HANDSS-55: A TRU WASTE REPACKAGING SYSTEM FOR THE SAVANNAH RIVER SITE

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ABSTRACT

The U.S. Department of Energy's (DOE) funds technology development to meet its clean up objectives through the Office of Science and Technology (OST). OST has set up focus areas and cross cuts reflecting the major problem and technology development areas within the DOE complex. The Transuranic and Mixed Waste Focus Area (TMFA) works to deliver engineering and technological solutions to DOE sites related to the characterization, treatment and disposal of both transuranic and mixed waste. The TMFA works with the individual DOE sites to identify their technology needs. Many DOE sites have similar problem areas, and the TMFA works to efficiently use the DOE's funds for technology development to have the greatest complex wide impact.

The focus areas utilize the cross cutting programs for technical expertise to identify and forecast technology development. The TMFA works with the Robotics Cross Cutting Program (RBX) to solve the handling issues related to preparing mixed waste for treatment and disposal. The TMFA and RBX are currently developing a Handling and Segregating System for 55-gallon drums of mixed waste (HANDSS-55) for use at the Savannah River Site (SRS).

HANDSS-55 is a waste sorting and repackaging system to prepare transuranic mixed waste for disposal at the Waste Isolation Pilot Plant (WIPP). HANDSS-55 is a remotely operated system that opens 55-gallon drums of mixed waste, transfers the contents to a sorting table, removes the non-compliant items, volume reduces the excess containers, and repackages the waste into polyethylene canisters. The system is divided into four modules: 1) the Waste Sorting Module, 2) the TRU Waste Repackaging Module 3) the Process Waste Reduction Module and 4) the System Integration and Control Module. HANDSS-55 is being developed by three teams: 1) the Idaho National Engineering and Environmental Laboratory, 2) the Savannah River Technology Center, and 3) the Pacific Northwest National Laboratory. The four modules will be integrated and demonstrated at the Western Environmental Technology Office (WETO) of DOE at Butte, Montana. After demonstration at WETO, HANDSS-55 will be deployed by SRS.

SRS is a dedicated end user and an active participant in the HANDSS-55 development effort. SRS has not only participated in the development but is also providing in-kind funding for containment structures and ancillary equipment. The HANDSS-55 development effort is a successful pilot for joint cooperation between focus areas and crosscuts, utilizing multi-site development teams, with strong end user involvement from the project's conception.

BACKGROUND

The Transuranic and Mixed Waste Focus Area (TMFA) was formed to support the Department of Energy's (DOE) cleanup goals. The mission of the focus area is to provide solutions to the DOE's clean up problems. The TMFA is co-managed by DOE's Idaho Operations Office (DOE-ID) and the Carlsbad Field Office (CBFO). The TMFA utilizes the cross cutting organizations to bring specialized expertise in the area of robotics to help with solving DOE needs. Robotics development within the TMFA is funded through the Mechanical Systems work package. The

Mechanical Systems work package works closely with the Robotics Cross Cut (RBX) to evaluated DOE technology needs and develop or adapt solutions.

The TMFA is developing a handling and segregating system for 55-gallon drums of mixed waste called HANDSS-55, as shown in Figure1. HANDSS-55 was originally to be deployed at the Idaho National Engineering and Environmental Laboratory (INEEL). However, due to decisions related to environmental permitting the INEEL decided not to continue with development. At that time the TMFA contacted other DOE sites that had needs for a waste segregating and repackaging system. The Savannah River Site (SRS) identified a need to sort and re-package at least 30,000 drums of transuranic waste and committed in-kind funding to support the development and deployment of this system. The first step to transfer this development effort was to identify of the Functional and Operational Requirements (F&OR's) for deploying HANDSS-55 at SRS. The INEEL Robotics Group was the primary developer for the system when it was scheduled for deployment at the INEEL. As requirements developed for deployment at SRS, two additional robotics organizations were brought on board through the RBX. Personnel from the Pacific Northwest National Laboratory (PNNL) supported end effector development and conversion of the system for use on Remote Handled (RH) TRU waste, and the Savannah River Technology Center (SRTC) was included for its expertise on bagless transfer and for deployment support.

