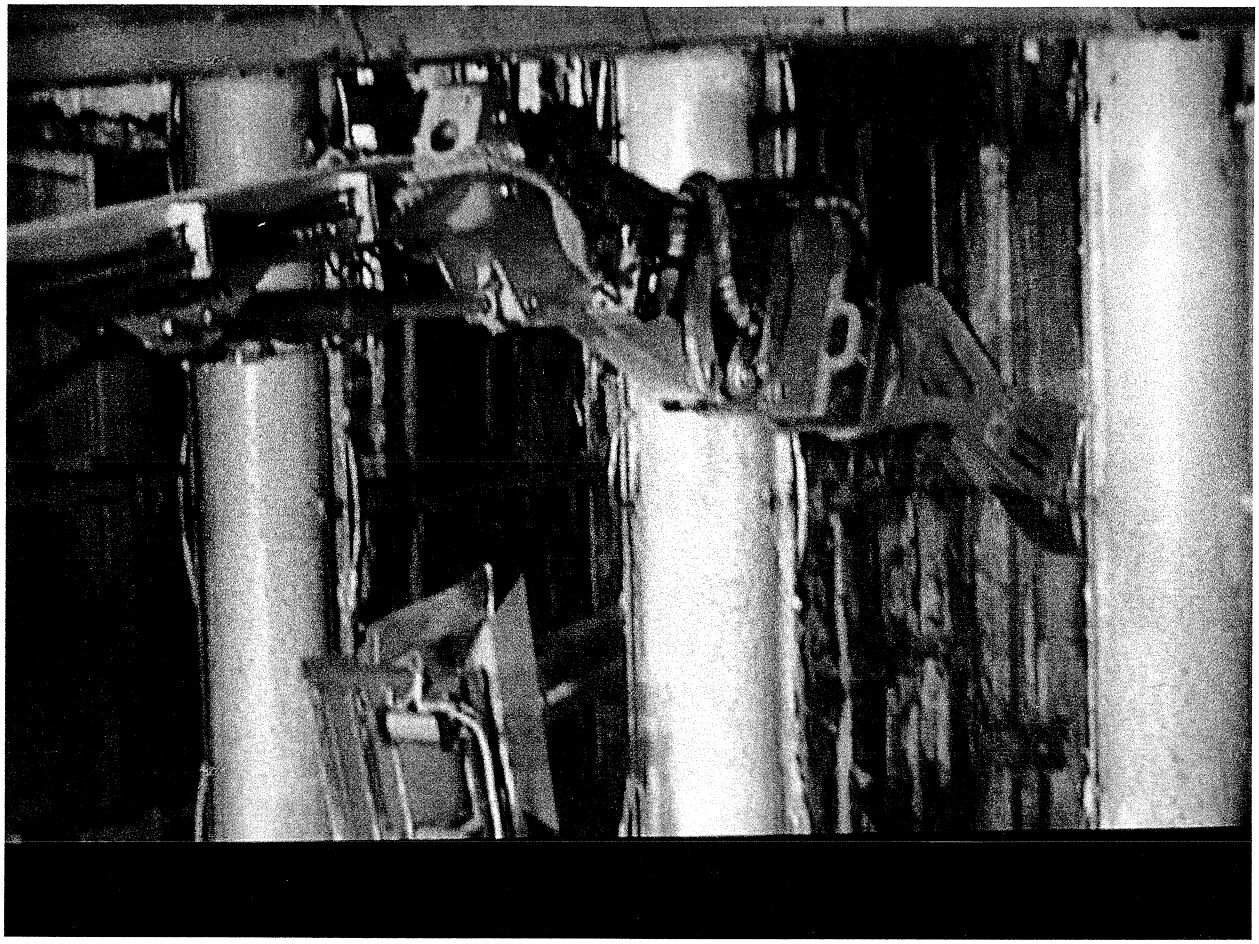
BROKK TECHNICIAN AT WORK OPERATING THE BROKK MANIPULATOR.



