

Fluor Hanford ALARA Center

Weekly Activity Report for December 3, 2007

Assistance, Demonstrations, Research, and Tours Provided by the Center

1. Provided a tour of the ALARA Center to resident DNFSB representative.
2. The FH Respiratory Protection Committee and CH2M Industrial Hygiene Rep attended a demonstration by MSA (Mine Safety Appliance) at the ALARA Center. In attendance were the MSA regional sales manager and the MSA Head of Sales from the Corporate Office. The topic of the Demo was the new OPTIMAIR TL powered respirator. The system is a PAPR blower/filter housing that can be attached to a tight fit mask or a soft hood. The local sale rep discussed a number of new features with the OptimAir TL system. Many of these features that have come from resolution with problems with similar system from MSA and other vendor's equipment at Hanford. Contact Paul Steiger, MSA, at 509/939-1113 or Mike Schmoltd, Fluor Respiratory Site Tech Authority at 373-5116, or MSA web site at: www.MSAnet.com.
3. Forwarded info on Bladewerx Real-Time Airborne Alpha Monitoring to ALARA Coordinator at the DOE West Valley site. T-Plant Radcon will be testing the units soon. See <http://www.bladewerx.com/>

New Process, Tools, or General ALARA Information

1. Found a website for a company that is accomplishing some unique D&D work that may be useful at Hanford. Carter Technologies Co. is at <http://pages.prodigy.net/cartertech/> Carter Technologies is a pioneer in underground engineering using horizontal containment barriers, high pressure jet grouting, chemical stabilization, in-situ construction of barriers for environmental remediation, bio-remediation, custom grout design underwater grouting, and design to order inventions. Carter Technologies is a provider of construction technology, special materials, and consulting engineering for unique underground or environmental challenges. The website contains several photos of how to contain a burial ground in-place. At the upcoming Waste Management Symposium they are giving a presentation on using molten wax as a dust control agent during demolition. See photo below.



Molten Wax As A
Dust Control Agent F

2. Attached to the email is a newly revised list of the websites we use and vendors that we have had successful dealings. It is a living document and often changes daily. If we missed anything, please forward the info to L. Waggoner.
3. The 3-M rep set up a new display of their latest respiratory protection equipment. At the suggestion of B. DeLeon, we forwarded photos to HAMMER of the five vendor's displays set up at the ALARA Center of respiratory protection equipment. They will share the information with the

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instructors that teach respiratory protection at HAMMER. The vendors are Delta Protection, 3-M, MSA, Bullard and Scott.

4. A list of companies that have shielding on display at the Hanford ALARA Center, or that we have a first-hand recommendation that the company does quality work is attached. This list does not include all shielding manufactures. Additional shielding companies can be found by performing an internet search. Our intention is to provide a starting point for radiological or design engineers assigned to a shielding project. We encourage you to visit each site before making any shielding decisions. Please let us know if you think a company should be added to the list.



Custom Shielding
Companies.doc

If you are trying to shield gamma radiation, use high-density materials like lead, steel, or thick concrete. If you are trying to shield neutrons use materials that are rich in hydrogen like water, polyethylene, and boron. For beta radiation, use rubber matting or aluminum. Contact the ALARA Center for assistance.

Decommissioning and Deactivation Activities and Information

1. Lessons Learned: **We are not alone**. The National Air and Space Administration (NASA) is decommissioning their facilities and has a Newsletter to inform the public. See <http://www.lerc.nasa.gov/WWW/pbrf/newsletters/10-06newsletter.pdf> and <http://www.grc.nasa.gov/WWW/pbrf/newsletters/2-07.pdf> and <http://www.grc.nasa.gov/WWW/pbrf/newsletters/6-07newsletter.pdf>

2. Interested in decontaminating a room or hot cell using decontamination agents and foam? See <http://www.osti.gov/bridge/servlets/purl/10174861-fbs6j1/10174861.PDF> Found another interesting document on Demolition using Robots at <http://www.neimagazine.com/story.asp?storyCode=2029963> and another article on Nuclear Waste at <http://kanat.jsc.vsc.edu/student/grykien/mainpage.htm>

3. Read how glove boxes and barriers can be tested using fluorescent powder. <http://www.osti.gov/bridge/servlets/purl/266621-yN95fP/webviewable/> We use fluorescent powder obtained from Lynn Peavey Corp at <http://www.lynnpeavey.com/> The powder, and black light provide inexpensive way to simulate contamination. Read the Lesson Learned history from Deactivating the Hanford PUREX facility at http://www.osti.gov/bridge/product.biblio.jsp?query_id=0&page=5&osti_id=331596

4. Workers at INEL are preparing to ship highly radioactive TRU waste to WIPP. This waste has



3479754.pdf

to be handled remotely. Read about this process on the attached file.

Contacts

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Come visit us at the Fluor Hanford ALARA Center; we are located on the Hanford site at 2101M/200E/226. We will do our best to help you with your radiological engineering, ALARA, and D&D challenges. You can also send us questions, comments, and your lessons learned via e-mail or you can contact us by phone. Contact information is below.

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ALARA Center Website: www.hanford.gov/rl/?page=974&parent=973

Please help us keep our e-mail address list current by letting us know if you would like added or removed from our distribution, and by keeping us informed of any e-mail address changes. Thank you for your help. We look forward to hearing from you.

Molten Wax As A Dust Control Agent For Demolition Of Facilities

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ABSTRACT

Molten wax shows considerable promise as a fixative and dust control agent in demolition of radioactively contaminated facilities. Sticky molten wax, modified with special surfactants and wetting agents, is capable of not only coating materials but also penetrating into friable or dusty materials and making them incapable of becoming airborne during demolition. Wax also shows significant promise for stabilization of waste residuals that may be contained in buildings undergoing demolition. Some of the building materials that have been tested to date include concrete, wood, sheetrock, fiber insulation, lime, rock, and paper. Protective clothing, clay, sand, sulfur, and bentonite clay have been tested as surrogates for certain waste materials that may be encountered during building demolition. The paper describes several potential applications of molten wax for dust control in demolition of radioactive contaminated facilities.

