A SYSTEM TO CONTROL CONTAMINATION DURING RETRIEVAL OF BURIED TRU WASTE*

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ABSTRACT

This paper discusses design features of a contamination control system for use during retrieval of buried transuranic (TRU) waste at the Idaho National Engineering Laboratory (INEL). Between 1952 and 1970 over 56,000m^3 of primarily Rocky Flats Plant (RFP) generated TRU waste was stored at the INEL in shallow land filled pits and trenches, which consisted of sludges, cloth, paper, metal, wood, concrete, and asphalt contaminated with micron-sized, oxidized particles of plutonium and americium. Retrieval for final disposal is one of the options being considered for this buried waste.

This contamination control system is an important subsystem of an overall retrieval system design involving containment buildings, remotely controlled excavators and transporters, separation systems, and final disposal options. The main contaminants to be controlled are plutonium and americium compounds associated with the TRU waste. The contamination control system is comprised of the Dust Suppression System (DSS) and a Rapid Monitoring System (RMS). The DSS is a grouping of subsystems including:a) the innerbuilding laminar flow ventilation system b) the Lifting and Moving System (LAMS) which provides mobility for c) the Contamination Suppression System (CSS). The RMS consits of state-of-the-art air monitors and detection systems for measuring loose contamination. To complement and guide the design effort, engineering background experimental studies were performed on the DSS and RMS. The results of these studies are summarized along with a discussion of the general design features.

INTRODUCTION

This paper discusses design features of a contamination control system for use during retrieval of buried transuranic (TRU) waste at the Idaho National Engineering Laboratory (INEL). Between 1952 and 1970 over 56,000m^3 of primarily Rocky Flats Plant (RFP) generated TRU waste was stored at the INEL in shallow land filled pits and trenches, which consisted of sludges, cloth, paper, metal, wood, concrete, and asphalt contaminated with micron-sized, oxidized particles of plutonium and americium. Retrieval for final disposal is one of the options being considered for this buried waste.

During FY-89 the INEL performed conceptual and preliminary designs for a remotely operated retrieval system that could be safely used in a hot demonstration retrieval of a buried pit at the INEL. The overall retrieval system design involves containment buildings, remotely controlled excavators and transporters, separation systems and final disposal options. The contamination control system reported herein is part of that system. However, the INEL is currently considering options for the buried TRU waste using CERCLA [Comprehensive Environmental Response, Compensation, and Liability Act] guidelines.

Under CERCLA a Remedial Investigation/Feasibility Study [RI/FS] will be performed where alternate technologies for handling the buried waste will be examined, including retrieval. To support this, the INEL is currently investigating features of retrieval thought to contain unknowns based on the FY-89 design work. Therefore, the design features of the contamination control system discussed in this paper will contribute toward establishing the data base on retrieval and will be used in actual buried waste retrieval if that is the option chosen for the INEL buried waste.

Previous INEL work on contamination control during retrieval [1] included a preconceptual design that involved maintaining the natural moisture content in the pits and trenches to reduce fugitive dust during excavation, a laminar flow ventilation system to control inner building air quality and effective monitoring of contamination spread. The philosophy of the contamination control system was to maintain a relatively radiologically clean operation allowing rapid personnel entry to perform routine and nonroutine maintenance on the remotely operated equipment. The design features discussed in this paper started with these concepts and expanded them into a systematic approach to controlling contamination during retrieval.

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Discussed first in this paper are the major features of the contamination control system that was primarily designed to control fugitive contaminated dust and provide rapid monitoring capabilities. Next, pertinent results of experimental engineering background studies are summarized. Finally, ongoing work on transuranic contamination control being performed at the INEL is discussed.

CONTAMINATION CONTROL SYSTEM DESIGN

The Contamination Control System consists of two major features: the Dust Suppression System (DSS) and a Rapid Monitoring System (RMS). The DSS is composed of the building laminar flow ventilation system, the Lifting and Moving System (LAMS), and the Contamination Suppression System (CSS). The RMS includes monitoring devices to track on-line airborne and loose plutonium contamination levels. The Contamination Control System discussed in this paper was designed primarily for application within the inner building where the excavation occurs. However, the design features developed for the inner building can be applied to other features of the overall retrieval system design such as in the separation area.

DUST SUPPRESSION SYSTEM (DSS)

The primary mechanism for the spread of plutonium/americium contamination is in the form of contaminants attached to fugitive aerosolized dust. [1] Therefore, by applying systems to control aerosolized dust, during retrieval, the contamination spread can be controlled.

