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Title: UNIQUE FEATURES IN THE ARIES GLOVEBOX LINE

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UNIQUE FEATURES IN THE ARIES GLOVEBOX LINE

Abstract: A series of unique features have been incorporated into the Advanced Recovery and Integrated Extraction System (ARIES) at the Los Alamos National Laboratory, TA-55 Plutonium Facility. The features enhance the material handling in the process of the dismantlement of nuclear weapon primaries in the glovebox line. Incorporated into these features are the various plutonium process module's different ventilation zone requirements that the material handling systems must meet. These features include *a conveyor system* that consists of a remotely controlled cart that transverses the length of the conveyor glovebox, can be operated from a remote location and can deliver process components to the entrance of any selected module glovebox. Within the modules there exists *linear motion material handling systems* with lifting hoist, which are controlled via an Allen Bradley control panel or local control panels. To remove the packaged products from the "hot" process line, the package is processed through *an air lock / electrolytic decontamination process* that removes the radioactive contamination from the outside of the package container and allows the package to be removed from the process line.

INTRODUCTION

The purpose of the ARIES process is to receive nuclear weapon primaries (pits), disassemble them, provide a product of either a plutonium metal button or plutonium oxide powder, package the product in an appropriate container to meet material disposition requirements for long term storage (DOE -STD-3013-96) and assures that the material is in an unclassified inspectable form appropriate for the application of traditional international safeguards. The system has been built with the intent of minimizing the operator handling of the radioactive material and reduce the exposure to the material handlers.

The ARIES glovebox processing line is shown in Figure 1. It consist of a central long narrow conveyor glovebox that connects to a series of gloveboxes or modules in which the processing is performed. Between the main conveyor glovebox and the modules there exists an airlock transfer system that connects to the various modules gloveboxes.

This paper will describe four material handling systems, the central material handling system of the process in the conveyor glovebox, two different type of material handling system within three of the processing gloveboxes modules and a special process for removing the material package container from the hot glovebox environment which is performed in another module.

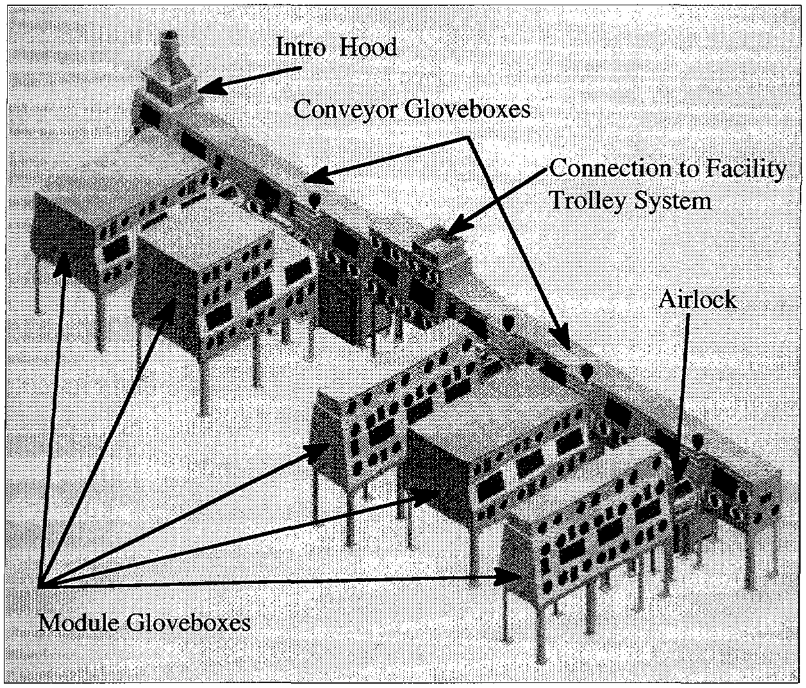

Figure 1: ARIES Process Glovebox Line

CENTRAL MATERIAL HANDLING SYSTEM

Movement of process materials and maintenance items between the ARIES glovebox modules utilizes a specialized conveyor transport system that automatically delivers items to each module. This material handling system consists of several components. The main components exist in a 42 foot conveyor glovebox that extends the length of the system (See Figure 2). It connects to all the process module gloveboxes, and connects to the TA-55, PF-4 building trolley system through an existing drop box. A conveyor transport cart travels the length of the conveyor

