

GLOVEBOX SYSTEMS DESIGNED FOR THE CHARACTERIZATION AND REPACKAGING OF LLW, TRU, AND MIXED WASTE

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ABSTRACT

This paper will discuss the key elements considered in the design, construction, and use of two separate glovebox systems for the characterization and repackaging of LLW, TRU, and Mixed Waste. One glovebox system was designed and built for Bechtel Nevada and is currently in use at the Nevada Test Site. The second unit was designed and built for Rocky Flats Engineers and Constructors (RFEC) and is currently being installed at the Rocky Flats Environmental Technology Site, and is scheduled to be operational by the time this paper is presented.

Each of the glovebox systems were "Fast Track" projects, and were designed, fabricated and tested by Absolute Control Systems in Wheat Ridge, Colorado. Mr. Newman was the Lead Design Engineer for both projects.

INTRODUCTION

Due to the anticipated opening of the Waste Isolation Pilot Plant (WIPP), several Department Of Energy (DOE) sites are building and operating facilities designed for the conversion of stored transuranic (TRU) waste into certified packages for shipment to WIPP. Much of the stockpiled waste at these sites is either low level radioactive waste (LLW), waste contaminated with transuranic (TRU) materials, hazardous materials, or a combination of all of these, which is commonly referred to as mixed waste. Unfortunately, when the waste was originally packaged, years ago, the stringent WIPP waste acceptance criteria did not exist. In order to meet the current criteria, most of the waste must be sorted, categorized, and repackaged. The preferred method for safely sorting and repackaging the waste, minimizing personnel exposure, is with the use of properly applied glovebox technology.

In the last two years, Absolute Control Systems (ABSOLUTE) has been contracted to provide two separate glovebox systems for use in the sorting, characterization and repackaging drums of waste into WIPP certified 55 gallon drums and or Standard Waste Boxes (SWBs). The following text will describe in detail the reasoning and methodology used to get from basic concepts and criteria to completed working turnkey glovebox systems and equipment. Both projects were completed in record time in order to meet government imposed deadlines for the processing of the stored waste. The first project for Bechtel Nevada (system #1) was completed in 120 days from start to finish and the second project for Rocky Flats Engineers And Constructors (system #2) was completed in only 90 days from start to finish.

PROCESS / OPERATIONAL REQUIREMENTS

The process and operational requirements for both systems were essentially the same. Existing drums of waste must be opened and have the contents removed. The contents must then be sorted and characterized to separate the WIPP compatible waste from the non-compatible waste. The majority of the waste to be processed was thought to be laboratory debris, consisting of items such as used gloves, used paper products, used anti-contamination clothing, and broken glassware. Included in the waste are some items that are prohibited for shipment to the WIPP Site, such as, waste that is ignitable, corrosive, reactive, pyrophoric nonradioactive material, liquid, or materials in pressurized containers (e.g., spray cans). These prohibited items must be removed from the waste before it is re-packaged. To satisfy the process requirements the following technical challenges had to be addressed:

- * Drum Handling - Drums must be transported from storage and presented to the glovebox for opening and removal of contents
- * Drum Opening - Drums must be opened with out exposing the operators or facility to the hazards contained in the waste.
- * Waste Removal - Waste must be removed from the drums with out exposing the operators or facility to the hazards contained in the waste.
- * Waste Input - The waste must be placed into the glovebox with out exposing the operators or facility to the hazards contained in the waste.
- * Waste Handling - Methods must be devised for handling the waste inside of the glovebox.
- * Waste Storage - Methods and space must be provided for interim storage of waste while sample analysis is performed.
- * Waste Sorting and Characterization - The waste must be safely sorted by hand and identified for characterization.
- * Empty Drum Removal - Once the incoming drums are empty they must have the lid placed back on them and then moved to the disposal or decontamination site with out exposing the operators or facility to the hazards contained in the waste.
- * Waste Sampling - Some of the waste can not be identified by visual alone and must be analyzed by an analytical laboratory, so a method for safely removing samples from the glovebox is required.
- * Drum Repackaging - Once the waste has been sorted and characterized it must be repackaged in a new drum for shipment to WIPP.
- * Drum Removal - The full drums must be closed and removed from the system and transported to the facility shipping area.