As a case-study, this paper describes a research test performed for a pipeline closure project being completed by the Idaho Cleanup Project at the Idaho National Laboratory. The project plans to excavate and remove a section of buried Duriron drain piping containing highly radioactive and friable and 'flighty' waste residuals. A full-scale pipeline mockup containing simulated waste was buried in sand to simulate the direct-buried subsurface condition of the subject piping. The pipeline was pre-heated by drawing hot air through the line with a HEPA vacuum blower unit. Molten wax was pumped into the line and allowed to cool. The line was then broken apart in various places to evaluate the permeation performance of the wax. The wax fully permeated all the surrogate materials rendering them non-friable with a consistency similar to modeling clay. Based on the performance during the mockup, it is anticipated that the wax will be highly effective in controlling the spread of radiological contamination during pipe demolition activities.

INTRODUCTION

Demolition of radioactive contaminated facilities is complicated by the threat of airborne dispersal of minute particles of radioactive material that can originate from building debris and even the settled dust within such facilities. The presence of friable asbestos fibers found in many buildings undergoing demolition is also a concern. Traditional techniques, such as spraying these materials down with water or fog is somewhat effective, but it often creates other hazards and still requires the use of glove bags, boxes, or other contaminants. There are a number of spray-on coatings available but these do not have the ability to permeate inside the construction materials. When the building materials are broken up during demolition contaminated dust or friable asbestos fibers may still be released.

Molten Waxfix wax technology was originally designed for underground grouting work in radioactive contaminated burial sites but may have numerous applications in demolition of contaminated facilities. Due to the unusual surfactant properties of the special wax, it tends to penetrate into building materials and exposed surfaces. Pre-heating the materials can enhance this penetration effect. While the wax remains molten, it penetrates surfaces much like a light penetrating oil or gasoline. However once the wax cools, all the permeated material becomes a waterproof solid. Generally the wax can permeate through any material that would adsorb water or gasoline. This includes all fibrous materials such as wood but excludes metal, plastic and glass. The Waxfix molten wax used in this work is not brittle but malleable and slightly sticky at ambient temperature and has surfactant properties that allow it to displace water. Typical melting point of the non-flammable wax is about 51.6 Celsius (125F).

PERMEATING BUILDING MATERIALS

Tests have shown that the wax is able to permeate into concrete much as wax travels up the wick of a candle. The wax is not simply on the surface but in the microscopic pores of the material. Concrete floors and walls often have contamination that has entered into the surface of the concrete within the first quarter inch from the surface. Molten wax can permeate the first 6 millimeters, (0.25 inches) of concrete and tie up this contamination so that it is not released when the concrete is broken up. If the treated portion of concrete is crushed, no contaminated dust will be generated. Since contamination is often limited to the first few millimeters of a concrete surface, wax may be attractive as a pre-demolition agent.

The depth of penetration of the wax into concrete is a function of the relative temperatures and total mass heat capacity of the concrete compared to that of the wax pored on the concrete. The wax continues to flow until it cools enough to solidify. For example if a very thin layer of molten wax is simply sprayed onto a room temperature concrete slab in a thin film, the wax will not penetrate the concrete significantly because it is rapidly cooled by the greater thermal mass of the concrete. However if the slab is pre-heated to a temperature above the melting point of the wax by heat lamps and a 6 millimeter, (0.25 inch) deep pool of molten wax is applied over a large area at a high

temperature, the wax could easily penetrate 24 millimeters, (1inch) into the concrete depending on the permeability of that concrete. Ceiling and wall slabs may be permeated effectively by pre-heating the surface and spraying the wax through a fire hose nozzle. Penetration will always be limited by permeability of the concrete or covering materials. If an intact epoxy coating covers the concrete floor the permeation would be greatly impeded, but it will still penetrate in the area of any scratches in the coating.



Figure 1: Waxfix permeation and wicking action in shale rock

Materials with a low heat capacity such as ceiling tile, insulation and wood may not require pre-heating if deep penetration is not required, because the molten wax itself can carry enough heat to warm these materials to above the melting point of the wax. Asbestos in wallboard, insulation and ceiling tiles could be sprayed with sticky molten wax and then demolished immediately without release of airborne fibers. Disposal of the treated asbestos material may be completed more easily since the fibers are no longer dispersible.

Building interiors can be heated with radiant or forced air heating systems to achieve a high ambient temperature before treatment. For temporary buildings erected for excavation of contaminated soil, a molten wax may be spray applied to the interior before operations begin. After the work is complete a second spray application of wax will bond the contaminants into the layers of wax to facilitate dust-free demolition.

Tests in dry soil have shown that molten wax tends to give off vapor that can cement particles of sand together that are some distance above the areas contacted by the molten wax. It has also been noted that lab areas adjacent to vats of molten wax may be coated with a thin film of wax that appears to be vapor deposited. It may be possible that the

interior of buildings can be fogged with vapor phase wax to fix dust in inaccessible locations such as roof trusses and piping and wiring. This application has not been tested but seems feasible. Molten wax could also be applied as a vapor to air duct systems to fix contaminants in place without damaging the system.

SEALING OF GROUND SURFACE OVER TANK FARMS

Some tank farms such as those at the Hanford site have suffered ground contamination from liquid spills. Rain drives this contamination further downward toward the water table. Placing an impermeable cover over the bermed site is complicated by the myriad of pipes, wires, sensors and equipment that is buried in the gravel cover. The area over each tank is typically a gravel-covered area. A tanker truck of molten wax may supply molten wax through an instant heater that heats the wax to 300°F/149°C as it is sprayed out onto the gravel through a large hose. If the area is inaccessible to workers on foot the molten wax may be distributed through a concrete pumping boom. The wax will pass through the gravel, encapsulating potentially dusty contamination and will soak into the underlying soil and form a waterproof barrier layer.