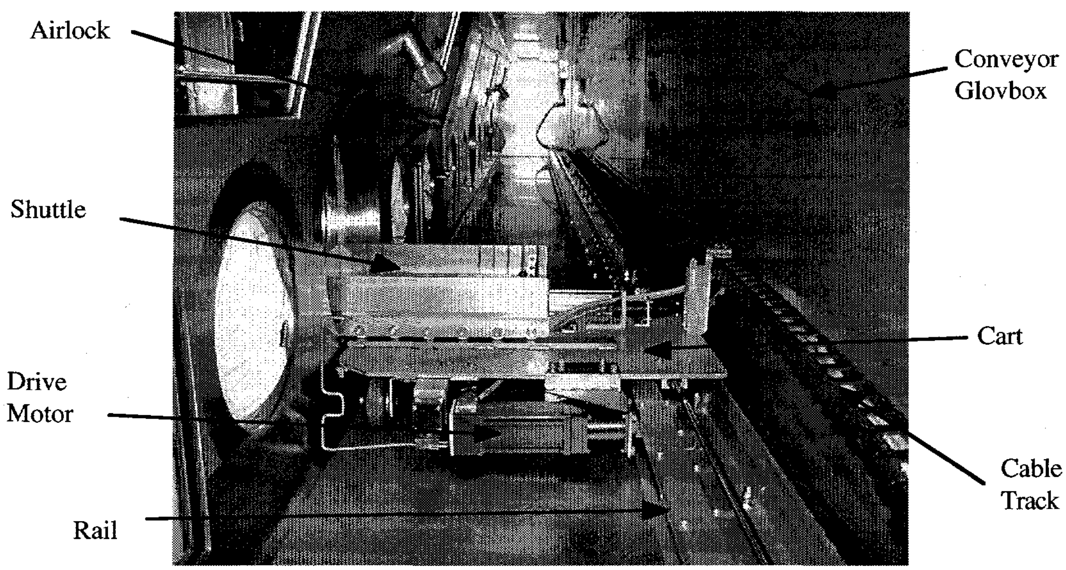

Figure 2: Cart and Shuttle System in the Conveyor Glovebox

glovebox and connects to the module gloveboxes through an airlocks at each module. The atmosphere in the process modules is inert so that the process requires that the integrity of the module glovebox be maintain during the transfer. A specialized shuttle that mounts on the conveyor transport cart automatically delivers or receives components in each module glovebox. The shuttle has an adjustable tray in which the payload is placed. A detailed description of this system has been previously presented, (H.E. Martinez et al., 1997).

Four of the five ARIES process modules require a very pure inert gas atmosphere, either argon or helium. Therefore, the use of pump-down vacuum airlocks are required in order to transfer material from the conveyor gloveboxes, which is dry air, to each of the specific modules. The vacuum and purge controls are mounted above the airlock chambers and are controlled through cart-shuttle motion control process. The system is shown in Figure 3. The Allen Bradley control panel from which the process can be controlled is on the opposite side and is shown in Figure 4.

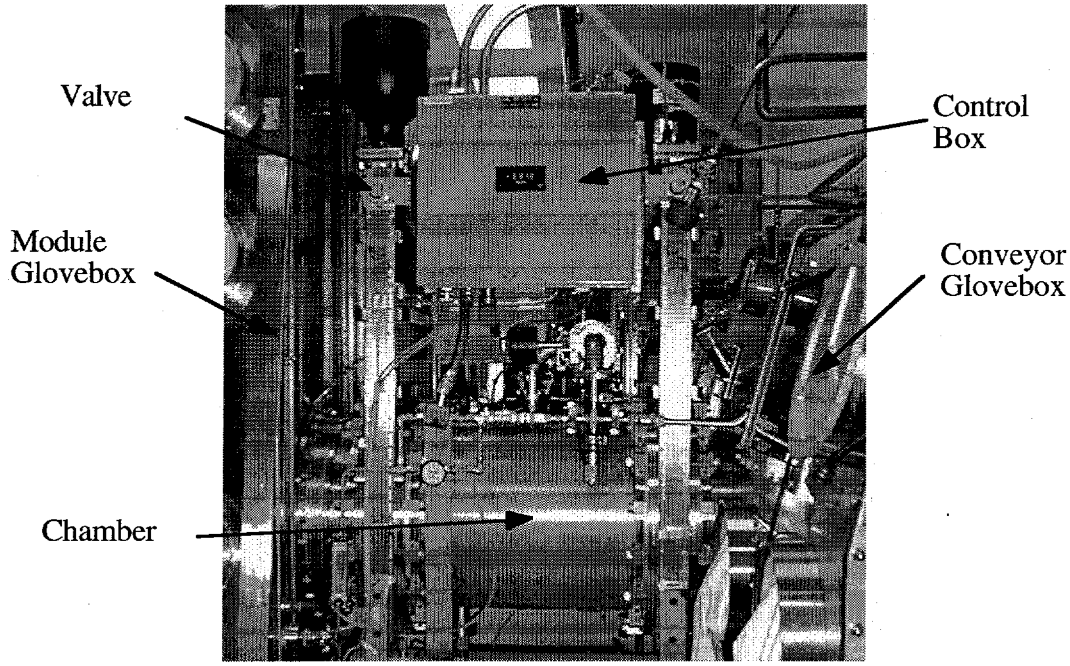

Figure 3: Airlock System with Vacuum and Purge Controls

The cart and shuttle system is operable from an Allen Bradley remote control panel on top of each module glovebox airlock or from the supervisory control and data acquisition (SCADA) computers. The automatic system is used to transfer the payload from anywhere in the conveyor glovebox through the airlocks and into each of the selected module gloveboxes. The control system stops the conveyor cart immediately in front of the door of the selected module airlock after a "send to" command from the operator on the remote control panel. After a "drop off" command on the control panel from the operator, the conveyor side (inner) airlock gate valve is opened and the shuttle motor on the cart drives the shuttle tray containing the payload into the airlock. When the shuttle motor on the cart is activated, a shuttle motor in the airlock is operating and pulls the payload into the airlock. Once inside the airlock, sensors are used to detect that the shuttle is in the proper location. Then the conveyor side airlock door is closed and the airlock is evacuated and backfilled with an inert gas. When the module side gate (outer) valve door is opened, the airlock shuttle motor and gear belt drive system drives the shuttle onto the glovebox module. When the shuttle motor in the airlock is activated, the shuttle motor in the module is operating and pulls the payload into the glovebox.