* Process Documentation - All waste processing and characterizing was to be recorded on video.

The incoming waste drums were defined as standard 55 gallon steel drums in good condition, clean on the outside, not broken open, and stable enough to be lifted by grabbing around the outer perimeter. The lids are removable and fastened by bolt and nut style closing rings. Drums that are overpacked in 85-gallon drum overpack containers must be removed from these overpacks before they can be processed in the glovebox system. Once sorted, the WIPP waste must be packaged in new or re-cycled 55 gallon drums for shipment to the WIPP facility. Both systems had throughput requirements to manually process three to four drums per day. The maximum weight for incoming 55 gallon drums was determined to be 800 lb, but on average the drums were expected to be in the 200 to 300 lb range. In order to handle all situations the handling equipment for both systems was designed for 1000 lb maximum capacity.

Personnel intended to operate the system shall be qualified in techniques for the proper handling of TRU waste, be a trained radiological worker, and must follow all necessary safety procedures for handling radioactive material. Previous glovebox use and operational experience is recommended.

GLOVEBOX DESIGN FEATURES

Both glovebox systems were designed and drawn using the latest version of AUTOCAD software. System #1 was based on glovebox industry standards as defined by the American Glovebox Society (AGS) "Guideline For Gloveboxes" AGS-G001-1994. System #2 was based on a combination of AGS standards and Rocky Flats Glovebox Standards.

Strict attention to operator reach and ergonomics are a critical part of every glovebox design. A plywood mock-up was created for System #1 in order to demonstrate the drum input technique and to make sure all of the planned activities could be performed through the glove ports in the wall of the glovebox. The fabrication of system #1 provided the mock-up for system #2.

Both of the waste handling facilities were designed and set up as a typical nuclear materials handling facility, which requires three levels of containment and cascading negative pressure air flow, with the glovebox being the most negative with respect to the atmosphere. The gloveboxes provide the primary containment for the waste handling operations. They are set up inside of a secondary containment structure located inside of a tertiary containment building. System #1 was placed in a specially constructed "Perma-Con" enclosure and system #2 was placed in a modified existing paint booth. Each of these facilities were equipped with HEPA filtration blower systems to provide negative pressure containment.

General Glovebox Configuration

The glovebox for system #1 consists of two gloveboxes connected together, separated internally by a vertical opening counterweighted door. The first glovebox in the direction of the material flow is called the Input Glovebox and the second glovebox is called the Staging Glovebox.

The Input Glovebox was designed for handling the incoming waste drums, waste removal, sorting, and re-packaging into new 55 gallon drums. The incoming drums are attached to the end of the glovebox in a horizontal position to a large bag ring. A plastic sleeve is used to maintain containment during drum de-lidding and unloading operations. Once attached, the operators,

working through the gloves, remove the drum lid and the drum waste. They then sort and characterize the waste and place it into a new drum attached to the bottom of the glovebox. Any liquids and waste items that require further analysis, other than visual, are passed into the adjacent Staging Glovebox.

The Staging Glovebox was designed for temporary storage of jugs and cans of liquids and unknown waste items. It has shelves for material storage, a small air lock for inputting tools or sample containers, a small bag ring for the safe removal of small items and samples, and a 55 gallon drum bag out port for the removal of large items.

The glovebox for system #2 also consisted of two glovebox sections connected together, but did not have a door between them. It was designed to function the same as system #1 with waste sorting and re-packaging in the first section and temporary storage and handling of suspect waste in the second section.

A detailed seismic analysis was performed on both systems. System #1 was analyzed in accordance with Uniform Building Code (UBC) for Seismic Zone 3. System #2 was analyzed for seismic category PC-3 (DOE Standard 1020-94, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities) with a maximum horizontal ground surface acceleration equal to 0.25g ZPA. Both systems were designed to maintain structural integrity and remain leak tight during a seismic event.

