

TRU WASTE CHARACTERIZATION CHAMBER GLOVEBOXES

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Abstract: Argonne National Laboratory-West (ANL-W) is participating in the Department of Energy's (DOE) National Transuranic Waste Program in support of the Waste Isolation Pilot Plant (WIPP). The Laboratory's support currently consists of intrusive characterization of a selected population of drums containing transuranic waste. This characterization is performed in a complex of alpha containment gloveboxes termed the Waste Characterization Gloveboxes. Made up of the Waste Characterization Chamber, Sample Preparation Glovebox, and the Equipment Repair Glovebox, they were designed as a small production characterization facility for support of the Idaho National Engineering and Environmental Laboratory (INEEL). This paper presents salient features of these gloveboxes.

INTRODUCTION

Argonne National Laboratory-West is participating in the Department of Energy's (DOE) National Transuranic Waste Program, in support of the Waste Isolation Pilot Plant (WIPP)¹. It has developed a facility to characterize and repackage drums of contact-handled transuranic (CH-TRU) mixed waste from the Idaho National Engineering and Environmental Laboratory (INEEL). This facility, termed the Waste Characterization Area (WCA)², is located within Argonne's Hot Fuel Examination Facility (HFEF)³, in the high bay area. The WCA is a series of processing rooms surrounding three alpha containment gloveboxes. These boxes, called the Waste Characterization Gloveboxes, are used to support the characterization process at HFEF. Limited space at HFEF and the need to characterize a production volume of drums, drove the design and layout presented in Figure 1.

The Idaho National Engineering and Environmental Laboratory (INEEL) is one of the first DOE complex sites scheduled to ship waste to WIPP. All waste proceeding to WIPP must be characterized to meet repository license requirements established by the State of New Mexico and the Environmental Protection Agency (EPA). WIPP-required characterization consists of headspace gas sampling, non-destructive assay to determine radioisotope inventory, and non-destructive examination in the form of real-time radiography to determine the waste's physical character. A selected sample of the total waste destined for WIPP must be intrusively characterized. Intrusive characterization consists of opening the drum; removing, cataloguing, and weighing its contents for debris waste or extracting a core sample for homogeneous waste; and re-packaging the contents, if practicable, into a new, polyethylene-lined waste drum. This effort is required to certify the validity of the non-destructive examinations performed on the total waste volume planned for shipment. The amount of waste from the total population required to undergo intrusive characterization varies among waste types and generator sites, and is based on previous characterization activities.