The HANDSS-55 development team is comprised of engineers and scientists from the INEEL, SRTC, PNNL, the Western Environmental Technology Office (WETO) and the International Union of Operating Engineers (IUoOE). The system will be integrated and demonstrated by MSE Technology Applications at Butte, Montana.

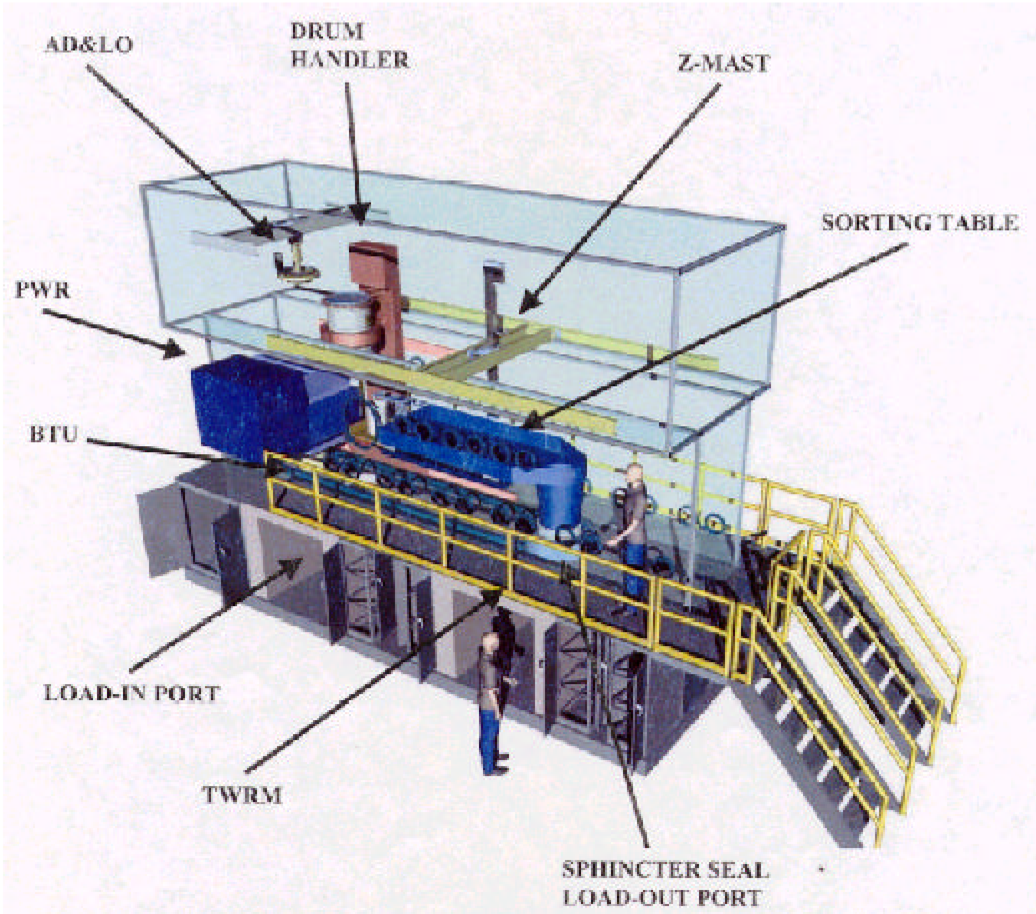

Fig. 1. HANDSS-55 Components

HANDSS-55 DEVELOPMENT

HANDSS-55 is being developed to allow verification of nondestructive examination processes and to remove the identified Waste Isolation Pilot Plant (WIPP) non-compliant items. The primary non-compliant items that are anticipated are aerosol cans and containers of liquids. These items will be removed from the waste stream by HANDSS-55 but will not be treated. Non-compliant items will be bagged out of the HANDSS-55 system.

HANDSS-55 is being developed to repackage TRU waste contaminated with Pu-238, which poses a severe contamination control problem. Therefore, this development effort is a testing ground for use on remote handled waste. Due to the unique contamination characteristic of Pu-238, HANDSS-55 must implement three levels of contamination control. The first level of contamination control is the glovebox, around the HANDSS-55 equipment, which is housed within two more containment structures. Due to the three levels of containment that are necessary to protect the workforce, this was an excellent proving ground for the technology relative to remote operability and maintainability.