System #1 Glovebox Features

The glovebox shell was constructed from 7 ga. (.188" thk) 304L stainless steel sheet, formed and welded together into a unibody styled shape with coved internal corners. It was continuous welded and completely polished inside and out to a #4 finish, thus minimizing cracks and crevasses that could become contamination traps. The Input Glovebox section was double sided with three work stations per side. The Staging Glovebox was also double sided with only two workstations per side. A work station is defined as a working area for one person to work at with a window and one pair of gloveports.

The gloveports were of the "weld-in" oval style, sized to fit standard 10" dia. two piece drybox gloves. The two piece glove design allows the replacement of the hand portion of the glove separate from the shoulder sleeve. Oval gloveports are designed to provide better operator comfort and reach by allowing the operator to get his/her shoulder into the ring. Also the oval design can accommodate operations personnel of different heights. The gloves stretch around the outside of the ring and are sealed in place by a removable band clamp. The gloves can be changed without breaking the glovebox containment with the old contaminated glove ending up inside of the glovebox.



Figure 1 - GLOVEBOX SYSTEM #1

The side walls of the glovebox were sloped to improve operator viewing and comfort. The clampstrip style viewing windows were mounted to the sloped portion of the wall. The windows were made from 3/8" thick laminated safety glass and the channel gaskets were neoprene.

Small windows were placed on the top of the glovebox for externally mounted lights for interior illumination. By mounting the lights on the outside of the glovebox the bulbs can be easily replaced without breaching the glovebox containment and exposing the maintenance personnel to the hazards inside. The lights were incandescent flood light style lights with a remote switch and a dimmer control for adjusting the lighting intensity.

The two glovebox sections were separated by a vertical operating counterweighted door. The door is mounted in an enclosed door module that completely encases the door as it opens and closes. A single acting clamp, operable from the Input Glovebox side, tightly seals the door when it is shut, providing leak free separation between the two gloveboxes. Hidden counter weights balance the door to a near weight less condition for easy one handed operation.

The containment potential for the glovebox is enhanced by a negative internal pressure, meaning if there are any leaks they will leak into the glovebox. The pressure control system is completely manual and set up to provide 0.5 to 0.75 inches water column negative pressure with respect to the surrounding room. The system was also designed provide a containment air flow velocity of 100 feet per minute across an open gloveport in the event of an accidental glove breach. This was achieved by connecting the glovebox to the negative side of a HEPA filtered blower system. The inlet to the glovebox draws air directly from the surrounding room. Adjustable dampers are placed in both the inlet and exhaust air connections to the glovebox. In this system, the amount of air changes per hour is not a major concern, only maintaining containment.

Each glovebox was equipped with an inlet and exhaust HEPA filter. The exhaust filter keeps the contamination from entering the exhaust duct and the inlet filter prevents any contamination from

escaping in the event that the air system fails and the glovebox happens to experience any positive pressure or back flow from the air system. The filters and housings are the "push through" style, which means they can be changed without breaking the glovebox containment and exposing the operator by pushing the dirty filter into the glovebox.

Over pressure protection was provided by an oil filled pressure relief bubbler system set to relieve at (6 inches water column. A pressure relief bubbler works like a u-tube manometer allowing the air to "bubble" through a 6" high column of oil. This was necessary because of the possible failure of the compressed air connections inside of the glovebox that supply the air tools used in waste processing operations.

Shelves were placed in the staging glovebox on the end wall and between the gloveports at each workstation. They were sized to hold one gallon containers. Also on the end wall, a small 10" dia. bag ring and a 12" x 12" rectangular double door pass through was added for passing samples and small items in and out of the glovebox with breaking the containment.

Small radiation monitors were mounted on each side of the glovebox. These were used for protection against contamination spreading through the facility. Operators are required to scan their hands to check for contamination right after they remove them from the gloveports.

