CONF-860203--17

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MASTER

CONF-860203--17

DE86 008991

Paper to be presented at the 19th Midyear Topical Symposium of the Health Physics Society, Knoxville, Tennessee, February 2-6, 1986

*Operated by the Martin Marietta Energy Systems, Inc., under contract DE-AC05-84OR21400 with the U.S. Department of Energy.

PLACEMENT OF THE RADIOCHEMICAL PROCESSING PLANT AT OAK RIDGE NATIONAL LABORATORY INTO A SAFE STANDBY CONDITION

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ABSTRACT

Extensive upgrade, cleanup, and decontamination efforts are being conducted for appropriate areas in the Radiochemical Processing Plant (RPP) with the goal of achieving "safe standby" condition by the end of FY 1989. The ventilation system must maintain containment; thus, it is being upgraded via demolition and replacement of marginally adequate ductwork, fans, and control systems. Areas that are being decontaminated and stripped of various services (e.g., piping, ductwork, and process tanks) include hot cells, makeup rooms, and pipe tunnels. Operating equipment that is being decontaminated includes glove boxes and hoods. Replacement of the ventilation system and removal of equipment from pipe tunnels, cells, and makeup rooms are accomplished by contact labor by workers using proper attire, safety rules, and shielding. Removal of contaminated ductwork and piping is conducted with containment enclosures that are strategically located at breakpoints, and methods of separation are chosen to conform with health physics requirements. The methods of cutting contaminated piping and ductwork include portable reciprocating saws, pipe cutters, burning, and plasma torch. Specially designed containment enclosures will be used to prevent the spread of radioactive contamination while maintaining adequate ventilation.

INTRODUCTION

Work is under way to place the RPP into a "safe standby" condition by the end of FY 1989. This condition is similar to that defined as a type of decontamination and decommissioning (D&D) by the DOE Surplus Facilities Program, except that packaged, solidified radioactive materials will continue to be stored in the RPP in shielded, isolated storage wells. Services are being upgraded or replaced to maintain the plant in a safe mode while other areas are being decontaminated and isolated.

The RPP (Fig. 1), which is operated by the Pilot Plant Section of the Chemical Technology Division, includes the laboratory, glove box, shielded hot cell, and shielded storage facilities that are contained in Building 3019, as well as adjacent service facilities, which include the 3020 Ventilation Stack and the Building 3100 Storage Vault. Decontamination and decommissioning of the High Radiation Level Analytical Facility (HRLAF), located at the western end of Building 3019, is not discussed in this paper. This facility is now inactive and is the responsibility of the Analytical Chemistry Division. It is scheduled for decontamination and decommissioning starting in FY 1986. All facilities within the RPP are fully safeguarded such that multikilogram amounts of the fissile isotopes of uranium and plutonium may be stored and processed. Equipment in the shielded hot cells is operated remotely but is directly maintained. Many of the facilities have been in use for over 40 years. During this time, several well-known methods for nuclear fuel reprocessing (Purex, Thorex, Fluoride Volatility, etc.) have been developed and operated.

Since 1963, the RPP has been designated as the national repository for ^{233}U. Currently, in addition to facilities for processing high-purity ^{233}U, the RPP contains the Consolidated Edison Uranium Solidification Program (CEUSP) Facility, which is being used to convert a special batch of uranium (containing both ^{235}U and ^{233}U) from a nitrate solution to a solid oxide form. Also, the RPP contains the Plutonium-Uranium Microsphere Preparation (PUMP) Facility, which was used recently to prepare kilogram quantities of mixed oxide microspheres. In addition, several chemical laboratories and glove box facilities in the west end of Building 3019 were operated until recently by the Analytical Chemistry Division and were used to perform a variety of radiochemical analyses.

The piping, equipment, and hot cells are still contaminated with residual fission products (primarily ^{137}Cs and ^{90}Sr). However, the major contamination sources are alpha emitters, particularly plutonium, uranium, and the decay daughters of ^{232}U (Fig. 2). The key daughters governing most safety considerations are ^{220}Rn and ^{208}Tl. The ^{220}Rn is a gaseous decay product (half life = ~1 min) that creates a continuing source of airborne contamination. The ^{208}Tl emits a 2.6-MeV gamma ray, which dictates the degree of shielding that is needed. Also, the laboratories, hoods, and hot cells that were used for analytical chemistry purposes are contaminated with transplutonium actinides as well as fission products. The off-gas ducts and liquid drains from these facilities have been corroded extensively by the variety of chemicals that have been handled over the years.