CONTAMINATED LIQUIDS DISPOSAL

Molten wax can also aid in contaminated liquids disposal. Liquids that have been taken up by polymer or clay absorbents and placed in drums can be post treated by saturating them with molten wax to produce a more secure disposal waste form. Liquids disposal can be difficult and costly. Polymer beads are commercially available from several manufacturers in various type that can that can absorb either organic or water based liquids. A partially full drum of liquid may be solidified in just a few minutes by simply pouring a quantity of these beads into the drum. However the polymer beads remain wet to the touch and the liquids can still evaporate or leach. The sorbed beads can be mixed with cement but there remains some potential for release. The beads can be incinerated or processed into glass but this is very costly.

Instead of making glass, drums of the sorbed polymer material can be microencapsulated using molten wax at a nominal cost. The drum is placed in a warming room to raise the temperature of the material to above the melting point of the wax. (130 F. to 170F melt point available) Then molten wax is introduced into the drum to displace all of the air out of the drum and fill the void space between the absorbent beads. The wax will also permeate into the surface of the beads forming a waterproof and air-tight seal around each one. The drum may then be topped off with wax, sealed and removed to ambient temperature. During cooling, a head of molten wax will be maintained on the drum to eliminate formation of any headspace in the drum. The lack of headspace will reduce the potential for development of gas pressure from radioactive decay, as any gas evolved will remain distributed and trapped in the sticky wax.

CASE STUDY:

WAX AS A PENETRATING FIXATIVE FOR SEDIMENT IN BURIED PIPES

As part of a remediation project being conducted by the Idaho Cleanup Project at the Idaho National Laboratory, a buried drain line that runs between a hot cell facility and a tank system will be excavated, sectioned, removed, and packaged for disposal. The line is constructed of four inch Duriron bell and spigot pipe and contains up to 38 millimeters, (1.5 inches) of highly radioactive dry, friable, crusty sediment. Duriron Pipe is a high silicon cast iron that is corrosion resistant but so hard and brittle that it cannot be cut with a saw but must be broken with a snap-cutter tool. The line is buried between up to 3 meters, (10 feet) deep and is approximately 45 meters, (150 feet) long.

The pipe material construction necessitates a snap cut, and the direct radiation fields associated with the pipe necessitate remote operations. It is desirable to employ an effective fixative to the interior surfaces of the pipe and the residuals contained in the pipe to eliminate the potential for contamination spread during the remote pipe snap-cutting, retrieval, and packaging. The project has previously investigated a variety of commercially available fixative materials to fill and stabilize the pipe before sectioning. Previous tests indicated that though the tested fixatives filled the void space they did not penetrate into the sediment, thus the dry unconsolidated sediment could still pose a contamination control problem during piping removal operations. Project management and engineering personnel decided to perform tests using an innovative penetrating grout made from molten wax. In theory, the molten wax would coat the interior surfaces of the pipe and saturate the sediment in the pipe and convert it into a malleable and non-dusty material before the pipe is broken.

TEST PIPE SETUP

A near full-scale test was conducted under contract to CH2M-WG IDAHO to verify that the Waxfix fixative process could meet project requirements while also meeting site safety and operational requirements. A test loop of 6 Duriron pipe segments, 2 half segments and 6 bends was prepared for the full-scale mockup test. Pairs of 2 pipes each were arranged in 3 parallel rows on the shop floor connected by U bends. Another 90-degree bend and a vertical riser of Duriron pipe was installed on each end about 4 feet high. The test setup utilized about 16.8 meters, (55 feet) of 101.6 millimeter, (4 inch) Inside diameter Duriron pipe set up in a loop on blocks in a bed of sand and covered with a foot of soil to simulate burial. Temperature probes were attached to the outside of each joint of pipe. Prior to assembly of the pipe loop, each joint of pipe was partially filled with a different waste surrogate. The chemical composition of the sediment in the real pipe was unknown but a video camera inspection had shown it to be a hard and crusty deposit with the potential to be dusty when broken. Surrogates used were:

- Dry Bentonite Clay with a coating of hard cement grout
- High strength concrete made with cement, sand and bentonite.
- Dry Portland Cement with a hard cap formed by sodium silicate
- Dry hydrated Lime with a hard cap formed by sodium silicate
- Dry mixture of cement, sulfur, plaster and flyash with a hard cap formed by sodium silicate

- A Dry mixture of Portland cement, ground blast furnace slag, and bentonite clay with a hard cap formed by sodium silicate

The last four materials have sodium silicate sprayed on the top surface to simulate the hard crusty surface seen in the video inspection. Sodium silicate reacts with cement or lime to form a hard impermeable surface. The surrogate materials are intended to represent a range of permeability and to be dusty when broken. The surrogate material was loaded into each Duriron pipe using a half-section of 4" PVC pipe. The Duriron pipe was then rolled over to place a uniform layer of surrogate on the "floor" of the pipe. The thickness of the surrogate varied from 38 millimeters, (1-1/2 inch) thick to 63 millimeters, (2-1/2 inches) thick. The thicker areas are intended to simulate partial blockages that may possibly exist in the un-inspected areas of subject piping.

PROCEDURE

An 8.8-kilowatt (30,000 BTU) x 8.5 cubic meter, (300 CFM) forced air propane heater was fitted to the pipe riser on one end of the mockup. This heater, with a 178-millimeter, (7-inch) diameter tubular body and a continuous ignition system was able to heat the entire pipe to over 82 Celsius, (180 degrees F) in less than 4 hours. The simulated waste in the Duriron pipe left an airflow path as small as 19 square centimeters, (3 square inches) in places so achieving the desired high airflow rate could not be done by the small fan of the heater alone. An industrial 6.5 horsepower shop vacuum with HEPA filter was connected to the discharge end of the line to increase the airflow rate and maintain the pipe at negative pressure. A simple heat exchanger made of aluminum air ducting was used to reduce the inlet temperature to the shop vacuum. This method produced a robust airflow estimated at 8.5 cubic meter, (300 CFM) that proved very effective at heating the Duriron pipe.