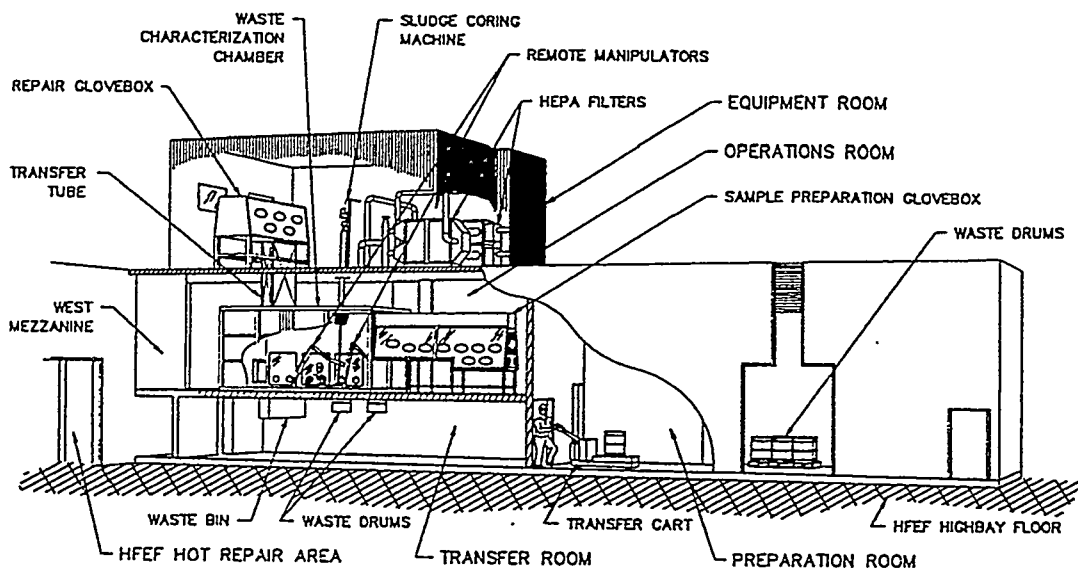


Figure 1. WIPP WASTE CHARACTERIZATION AREA

The TRU Waste Characterization Gloveboxes were proposed in 1990 to improve characterization and repackaging operations performed in HFEF's Hot Repair Area in support of the National Transuranic Waste Program. They would provide a dedicated facility for WIPP operations, allowing increased throughput and greater characterization capabilities. These gloveboxes would be built in a limited available area of the HFEF high bay and would make productive use of a previously unused space. Construction of the boxes in the High bay would allow the HFEF safety assessment to envelope their future productive work, and would decrease the cost normally incurred for this type of facility. The boxes would also reduce the potential for alpha contamination spread in HFEF and reduce the potential for radiation exposure to operators. As such, this proposed modification to HFEF was supported by the National Transuranic Waste Program.

The TRU Waste Characterization Gloveboxes are designed in accordance with DOE's General Design Criteria, formerly DOE Order 6430.1A, including Division 13, 'Special Facilities,' applicable paragraphs of Sections 1300, 'General Requirements', and 1324, 'Radioactive Solid Waste Facilities'. No safety-class structures, components, or systems, as defined by this order, are required for this facility. Waste drum handling and characterization operations fall within HFEF's existing safety envelope; hence, no unreviewed safety questions were raised in a detailed assessment of these operations⁴.

Three levels of confinement are defined by these gloveboxes and their positioning within HFEF. Two separate systems, the cell exhaust and the laboratory exhaust, ventilate the primary and secondary confinements. Facility locations with the greatest potential for contamination are maintained at negative pressure with respect to locations with lower potential for contamination. Ventilation air flows inward from the outermost confinement boundary to the glovebox interiors. Contaminated air exhaust from inside the gloveboxes is filtered by at least two in-series banks of HEPA filters and an adsorbing carbon filter.

The characterized CH-TRU waste consists of a variety of materials and packaging configurations, including debris such as paper, cardboard, plastic, rubber, glass, ceramics, and metals. Homogeneous material is also included such as radioactive material production process sludges. The waste is contaminated with radioactive and hazardous constituents. Most of the waste being characterized originated from Rocky Flats. Rocky Flats waste is contaminated primarily with a weapons-grade plutonium isotope mixture (commonly referred to as Pu-52) and the ingrowth product, americium-241. Approximate weight percentages of the key isotopes are: Pu-238, 0.01%; Pu-239, 93.8%; Pu-240, 5.8%; Pu-241, 0.4%; Pu-242, 0.002%; and Am-241, 0.4%⁴. Key hazardous constituents considered in environmental analyses for the WCA include 1,1,1-trichloroethane, carbon tetrachloride, 1,1,2-trichloroethene, 1,2,2-trifluoroethane, trichloroethylene, methylene chloride, methyl alcohol, butyl alcohol, xylene, cadmium, lead, mercury, beryllium, asbestos, lithium, and nitric acid. The design basis for this facility assumes a maximum of 400 drums (208-Liter size) can be characterized/repackaged per year.

TRU WASTE CHARACTERIZATION GLOVEBOXES

The TRU Waste Characterization Gloveboxes, consisting of the Waste Characterization Chamber (WCC), the Equipment Repair Glovebox (ERB), and the Sample Preparation Glovebox (SPB), have been built in a limited space to optimize a small scale intrusive characterization process. The first of these gloveboxes has been operational since April 1994. Over four-hundred drums of debris and residue waste have been processed since operations began. All work performed on alpha-contaminated TRU waste and related contaminated equipment is performed in one of these three boxes.

The WCC was the first of the gloveboxes to be fabricated and installed. This box began radioactive material operations in April 1994. Subsequently, in September 1994, operations were curtailed for an approximate 8-month period to add the remaining two boxes. The SPB and the ERB were interfaced to the WCC, which was already contaminated, without incurring spread of contamination outside the original confinement boundary.