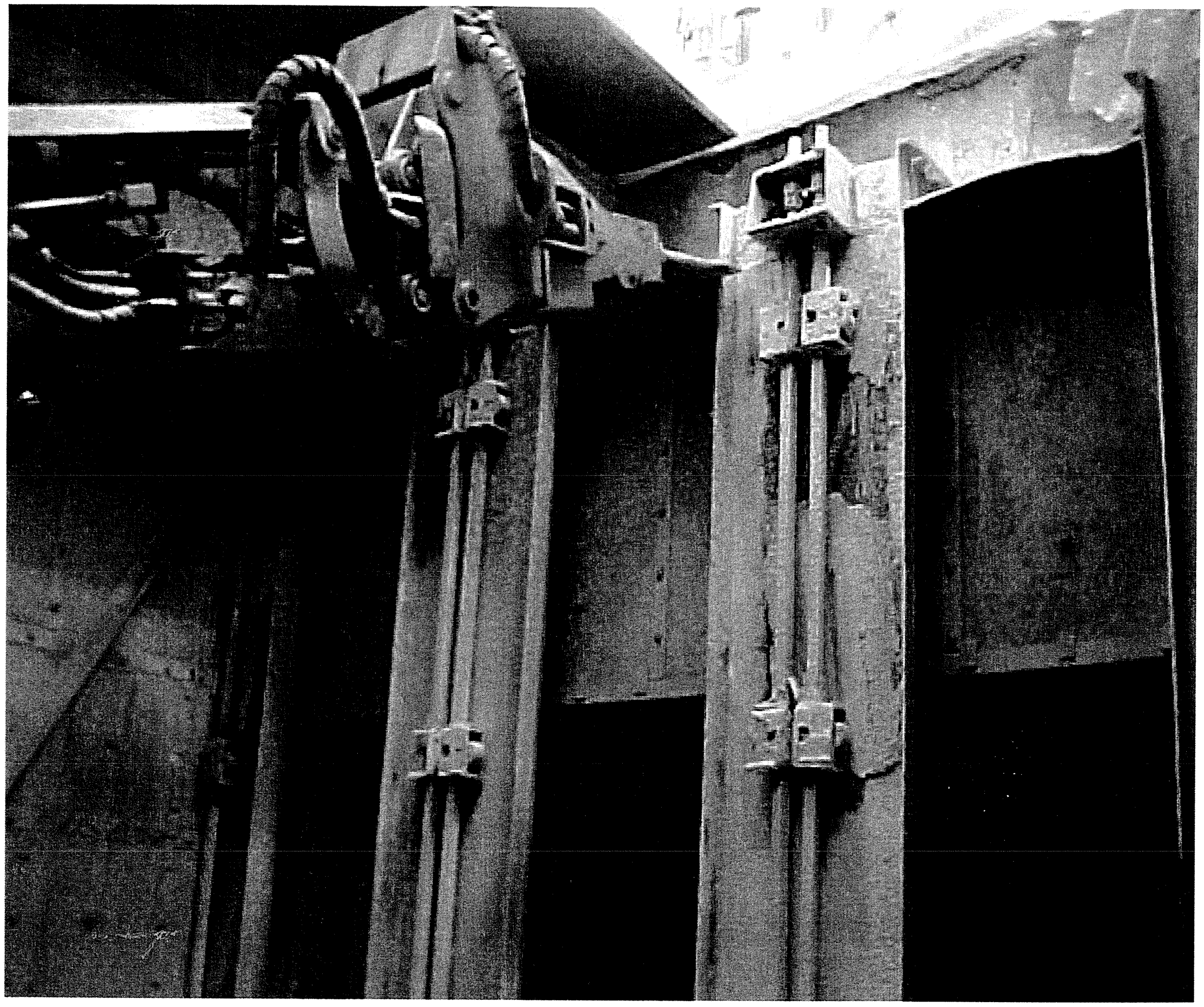
VIEW OF FIRST FILTER ELEMENT BEING PLACED INTO HAMMER MILL

ONE OF THE FOUR DURATEK WASTE LINERS BEING PLACED INTO THE TRANSPORT SHIELD ON THE TRAILER. THE TRANSPORT SHIELD WAS CONSTRUCTED OF 1" STEEL PLATE WITH LEAD BLANKETS.

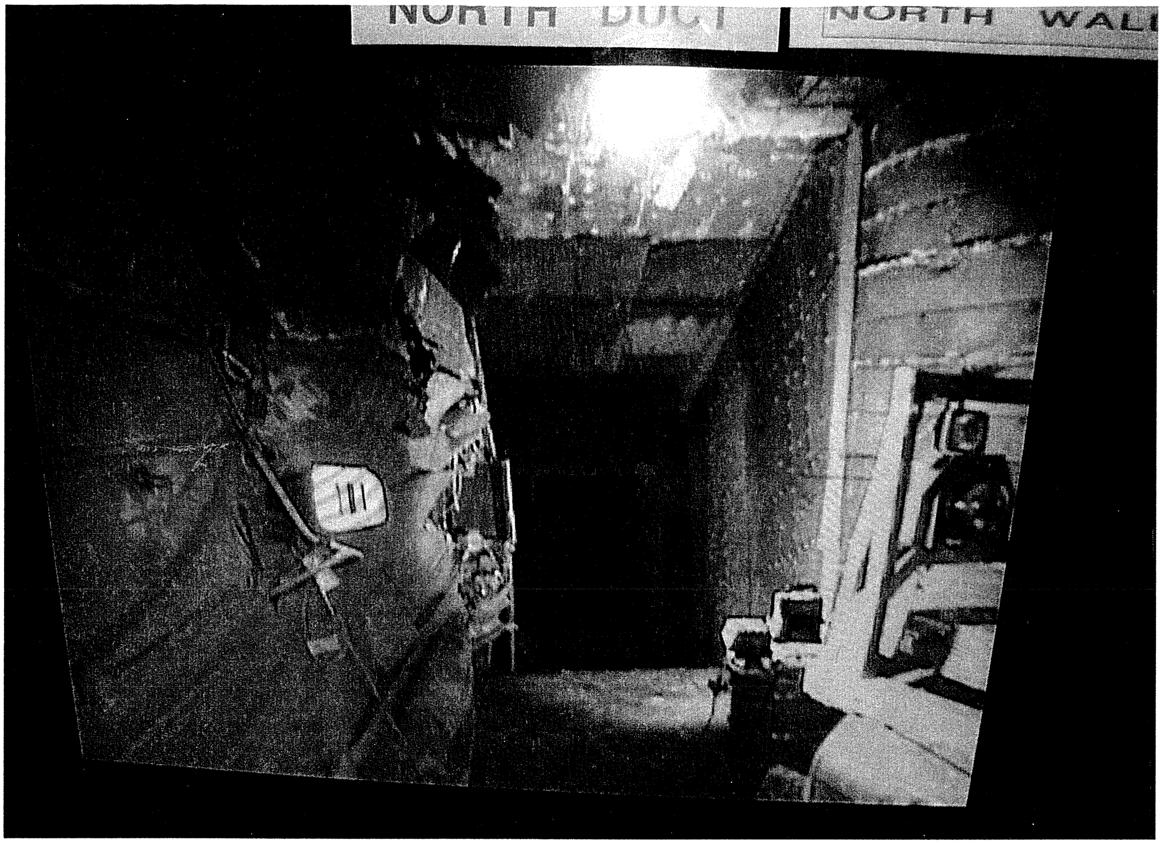
THE FIRST DURATEK LINER ON THE TRUCK AND READY FOR SHIPMENT TO HANFORD. THIS LINER CONTAINED ONE-HALF OF THE NORTH BGD FILTER ELEMENTS.