HANDSS-55 is a remotely operated waste repackaging system made up of four modules: 1) the Waste Sorting Module, 2) the TRU Waste Repackaging Module 3) the Waste Processing Module,

4) the System Integration and Control Module. HANDSS-55 is being designed in a modular format for easier duplication of the modules at other sites.

WASTE SORTING MODULE

The Waste Sorting Module consists of the Automated Drum and Liner Opener (AD&LO), drum handler and the Sorting Station, these components are shown in Figure 2.

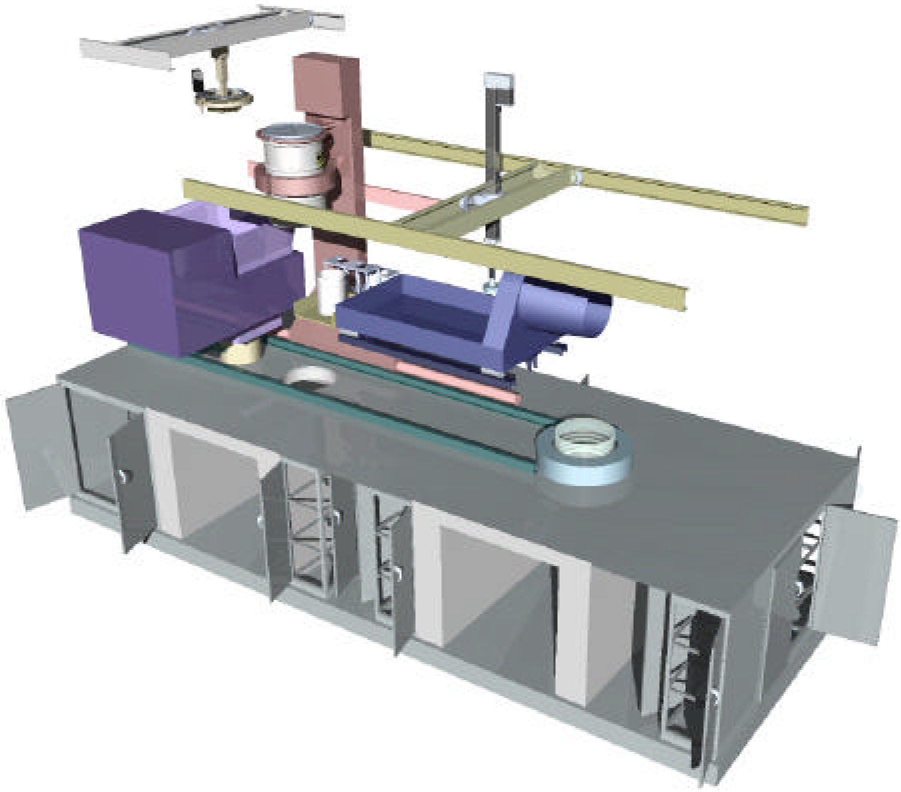

Fig. 2. Components of Waste Sorting Module

Starting at left side of Figure 2. The first component shown is the overhead mounted AD&LO, then the drum handler, next is the bridge mounted universal end effector, which is above the sorting table and the funnel. The funnel is shown folded up and above the load out port.

The SRS waste is also unique because of its packaging arrangement, which is a rigid 90 mil polyethylene liner inside a standard waste drum. The liner lids were pressed into place when sealed and in some cases were also chemically bonded. Due to it being unknown as to which drums were pressure sealed and which were chemically bonded, a drum and liner opening system had to be developed that could remove the drum lid but also be adaptable to removing the liner lid.

The AD&LO opens both the 90 mil rigid high-density polyethylene liners and the standard 55-gallon metal drums. Inside the liners, the waste is packaged in separate sealed plastic bags. A photograph of the AD&LO is shown in Figure 3. The separate waste bags or waste cuts are sealed by taped methods referred to as j-wraps or horsetails. The drum opening system takes into account the probable location of the waste cuts while opening the drums to minimize the potential for prematurely breaching the waste bags, thus spreading contamination.