These boxes exist to protect the worker from alpha contamination and radiation exposure. They are protected by a dedicated CO₂ Fire Protection System (FPS), certified to achieve a minimum of 20% CO₂ concentration for a period of at least 20 minutes following a fire event. During the event, the glovebox ventilation system is isolated from the facility ventilation system. In the paragraphs which follow, the purpose and salient features will be presented for each glovebox.

Waste Characterization Chamber

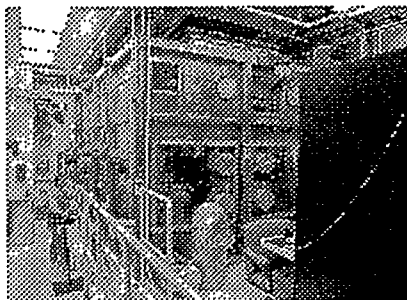


Figure 2 The Waste Characterization Chamber

The Waste characterization Chamber (WCC) is the largest of three boxes. Its 'open-room' design, as shown in Figure 2, allows for maximum direct operator interface, and is the box where waste is introduced for characterization. It is constructed of 4.5mm thick (3/16") AISI 304 stainless steel, and all interior corners are rounded to a minimum radius of 6.4mm(1/4 inch). All interior surfaces are polished to a 125 μ inch surface finish to improve efficiency of decontamination. See Figure 1 for its position with respect to the other boxes.

Three sides of the 2.4 x 4.5 meter (8' x 15') rectangular box, are windowed with a total of eight, ~1-meter (36") square panes of LEXAN® Model MR-4000 polycarbonate. This material has High UV yellowing resistance, acts as part of the primary containment boundary, and provides superior impact resistance. Laminated safety glass panes overlay the interior of the LEXAN® windows for protection from fire. Leaded glass laminate panes overlay the window exteriors to reduce radiation exposure. Twenty -two access glove ports (Central Research Model C-18885, push-through type) are inset into the LEXAN® windows to optimize operator access and view ability.

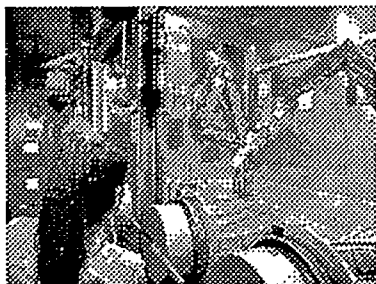


Figure 3 Schilling Titan 7F Manipulators

As shown in Figure 3, two Schilling Titan 7F tele-robotic manipulators are positioned in the center of the WCC floor to assist in the removal of up to 90 kg (250 lb.) items from the characterized waste drums. A 680 kg (1,500 lb.) capacity articulated jib crane, suspended from the non-windowed south wall, removes the heaviest and most awkward items. Since operations have commenced, the crane has proven the more valuable component in removal of heavy items from waste drums.

Each examined drum is interfaced with the WCC through a drum port opening in the floor of the glovebox, as shown in Figure 4. A containment bag ensures a seal between the drum and the drum port. The chamber incorporates drum port interfaces for two 208-liter drums, a 30cm diameter (12") small tool transfer port, and a 60cm x 120cm (2' x 4') cross-section vertical transfer port in the ceiling of the WCC. This port is the interface of the ERB with the WCC, and allows equipment to be moved there for repair.

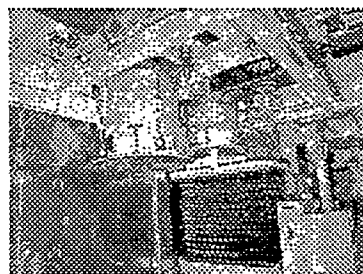


Figure 4 Waste Drum Interface with the WCC Floor

Numerous manual and pneumatically operated hand tools assist operators in performing operations ranging from sampling the waste bag headspace to cutting up unusable 55 gallon drums for disposal.



Figure 5 Core Sampling System Operation

Also located inside the box are the core sampling and headspace gas sampling systems. The core sampling system (CSS)⁵ extracts drum-length core samples from drums of solidified process sludges. Consistencies range from a gooey mud to hardened concrete. The CSS is a variant on commercial rock drilling equipment, augmented with computer controls to sense and limit rotational speed, torque, and drill head down-force. Figure 5 shows the CSS in operation.

The gas sampling system collects headspace gas samples into passivated SUMMA® canisters and simultaneously analyzes samples for each of 29 target volatile organic analytes, as required in the Transuranic Waste Characterization Program Quality Assurance Program Plan (QAPP)⁶.