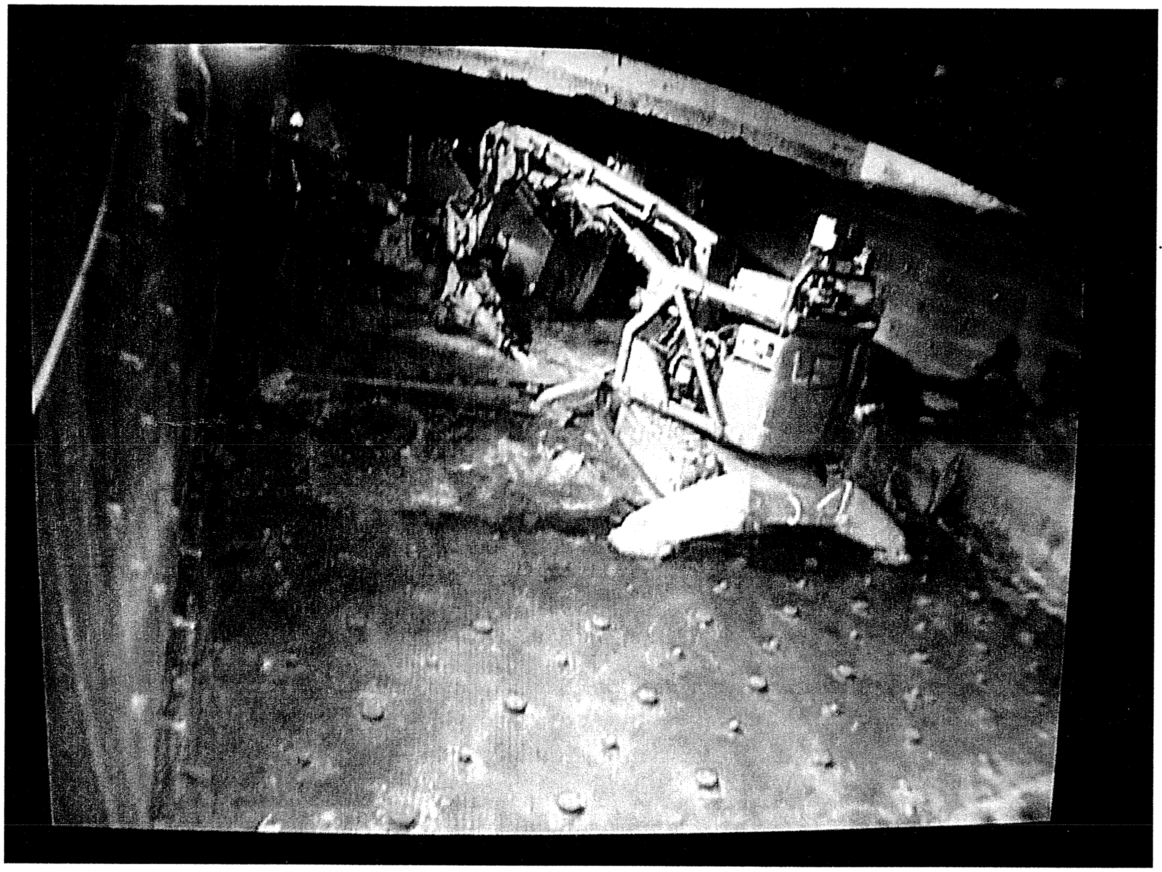
THE BROKK SHEAR BEING USED TO CUT THE FILTER FRAME 4" HORIZONTAL SUPPORT MEMBERS
(VIEWED FROM THE VIDEO MONITOR ON THE BROKK CONTROL CONSOLE)



VIEW FROM THE VIDEO CONSOLE OF THE BROKK MANIPULATOR IN ACTION REMOVING THE UPSTREAM NOSEPIECES.