This paper will describe the decontamination, decommissioning, and equipment replacement activities that are being carried out simultaneously with the solidification and storage of all radioactive materials now in liquid form. Replacement of the ventilation system and removal of equipment from pipe tunnels, cells, and makeup rooms are accomplished by contact labor using proper attire, safety rules, and shielding. Removal of contaminated ductwork and piping is conducted with containment enclosures strategically located at breakpoints, and methods of separation are chosen to conform with health physics requirements. Containment enclosures are designed to prevent the spread of radioactive contamination while maintaining adequate ventilation. The ventilation system, which is marginally adequate and must be improved to maintain containment with minimal surveillance, is being upgraded via demolition and replacement of ductwork, fans, and control systems. Hot cells, makeup rooms, and pipe tunnels are being decontaminated and stripped of various services (e.g., piping, ductwork, and process tanks). Operating equipment that is being decontaminated includes glove boxes, sample blisters, and hoods. Methods of cutting contaminated piping and ductwork include portable reciprocating saws, pipe cutters, burning, and plasma torch.

BASIC CONSIDERATIONS

Three activities are necessary for all decontamination and contaminated-equipment removal efforts: (1) detailed strategic planning of jobs before action is initiated; (2) design and construction of temporary containment, if needed; and (3) worker dress-out and preparation. The purpose of the intensive planning is to provide procedures sufficiently detailed to accomplish the job while preventing release of radioactive materials or excessive exposure of personnel. Breaching of any pipe, ductwork, or equipment requires extensive preparations to determine the condition of the equipment. Temporary containment enclosures are used to prevent spread of contamination when a contained area or piece of equipment must be opened. Worker dress-out is designed to give maximum protection from the intake of radioactive materials, particularly alpha contamination, which constitutes the major hazard within the plant.

Strategic Planning

For most nonroutine decontamination, a sequence of work is used to direct the work personnel. When there are high levels of either contamination or penetrating radiation, or under difficult working conditions, workers follow a written procedure that (1) gives step-by-step details specifying how and when the work is to be done and (2) tells workers what to expect and what action to take if problems arise.

The system for doing work on contaminated equipment in the RPP includes description of the work to be done, surveys and permits, work sequences, precautions, and procedures for abnormal conditions. The steps are as follows:

1. A work request is issued giving details for the proposed work to the Maintenance Coordinator (MC). (The MC is the liaison between operations and maintenance groups.)
2. If the work is complex, a conference is arranged. Input from appropriate sources is solicited, and a copy of the proposed work plan is provided to concerned parties.
3. The participants meet and reach a consensus on the adequacy of the work plan. If the plan is acceptable, the work may begin.
4. If the plan is not acceptable, changes are suggested by the participants, and the requested revisions or changes are then made by the originator. Any controversies are resolved by management.
5. A final review meeting is usually held to ensure that all participants are aware of the work plan.

Temporary Containment

Provisions for temporary containment are required when contaminated systems are opened, such as during replacement of glove box windows or when pipes or ducts are cut. The function of temporary containment is to prevent the spread of contamination that may be exposed during the operation. Control is achieved by proper construction, so that there are no significant paths of leakage to the outside, and by providing for a negative pressure inside the containment relative to the surrounding area, so that ventilation flow is always into the containment enclosure. In some applications, HEPA or roughing filters are built into the walls of the tent or containment structure to prevent backflow of contamination. An adequate flow of air into the work area also enhances protection of the working personnel.

Temporary containments are constructed according to standard designs, varying from single-layered plastic tents constructed on a wooden framework to multiple-layered, heavy-gauge plastic tents constructed on heavy frames, to plywood-framed enclosures. During demolition and replacement of the ventilation system ductwork outside the building, multiple containment enclosures were built 15 m off the ground on scaffolding that extended continuously for 30 m (see Fig. 3). Figure 4 shows a typical containment enclosure constructed for contamination control during piping work.

Worker Dress-out and Preparation

The basic dress-out procedure has been developed over a period of years and is designed to provide two layers of protection between the worker and the source of contamination. This procedure allows the outer layer of protection to be removed when exiting the contaminated area and thus limits the spread of contamination. The general procedure for dress-out is achieved by adding articles of clothing in the following order:

1. An inner pair of coveralls with contamination zone (C-Zone) shoes. Personnel pocket dosimeters and badge dosimeters are worn on the inner coveralls; however, in some cases, a self-reading pocket dosimeter may be worn on the outer layer when it is necessary to monitor the gamma radiation dose as the job progresses.
2. Inner shoe covers, which are taped to inner coveralls.
3. Outer coveralls.
4. Outer shoe covers, which are taped to the outer coveralls.
5. A pair of rubber gloves worn over a pair of thin cotton gloves; the rubber gloves are taped to the inner coveralls.
6. An outer pair of rubber gloves, which may be taped to the outer coveralls; however, for jobs where gloves will become contaminated rapidly, the outer coverall sleeves are taped to the inner coveralls and the gloves are left free.
7. A respirator.
8. A hood, which is taped on. Care must be taken to give enough space for freedom of movement.