The Visual Data Acquisition System, also located in the WCC, records all characterization activities occurring with each drum. Seven externally mounted color cameras capture these activities for a record on VHS video tape, also required by the WIPP QAPP.

Another important feature is the smear counting station, located on the east wall of the WCC. At this station, contamination smears are analyzed for alpha and gross gamma contamination without removal from the WCC. The photos in Figure 7 show station configuration. During characterization, contamination levels provide additional information on the waste's character and necessary handling precautions. Counting smears without removal from the WCC improves the efficiency of operations and increases drum throughput. As in the analysis instrument interface, a 0.013mm thick (0.0005 inch) MYLAR® window allows analysis of the smear and confinement of contamination. Key to its success is an air curtain across the window to keep loose contamination from lighting on the window and compromising the accuracy of the count. A smear holder slide allows consistent presentation of the smear to the window and the analysis probe. A second smear counting station is also used in the SPB.

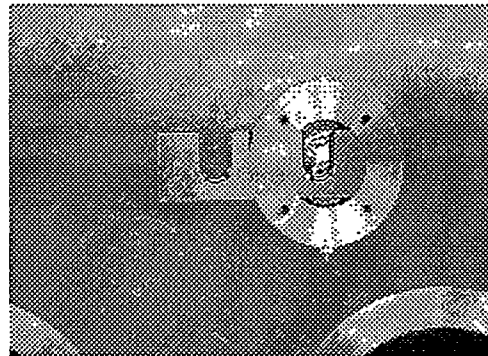


Figure 7 Smear Counting Station
Above: Probe and air curtain piping outside WCC
Right: Mylar Window and smear slide inside WCC

Sample Preparation Glovebox

The Sample Preparation Glovebox (SPB) makes up the 'east wing' of the glovebox complex. See Figure 1 for its location. It provides a clean area, separate from the sample collection area of the WCC, where extracted core samples of solid waste residues may be prepared and transferred out for shipment. Figure 8 presents a photo of its layout.

The SPB was installed approximately one year after commencement of radiological operations in the WCC. Hence, it was desired that the tie-in create minimum impact on WCC operations and confinement integrity. To accomplish this, two round glove ports, on the east side of the WCC, were sacrificed to complete connection between the boxes. An adaptor tube was attached to existing protruding threads on the glove port rings. The attachment was made while gloves were still in each glove ring, maintaining the primary confinement boundary of the WCC until completion of the SPB installation. Following installation and glove removal, ventilation airflow was balanced between boxes to ensure to-WCC airflow sufficient to minimize the potential for cross contamination from the WCC to the SPB.

A sliding rail arrangement, integral to the adaptor tube, allows transfer of samples to the SPB from the WCC. Sample containers are moved on a transfer tray from the collection area in the WCC, by jib crane, to the area of the adaptor tube. The transfer tray is placed on the sliding rails which project into the WCC. The technician then reaches into the WCC through the adaptor and slides

the sample containers and transfer tray into the WCC, where they are laid out in the SPB sample process area.

The SPB is divided into three sections. The area closest to the WCC is the sample processing section (Figure 8, right side). Samples are laid out on a sliding table, where technicians isolate, weigh and repackage samples for movement to the analysis section or for transfer out of the SPB to another location. Access to this section is from both the north and south sides of the SPB, through eight oval glove ports (Central Research Model D-35711). The analysis section of the SPB is located on the eastern most side of the box (Figure 8, left side), where an X-Ray Fluorescence (XRF) spectrometer can be used to screen samples for the presence of RCRA hazardous metals. Analysis instrumentation is maintained outside the confinement boundary by use of an analytical instrument interface shown in Figures 10 and 11. The transfer section, located in the center of the SPB, allows samples to be transferred out of the confinement through the SPB transfer tube. Ventilation air flow through the SPB proceeds from the analysis section, to the transfer section, to the sample process section and into the WCC. Airflow again moves from areas of lower contamination potential to greater.