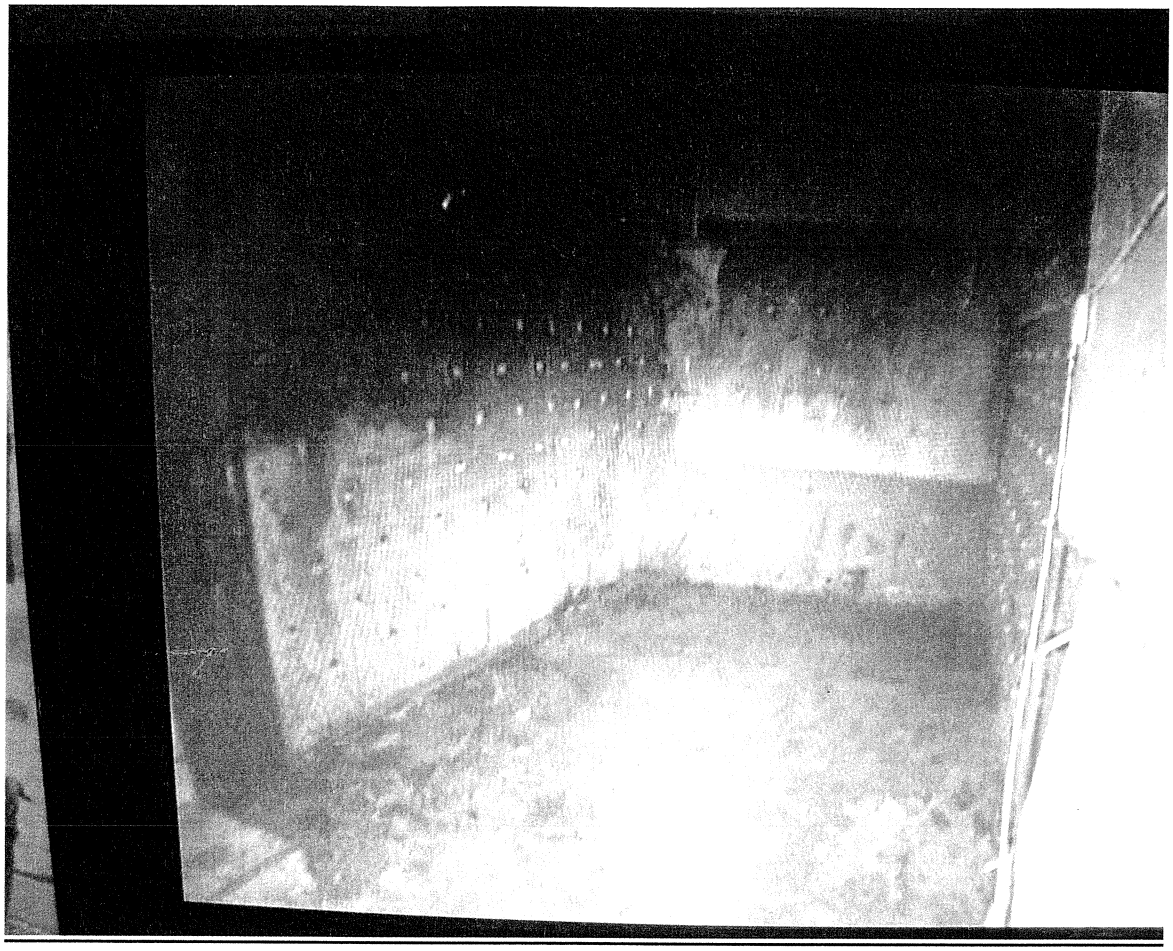


PRIMARY LINER IN THE NORTH BELOW-GROUND DUCT PRIOR TO REMOVAL



BROKK MANIPULATOR REMOVING PRIMARY LINER.

VIEW FROM THE VIDEO CONSOLE OF THE SOUTH BGD FILTER AREA LOOKING NORTH AFTER THE INNER BINDING PLATES HAVE BEEN REMOVED TO EXPOSE THE ALUMINUM THERMAL BARRIER. THE DUCT TURNING VANES CAN BE SEEN LEFT OF CENTER.

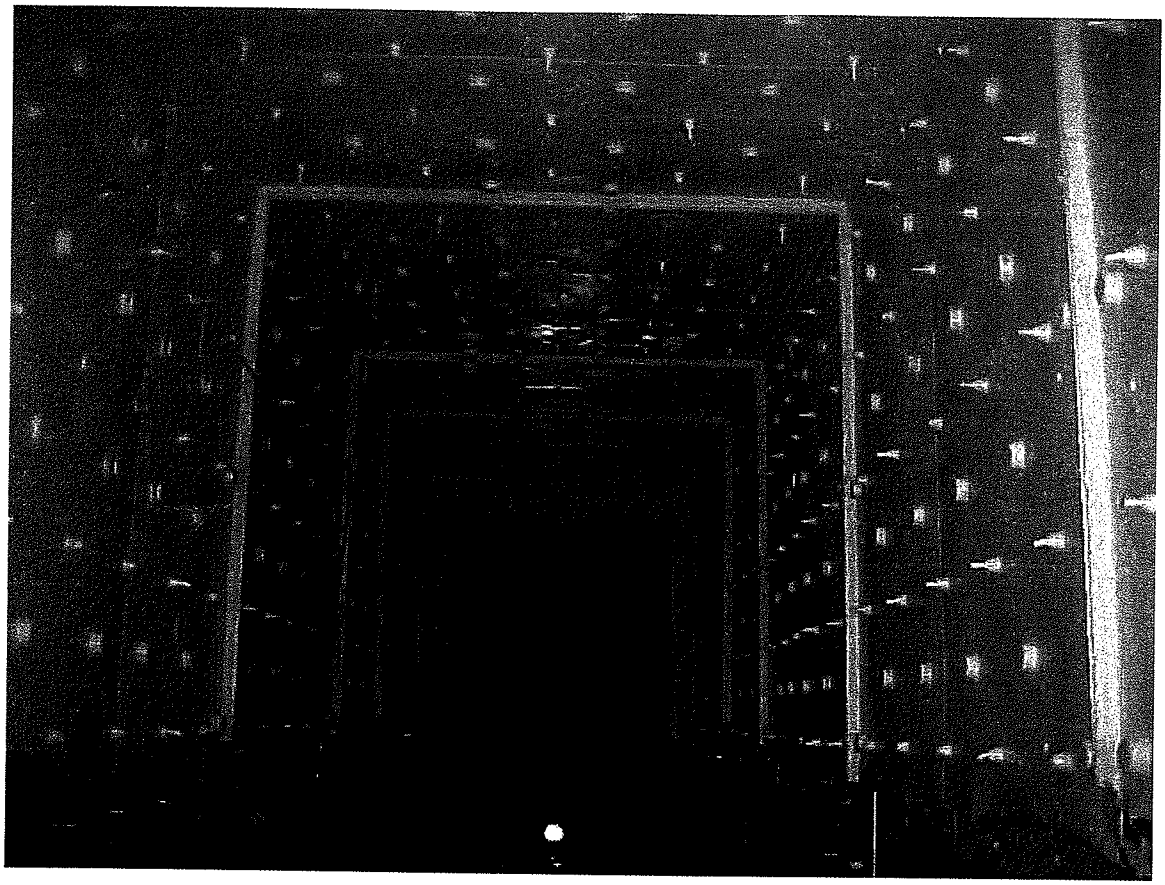


VIEW OF SOUTH REACTOR PLENUM AREA AFTER REMOVAL OF INNER BINDING PLATES, ALUMINUM THERMAL BARRIER, AND THE OUTER BINDING PLATE FLOOR.