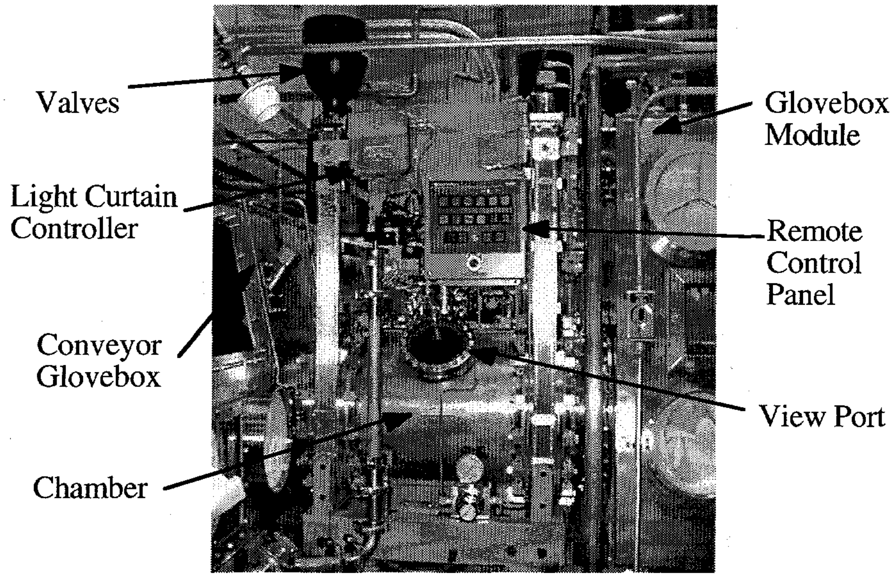

Figure 4: Airlock Control System from Ready Panel

Once inside the module glovebox, sensors are used to detect that the shuttle is in the proper location and the gate valve is closed. The payload is removed either manually or automatically, depending on the module. To return the shuttle either with a processed payloads or empty, the operator will execute a "pick-up" command on the control panel and the shuttle will automatically leave the modules and reside in the conveyor until the next "send to" command. Figure 5 shows a graphical cross section of the conveyor cart and shuttle system in an airlock.

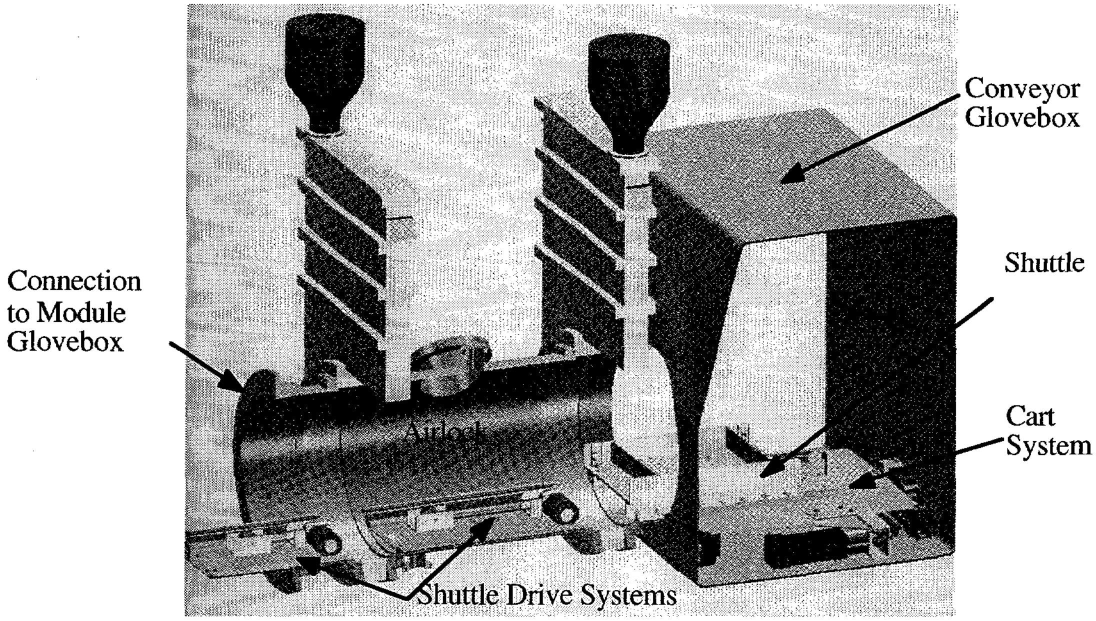

Figure 5: Cross Section of the Cart and Shuttle System

Safety Interlocks

A photoelectric sensor arrangement monitors the area in the conveyor glovebox between the glovebox glove ports and the conveyor cart. A transmitter at one end of the glovebox directs a beam of light toward the receiver located at the opposite end of the glovebox. An object in the path of this light beam will interrupt, causes the control system to halt the conveyor cart. This light beam barrier serves a dual safety function. First, it is interlocked to halt the cart in the event that an operator has inadvertently interrupted the light beam by moving the gloves into the glovebox. Secondly, it prevents the cart from moving until all the gloves are free of the light barrier area, thus ensuring that the cart will not snag and possibly tear a glove. In the front and back of the cart a set of trip switches sense for obstacles below the photoelectric sensors. These trip switches are intend to sense an item below the photoelectric sensor. A light curtain has been installed at the glovebox entrance to each module in order to protect from closing a gate valve on a piece of equipment and to avoid a mishap if an operator is in the glovebox while the gate valve is closing. A picture of an assembled light curtain is shown in Figure 6. Emergency stop buttons have been place on all the control panels for emergency situations. The controls for the light curtain and the emergency stop button on the remote control panel can be seen in Figure 4 on previous page.