The following items may be worn for specific jobs:

1. a vinyl suit over coveralls for short-term (<30-min) work or self-contained air-supplied suits for longer periods, in instances where water or other liquid may be encountered or very high levels of surface and/or airborne contamination are involved;
2. a safety harness and safety line outside of coveralls; and
3. overshoes, which are placed over shoe covers in cases where work on ladders or elevated platforms is conducted.

UPGRADING OF THE VENTILATION SYSTEM

Prior to the decision to move toward solidification and storage of all radioactive materials and placement of the processing equipment in standby condition, the ventilation system in the RPP was in need of upgrading. The ductwork in the system was predominantly carbon steel and had been corroded significantly, particularly in the western branches through which the Analytical Chemistry Division facilities were vented. Moreover, the emergency backup system for the two electrically driven fans was a single, steam-driven fan, whose operation required switching a series of electrically controlled, mechanically operated damper valves. Thus, the entire backup system was subject to failure if either the steam system, the turbine fan, the electrical controls, or the mechanically operated dampers failed. In addition, if an electrical power outage occurred, no further backup capability existed and the return to normal operation would require action by operating personnel who were not present during off-shift hours. The multifold dependency of the backup system mandated a high degree of surveillance and maintenance.

Thus, the decision was made to install a new ventilation off-gas system. This is now in progress. The replacement (Fig. 5) is to be more simply operated and will have a much higher degree of backup capability. In normal operation, it will have two electrically driven fans, each of which will have a backup. Any one of the four will be able to maintain safe conditions (negative pressures in the containment areas) if necessary. Emergency power for the fans will be provided by two diesel-powered generators, with each generator serving two fans. Rather than controlled dampers, only a simple backflow preventer damper in each fan exhaust line will be used. The new electrical control system will allow repeated switching of fans, as necessary, to provide continued backup capability. The new fans and ductwork will be of stainless steel construction.

The ductwork routing inside the plant is a patchwork of additions made over the years and does not provide optimum ventilation for all primary and secondary containment areas. Therefore, some rerouting will be necessary. Also, holes through which inleakage of unconditioned air occurs must be sealed to increase the negative pressure to desired levels.

Replacement of Contaminated Equipment

The ductwork being replaced in the ventilation system upgrading is not classified as transuranic waste. Most of it is contaminated internally with 30 to 700 Bq/g of transuranic plus nontransuranic radionuclides. Contamination levels in portions of the ductwork upstream of the filters range to >1500 Bq/100 cm^2. These levels dictate that, during the demolition procedures, the following dress-out is required: two pairs of coveralls, full mask, shoe covers, gloves, etc., as described earlier. Additionally, temporary containment enclosures are required to prevent the spread of contamination to the environment and to protect the workers from excessive internal contamination.

Much of the ductwork being demolished is in an elevated position and hence requires the construction of elaborate scaffolding to provide the workers easy access to the ductwork. Containment enclosures are constructed at each place along the scaffolding where the duct is to be separated. Separation is by flange disconnection or by cutting with a reciprocating saw; no burning is allowed. Containment enclosures are constructed not to be airtight but, rather, to be of sufficient integrity to minimize the probability that any dust reaches the environment. The tops are constructed to be removable so that, once the ductwork is broken free and capped, it can be lifted by a crane from the scaffold area to a truck below.

During demolition, it is necessary for all ductwork that is removed to be immediately capped at all ends, double wrapped in plastic, and taped. Ventilation is maintained through the ductwork until its removal. This is done by beginning the disassembly at the farthermost point from the fan (vacuum source) and proceeding toward the fan. The end of the duct at which the last flange break or saw cut took place is capped so that the inrush of air that occurs when the next flange is broken or the next cut is made will retain the contaminated dust inside the duct.

CLEANOUT OF HOT CELLS, GLOVE BOXES, AND CHEMICAL LABORATORIES

After completion of the processing operations to solidify and store all radioactive materials now in liquid form, the hot cells, glove boxes, and chemical laboratories will be cleaned and decontaminated sufficiently to permit secure containment by means of periodic custodial surveillance and maintenance.