The bolt ring on the waste drum is removed prior to loading the drum into HANDSS-55. The AD&LO uses a suction system to remove the lid. It then uses the suction system to orient the cutter blade with the top of the rigid liner. The AD&LO inserts a single cutting blade, which revolves around the drum while the liner is being cut. The cut is made in multiple passes. After the cut is completed the suction system is used to remove the top of the liner to gain access to the waste. After the drum and liner are opened, the drum handler moves the drum to the sorting station.

Fig. 3. Automated Drum and Liner Opener (AD&LO)

The Sorting Station includes: 1) a vibrating/tilting sorting table; 2) universal end effector; 3) an XYZ Deployment System; 4) a three-dimensional imaging system; 5) a waste bag opening system; and 6) a non-compliant item accumulation area. The system is modular in design to accommodate database management tools, additional load-out ports and other enhancements.

The sorting table is a stainless steel surface with 6-inch sides that can be raised to a 20 percent incline. The operator identifies the non-compliant item on a touch screen and it is automatically removed from the waste stream by the universal end effector. The universal end effector is a three-finger gripper that was purchased from Barrett Industries. The selection of the Barrett Hand was made using expertise from the University of New Mexico, their research was supported by a program funded by the Robotics Cross Cut. The three dimensional (3-D) imaging system allows the operator to have accurate depth perception within the waste stream, utilizes a unique dot matrix system vision system. The vision system is being developed in cooperation with the Star Cam Company and the INEEL. After removal of the non-compliant items, the compliant waste is transferred to a polyethylene canister by raising the sorting table to an incline, which forces the waste to slide down to a funnel, where the waste is gravity fed to the canister. The sorting table can be vibrated to enhance the rate at which waste slides down the table. Some items, such as duct tape has adhered to the table, but was dislodged by the other waste sliding down the table.

The sorting and segregating of a 55-gallon drum of waste, using manual methods would take at least one day per drum. The HANDSS-55 Waste Sorting Module is designed to significantly decrease the time required for sorting and repackaging by automating those functions that are strenuous and tiresome for an operator to perform. This module allows the operator to identify the items that need to be segregated from the waste stream and then, under computer control, pick up that item and transfer it to the waste accumulation area. The operator identifies the object by touching its visual image on a color display screen with his finger. The computer then determines the location of the object, and performs a high-speed image analysis to determine its size and orientation, and the gripper on the universal end effector can pick it up. Now the operator verifies the correct object has been picked up, by either a voice command or use of a function key, then the object is deposited into the non-compliant item collection area. Once the non-compliant items have been removed, significant time can be saved by quickly clearing the rest of the waste stream item into the load out port in a one-step operation. The operator performs this operation using a simple voice or function key command while sitting at the control console. Video images of the in-cell operations are displayed at the console to allow the operator to monitor all operations being performed in the glovebox.

TRU WASTE REPACKAGING MODULE

The TRU Waste Repackaging Module (TWRM) is made up of a sphincter seal, the polyethylene waste canister, an infrared welding system, and drum lifting and positioning devices.

The compliant waste is packaged using a “split plug” bagless transfer method that was developed by the Savannah River Technology Center (SRTC). This system is a modification of a stainless steel packaging method that is used for packaging Plutonium Pits. In the split plug process, a waste-receiving canister, which contains a hollow plug, is inserted through a sphincter seal into the glovebox. Once inside the glovebox the hollow plug is removed from the container to allow filling of the waste canister with the compliant waste. This method uses a sphincter seal to maintain contamination control and an opaque polyethylene canister, a black hollow plug, and infrared welding to seal the canister. The polyethylene canister is approximately 14 inches taller than a standard 55-gallon drum and this excess height is called the collar. The polyethylene canister is shown in Figure 4. The canister is loaded with compliant waste through the funnel at the end of the sorting table. Below the collar on the canister, the diameter narrows to provide a seating surface for the hollow plug. A skirt is put over this seating area to protect it from becoming dirty from the waste. After the canister has been filled, the funnel and skirt are removed, and the black hollow plug (shown in Figure 5) is seated in this concave area.