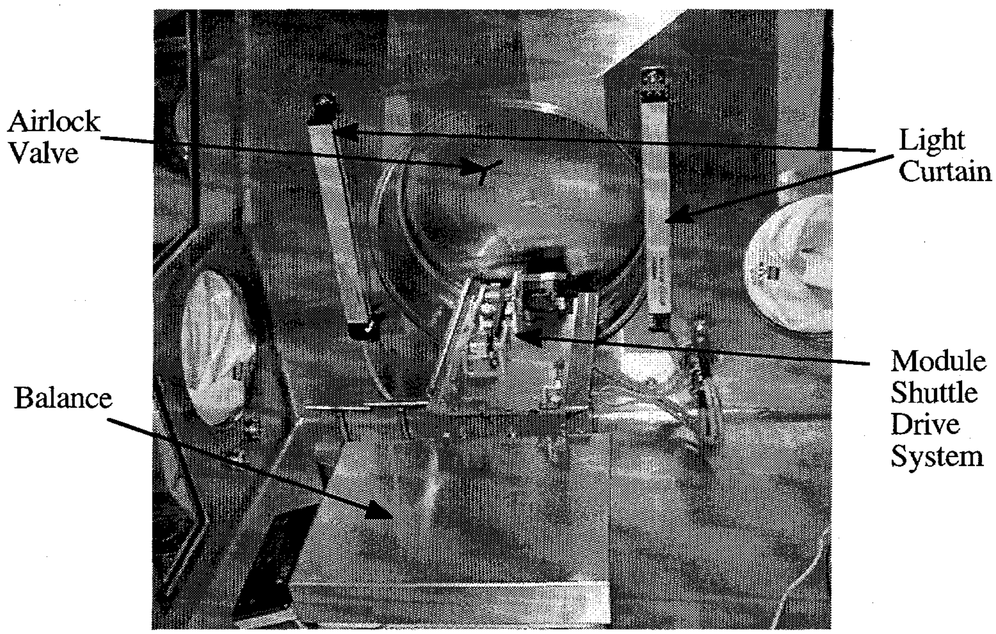

Figure 6: Light Curtain and Shuttle Assembly in the Glovebox Module

OVERHEAD X-Y AND Z MOVEMENTS IN A PROCESS MODULE GLOVEBOX

A commercial material movement system has been modified and installed on the ceiling of a process glovebox module. The module glovebox is used to convert a classified component into a billet of Pu metal which will be later packed in a permanent storage container. The material movement system is used to load and unload a furnace that is use to process the material. The glovebox tall, and contains four vertical glove port work stations. The system consist of three linear drive rails mounted on the ceiling of the glovebox with two drive motors. Figure 7 is a graphical representation of the system. Attached to one of the rails is a small 300 pound, 10 foot chain, brushless electric chain hoist that is used to lift and raise the pay load.