Hot Cells

The RPP contains a bank of seven heavily shielded hot cells in which remotely operated and directly maintained radiochemical processing operations have been performed for many years. Most of the cells have square floor areas (~6 m × ~6 m) and are ~8 m high. One cell has only half the normal floor area, and two others are interconnected to form a large work space. All are shielded by 1.5-m-thick concrete walls and a 1.5-m-thick roof.

Most of the hot cells have personnel entry doors at the floor level and 2.7-m^2 equipment hatches in the roof. Equipment is transferred through the hatches to and from the high bay area (called "the penthouse") above the cells by means of a 10-ton bridge crane located in the penthouse. The chemical processing equipment consists of a variety of tanks (with a typical capacity of ~1 m^3), columns (5 to 15 cm in diameter and up to 11 m tall), pumps, and piping. There are numerous piping penetrations in the cell walls and roof which connect to accessory tanks, pumps, instrumentation, and utility services located above and adjacent to the cells. Ventilation air enters through the bottoms of most of the cells and is exhausted through ducts at the tops of the cells.

The cleanout that is planned for the hot cells will consist of (1) removing selected equipment, tanks, and piping from the cell floors and walls; (2) thorough flushing of the cell floors with water and detergents; (3) thorough flushing of the internals of the process equipment with nitric acid solutions and water, followed by purging with air to dry the equipment; (4) conducting a final radiation and contamination survey and mapping; and (5) disconnecting unnecessary utilities and process instrumentation. Cell lighting, fire prevention sprinklers, floor sump liquid level instrumentation, and cell ventilation air flow will continue in-service. The sump levels and cell pressures will be periodically monitored by surveillance personnel. Annual cell inspections are planned.

Over the past years of operation, numerous decontaminations of the RPP have been performed. These have involved surface cleaning, equipment removal, piping disconnection and removal, etc. Usually, the goal was to improve background radiation levels and to decrease surface contamination so that the operations could be continued or new equipment could be installed.

In one of the more extensive efforts, Cells 6 and 7 were decontaminated by a factor of 10^3 by removal of loose equipment, debris, and shielding blocks and by flushing with about 400 m^3 of various types of decontaminating reagents. This was accomplished during a 5-month period. The remaining traces of transferrable contamination were then immobilized. These efforts reduced the general beta-gamma background to 30 mR/h and the long-lived alpha contamination in the air to 8×10^{-13} μCi/mL.

Flushing of the cell surfaces was accomplished by means of a manually applied Seller's "super booster" hydraulic jet. Reagents (detergents, degreasing solutions, acids, caustics, etc.) were prepared and heated in feed tanks and jetted through a wand of 1.3-cm-diameter pipe fitted with a nozzle. Using high-pressure steam metered through the hydraulic jet, a flow of 10 L/s was delivered at a pressure of 1.4 MPa. The Seller's jet is still used periodically to clean the cell floors and will be used again in the planned cell cleanout.

Glove Boxes

The RPP contains numerous glove boxes, which are used for a variety of operations with plutonium, depleted uranium, and freshly purified ^{233}U. The most significant group is the ^{233}U Oxide Conversion Facility, which is used to produce $^{233}U_3O_8$ or $^{233}UO_2$ powder by the ammonium diuranate precipitation-calcination process. After solidification and storage of all ^{233}U have been completed, the glove boxes and the processing equipment contained in them will be cleaned thoroughly and placed into standby condition. The glove ports will be sealed with metal covers, and the ventilation system, which maintains negative pressure inside the boxes, will be left intact. Liquid supply pipelines and all unnecessary process instrumentation will be disconnected. However, instrumentation to measure the negative pressure inside certain strategic boxes will be maintained and kept under surveillance.

Glove boxes that are deteriorated, or are otherwise no longer useful, will be decontaminated (if possible) to the extent that the remaining contamination can be classified as nontransuranic waste. These boxes will then be disconnected, packaged, and sent to the low-level-waste burial ground. If a box cannot be decontaminated sufficiently, it must be packaged in specially designed metal boxes for shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

Chemical Laboratories

The chemical laboratories in the RPP have been used primarily for performing radiochemical analyses on many nuclides and solutions. Most of the preparative work, such as the separation of ^{90}Y from ^{90}Sr, was performed in fume hoods through which the laboratory room ventilation is exhausted. The analytical chemistry operations have been transferred to newer facilities at ORNL. Other low-activity-level process development work may be done in the RPP laboratories; therefore, the laboratory hoods have been cleaned and decontaminated. To perform the decontamination, direct contact methods were used by workers dressed in protective attire (as previously described) and guided by health physics surveys and monitoring. Liquid drain pipelines from the laboratory facilities have become contaminated and deteriorated; therefore, their replacement is being planned. A phased replacement, such as that being used for contaminated ducts in the ventilation system, will be used for the liquid drains.