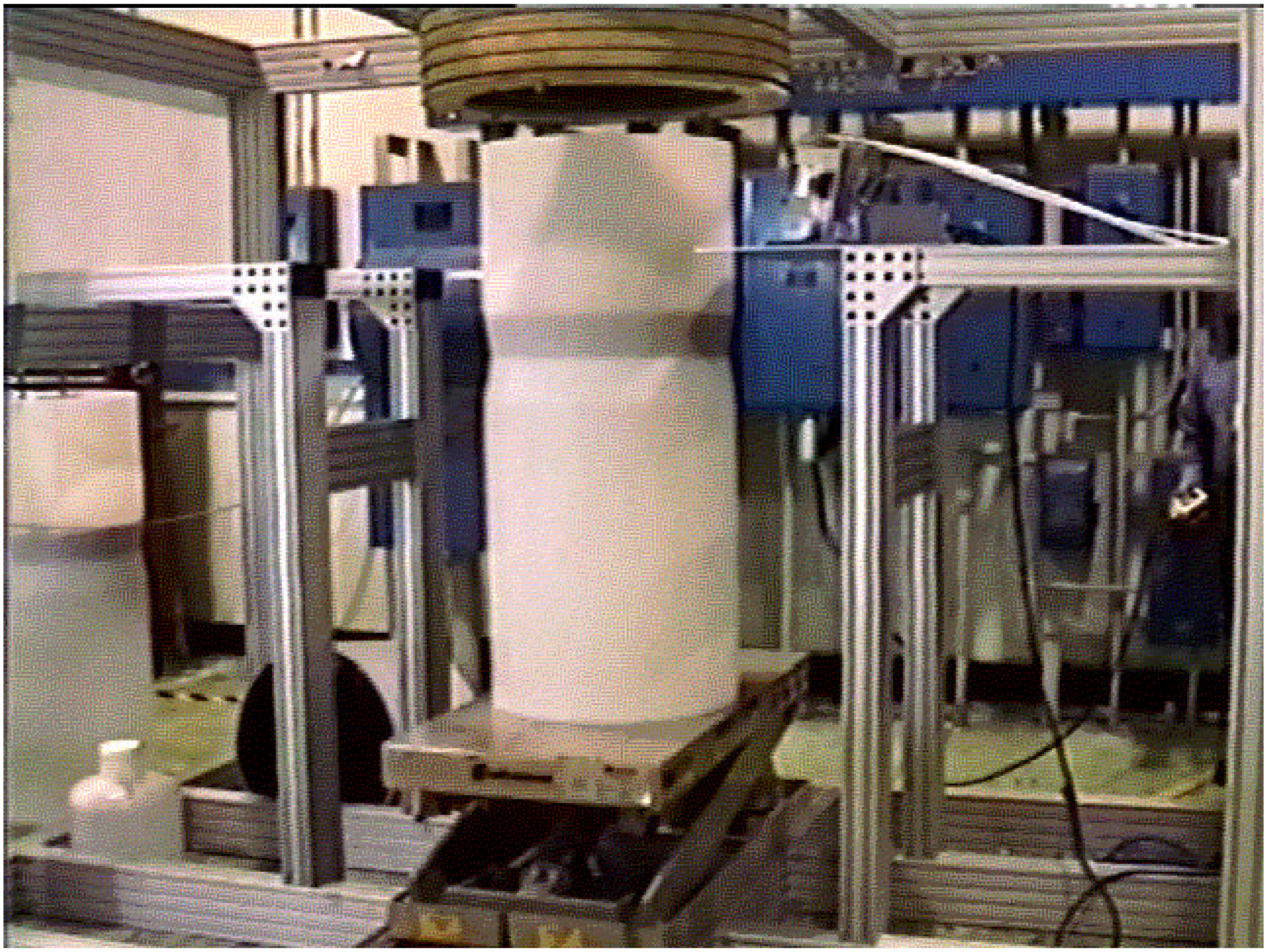

Fig. 4. Photograph of polyethylene canister under sphincter seal mock-up

The infrared welder encircles the canister and the canister and plug are heat-sealed. The infrared welder is a series of halogen lamps that provide the energy to make the weld. The principle behind the welding technique is that the light energy passes through the opaque polyethylene and is accumulated in the black hollow plug. The black plug heats up and melts to the opaque container. Air is blown on the welding process to control the heat to prevent puckering. One unique aspect of this welding process is that it is done below the glove box and can be visually inspected. After the weld has been deemed good, the hollow plug is cut between its top and bottom separating the collar from the canister. This cut is made using an adapted commercially available pipe cutter. The inside of the hollow plug provides the clean surfaces that have not been exposed to contamination while the plug was inside the glove box. After the cut has been made the container is lowered and separated from the collar, the collar stays in the sphincter seal maintaining a seal with glove box. The new top surface of the container is clean, as is the bottom of the collar. The next container is used to push the collar into the glovebox and provides the new seal with glovebox. The collar and the used drum and liner are shredded in the Process Waste Reduction Module.