System #2 Glovebox Features

The glovebox shell was constructed from 7 ga. (.188" thk) 304L stainless steel sheet in the walls and 1/4" thk. 304L stainless steel plate in the floor and the sloped front end. The sheet and plate were formed and welded together into a unibody style shape with coved internal corners. It was continuous welded and completely polished inside and out to a #4 finish, thus minimizing cracks and crevasses that could become contamination traps. Both glovebox sections in this system were double sided with three workstations per side.

The gloveports were 8" dia. round per Rocky Flats glovebox standards and were welded in the wall of the glovebox. The gloves supplied were special one piece molded lead loaded gloves that provide radiation shielding equivalent to a .2 mm thickness of lead. The gloves stretch around the outside of the ring and are sealed in place by a removable band clamp. The gloves can be changed without breaking the glovebox containment with the old contaminated glove ending up inside of the glovebox.

The side walls of the glovebox were sloped to improve operator viewing and comfort. The clampstrip style viewing windows were mounted to the sloped portion of the wall. The windows were made from 3/8" thick laminated safety glass and the channel gaskets were neoprene. Lead glass panels that were 1/4" thick were placed over the safety glass window to provide radiation shielding equivalent to 1.5 mm lead thickness. All of the windows were also covered with bullet proof glass panels to protect the containment windows from breakage by flying projectiles caused by a severe weather event such as a tornado. The 1 3/4" thick bullet proof glass was mounted in its own frame which allowed for easy removal and handling.



Figure 2 - GLOVEBOX SYSTEM #2

The lights were also placed externally on the ceiling of this glovebox system, similar to System #1. These lights were fluorescent tubes instead of incandescent. Fluorescent lights run a bit cooler than incandescent lights and are the light of choice for gloveboxes when dimmer control is not needed.

The system #2 glovebox had the same type of pressure control and HEPA filtration as system #1. This type of pressure control is very common and is used on most glovebox systems. The HEPA filters and housings were designed and built per Rocky Flats Glovebox Standards and were changeable from inside of the glovebox.

A Rocky Flats Standard dump valve arrangement was used to protect against loss of glovebox negative containment pressure. A dump valve is a large port, normally closed, fail open valve that bypasses the outlet dampers. The dump valve opens up an increased air flow that is triggered by a pressure switch when the glovebox internal pressure approaches atmospheric pressure.

The end wall of the glovebox had two small bag in/out ports for passing samples and small items in and out of the glovebox with breaking the containment. Two gloveports and a small window were added to help with the bag in/out operations.

Small radiation monitors were mounted on each side of the glovebox. These were used for protection against contamination spreading through the facility. Operators are required to scan their hands to check for contamination right after they remove them from the gloveports.

Drum Handling

At the start of the design for system #1 an extensive search was performed for available commercial drum handling equipment. Equipment was found that could do the job but in order to handle the required drum handling capacity of 1000 lb it would be special order with a rather long lead time. Due to the short project schedule ABSOLUTE elected to build a drum manipulator by

modifying a manual engine hoist with the addition of a standard drum rotator unit. The manual lift turned out to be very difficult to operate so a hydraulic cylinder and a small hydraulic power unit was added. This performed the task of manipulating the heavy drums quite nicely. For system #2 the lift portion was built from scratch.

The drum manipulator was capable of picking up a loaded drum setting on the floor, lift it up and rotate it a complete 360(. This allowed a drum to be lifted and presented in a horizontal position to the drum input in the end of the glovebox. Once the drum is clamped into the manipulator the operator has the option to move the drum around, lift it up and down and to rotate the drum to any angle to facilitate the dumping of the drum contents.

For getting drums in and out from under the glovebox in system #1 a commercial drum handling device was used, a Morse Model 80 Mobile-Karrier. This device worked well allowing a single operator to grab, lift, and transport an 800# drum with little effort.