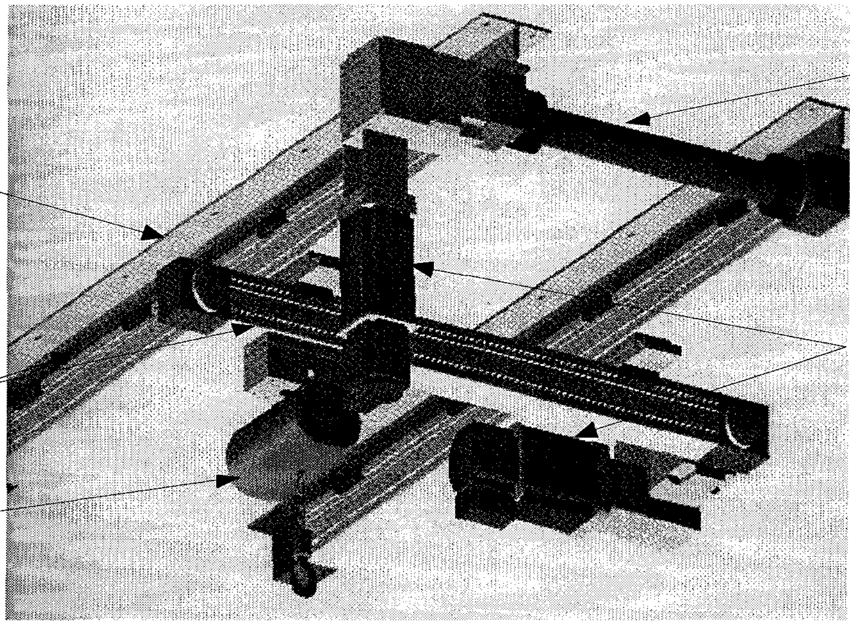

Figure 7: Material Movement System Layout

In this module, the material movement system has been suspended from the glovebox ceiling. The top of the glovebox is about 76 inches long by 53 inches wide, rails that are 72 inches long and 50 inches wide have been fitted on the glovebox ceiling. The material movement system includes three linear rails, gear reducers, and associated motors. Two six inch wide-flange aluminum I-beams have been secured to the top of the glovebox utilizing fourteen 5/16 -18 studs. These I-beams are located directly below the reinforcement angle welded to the top of the glovebox. The rails were assembled to the bottom side of the I-beams. The addition of the I-beam reduce the working height of the hoist so it was necessary to reduce to wed height of the I-beam. The standard 6" I-beam web was cut in half and the split webs bolted together side by side. This provide an additional 3 inches of working height, to accommodate the various features require by the assembly. The weight of the entire system was determined to be 250 pounds, the anticipated pay load for the moving system will be about 60 pounds. Analyses were performed to determine the number of studs required to support the equipment. The analyses included calculating the tightening torque and associated stress, as well as the stress due to the expected load. As expected, the stress due to the tightening torque which includes the tensile stress and the torsional stress is much larger than the stress due to the entire load. It was determined that fourteen studs give a substantial factor of safety. From the data one could conclude that the finite element stress and deflection analytical results indicate that the I-beams are effectively distributing the load across the glovebox and confirms that the load associated with the material movement system does not pose any stress or displacement problem.

The two longitudinal rails are conneted with a common shaft and driven by a single motor that is placed vertically using a 90 degree gear box. The cross drive is driven buy a motor place horizontally, with the motor body facing inward. The hoist is place at the opposite end of the of the cross drive rail. A total of four limit switches are used to prevent excessive end travel and possible damage to the motors or rails. Figure 8 and 9 show the assembly of the system on the glovebox ceiling. The two motors are operated via two controllers that are initially programmed by a personal computer to move to predetermined locations in a prescribed fashion. An Allen Bradley remote control panel with identified locations, sends a signal to the Allen Bradley Programmable Logic Controller and commands the motor controllers to drive the motors to center the hoist at the programmed location. The hoist is manually controlled to be lowered and raised from outside of the glovebox at the Allen Bradley control panel, and the Programmable Logic Controller turns on a relay to control the up and down movement of the hoist.

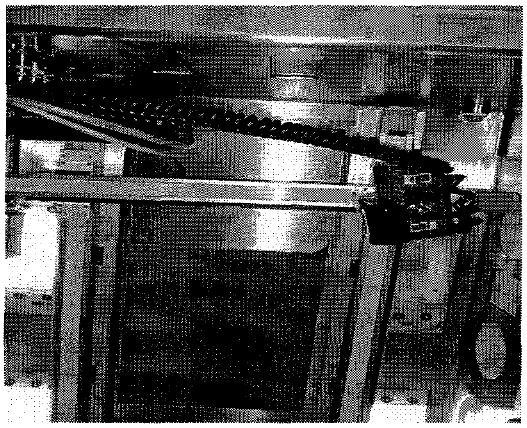

Figure 8: Overhead System, View 1

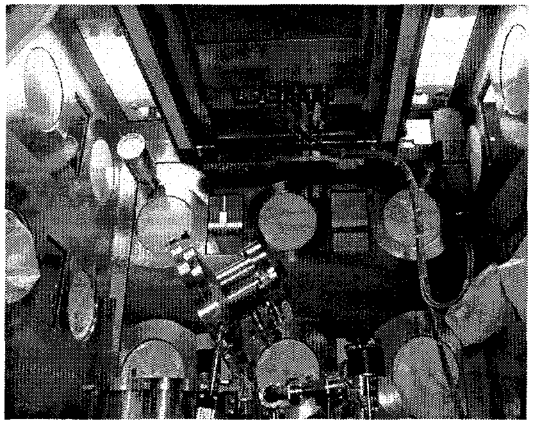

Figure 9: Overhead System, View 2

OVERHEAD X AND Z MOVEMENTS IN TWO OTHER PROCESS MODULE GLOVEBOX

A glovebox hoist mechanisms is used in two ARIES pit disassembly and conversion processing glovebox modules. They are used for remote handling of weapon pits and various other fixtures needed during the disassembly and material conversion processing.

The hoist assemblies consist of two acme screws used in conjunction with a T-rail mounting bracket attached to the glovebox ceiling. One acme screw is used to drive a trolley assembly along the entire length of the glovebox and the other screw is used to provide the hoisting function. Two linear guide rails (one on each side of the T-rail) are used to guide the respective acme screw nuts along the length of the glovebox and acme screws. A 3/32" wire rope, which is fixed at one end, is guided through a pulley on the trolley assembly, it then travels down through a pulley on the load assembly, travels back up to a second pulley on the trolley assembly, wraps around a pulley at the far end of the T-rail, and attaches to the acme screw nut. Rotating the acme screw causes the acme screw nut to travel the length of the glovebox, which raises and lowers the load assembly with an effective pull ratio of 2:1. Figure 10 shows the layout of the trolley assembly.

Two drive motors (one for each acme screw) are mounted externally to and on top of the glovebox. The drive motion is transferred through 90 degree worm drive gear, a set of toothed gears, and a chain drive to a ferrofluidic feedthrough which allows the rotary motion to penetrate the glovebox wall while maintaining a seal. A shaft coupler was used to connect the ferrofluidic seal output shaft to the acme screw end shaft. The motors are controlled by a programmable SCR controller with an operator pendant which allows both direction and speed control of both motors. Holding torque in the event of power failure is provided by the combined friction effects of the acme screw and screw nut traveler.