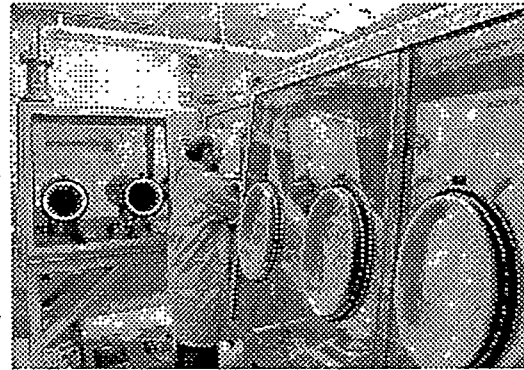


Figure 8 Sample preparation Box

The transfer tube allows rapid out-transfer of samples for packaging and shipment. An approximate 1-meter (36") long, 10cm (4") diameter, stainless steel pipe is mounted on a 45° angle to the bottom of the SPB. An air-tight, lockable hatch on the upper portion allows transfer of samples, in sizes ranging from 40ml vials to 250ml wide mouth jars, from the SPB to the inside of the transfer tube. Attached to the bottom of the tube is up to 6 meters (20') of PVC sleeve which slides over the outside of the pipe. The PVC is encased in a removable, transparent, secondary confinement container which allows observation of the PVC sleeve during the transfer procedure and protects it during operation. Attached to the lower confinement container is an air-tight cover, removable for sample transfer operations, but which remains in place during non-transfer periods. Figure 9 shows the transfer tube capped and the transfer sleeve stowed.

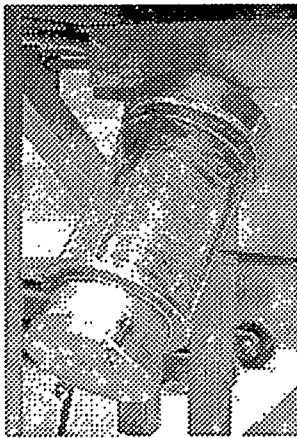


Figure 9 Transfer Tube

Items to be transferred from the SPB are placed into the transfer tube through the upper hatch. The item slides down the tube until it contacts the lower confinement container removable cover. The item is isolated from the cover by the presence of the PVC sleeve on the end of the pipe, whose open end has been heat sealed prior to installation. Additional items may be queued in the transfer tube for individual or multiple item bag-out. When the upper hatch is closed behind the items, the transfer tube is isolated from the SPB.

The lower cover is then removed and the PVC sleeving pulled down and out from around the transfer tube pipe. The queued items follow into the PVC sleeve in a series fashion. A small HEPA filter, located on the side of the transfer tube, allows air to flow into the transfer sleeve. This precaution minimizes negative pressure transfer from the box, which allows positioning and movement of the items within the sleeve prior to heat seal and cut-off from the sleeve. A thermal impulse heat sealer is used to isolate and separately package each item. A cut is made at the seal joint

and the extracted item is considered "packaged" for storage or shipment. Potential contamination is sealed inside a "bag" with a clean exterior. Any unused PVC sleeving is stowed up around the transfer tube and the lower cover is replaced.

When the sleeving has been consumed, the lower confinement container is removed. New PVC sleeving, with one end heat sealed, is slid up around the old PVC sleeve stub and sealed to the top of the transfer tube. The PVC sleeve stub is removed and discarded using the transfer technique previously presented, and the confinement container is replaced.

In the analysis section of the SPB, an analytical instrument interface allows use of a Spectrace 9000 portable analyzer for sample screening of RCRA hazardous metals. A sensor mating interface was developed with a replaceable receptacle and MYLAR® window to allow analysis without breach the SPB confinement boundary and without contaminating the analysis probe. Figure 10 shows the sample interface inside the glovebox. The MYLAR® window acts as the primary confinement boundary and x-ray window for the analyzer. MYLAR®, 0.013mm (0.0005 inch) thick, is attached to the window frame by means of a retaining ring which snaps into place as it is forced down around the MYLAR® material. The result is a taut, wrinkle free window which does not interfere with the analysis of the sample presented at the window.