After heating the pipe for 4 hours, all areas were at least 82 Celsius, (180 degrees F). A hand pump was used to transfer molten Waxfix grout from a heated drum into the test pipe. Transfer was ended when the standpipe on both ends of the test loop filled to near the top. Additional molten wax was added every hour to maintain the system full as the wax permeated into the surrogate material. The pipe remained hot above the 51.6 Celsius, (125 degree F) melting point of the wax for about 6 hours.

The next day all the soil was removed (See Fig 2) and the pipe was broken with a snap-cutter in over 20 places to evaluate the effectiveness of the treatment. (See Fig 3) The molten wax completely permeated all of the surrogate materials. The dusty material became non-dusty and slightly sticky. Some other places were broken with a large hammer to demonstrate that the surrogate materials had been completely permeated and rendered non-friable and non-dusty. (See Fig 4)



Figure 2: Pipe test loop after wax treatment and removal of soil



Figure 3: Top left to right pipe 6, 5, and 4 and bottom left to right pipe 3, 1, and 2



Figure 4: Pipe 1, Dry bentonite surrogate with cement grout cap, broken with hammer

Mockup testing indicates that the wax fixative appears to be highly effective as a stabilization media for use in buried piping containing waste residuals in situations in which contamination control is critical. The molten wax coats the interior of the piping and completely permeates all tested waste surrogates. This allows sectioning of the piping while mitigating the potential for a dry, dusty, friable waste residuals to become airborne. This is of particular importance with remote operations, with cutting techniques such as snap cutting in which significant energy is imparted to the pipe being cut and with highly 'flighty' radiologically-contaminated material.

The most critical aspect of the use of molten wax as demonstrated in the mockup is the pre-heating of the piping and waste residuals. While pre-heating of the pipe is not strictly necessary with a relatively short pipe, it serves to increase the degree of permeation with unknown sediment materials. The hot air-flow method of heating was selected because it could be performed at negative pressure and it provides a slow and predictable temperature rise. The concurrent heating of the soil around the pipe will allow molten wax encapsulation of adjacent soil if historical leakage has occurred.

As a result of the excellent results observed during the mockup, it is anticipated that the process will undergo further testing during upcoming integrated mockup activities and will be used during actual remediation of the subject piping.

CONCLUSIONS

Molten wax has many potential applications for safe decommissioning and demolition of radioactively contaminated facilities. It can be used on both wooden, metal, and concrete structures. It can be sprayed onto surfaces as a coating but it can also be applied as a penetrating fixative and waterproofing agent. Wax is likely to be especially useful for asbestos fiber materials. It can also be used to waterproof soil over a tank farm site. Molten wax is relatively low cost at about eight dollars per gallon and can be heated and applied from a steel drum that can be handled by commonly available equipment. In larger applications wax can be delivered to a site as a molten liquid in common carrier tanker trucks. Molten wax can also be useful as a low-tech method of treating radioactive liquid waste at a much lower cost than comparable methods.

FH ALARA Center List of Custom Shielding Companies

Rev. 0

Below is a list of companies that have shielding on display at the Hanford ALARA Center, or that we have a first-hand recommendation that the company does quality work. This list does not include all shielding manufactures. Additional shielding companies can be found by performing an internet search. Our intention is to provide a starting point for radiological and design engineers assigned to a shielding project. We encourage you to visit each site before making any shielding decisions.

Company Name	Contact Information	Notes
ecoMASS	www.ecomass.com (512) 306-0020	Non-Hazardous/nontoxic pellets or molded parts.
Transco	(312) 427-2818 www.transcoproducts.com	Shielding metal reflective insulation lead, or stainless.
Newport News Industrial HotGuard Radiation Shielding	www.nni.nns.com (800) 627-0353	Non-Hazardous materials, can be ordered in sheets and cut to fit.
NFSRPS Radiation Protection Systems	www.rpsct.com www.nfsrps.com (904) 285-9814	Mobile shield wall, shield boots, survey caves, blankets.
R. L. Mussman	(360) 874-0153 www.rlmussman.com	Coated lead molded to piping.
Hot Cell Services A Sovis Company	www.hotcell.com (253) 854-4945	Radiation shielding windows, lead glass bricks and slabs, shielded gloveboxes, view ports.
TRI-E Radiation Technologies	www.trietechnologies.com (513) 870-3844	Gamma-guard technology Neutron guard technology Super absorbent complex polymer technology.
Innovative Industrial Solutions	http://www.i-i-s.net/products/radishield.aspx (501) 968-4266	Non-hazardous synthetic composite that can come in sheets, pipe wrap, or custom molded. Radishield shielding.

**FH ALARA Center List of
Custom Shielding Companies**
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Nuclear Lead Company	www.nuclearlead.com (800) 621-5848	Molded lead to fit the application or lead walls.
Dufrane Nuclear Shielding	http://www.dufrane.com/ (860) 589-2098	Drum shields, frisker caves, water shields, water window shields, high density concrete.
Nuclear Power Outfitters	www.alarasolutions.com (815) 344-1166	Lead blankets, bricks, racks, etc.
Thermo Electron Corporation	www.thermo.com/rmp (505) 428-3535	Custom lead fit lead blankets.
Lancs Industries	www.lancsindustries.com (425) 823-6634	Lead blankets, bricks, racks, etc.
Frham Safety	www.frhamsafety.com (615) 254-0841	Lead blankets, bricks, racks and Radishield shielding.
G/O Corporation	www.gocorp.com (800) 933-8501	Lead blankets, bricks, racks, etc.