A total of four limit switches are used to prevent excessive end travel and possible damage to the acme screws. The limit switches are an integral part of the control electronics. When a limit switch is engaged, any further movement of the

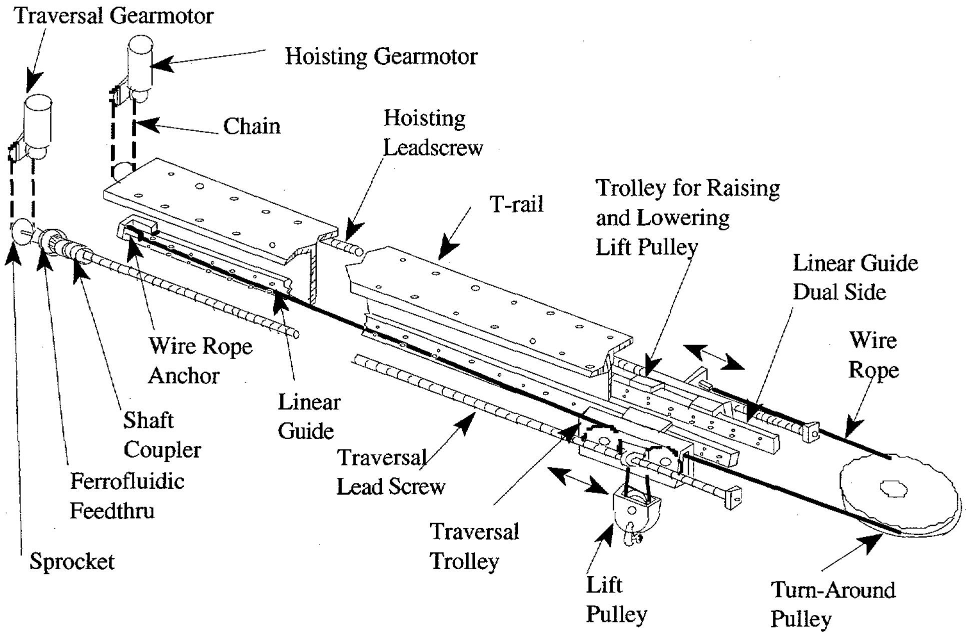

Figure 10: Cross Section of Trolley Lift Assembly

acme screw nut in the direction that tripped the limit switch is prevented. However, motion in the opposite direction (allowing the screw nut to drive away from the limit switch) is allowed by the controller.

The load assembly consists of a quick release pin which can be used to attach two different load holding fixtures to the hoist. One fixture is a three finger gripper assembly which is pneumatically actuated. This gripper can be used for remote pick up of bisected pit hemi shells, product cans, or various tools for transport to and from the glovebox airlock. A second fixture consists of a vacuum chuck which can be used to pick up and transport whole pits. A three way valve, mounted external to the glovebox, is used to select either vacuum or pressurized argon depending on which lifting tool is used with the hoist. A manual valve on the load assembly is used by the operator to activate the vacuum or pneumatic function required to operate the selected fixture. A view of the system is shown in Figures 11.

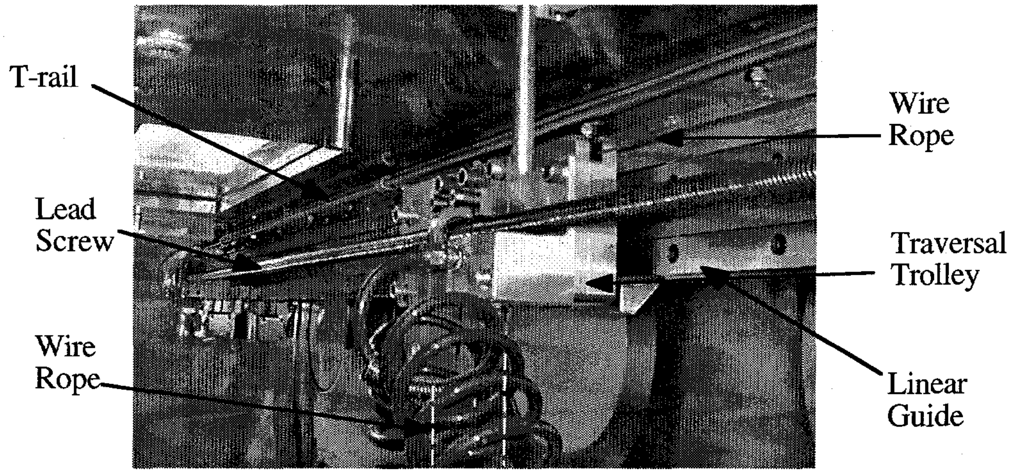

Figure 11: Traversal Trolley System at Middle of Glovebox

The load limit for the hoist assembly is 230 pounds. This value was derived assuming a safety factor of 8, based on a 920 pound breaking strength value for 3/32" diameter wire rope. Since the hoist has an effective pull ratio of 2 to 1, the load seen by the wire rope is half of 230 pounds (920 pounds/8, or 115 pounds). Engineering safety analyses were based on reaction forces seen by the various components assuming a 310 pound dead load (33% higher than the load limit) on the holding fixture.

CAN OUT USING ELECTROLYTIC DECONTAMINATION METHODS

One of the major modules of ARIES is the Electrolytic Decontamination Module. Once the task of canning and packaging of the metal or metal oxide in inspectable, hermetically sealed is compelled, the package under goes and initial helium leak test. The task of processing the material container through electrolytic decontamination is to reduce to levels of activity below specifications for release into the laboratory room. To allow removal of the can from the glovebox the can must meet the following alpha limits: direct readings ≤ 500 dpm/100cm^2; swipable readings ≤ 20 dpm/100cm^2. The electrolytic decontamination of 304L stainless steel material containers has been previously verified on experimental systems, in this module the process is demonstrate in an integrated process.