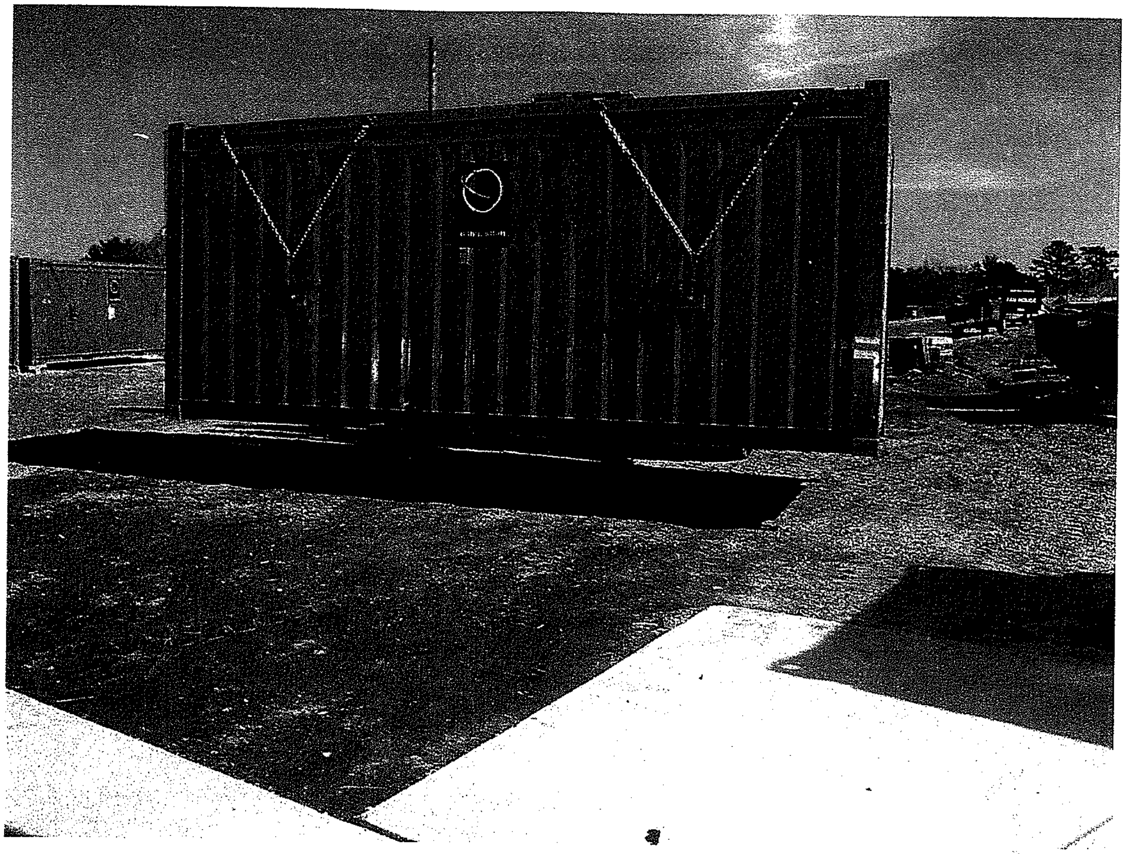
VIEW LOOKING IN THE NORTH BGD FILTER OPENING OF AN MHF WASTE LINER ("SUPER SACK") FILLED WITH ALUMINUM THERMAL SHIELD

VIEW OF A SEALAND CONTAINER LOADED WITH WASTE AND READY TO BE CLOSED UP FOR SHIPPING TO ENVIROCARE

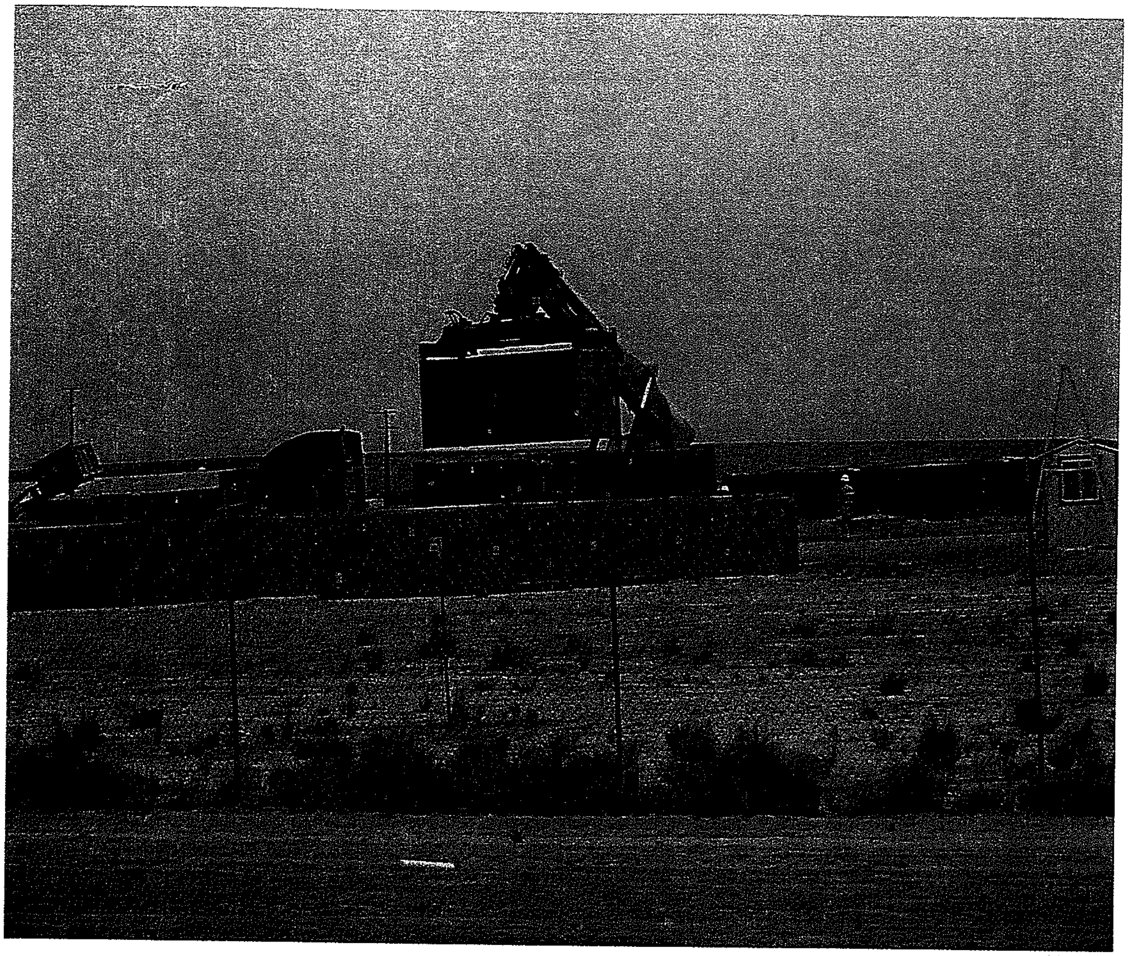
VIEW OF THE NORTH BGD AFTER REMOVAL OF THE WETTED PORTION OF THE OUTER BINDING PLATE.