Remote Handling Equipment for a High- Level Waste Waste Package Closure System

International High-Level Radioactive
Waste Management Conference

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The INL is a
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operated by
Battelle Energy Alliance



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Remote Handling Equipment for a High-Level Waste Waste Package Closure System

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Abstract – High-level waste will be placed in sealed waste packages inside a shielded closure cell. The Idaho National Laboratory (INL) has designed a system for closing the waste packages including all cell interior equipment and support systems. This paper discusses the material handling aspects of the equipment used and operations that will take place as part of the waste package closure operations. Prior to construction, the cell and support system will be assembled in a full-scale mockup at INL.

I. BACKGROUND

Nuclear reactors for the generation of energy and conducting research have been in existence for more than 50 years. Spent nuclear fuel (SNF) and associated high-level waste (HLW) have accumulated in temporary storage as a result of these activities. Locations for a geological repository have been evaluated for permanent disposal of the SNF and HLW.

During repository operations, commercial and government-owned SNF and HLW will be loaded into casks and shipped to a repository. Materials will be transferred from the casks into waste packages (WPs), closed, and placed into an underground disposal site. Closure operations include placing lids onto the WP and welding the lids onto the container, filling the inner container with an inert gas, performing nondestructive examinations on welds, conducting stress mitigation and material handling. All WP loading and closure operations will be performed in hot cells.

To fulfill this need, INL has been contracted to design, build, and demonstrate a full-scale mockup of the proposed closure cell. The INL system mockup may also be transferred to the contractor and used for operator training.

II. OPERATIONAL AND DESIGN ISSUES

There are a number of issues associated with material handling in a closure cell. These issues are tied to the operations that are required for the remote delivery or retrieval of a wide variety of equipment and materials necessary for WP closure

or to the support of that closure equipment. The primary output from the closure cell is a correctly sealed and tested WP that may then be placed in a repository.

A typical closure cell may be 30 ft wide × 40 ft long × 29 ft high (inside dimensions). The layout of the cell is focused around an engineered hole in the floor, providing access to the WP containing radioactive material. The top of the WP is positioned within this hole by facility operations within a predetermined tolerance range. An elevation view of a closure cell is shown in Figure 1.

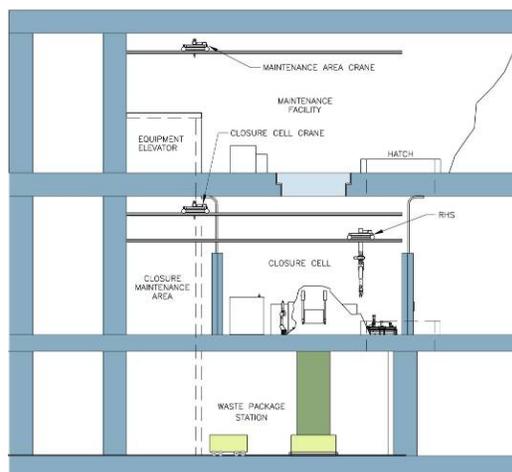


Fig. 1. An elevation view of a typical closure cell.

All material handling operations are performed remotely because of the high radiation fields expected from the WP. This includes all WP

closure, maintenance, repair, and replacement operations.^a Although not described in detail in this paper, the WP is seal welded and inspected by two robotic manipulators mounted on a carriage assembly around the access hole. In addition, the closure cell includes numerous strategically placed lights and cameras. Design for remote operations makes operations inside the cell as cost effective and productive as possible.

III. CLOSURE CELL DESCRIPTION, CAPABILITIES, AND PERFORMANCE

The closure cell handling equipment is designed, built, and installed using standard off-the-shelf equipment to the maximum extent possible. This approach allows components and component assemblies to be readily exchanged, minimizing downtime. A modular equipment philosophy is also being adopted to assist in maintenance and repair operations. Using a modular approach ensures that components and systems can be designed, fabricated, and installed with a minimum of interface and operational readiness problems. Repair and replacement of equipment is also made easier because of modularity.

IV. PRIMARY COMPONENTS AND SUBASSEMBLIES

Closure cell remote handling systems (RHSs) are composed of a variety of equipment and systems located both within the closure cell environment and outside the closure cell in an adjacent support area. Within the closure cell are the RHS, master-slave manipulators (MSMs) and the overhead bridge crane (OHC). In the closure cell support area is a manually operated overhead crane and a glovebox assembly that contains a materials/equipment transfer cart and an overhead manipulator system, both remotely operated. The operator end of the MSMs is located in the closure operating gallery. Each of these systems will be described in greater detail in subsequent sections. A layout of the closure cell, closure support area, and closure operating gallery is shown in Figure 2.

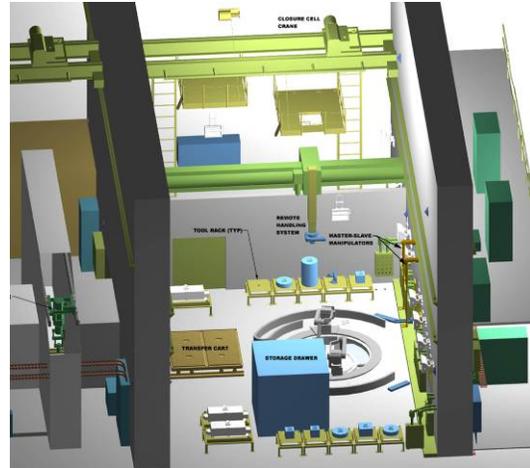


Fig. 2. A preliminary view of the closure cell and associated areas.