Figure 10 Analytical Instrument Interface with protective cover removed

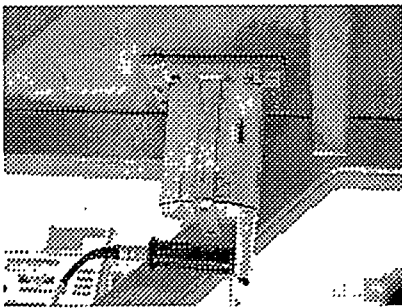


Figure 11 Instrument Probe Connected on the outside of the interface

The instrument probe is bolted into a machined receptacle under the SPB floor, which also holds the window frame. This receptacle, which is shown in Figure 11, acts as a secondary confinement boundary in the event the window is compromised. The MYLAR® window is replaced, with its frame, by lowering the detector probe, removing the old frame, and inserting the new. The SPB negative pressure and the 3.8cm (1.5") diameter hole, present during frame replacement, ensures sufficient entrainment velocity to minimize/prevent contamination spread during the replacement procedure. The MYLAR® window and frame were verified capable of withstanding the 100mm (4") water gauge, design pressure of the SPB.

Equipment Repair Glovebox

The Equipment Repair Glovebox (ERB) is the third of the Waste Characterization Gloveboxes. It is located in the WCA Equipment Room directly above the WCC. See Figure 1 for its location. The ERB is used for repair and limited operation of either Schilling® Titan 7F, or Central Research Laboratories® Model L, manipulators. The ERB can also be used for service, repair, and check-out of the WCC jib crane winch/motor assembly. Replacement inner pane window assemblies for the WCC are transferred into the WCC interior through the ERB.

The ERB is fabricated from 4.5mm thick (3/16"), AISI 304 stainless steel. The interior surface is finished to 125µin to facilitate decontamination and cleaning. Light fixtures are mounted on the window exteriors to provide interior illumination. The installed box is approximately 2.7 meters (9')

high with an overall length of 4.9 meters (16 feet). Ventilation and fire protection are provided by systems supporting all the gloveboxes, and which have been described previously. The loaded ERB imposes a maximum floor load (to Equipment Room floor) of 340 kg/m^2 (70 lb/ft^2) with a maximum point load of 360kg (800 lb.). The loaded ERB will remain intact when subjected to the design basis earthquake stipulated in DOE Order 6430.1A. Its design pressure differential is 100mm (4") water.

As depicted in Figure 12, The ERB consists of two sections with different profiles. The repair section is 86cm (34") wide at the working (deck) level and tapers up to a 43cm (17") ceiling. Operator Access is through 10 oval glove ports (CRL Model D-35711) on both sides of this section. The difference in ceiling and floor widths slopes the windows to an angle of 10° from vertical to reduce glare and maximize operator view. The 3-meter (~10') length of this section accommodates repair and maintenance of manipulators. A detail work area is located on the south end of the repair section. It is 40cm long x 73cm (29") wide x 46cm (18") high. This area allows direct technician access to intricate mechanisms while looking directly over the work piece. Four (4) round glove ports (CRL Model C-18885) provide ready access to this area. Figure 12 shows a view of the tapered repair section.

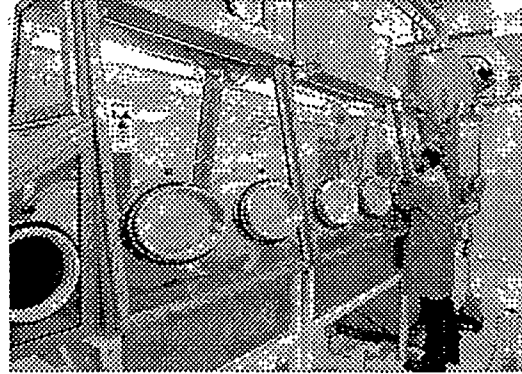


Figure 12 Equipment Repair Box

The working level (deck) of the repair section is 106cm (42") above the floor of the WCA Equipment room. Oval glove ports are positioned 140cm (55") above the Equipment Room floor. They are spaced as close as possible to the ideal 53cm (21") center-to-center spacing. Round ports are used for access to the detailed repair area and for maintenance of the hoist and trolley. The seven 20cm(8") diameter round ports are the same CRL model C-18885 (push through-type) ports utilized in both the WCC and the SPB. One port is used for small tool insertion.

Five (5) tool bins are inset below the working deck. Bins are nominally 30cm (12") wide x 30cm(12") deep, and run adjacent to the windows on either side. A removable lid covers each bin; recessed into the deck so that it forms a flat portion of the deck when in place. Two rows of blind, $\frac{3}{8}$ -16 UNC x $\frac{3}{4}$ " deep, threaded holes are located on 15cm (6") centers along the deck centerline. Vices, holding fixtures, or similar items may be mounted here to facilitate the repair of manipulators and other equipment. The deck and tool bins will support 450kg(1,000 lb.) of tools, fixtures, and equipment.