Glovebox Drum Input

Both systems utilized the "Bag In" technique for getting the waste into the glovebox. A bag sleeve is used to maintain containment between the drum and the glovebox during drum de-lidding and waste transfer into the glovebox. The bag sleeve is first placed over the top of the un-opened drum to be processed. The bag edge is then taped to the outside of the drum to seal the bag to the drum. The drum is then clamped into the drum manipulator and moved to a position in front of the glovebox input station. The operator controls the manipulator to lift the drum up and turn it horizontal and move it close to the bag ring on the end of the glovebox. The open end of the bag is then attached to the bag ring sealing the drum to the glovebox.

The drum is then moved forward placing the drum into the glovebox. Operations personnel working through the gloves remove the lid from the drum inside of the glovebox. The lid is placed on the floor of the glovebox. The waste transfer tray is rolled into position under the end of the drum. The operator then turns the crank on the drum manipulator to rotate the drum causing the waste to dump from the drum into the transfer tray. Once all of the waste has been removed from the drum, the lid is placed back to the drum from inside of the glovebox and it is rotated back to the horizontal position.

The drum manipulator is then pulled back moving the drum out of the glovebox. The bag is then gathered up between the bag ring and the drum and tightly clamped and taped in two places. A cut is made between the two clamps separating the drum from the glovebox. The drum is then rotated, lowered, and set on the floor where it can be transported to a decontamination or disposal site. The bag stub still on the drum, provides containment protection over the contaminated drum top. See Figure 3 for picture of the drum input process.



Figure 3 - DRUM INPUT PROCESS

Glovebox Drum Output

Both systems utilized standard bag out techniques for safely removing the waste from the glovebox system. The bag rings were mounted in the floor of the gloveboxes. The new empty drums were placed under the bag rings to catch the waste. The drum sat on top of a scale for weight determination as the drum is filled. A hydraulic lift was used in system #1 to lift the drum up closer to the bag ring. See Figure 4 for a graphical description of how the standard bag out process works.

System #2 was designed to accept Standard Waste Boxes (SWB) as an alternate to drums as a waste output container. A SWB can fit on the scale under the bag ring in either of the two glovebox floor mounted bag rings.

Glovebox Waste Handling

Waste handling operations inside of the gloveboxes were performed the same for both systems. Each system was provided with two rolling trays capable of handling 1000# of waste. The trays roll on stationary rails welded to the entire length of the glovebox floor. The trays can travel across both gloveboxes from one end to the other. The waste is dumped from the drum directly onto one of the trays and then manually rolled across the glovebox to over the top of either bag ring where it is passed into a drum. The trays incorporated a special 8 wheel design that allows the loaded tray to span the gap in the track between the two connected gloveboxes.