IV.A. Closure Cell

IV.A.1. Remote Handling System

The RHS provides for the bulk of equipment and material handling operations within the closure cell. It is an integrated system composed of an overhead bridge assembly (which runs on wall mounted rails), an accompanying trolley assembly, and a telescoping mast assembly. The mast assembly includes a rotary actuator and remote tool interface plate, which provides for rotation of attached tools and equipment. This remote tool interface plate allows the interchange of a variety of tools and equipment needed to perform operations inside the closure cell. Tool plates function by disconnecting into two parts. The main part of the tool plate is attached to the bottom of the telescoping mast. Services (electric, pneumatic, hydraulic, data, etc.) pass through the main part to mating tool plate, which interfaces with tools and equipment used inside the cell. Tool plates mount to the telescoping mast through a compliance device that accommodates mismatched interface surfaces during connection and disconnection operations.^b A view of the preliminary mast, rotator, compliance device, and tool plate interface are shown in Figure 3.

^a Manned entry is possible when no waste package is in place. The totally remote aspect is necessary when a waste package is in place in the closure cell and problems arise.

^b Depending on the positional capability of the final control and machine vision systems, all the axes provided by the compliance device may not be required for this application.

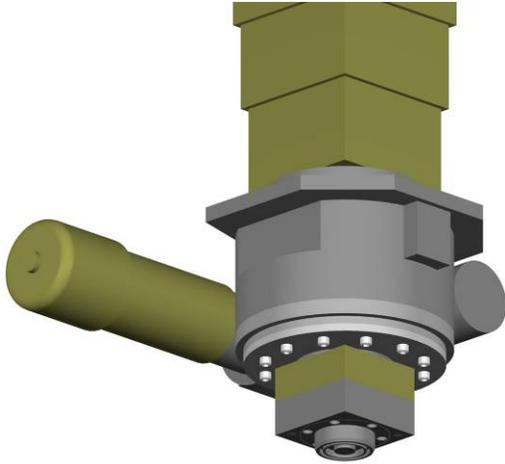


Fig. 3. A view of the mast, rotary, compliance, and tool plate equipment.

Another primary tool that connects at the bottom of the mast is a remotely operated manipulator system. The manipulator is teleoperated and provides for dexterous arm operations within the cell. Operations using the manipulator include such items as assisting with cable and hose management issues, retrieval of dropped tools and equipment, repair and replacement of equipment in the cell, and other necessary operations. This type of manipulator is standard in situations where remote handling operations are required. Experience has shown that they are essential for handling off-normal situations, especially in hazardous environments.

The manipulator itself adds flexibility to the operations with an interchangeable tool interface. A variety of tools may be used with the arm including grippers, hooks, and other special end effectors. The RHS (including the manipulator) is graphically depicted in Figure 4.

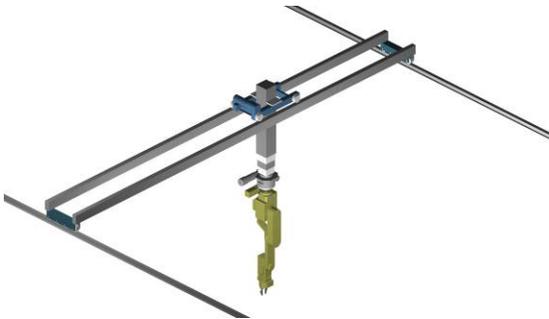


Fig. 4. The RHS consists of a bridge, trolley, mast, and removable manipulator.

The RHS is operable in either teleoperated or robotic mode. Teleoperated mode will be used when dealing with an off-normal situation. That is, an event where it is not feasible to operate the system in robotic mode or it is not prudent to do so. An example of this would be to pick up an item that has fallen to the floor. Another example may be to untangle twisted wires, hoses, or cables. Some repair and replacement of items in the cell may also be teleoperated. Teleoperation activities require supplemented vision. Therefore, 3-D stereovision will be used to supplement the operator's vision during teleoperation activities.

Robotic mode provides for preprogrammed and automated moving of the RHS. This mode will be used primarily in pick-and-place applications that are "routine." Preprogramming of the RHS will be performed to assist operations in performing accurate work with repeatability. Programming of the RHS will be supplemented with machine vision technology. This technology provides significantly higher precision and confidence of alignment than a typically instrumented bridge/mast system. Machine vision aids in positioning of the RHS relative to selected objects for placement, connection, and disconnection operations. Ultimately, this will increase productivity and reduce the opportunity for operator error. Each closure cell includes one RHS. The INL mockup includes one RHS unit to confirm the positioning capability and verify material handling tasks.

IV.A.2. Master-Slave Manipulators

The MSMs are teleoperated devices used primarily in hazardous material handling operations. MSMs have a long and distinguished history of success in working in hazardous environments. They, because of their design and physical interface, become an extension of the operator's hands and arms. As such, they provide the ability to perform work precisely and accurately. Although payload is limited compared with other types of manipulators (such as hydraulic or pneumatic assisted), operators can perform tasks requiring finesse, handling of small pieces and parts, and assembly/disassembly of equipment. In this application the MSMs are needed to support the welding robots that are being used to seal weld the WPs. The center line of the access hole, where the MSM must reach, is located 10 feet from the cell interior wall. Because this distance is beyond the nominal work envelope of the MSMs, the MSMs are factory modified to provide reach

beyond their normal range of motion. Each closure cell requires one pair of master-slave units. The INL mockup includes one pair for the demonstration.

IV.A.3. Closure Cell Bridge Crane

An overhead bridge crane is installed on a rail system, located near the ceiling of the cells. It will be positioned above the RHS to preclude collisions or unintentional contact between them. A 15-ton crane is specified for this application. This will provide adequate lifting capability for materials and equipment planned for the cells.

The crane is remotely operated from the closure operating gallery control consoles. Control is primarily by video cameras. Limited line of sight viewing is available at the cell windows. The crane includes an upper limit indicator to identify when the crane hook is stowed in its upper position. Supervisory control is implemented to preclude collisions of the crane hook or cable with the RHS as equipment is moved around the cell. At present, the RHS equipment has priority of motion within the cells. Crane motions are designated as secondary. A typical overhead crane is shown in Figure 5.