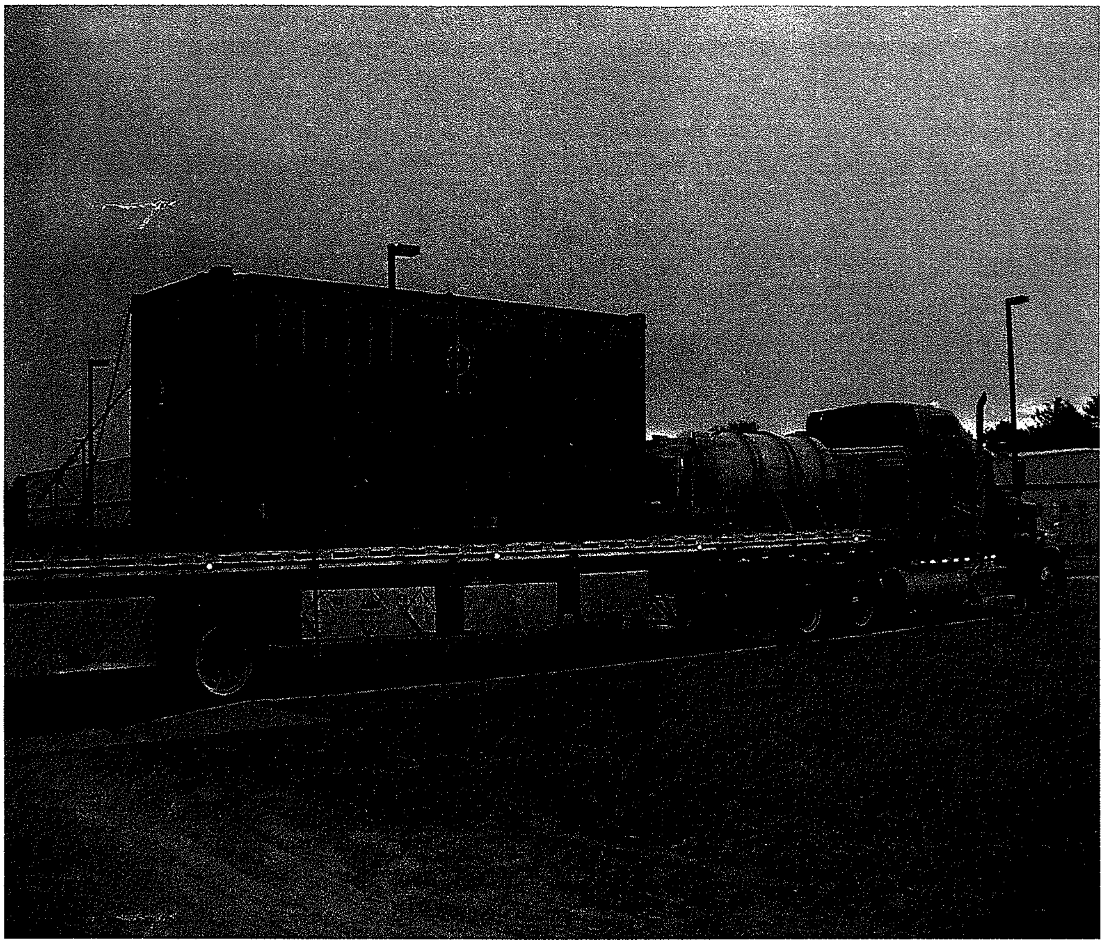
VIEW OF NORTH BGD AFTER REMOVAL OF INNER BINDING PLATE ALUMINUM AND WETTED PORTIONS OF THE OUTER BINDING PLATE-A WHITE, RUST-INHIBITING COATING HAS BEEN APPLIED.



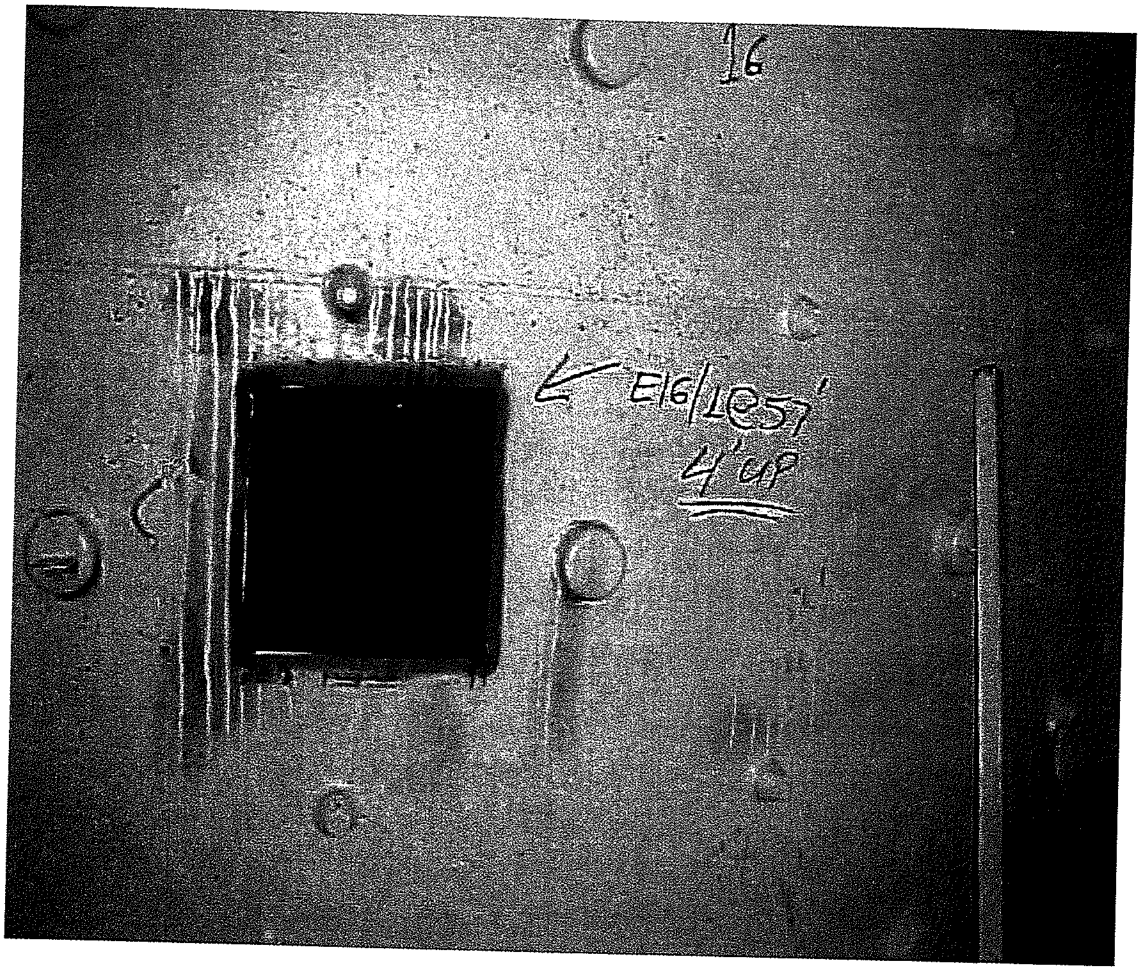
FIRST SEALAND CONTAINER WITH PRIMARY LINER WASTE IS FULL AND READY TO SHIP TO ENVIROCARE.