Fig. 5. Photograph of the black hollow plug

PROCESS WASTE REDUCTION MODULE

Due to the transfer and disposal costs related to TRU waste the reduction in the volume of the secondary waste streams is very important. The volume reduction and disposal of the 14-inch collar that remains after the polyethylene canister is sealed was a significant issue when developing the TWRM. A method of volume reduction had to be selected that would be able to size reduce not only the collar but also the used drum and 90 mil high-density polyethylene liner.

The emphasis in this module was to investigate thoroughly the availability of commercially available equipment. During the technology selection process the main criteria considered equipment reliability, ease of maintainability, space constraints, and cost. Many different alternatives were analyzed based on the previous criteria. Options investigated included drum crushers, multiple axis crushers, high-speed shredding, thermal processes and cryogenic crushing. Many combinations of these methods were also considered.

Originally a cryogenic crusher was selected as the preferred alternative, but due to safety issues related to high-pressure gases within a glovebox environment and the need to volume reduce the collar, this method was abandoned. A low-speed high-torque shredder was determined to be the best option for HANDSS-55. The shredder is depicted in Figure 6. The shredder will volume reduce the drums, liners, and the other process waste too less than 5 times its original size. The output of the shredder must be of a small enough size to easily fit within the load out canister. Adding the shredded material to the canister provides a cushion between the canister and the gravity loaded waste. The shredder is being procured from a commercial vendor with only minor adaptation.