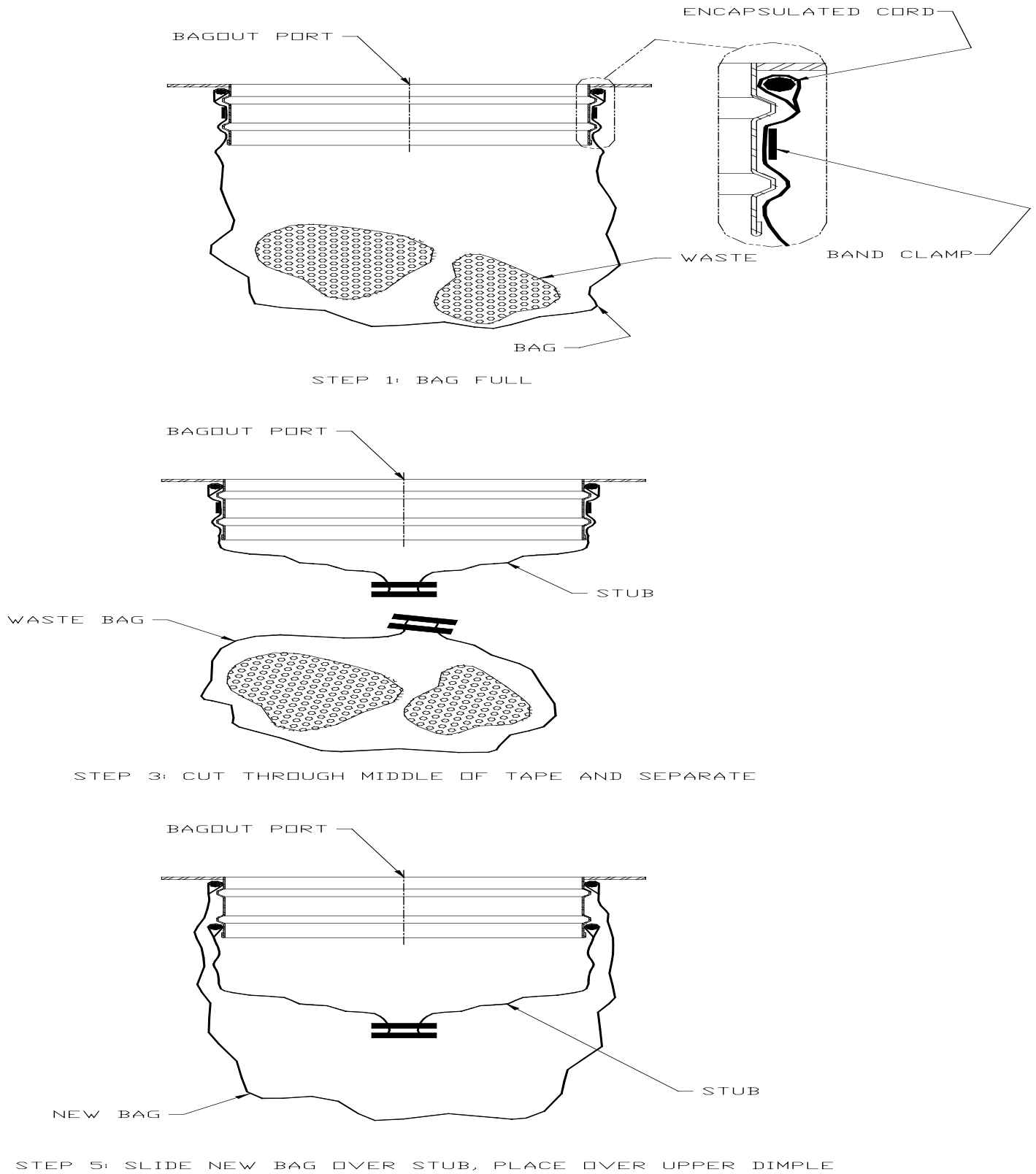


Figure 4 - STANDARD BAG OUT PROCESS

A manual overhead monorail trolley hoist was mounted in the ceiling of the glovebox. System #1 had a hoist in each glovebox which did not travel between them because of the door. System #2 had only one hoist that could move across both gloveboxes. The trolley hoists were rated at 1000# maximum lifting capacity and were to be used as required for moving heavy or large waste items through the gloveboxes.

An assortment of small tools were provided to assist in handling the waste. Small rakes were used to help reach the waste in the drums as they are being emptied. A drum de-lidding tool was used to help in opening stuck drum lids. Compressed air connections were provided in System #1 to power air tools such as an air ratchet and air chisels for loosening the drum lids. System #2 had electrical receptacles inside to power electrical tools such as a power chisel to be used to break up any solidified chunks of solid waste.

Stainless steel mirrors were mounted on the inner walls between the gloveports at each work station in the system #2 glovebox. These enhanced the vision of the operators allowing them to see in the lower corner of the glovebox as they are working.

The system #2 glovebox got a stainless steel impact pad that was mounted in the front drum input section of the glovebox. This was to provide added protection to the glovebox floor as heavy waste items are dumped out of the drums.

Operator Platform

The gloveboxes on both systems were set up on tall support stands to allow enough clearance between the bottom of the glovebox and the floor to place drums and waste boxes and to perform the bag out operations. This put the gloveboxes too high for an operator to reach standing on the floor. An operator platform was built around the perimeter of each system to allow personnel to properly operate the system.