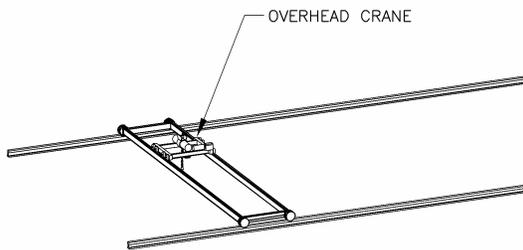


Fig. 5. The closure cell will have an overhead crane to provide heavy lift support.

IV.A.4. Miscellaneous Closure Cell Equipment

Within the closure cell are a number of tools and pieces of equipment that support WP closure operations. The RHS transports this equipment within the cell. Depending on their function, these tools include a remote interface (for the RHS) or hoist rings for the crane or both. A listing of major tools is provided as follows:

- Tool racks — The tool racks provide a storage location for the tools when not in use.
- Storage drawers — The drawer assembly is an engineered cabinet with drawers. It provides for storage of the two lids that are ultimately welded onto the WP. It resembles a large file cabinet. The drawers also provide lay down area for several large, round, and flat pieces of equipment that are used to perform calibrated leak checking of finished welds on the WP.
- Lid lifting tool — This tool provides for movement of the WP lids from the glovebox transfer cart to the storage drawer and then to the WP.
- Evacuation rings — These are large donut shaped rings that are sized and used for leak testing finished welds on the WP. They are installed on the WP by the RHS, perform a calibrated leak test, and are replaced back into the storage drawer.
- Leak detection probe tool — This is a specialized tool used to detect the exact location of leaks in a WP weld. It is transported by the RHS to and from the WP.
- Hardware Device Control Module (HDCM) — This is a portable power/utility unit that interfaces with tools, allowing the RHS to perform other activities while equipment at the WP perform their intended functions. It is placed on the tool either prior to picking the tool up and placing it on the WP or after the tool has been placed on the WP.
- Purge port tool — This is an engineered system that provides for evacuation, and backfilling the inside of the WP, torquing a threaded plug in the inner lid, and leak testing the plug area.
- Stress mitigation tool — This tool is moved to and from the WP by the RHS and is used to reduce tensile stresses in the WP welds.

Other tools and equipment may be necessary to support closure of the WP in the closure cell. The above list represents the main items identified to date. A plan view layout of the closure cell and items discussed above is provided in Figure 6.

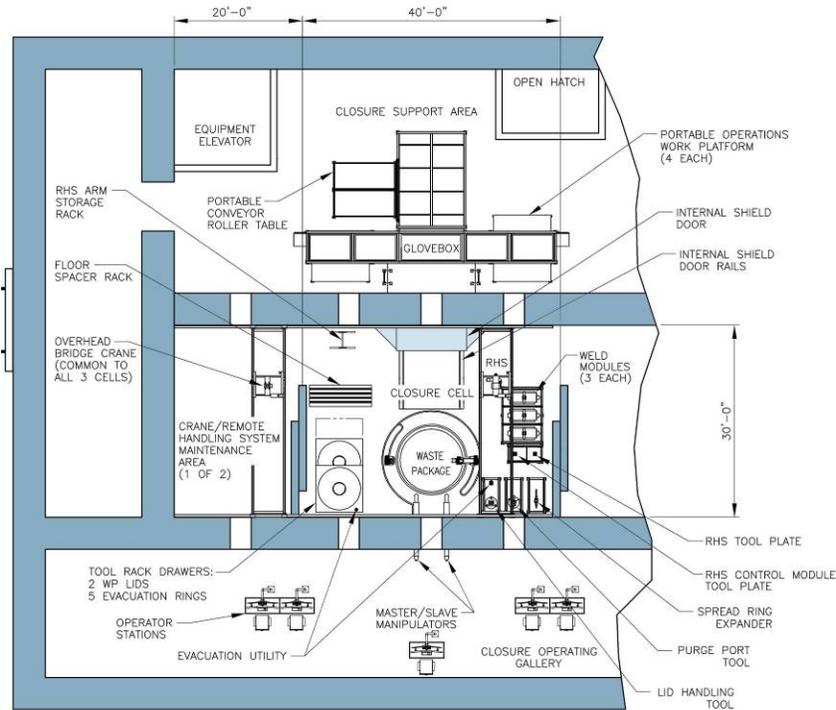


Fig. 6. A plan view of the closure cell layout and associated areas.

IV.B. Support Area

IV.B.1. Glovebox Assembly

The glovebox subsystem offers a safe and simple approach to supporting closure cell activities while protecting personnel from radiation and contamination. The design allows all material handling, servicing, maintenance, and packaging to be conducted within a contaminant confinement by personnel outside the confinement. Glovebox confinement consists of a transfer tunnel and a maintenance glovebox, as shown in Figure 7. The transfer tunnel connects a load-in area, glovebox area, transition area, and closure cell for moving materials into and out of the closure cell. Equipment is maintained and serviced in the maintenance area of the glovebox.

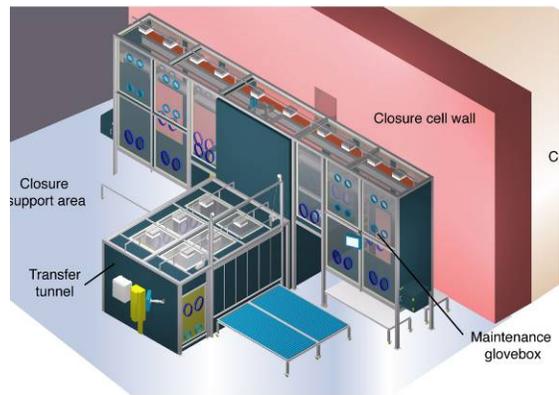


Fig. 7. The glovebox assembly is a multifunction enclosure for material movement, equipment service, and repair.