Ventilation System

The laminar flow ventilation system is designed to provide air cleaning within the inner building of the overall retrieval system. This inner building will move along as the retrieval of the buried waste proceeds and therefore is fixed in volume. The approximate dimensions of this inner building are 30 ft high by 140 ft long by 60 ft wide. This inner building is like a plutonium handling facility glove box wherein approximately 50 room volume air changes will be changed each hour. Flow will be introduced in a back wall through an adjustable set of flow straightening baffles and flow control louvers and the nominal linear flow in the inner building near the dig face will be 40 ft/min. Flow will travel across the retrieval equipment and excavation dig face and will be collected in exit duct work that is connected to prefilters, High Efficiency Particulate Air (HEPA) filters, and an exhaust stack. In addition to the ventilation flow, the inner building will be maintained at negative pressure relative to the outer building that will additionally be at negative pressure relative to atmosphere. A schematic of the inner building with back wall is shown in Fig. 1.

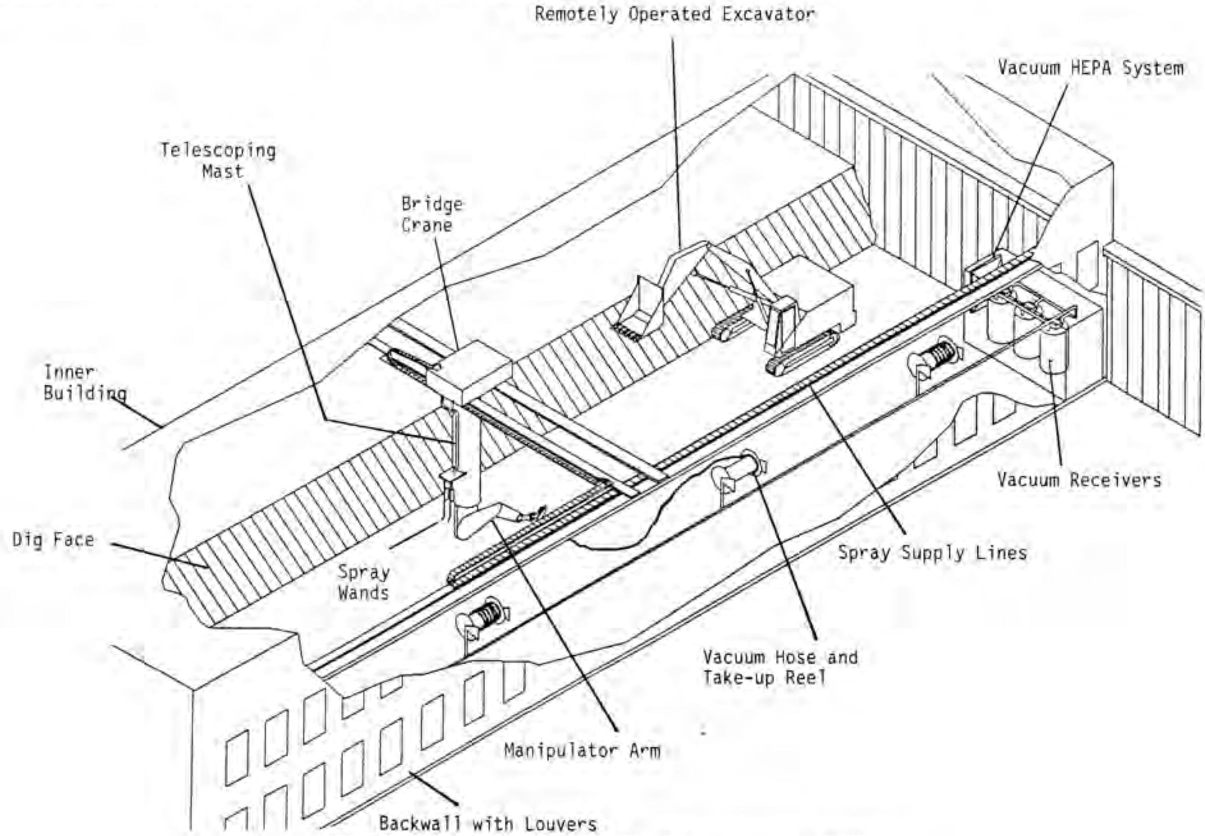

Fig. 1. Inner Building with Dust Suppression System.

Lifting and Moving System (LAMS)

An overhead crane and manipulator Lifting and Moving System (LAMS) provides mobility to the Contamination Suppression System (CSS) along with performing general lifting and moving functions within the inner building.

The major components of the LAMS (shown in Fig. 1) include an overhead crane with a telescoping mast and an one-arm, general-purpose manipulator mounted to the end of the mast. The LAMS has the capability to operate over the entire area of the inner building with the manipulator arm and is also capable of reaching the floor and the walls of the building. The LAMS is also capable of retracting sufficiently to allow the system to travel above the pit overburden.