In order to get the drums in and out from under the gloveboxes the platform had to be movable. On system #1 sections of the platform were designed to lift up and out of the way. They were counter weighted to meet the required 50# maximum lifting requirement. On system #2 the front sections of the platform were built on locking wheels which allow them to be easily moved out of the way for drum and SWB handling activities.

Both platform systems were constructed from stainless steel angle with diamond plate tops. The end sections had stair steps and OSHA approved hand rails that were placed where required for operator safety.

Camera/Video Recording Equipment

Part of the requirements for the characterization of the waste is to completely document the waste sorting and re-packaging process. Remote controlled color video cameras were mounted on the top of the glovebox over a window above the waste handling area inside of the glovebox. The camera is capable of zoom and pan & tilt by remote control from the facility control room. The waste handling operators will wear a head set with a microphone, allowing communication directly with the control room operator, and comments about the waste for the video tape.

Glovebox Fire Protection

The glovebox in system #1 was equipped with a CO2 Fire Suppression System built around an Ansul Autopulse 442R Agent Release Control System. The system was actuated by any one of the three pull boxes. Two were located on the glovebox, one on each side, and one was located by the secondary containment building exit door. The system could also be actuated by one of four heat detectors, one in each glovebox and two in the exhaust ducting. The temperature setting of the detectors in 140(F. The system could also be actuated manually outside at the CO2 bottle rack by pulling the manual lever.

Upon system actuation the glovebox will be instantly flooded with CO2 gas. It was designed to run for approximately 30 minutes and achieve and hold a minimum of 70% CO2 concentration for 20 minutes. The system was supplied with four 75# cylinders of CO2. During actuation the inlet dampers to the glovebox will automatically close and the exhaust dampers will fully open causing glovebox internal pressure remain negative to maintain containment.

The glovebox in system #2 was equipped with fire water sprinklers that were connected into the facility fire sprinkler system. The system was actuated by a temperature sensitive fusible link in each individual sprinkler head. The fire alarm was actuated by one of three heat detectors mounted it the glovebox ceiling. Criticality drains were installed in each glovebox to handle the water in the event that the system is set off.

GLOVEBOX CONSTRUCTION, TESTING, AND INSTALLATION

Both glovebox systems were manufactured under a fully compliant ASME NQA-1 quality control system. All welding was performed by welders certified per ASME Boiler and Pressure Vessel Code Section IX. All of the raw materials that were used were certified by chemical and physical material test reports and rigorously tracked by the material heat number.

The systems were completely fabricated, assembled and set up at the factory. An extensive Factory Acceptance Test (FAT) was performed on both systems that included the following:

- * Cleaning
- * Dimensional Verification
- * Finish Verification
- * Weld Inspection
- * Component Verification
- * Leak Testing
- * Functional Testing
- * Light Operation
- * Pressure Control/Balancing
- * Door Operation
- * Filter Change Out
- * Storage Shelf Operation
- * Glove Change Out
- * Drum Input Manipulator Operation
- * Drum Input Manipulator Load Test

- * Bag in Operation
- * Drum De-Lidding and Unloading
- * Material Transfer Tray Operation
- * Material Transfer Tray Load Test
- * Material Transfer Trolley Hoist Operation
- * Material Transfer Trolley Hoist Load Test
- * Weigh Scale Operation
- * Lift Operation
- * Turn Table Operation
- * Bag Out Operation
- * Camera System Operation
- * Fire Suppression System Operation
- * Damper Operation
- * Over Pressure Bubbler Operation

After successful completion of the FAT the systems were dis-assembled and shipped. Shipping was by exclusive use air ride truck that went from the factory directly to the job site. Once at the job site the equipment was installed and again tested. The Site Acceptance Test (SAT) which included many of the items that was in the FAT was performed to verify that the equipment survived the shipping and that everything was installed correctly.

To finally complete the project the final data package including things such as As-Built Drawings, Operation & Maintenance Manuals, Manufacturing & Quality Assurance Data Package, and signed off Test Reports, was completed and sent to the equipment owners.

REFERENCES

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