Electrolytic decontamination involves the anodic dissolution of contaminants under conditions similar to those used in industrial electropolishing. The process has been demonstrated throughout the DOE complex. At LANL electrolytic decontamination has been demonstrated on several surfaces, including stainless steel and highly enriched uranium. In this work electrolytic decontamination is being used in the glovebox canout, which will enable the stainless steel material containers to be handled outside the glovebox environment.

The glovebox for this process is divide into three partitions, one of the partitions is "hot" and conneted directly to the conveyor glovebox line without an airlock , the atmosphere is dry air and is the same as the conveyor glovebox. The helium leak testing of the material container, weighing and preparation is performed in the area. In this area the full negativity of the process is controlled and the glovebox is handled as a primary radioactive control zone. The second partition contains the solution handling system. The pumps and liquid tanks are maintained in this area as well as all the valves and control equipment. This zone is also a primary radioactive control zone except the inlet air is supplied from the room directly through a HEPA filter. This area is potentially hot and must be handled as such, and is vented into the process ventilation zone in order to maintain the negativity required. The third area or zone is like a hood, room air is supplied to the partition through several glove ports, the zone vents to the room air exhaust through a HEPA filter. This third zone is cold and should be free of radioactive contamination. Between the third zone and the first zone, the electrolytic decontamination fixture is place in the wall of the glovebox forming a passage as an airlock would. The electrolytic process permits the material container to be moved from the "hot" side to the "cold" side. Figure 12 is a layout of the glovebox and the location of the electrolytic fixture.

The material containers that are used in the ARIES process glovebox line are 6.5 inches high after assembly and have a 4.5 inch diameter. The can is formed by deep drawing the lower body as well as the short cover lid. The assembly is sealed by TIG welding under a helium environment at the interface of the lower body and the top lid. Figure 13 shows the material container on the shuttle as it is being delivered to the "hot side of the electrolytic decontamination module. When loaded into the fixtures the space between the can and the fixture is about 0.12″ all around the surfaces of the container. The flow in the entrance and exit is at 45° with the can lid to establish tangential flow of the electrolyte across the top and bottom of the container. The electrolyte flow spirals around the longitudinal section of the can due to the inlet and outlet porting. Figure 14 shows the arrangement of the can in the fixture.