The crane can make fast rate large distance movements that place the manipulator arm in position to provide a variety of precise tasks. The manipulator arm has been designed to provide a 200 lb payload at full arm extension of 6 ft. A 5000 lb capacity hook is also provided at the end of the mast for larger vertical lifts by the crane. The manipulator arm has sufficient mobility to rig the hook.

The LAMS is remote controlled from a fixed control station located up to 500m, from the excavation area. This remote operation of the system can be performed without direct visual contact of the crane manipulator arm because the LAMS is equipped with closed circuit televisions (CCTV) and lights. A camera and lights are mounted at the top of the mast and two cameras and lights are mounted at the base of the mast. The lights and camera automatically follow the end-effector so that the operator can devote his attention to the movement of the manipulator arm and the crane. The operator can manually override the controls and provide manual operation of the lights and cameras, if desired. Microphones will be placed at the manipulator arm to provide audio feed back to the operator. Along with the CCTV system, a collision avoidance system is aided by providing positional information of the LAMS to an overall system supervisory computer and by using a proximity sensor system to detect the presence of the objects within 6 ft of the base of the telescoping mast. The manipulator has a bilateral feedback system to allow the operator to directly experience the motion and forces acting upon the slave arm by reflecting the forces to the master arm at the control console.

In addition to teleoperation, the LAMS is also equipped with robotic operation by preprogramming moves of some functions of the LAMS. The robotic operation will be used for repetitive, routine operations such as positioning the LAMS to a home position, changing out end-effectors, grasping spray nozzles, positioning the spray wands, and retrieving RMS fallout coupons.

Contamination Suppression System (CSS)

The Contamination Suppression System, consists of subsystems to deliver dust control agents, moisture control agents, and provide local vacuum cleaning as shown in Fig. 1. It is designed for remote operation by the LAMS, but can also be manually operated, if necessary. The water, chemical, and power supply lines are designed to travel with the LAMS without obstructing equipment on the floor. The spray wands for delivery of the various sprays are located on the mast of the LAMS, within easy reach of the manipulator.

The dust control agent to reduce aerosolized dust is pressurized, demineralized water that is applied through an acoustically activated spray nozzle. This system was tested in engineering background studies[2] that will be discussed in a subsequent section of this paper. The spray rate is small [on the order of tenths of gpm] so that excessive humidity and mud is avoided. The nozzle generates an ultra-fine mist that is highly effective at capturing and removing contaminated dust from the air. In addition to the mist, dust suppression agents can be sprayed on the prepared floor near the excavation face to limit the generation of dust by movement of equipment.

A moisture control agent is used to prevent evaporation of the natural moisture from exposed surfaces. Tests[3] have shown that a moisture level of at least 15% will significantly reduce the generation of dust during retrieval operations. The most promising agent thus far experimentally[2] investigated is a proprietary, fast setting foam. The foam, a combination of water and nonhazardous reactants is mixed in a specially designed nozzle at the point of application and is effective for several months as a moisture and dust barrier.

The vacuum system, used to clean up debris spills on the operating floor or equipment, is recessed into the ventilation intake wall to conserve floor space as shown in Fig. 1. The receivers, positioned within a ventilated hood, are geometrically configurated to prevent a criticality and are also designed for remote replacement. The vacuum exhaust is HEPA filtered before to release back into the inner building. Hose reels are placed to minimize travel by the LAMS bridge.

A typical operating scenario for the LAMS and CSS would be as follows: During digging, the LAMS will be positioned off to the side of the excavator (see Fig. 1). While digging, the manipulator arm will direct a spray wand that delivers the dust control agent (a misting spray). After obtaining a bucket-full of waste, the excavator bucket will move to a position above a dumpster-transporter (not shown in Fig. 1). The excavated face will then be sprayed with a moisture control agent using a wand operated by the LAMS. The LAMS will then reposition the manipulator arm adjacent to the dumpster fill operation and provide a misting spray during dumping. Once the dumpster is filled, the moisture control agent is sprayed on the top surface of the dumpster to cover the waste with a foam material that acts as a dust and moisture barrier. The excavator bucket and LAMS/CSS components then move back to the dig face and repeat the cycle. Other contamination control functions will be to spray the entire dig face with the moisture control agent before encountering the waste. In addition, the vacuum system will be routinely used to clean expected dust on surfaces in the inner building.

RAPID MONITORING SYSTEM (RMS)

The RMS will provide "on-line" monitoring of airborne and loose plutonium/americium contamination within the inner building. In addition, the techniques developed for this inner building monitoring are applicable to other areas of retrieval including the separation/processing/storage systems. By maintaining "on-line" knowledge of airborne and loose contamination; established safety and operating limits can be followed. When considering manned, bubble-suited entry to the inner building, INEL safety conservatively has set the airborne contamination limit at 2×10^{-8} μCi/cc, which is 10000 times the Department of Energy maximum permissible concentration.