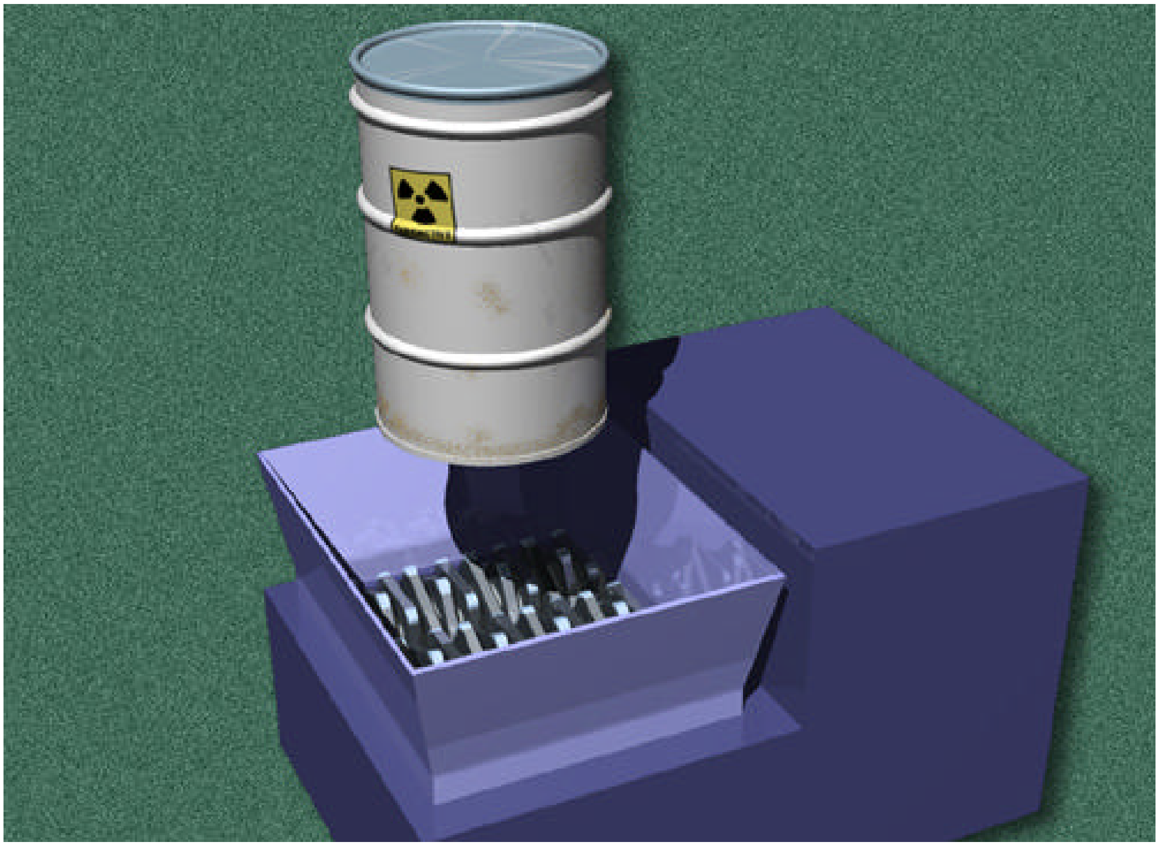

Fig. 6. Graphic of Process Waste Reduction Module

SYSTEM INTEGRATION AND CONTROL MODULE

The System Integration and Control Module (SCIM) is divided into two areas: electrical, which includes software development, and mechanical, which consist of the linking components called the TRU Waste Transfer System. The TRU Waste Transfer System is composed of the Drum Handler, the Bucket Translation Unit (BTU), and the TWRM Deployment System. The primary of objective of the SCIM is to allow the three operating modules and the glovebox to act as a seamless system instead of 3 pieces of equipment.

HANDSS-55 is being developed with three individual operating modules that must be integrated to work as a seamless system. The integration of these modules began with identifying the subsystems that are required to link the three modules together and then developing the functional and operational requirements for each subsystem. As each subsystem was developed it was documented in the solids model of the entire system. The solids models are incorporated into the component envelope for the system, to establish the geometric constraints for each of the subsystems and module components. System operation flow sheets were then developed to identify the steps and component interactions required to process 55-gallon drums. The linking components are being developed to satisfy the identified requirements. The solids models are incorporated into the component envelope to help ensure that the final system will fit within the geometric constraints placed on the overall design and aid in tight schedule and budget constraints.

A major part of the system integration of the modules is the control and integration software. The HANDSS-55 control system provides the operational control between the mechanical, electrical and computer components to provide the capability to sort and repackage drums of waste. The System Integration and Control Module (SCIM) uses a standard client/server model that is based on Microsoft's COM/DCOM (Distributed Component Object Model). This type of system allows for flexibility in expanding and redistributing control.

Two types of hardware controllers control the sensors and mechanical components within HANDSS-55. The first type of controller is an eight-axis controller, which handles the motor driven equipment such as the motion of the XYZ Positioning system for the sorting station. The second controller is a "smart" general-purpose controller that handles analog and digital input and output signals. These controllers provide very low-level control functions, but also are capable of being programmed. These controllers are connected to a general-purpose computer, which will allow access to server software. This connection to a local network will allow HANDSS-55 to be controlled from many server locations or a single location.

INTEGRATED DEMONSTRATION

As the modules are completed and tested at the development sites, they will be transferred to WETO in Butte for assembly and integrated testing. MSE Applications at WETO is the integration and demonstration contractor for HANDSS-55. Modules will start arriving at WETO during the 3rd quarter of fiscal year 2001 and continue through 2002. The integrated demonstration will take place during FY-03 and the modules will be transferred to SRS after its completion. This schedule is contingent on HANDSS-55 receiving sufficient funding to meet its schedule commitments.

GLOVEBOX FABRICATION

Development of the HANDSS-55 glovebox is being done in cooperation with the TMFA and the End User, the Solid Waste Division at SRS. The glovebox that will house HANDSS-55 is complex as shown in Figure7. The glovebox is "T" shaped and approximately 26 feet long, 4 $^{1}/_{3}$ feet wide at the bottom, 10 feet wide at the top and 19 ½ feet tall.. Many size restrictions were implemented due to the deployment location being within an existing structure at the SRS. The glovebox development is being lead by the end user and is being funded equally in multi-year commitments by the TMFA and the SWD at SRS. The glovebox is composed of the glovebox shell, drum load-in port, non-compliant load out port, and glovebox support structure.