The glovebox provides the capability to transfer materials as well as service and repair equipment brought from the closure cell. A transfer cart and shield doors are installed within the transfer tunnel. It is coupled to the wall of the closure cell and directly connected to the glovebox wings that are reserved for equipment maintenance and repair operations. The wings of the glovebox include see-through windows, gloveports and gloves, and a glovebox handling system (GHS). The GHS includes an overhead bridge, trolley, and telescoping mast. The GHS, shown in Figure 8, transfers equipment between the transfer cart and the glovebox wings and articulates tools and equipment within the glovebox envelope. The controls are similar to the closure cell RHS.

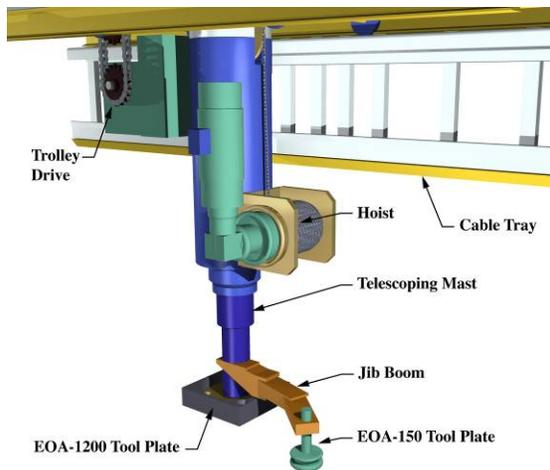


Fig. 8 An isometric view of the glovebox handling system.

Materials are introduced into the transfer tunnel through access doors and directly loaded onto the transfer cart. Differential pressure and capture velocity airflow ensure confinement is maintained during transfers. The transfer cart moves the materials from the support area into the closure cell. Materials transported on the transfer cart will be placed or received by the closure cell RHS. The transfer cart uses a linear synchronous motor that provides accurate positioning. Motor installation is configured so it remains outside of confinement and couples to the cart magnetically through the confinement floor.

Two shield doors are arranged in series in the tunnel to reduce radiation levels to as low as reasonably achievable. Only one door is opened at a time, functioning like an airlock. This sequence ensures shielding is always in place at the closure cell opening. The arrangement also creates a

radiological buffer zone for monitoring equipment exiting the cell to verify the equipment does not carry any unacceptably high radiation sources.

The tunnel is configured with gloveports, windows, and equipment to support material transfers. Features also allow surveying and decontaminating the interior, collecting and counting contamination surveys, monitoring interior radiation levels, and provide personnel access to the tunnel interior. The smear counter employs unique technology to count contamination smears without transferring materials outside the glovebox or breaching confinement.

The glovebox is divided into two wings: the tool tray maintenance wing and the general maintenance wing. Maintaining the welding and inspection tool trays including replenishing weld wire, refurbishing wear surfaces and repairing weld equipment is performed in the tool tray maintenance wing. The general maintenance wing is dedicated to maintaining the balance of closure cell equipment discussed above.

The essential element of glovebox design is to design “from the inside out.” That is, it is important to design the equipment and processes to be performed inside the system first, and then design the glovebox around this information. This is the approach taken in designing the glovebox and transfer tunnel presented herein. It is also important to recognize that a glovebox contains many of the same systems of a complete facility but on a smaller scale. Incorporated in the glovebox is a fire protection system, ventilation including HEPA filtration, lighting, piping, and utilities. The design also has to address safety basis accidents, including breach of confinement and seismic concerns.

IV.C. Brief Operations Overview

Many operations take place within the closure cell. All the operations are focused around successful WP closure. The process begins when the facility places a WP into position at the floor opening. The WP has the inner lid installed prior to placing it at the closure cell access hole. A high level process is described in the following sections. The process is greatly abbreviated for the purposes of this paper.

- a) The welding robots tack weld the lid into place and then complete the welds.
- b) Inspections of the welds are completed.

- c) Evacuation/backfill equipment is moved to the WP by the RHS and placed into position. The WP is vacuum purged and backfilled with helium, and a threaded plug is installed. The inner lid weld and plug are helium leak tested, using mass spectrometry for leakage. Following successful completion of leak detection, the test equipment is replaced into their storage locations.
- d) The MSMs place a purge port cap in place over the threaded plug and hold it in position while the cap is welded to the inner lid. Visual inspection of the weld follows.
- e) The middle and outer lids are introduced into the closure cell by the following sequence: 1) lids are received in the support area, 2) they are transferred into the glovebox and onto the transfer cart, 3) the transfer cart is moved into the closure cell through sequenced shield doors, and 4) the lids are lifted from the transfer cart, now in the closure cell, and transferred to storage drawers.
- f) A storage drawer is opened and exposes the WP middle lid. The RHS picks it up and places it onto the WP.
- g) The lid is welded to the WP then visually and eddy current inspected.
- h) The outer lid is then taken from a storage drawer and placed on the WP.
- i) The outer lid is welded in place, visually inspected, eddy current inspected, and ultrasonic inspected.
- j) Stress mitigation is completed, and the three inspections are repeated.
- k) The RHS then removes the weld tool trays and moves them onto the glovebox transfer cart. The cart delivers them to the tool tray maintenance wing inside the glovebox where they are refurbished for the next WP.

This cycle is repeated for each WP. The system is designed to complete the cycle within 44 productive hours. The effort includes documentation to address normal and off-normal situations and issues.

V. CONCLUSIONS

High-level waste and spent nuclear fuel will be sealed into standard WPs that will be placed into a repository for long-term storage. INL has designed, will produce, and will demonstrate a full-scale working prototype of a WP closure cell. Because of the highly radioactive nature of the materials, WP closure operations will be performed by remote methods.

Based on INL's successful history of design, operations, maintenance, repair, and decommissioning of over fifty nuclear test reactor and numerous hazardous chemical processing facilities, it was selected to design, construct, test, and demonstrate a WP closure cell. Experience in remote engineering design, remote material handling, process control, and remote facility operations provided the necessary background to design and demonstrate the remote handling equipment discussed in this paper.