As retrieval operations proceed, examining ongoing trend levels of airborne and loose contamination the retrieval techniques and contamination suppression techniques can be altered to meet the limits. This strategy of a relatively low operating limit and on-line knowledge of the trend of contamination levels will expedite the overall retrieval process by reducing downtime for elaborate cleanup. The INEL philosophy on safety demands "no uptake" of plutonium and these low limits support this philosophy.

The RMS consists of alpha Continuous Air Monitors or, alpha CAM's, for measuring airborne concentrations, and radiochemistry and Alpha Liquid Scintillation (ALS) techniques for measuring loose contamination.

The fast response alpha CAMs are state-of-the-art devices used to measure the concentration of airborne plutonium in the presence of naturally occurring thorium and uranium daughters, some of which are also alpha- emitting radioisotopes. Studies[4] performed at the INEL on state-of-the-art CAMs showed, the possibility of a Pu-239 measurement of 2.6×10^{-12} μCi/cc in 1 h (1 h is essentially "real-time" monitoring for alpha contamination).

The ALS techniques were examined at the INEL[5] for measuring plutonium content on filters and smears for loose contamination measurements. Present techniques can allow 1 pCi/g analysis in 1 h for digested samples. In a laboratory adjacent to the retrieval inner building filters are dissolved in a special scintillation material, further digested by microwave, and counted in an ALS system.

Radiochemistry techniques are also under investigation at the INEL and preliminary results show the possibility of 1 pCi/g in 1 h for a sample. These techniques will allow processing of fallout coupons [which are simply filters and filter holders] from the inner building essentially "real-time" such that trend levels for loose contamination can be achieved.

ENGINEERING BACKGROUND STUDIES

To support these design efforts, a variety of engineering background studies involving actual plutonium contaminated dust were performed including studies to determine candidate misting and fixant agents to control fugitive dust and ventilation flow studies to examine the effectiveness of laminar flow to clear the air of aerosolized dust. Both studies[2,6] showed that the actual plutonium particles from the Rocky Flats Plant tend to attach to the larger non-respirable soil particles (particles >5 μm aerodynamic mean diameter). The implication of this finding is that there is an inherent safety factor in dealing with aerosolized contaminated dust. Only respirable particles present a potential for uptake and the larger nonrespirable particles have attached to them 95% of the TRU activity.

Dust and moisture control agents for use in the CSS were tested at the glove box scale with actual INEL soil types. Some technically feasible candidates have been identified.[2] However future testing is recommended for feasibility of delivery in the large scale [to examine clogging, nozzle designs, and piping designs,].

Ventilation studies[6] in a wind tunnel designed to simulate features of the inner building ventilation system showed that there are flow eddies around retrieval equipment suggesting possible areas where contamination may build during retrieval operation. In addition, based on clearing studies of an aerosolized dust cloud, laminar flows in the range of 35 to 40 fpm are sufficient to clear contaminated dust from the work area. The aerosolized dust deposited out inversely proportional to the distance from the dust cloud. In these flow rates, reverse flow [away from retrieval equipment] was not observed.

CONCLUSIONS/FUTURE WORK ON CONTAMINATION CONTROL

In conclusion, the INEL has developed a system to control the spread of TRU contamination during exhumation of buried waste pits and trenches. The system involves an apparatus that reduces contamination spread by controlling the fugitive contaminated dust particles and rapid monitoring capabilities to track airborne and loose contamination levels. Dust spread is controlled by applying misting sprays, foams, and dust suppression agents using a remotely operated robotic arm mobilized by a telescoping arm and bridge crane. Any remaining fugitive dust in the air is cleared by a laminar flow ventilation system. Rapid monitoring is achieved by using state-of-the-art, fast turnaround [2.6×10^{-12} μCi/cc in 1 h] alpha CAMs for airborne and ALS and radiochemistry techniques for loose contamination (fallout coupons and smears).

The design features discussed in this paper are considered at the preliminary design phase. Because of the current charter to support the CERCLA process for the INEL buried TRU waste, detailed design work and equipment await the outcome of the RI/FS; however, work to address unknowns in the retrieval process continues. In the contamination control area future work includes: refinement and documentation of radiochemistry techniques; examination of foam and misting system delivery systems for feasibility; examination of a bubble suit decontamination unit to reduce uptake during bubble suit removal; and examination of advanced contamination control techniques such as electrostatic curtains for repulsion, attraction, or neutralization of contaminated particles.

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