REMOVAL OF CONTAMINATED SAMPLE BOTTLE CONVEYOR

During the peak years of the development of nuclear fuel reprocessing flowsheets at the RPP, a shielded conveyor system was installed to transport sample bottles from the processing area to the analytical chemistry facilities. The conveyor consists of a series of sample bottle carrier cups mounted between two chains that are moved by means of an electric drive motor from one terminal to the other. This configuration is surrounded by steel shielding (see Fig. 6) that is 10 to 50 cm thick.

During the years when the conveyor was used, several sample bottles fell out of the cups during transport and were broken inside the conveyor housing. Thus, the inside of the conveyor housing is highly contaminated with a variety of radionuclides, including actinides and fission products. In addition, rain water has leaked into certain areas of the housing and has caused the generation of contaminated rust debris. A high degree of health physics surveillance is required for the conveyor housing, and intensive decontamination efforts have been required on several occasions. This will not be practical after standby conditions have been reached; therefore, dismantling and removal of at least part of the conveyor system are being planned. Five methods of cutting the steel plates have been considered: plasma torch, portable hack saw, portable band saw, acetylene torch, and abrasive wheel. Current planning is focused on the portable hack saw or a portable acetylene torch; the hack saw is the more desirable choice because it will be much less likely to spread contamination to the air. Other provisions that will be needed to accomplish the job include (1) a 30-m-high, 20-ton crane; (2) extensive containments inside and outside the penthouse; (3) significant structural alterations to the supports for one corner of the penthouse; (4) removal and replacement of sheet metal from the sides of the penthouse corner; and (5) coordination of riggers, crane operators, iron workers, sheet metal workers, carpenters, health physics surveyors, and operations personnel.

SUMMARY

In summary, work is under way to put the RPP at ORNL into a safe standby condition by the end of FY 1989. This project requires that all radioactive materials now in liquid form be solidified and stored and that all processing facilities in the shielded hot cells, glove boxes, chemical laboratories, and accessory areas be decontaminated and cleaned to the extent that continued surveillance and maintenance activities are minimized. The ventilation system, which maintains a negative pressure in all primary and secondary containment zones, is being upgraded and will be maintained. In addition to special decontamination tools, basic considerations for the D&D activities include detailed strategic planning in advance of actual work, provision of temporary containment when needed, and careful attention to the details of worker dress-out and preparation.

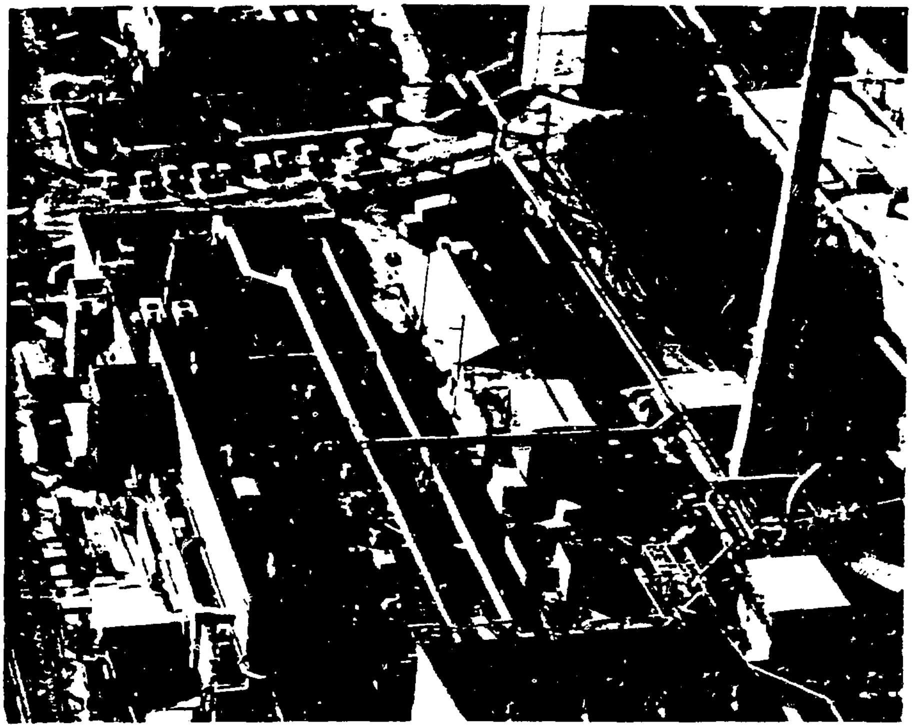

Figure 1. Aerial View of the RPP.