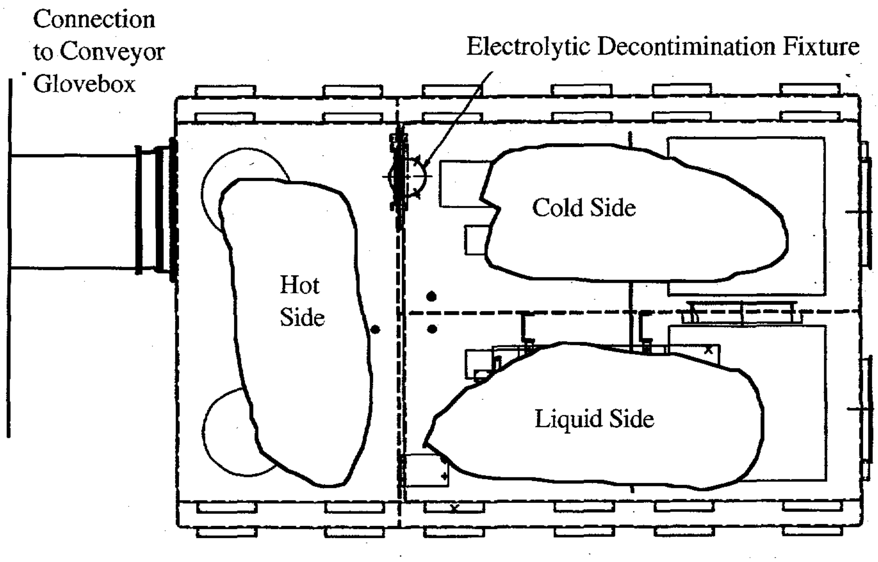

Figure 12: Glovebox Layout, Top View

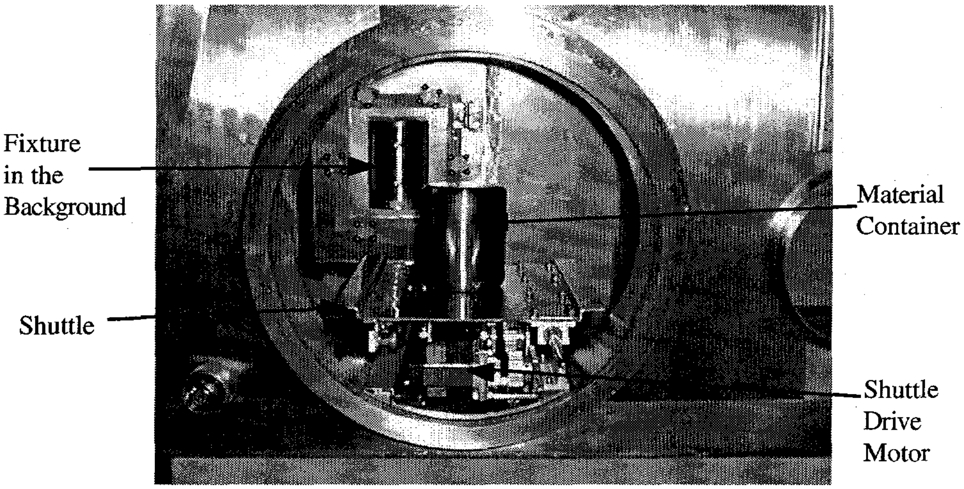

Figure 13: Material Container on Shuttle

For the electrolytic decontamination of material cans, the can is the anode, and the stainless steel fixture that holds the can is the cathode. An electrolyte solution (200 g/L Na_2SO_4) is pumped through the fixture across the surface of the material container at a flow rate of 0.5 to 1.0 gal/min. after having gone through an ultrafiltration process. A low DC voltage is applied across the fixture. The current that is generated is used to drive the chemical dissolution of the surface of the can, including the contaminants. The Fe and Ni components of the stainless steel form a hydroxide precipitate, which also contains the actinide contaminants. The electrolyte is filtered in a batch process using a Buchner funnel in the first zone of the glovebox. The electrolyte is thus recycled back to the liquid zone of the glovebox. The Cr from the stainless steel surface remains in solution and is precipitated and filtered in a similar batch process when the electrolyte becomes ineffective due to the Cr loading. The precipitates are discarded as either TRU or low-level waste.

Water is pumped through the fixture in both directions to remove any remaining electrolyte from the fixture. The surface of the container is heated and air dried prior to removing the container from the fixture. With the container dry it is removed from the fixture and swiped and direct readings are taken of its surfaces before the container is removed from the fixture. If the side wall of the container is free of activity, it is removed from the fixture and the top and bottom to the container examined for activity. With the container free of radioactivity it is helium leaked tested before it is removed from the glovebox. When free of contamination the container can be handled in the laboratory room and further processed.

The process has been fully developed and operates user computer control. Process signals from the flow loop monitor the system and allows the process to move from stage to stage with minimal or no operator intervention.

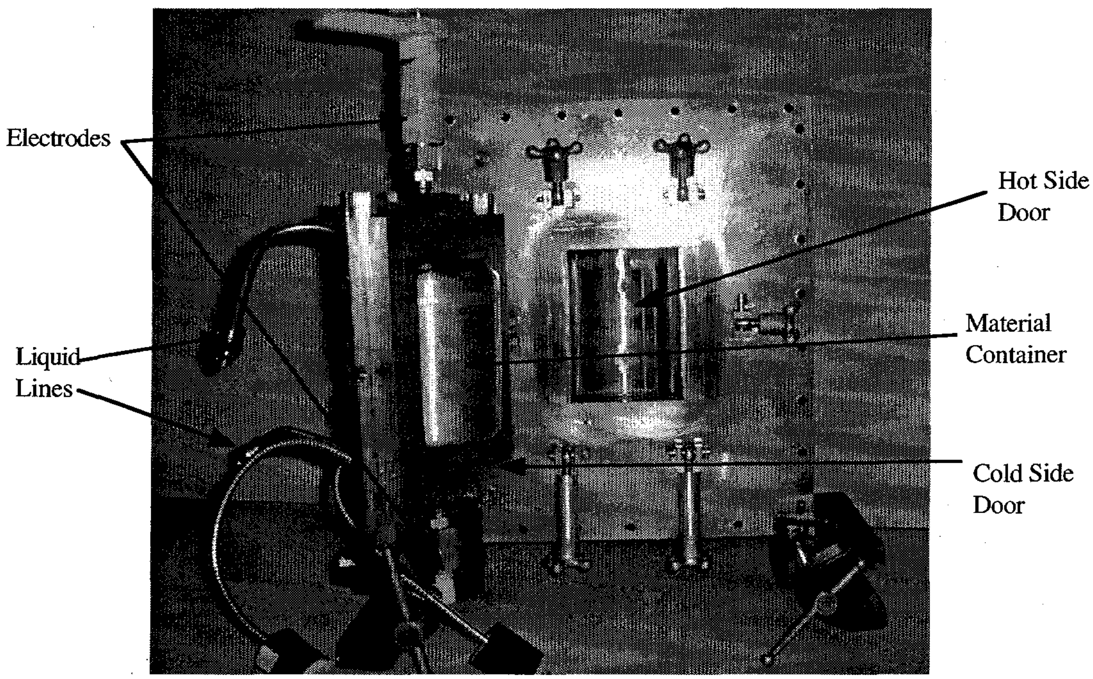

Figure 14: Fixture Arrangement

SUMMARY

The material transport system, the airlocks, and the airlock transfer system are operational in the ARIES conveyor system gloveboxes at the TA-55 Facility. The systems are awaiting final integration with the process modules of the ARIES system in PF-4. The two type of material handling system are operational and ready for use. The electrolytic decontamination system for the ARIES system has been tested and is ready for full demonstration. This system will provide a means of decontamination of the containers with very little operator intervention, again minimizing exposure time and reducing dose. The intent is that the described system will minimize exposure by minimizing time and lengthening the distance between the operators and the materials.

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1. DOE-STD-3013-96: "Criteria for Packaging of Plutonium Metals and Oxides for Safe long-term Storage", United States Department of Energy, September 1996.

2. H.E. Martinez, et al., 1997, "Update and Operation of the ARIES Conveyor Glovebox System", LA-UR-97-2839, Ameraican Glovebox Society Conference, July 21-24, 1997, Lakewood Colorado.

ACKNOWLDGEMENTS

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