FIRST BNL SHIPMENT OF LINER WASTE BEING OFFLOADED AT ENVIROCARE



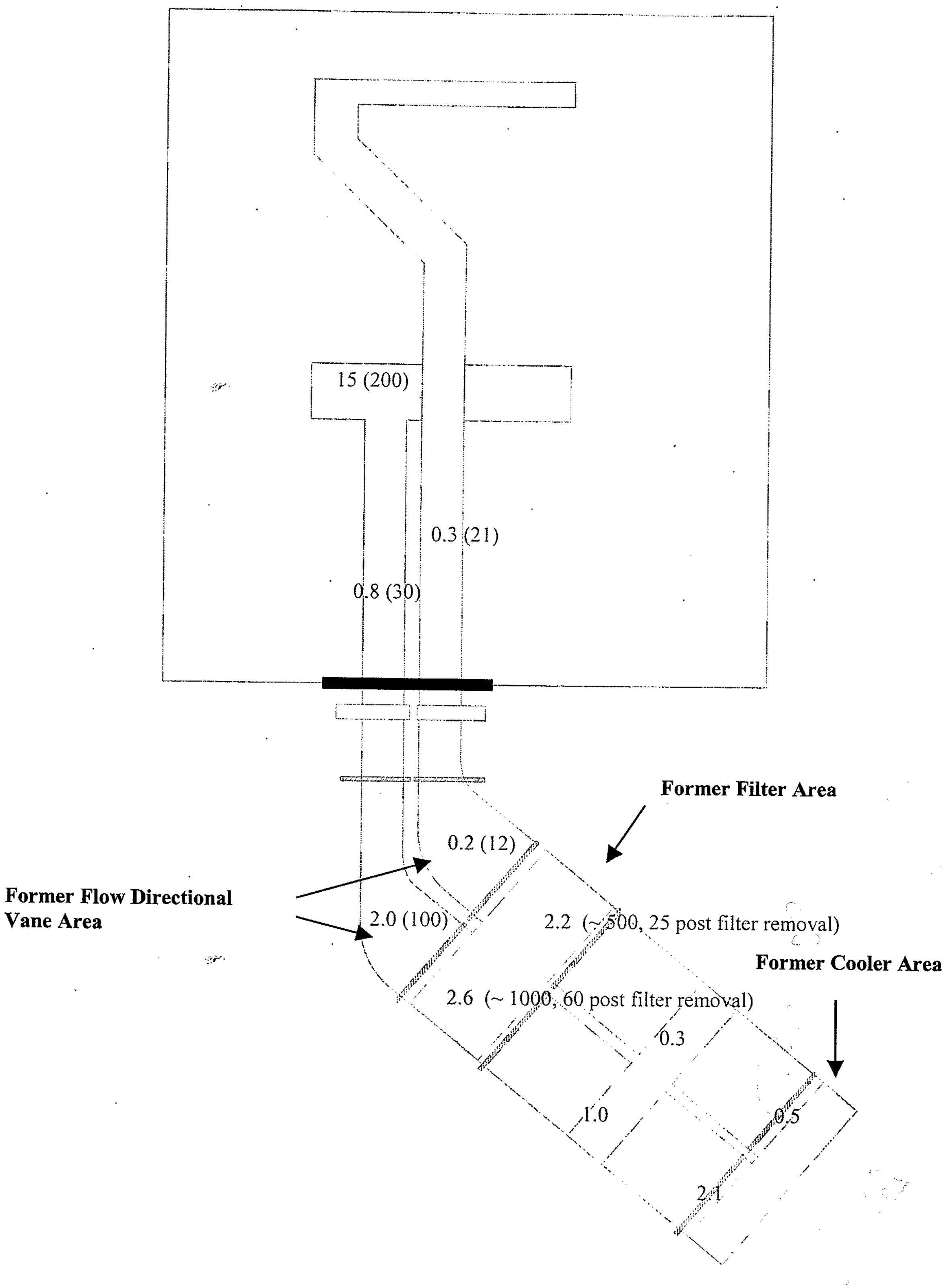
WASTE SHIPMENT TO ENVIROCARE WITH THE BGRR BGD FILTER WASTE SEPARATOR.