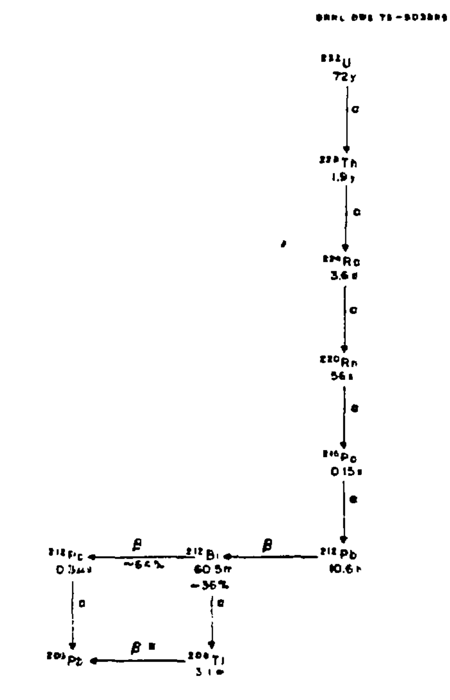

Figure 2. Decay Chain for ^{232}U.

Figure 3. Scaffolding for Ductwork Replacement.

Figure 4. Typical Containment Tent for Hot Work.

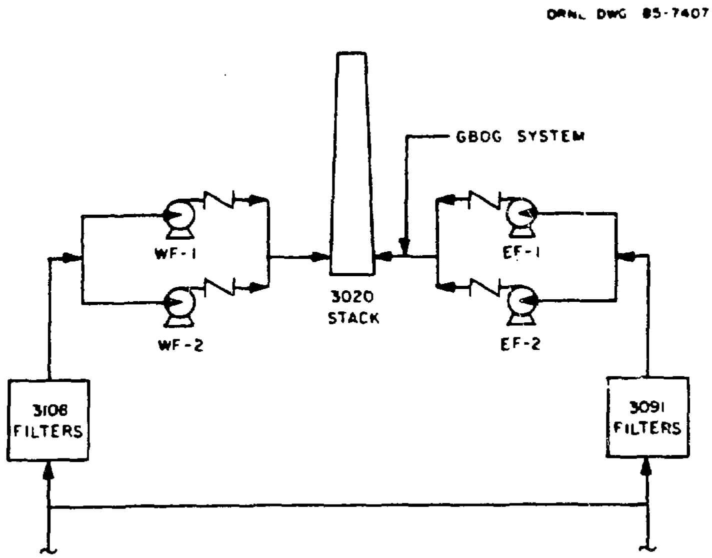

Figure 5. Schematic of New Ventilation System.

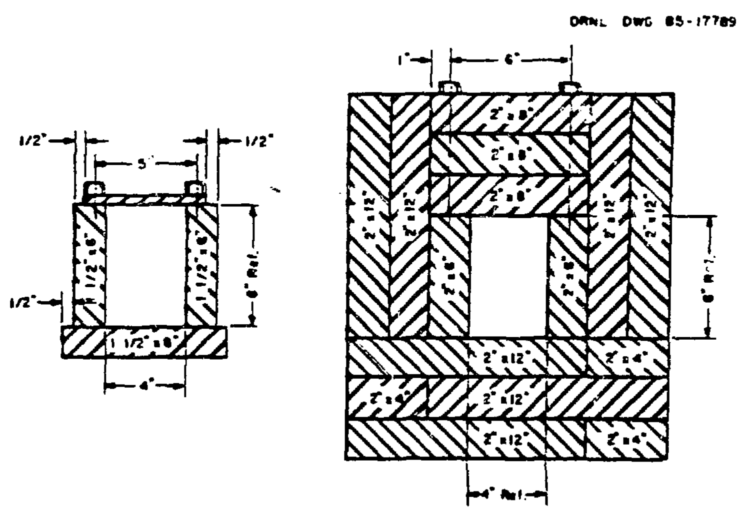

Figure 6. Typical Cross-Sections of Sample Conveyor.