The transfer section of the ERB is rectangular. Approximately 120cm (48") wide, it forms a nearly square work area to repair bulkier items such as the WCC jib crane winch assembly. 1-meter square vertical windows on three sides of the section, contain 6 oval glove ports. A 10cm (4") x 110cm (43") vertical slot is built into the wall of this section to allow insertion of replacement inner window panes for the WCC.

Hydraulic lines are routed from the manipulator hydraulic pump to the ERB to permit in-box manipulator troubleshooting, test operation, and check out. Schilling[®] electronic feed-throughs pass manipulator control to a standard schilling manipulator control console. Two repair fixtures hold the slave manipulator in such a way as to permit limited range movement while energized during test operation. Feed-through AC electrical power outlets and plant air(37 L/sec at 550 kPa(80 scfm at 80 psi)) allow in-box use of small power tools, etc.

A 225kg (500 lb.) hoist and trolley system transports equipment to or from the WCC and within the ERB. The hoist is a Yale® (model SEL1/4-20TH12S1) electric chain hoist. A 6.1m (20 foot) chain extends its reach through the transfer port to the floor of the WCC. The rail system is a Zimmerman Mfg., Inc. model ZRA2. The trolley drive system, developed for this application by Walker Stainless Equipment Company, travels the length of the ERB to within 40cm (16") of either end. Limit switches and mechanical stops prevent movement outside the range of control. Electrical feed-throughs transfer control of the system to a control pendant external to the box.

The ERB is connected to the WCC by a transfer portal in the roof of the WCC. A hatch in the deck of the ERB prevents access to the transfer port when not in use. As with the tool bins, the hatch is recessed into the deck to conform to the flat portion of the deck when closed. To allow unrestricted access, the hatch's lift off hinges allow complete removal.

As shown in Figure 12, windows consume 75% of the wall surface area of the ERB. The windows are glass clad polycarbonate, composed of a 3.2mm (1/8") thick non-yellowing polycarbonate pane (LEXAN® Model MR 5000), laminated between two 6.4mm (1/4") thick clear panes of flat safety glass. The layers are bonded with a 1.25mm (0.050") film of ultraviolet-stable urethane. The laminate combines the impact strength of polycarbonate with the fire and scratch resistance of glass. The windows are mounted to the ERB using bolted flange-style mounting brackets and extruded neoprene rubber gaskets. Since waste handling operations are restricted to the SPB and WCC, no leaded glass windows are used in the ERB.

The ERB, like the WCC and the SPB, is ventilated by the HFEF Cell Exhaust System. Air flow into the ERB is regulated at a rate between 1,100 and 1,400 L/min (40-50 cfm). The ERB is maintained at the same differential pressure as the other two WCC gloveboxes. The ventilation system is configured so that air flows from the Sample Preparation Box and WCC toward the ERB. This mitigates the migration of any airborne hydrocarbon (oil) contamination from manipulator repair to sludge sampling and sample preparation activities within the other boxes.

Testing has shown that the system will maintain a 38 m/min (125 fpm) entrainment velocity through three open glove ports or through the 0.11 m² (170 in²) window insertion slot. (Windows are inserted through a bag-in procedure, however the system capacity will maintain the capture velocity across the opening for capture of airborne particulates, in the event of bag failure.)

The ERB is protected by the CO₂ Fire Protection System (FPS) covering the WCC and SPB. Two heat detectors are positioned in the top of the ERB and tied to the FPS control panel. A manual discharge switch is located in the Equipment room to support ERB operation. One CO₂ discharge nozzle is located in the roof of the box, near the ventilation system inlet. The ventilation system is isolated in the event of a CO₂ discharge.

SUMMARY

The need for a dedicated facility to conduct characterization operations has driven the design of these gloveboxes. Lessons learned from day-to-day characterization and analysis have evolved into many of the equipment designs presented in this paper. This equipment has greatly improved the efficiency of characterization operations at ANL-W. Many DOE complex sites are beginning to determine what facilities are needed to certify their waste for shipment to WIPP. These designs can be valuable in determining the layout and makeup of future characterization facilities.

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