ONE OF SEVERAL LOCATIONS IN THE NORTH BGD WHERE A 12" X 12" SAMPLE COUPON WAS REMOVED FROM THE OUTER BINDING PLATE FOR RADIOLOGICAL CHARACTERIZATION

APPENDIX 5

BELOW-GROUND DUCT AS-LEFT RADIATION SURVEYS



All dose-rates are in "mR/hr"; Dose-rates in red are *prior to* remediation

APPENDIX 6

BELOW GROUND DUCT STRUCTURAL ANALYSIS

BROOKHAVEN NATIONAL LABORATORY

BGRR Facility

Below Ground Ductwork Liner Plate Analysis

Executive Summary

*I. **Introduction & History***

*II. **Scope of Work***

*III. **Analysis Approach and Method***

*IV. **Analysis Results***

V. ***Recommendations***

APPENDIX CONTENTS:

1. **Structural Analysis and Plate Analysis**
2. **References**

BROOKHAVEN NATIONAL LABORATORY

BGRR Facility

Below Ground Ductwork Liner Plate Analysis

Executive Summary

LiRo Engineers, Inc. was contracted to perform a structural analysis of the stud anchors supporting the two (2) remaining liner plates of the Below Ground Duct (BGD). This BGD is part of the Brookhaven Graphite Research Reactor (BGRR) facility located at Brookhaven National Laboratory. Sections of the original liner plate assembly have been removed from the lower 48" of the walls. In doing so, the remaining wall liner plate assembly is now hung from the wall, as originally was the ceiling liner plate assembly. Our analysis focused on the capacity of the stud anchors, and the stability of the liner plates to carry the its own weight (dead load) of the ceiling liner plate assembly and the remaining portion of the wall liner plate assembly.

As per the recommendation from BNL personnel, and along with LiRo's concurrence, the remaining lead anchors, which are located between the stud anchors, were ignored in the support analysis the liner plate assembly. The lead anchors were ignored in analysis due the fact that some of them are loose, according to BNL personnel, and are incapable of carrying any load.

LiRo's analysis results indicate that the ½" diameter stud anchors are comfortably capable of carrying the dead load of the liner plates safely. The induced stresses in the liner plate itself, is also very low. Based on the safety margins, it can be predicted that the system will remain safe for the next one hundred (100) years considering an overall 20% projected deterioration in the steel and concrete materials due to moisture and atmospheric conditions within the underground concrete duct.

BROOKHAVEN NATIONAL LABORATORY

BGRR Facility

Below Ground Ductwork Liner Plate Analysis

I. Introduction & History

The BGRR was constructed at the Brookhaven National Laboratory in 1950. It was the first reactor built to provide neutrons for research facilities and remained functional for 18 years. Reactor cooling was provided by filtered air from outside, and exhaust air passed through steel-lined and insulated concrete ducts. A typical concrete exhaust duct has 3 layers of steel plate lining. The two inner linings are ¼″ thick steel plate and are identified as the inner and outer binding plates. These inner and outer binding plates hold layers of crimped aluminum sheets called the thermal shield. The outermost lining is a 5/16″ thick steel plate called concrete liner plate. This assembly of plates are attached to the concrete duct chamber by ½″ diameter steel Nelson type studs and 5/8″ diameter lead anchors. The lead anchors are located midway between the stud anchors.

Decommissioning of the BGRR facility was initiated in 1968 and is scheduled to be completed in 2005. As part of the decommissioning process, the ¼″ thick inner binding plate, along with the crimped aluminum thermal shield sheets, have been removed from the exterior exhaust duct chambers. The ¼″ thick outer binding plate and 5/16″ thick concrete liner plate also have been removed from the floor areas and up to a height of 48″ from the wall areas of the duct chambers.

II. Scope of Work

Brookhaven National Laboratory assigned LiRo Engineers, Inc. the task of determining the capacity of the ½" diameter steel Nelson type stud anchors supporting the ¼" thick Outer Binding steel plate and 5/16" thick steel Concrete Liner plate on the full ceiling and a portion of the side walls of the concrete duct chamber.

No site visits were required as all pertinent information was obtained from the existing drawings provided to LiRo engineers by BNL personnel.

III. Analysis Approach and Method

Based on the information contained on the existing drawings provided by BNL, a computerized mathematical model of the remaining liner plate assembly and studs was simulated to represent the constructed condition. The one (1) ¼" and one (1) 5/16" thick steel plates are supported by ½" diameter steel Nelson type stud anchors spaced two (2) feet on center. The 5/8" diameter lead anchors were ignored in supporting the plates, as we were informed that some of these anchors are loose and therefore deemed incapable of carrying any load. A typical analysis width of 2 ft was considered for each assembly. The remaining liner plates are separated by a gap of 3 inches according to the detail "Typical Section of Nelson Studs", shown on drawing M-708-1A. The dead weight of the plates was the only considered load used in the analysis as no other additional loading is anticipated.

Finite Element Model Analysis was performed using STAAD III Structural Analysis Computer Program.

IV. Analysis Results

Our structural analysis results indicate low pull out and shear loads on Nelson type studs. These results were compared to the allowable values from the Nelson type Stud Catalog for 3000psi strength concrete. The results are as follows:

a. ***Analytical results***

A. Allowable Shear on ½" Nelson Type Studs = 2.22 kips
Calculated Shear on Stud = .11 Kips < 2.22 kips
OK

B. Allowable Tension Load on ½" Nelson Type Studs = 2.65 Kips
Calculated Tension on Stud = .10 kips < 2.65 Kips OK

C. Allowable Weak Axis Bending Stress on Plate = 27 ksi
Calculated Weak Axis Bending Stress = .25 ksi < 27 ksi OK

V. Recommendations

Since the calculated loads on the ½" Nelson studs, and the stresses in the liner plates are low, it is recommended that the plates may be left in place. Based on the safety margins it can be predicted that the system will remain safe for the next one hundred (100) years considering an overall 20% projected deterioration in the steel and concrete materials due to moisture and atmospheric conditions within the underground concrete duct.