INNOVATIONS RELATED TO THE HANDSS-55 DEVELOPMENT

Two innovative technologies are being developed as part of HANDSS-55. The TWRM is using a polyethylene canister that acts as a contamination barrier as well as a waste canister. This technology is unique due to the flexible nature of the polyethylene canister. The canister could be made three drums long to fit an RH-TRU 72-B container or sized to fit half a standard waste box. The TWRM polyethylene canister may be one of the major steps in adapting the HANDSS-55 technology for the RH TRU waste arena.

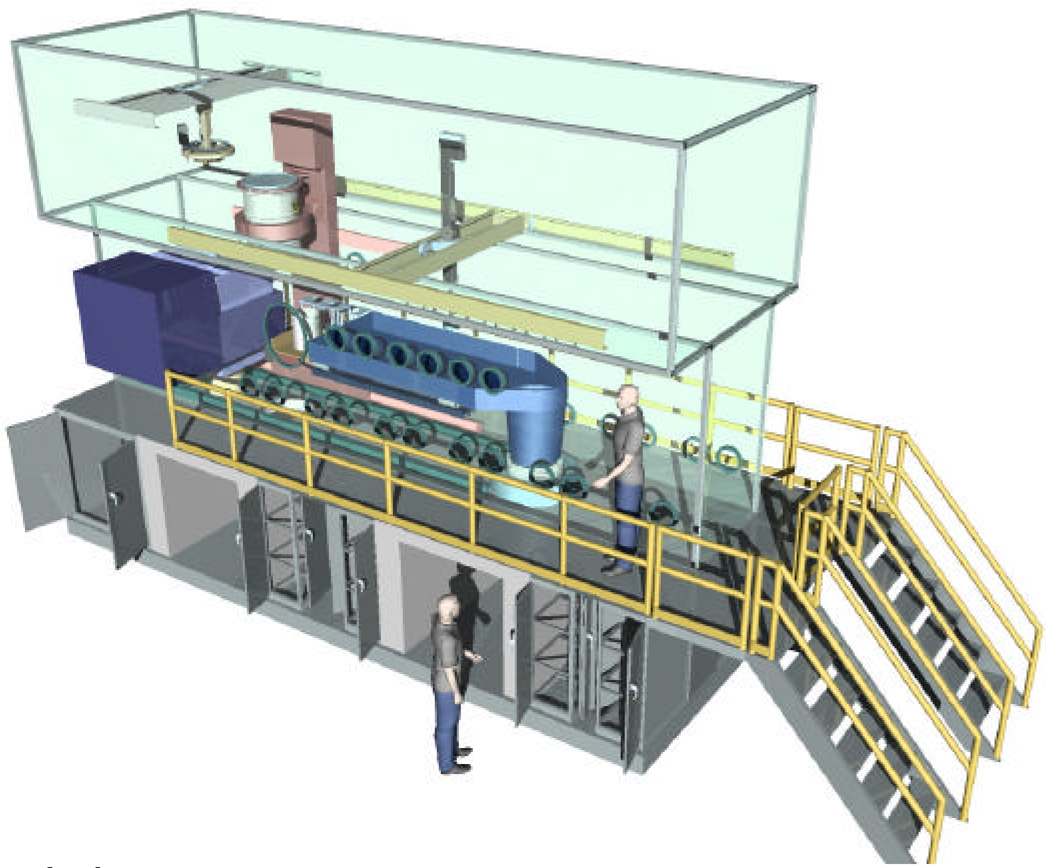

Fig. 7. Glovebox Layout

The second innovative technology is the development of a low-profile Z mast which is a collaboration between the HANDSS-55 development team and research and development project supporting decontamination and deactivation at the INEEL. The two groups are leveraging their funding to produce a low overhead profile Z-mast that has adequate extension to reach within waste containers. This technology is necessary for most mobile repackaging efforts.

The HANDSS-55 development effort has been unique from the beginning. It started out as a repackaging system being developed by RBX for the INEEL. It lost both priority with the end user and the funding organization and was picked up by the TMFA because it provided a solution in a high priority need area. It is now being developed as a collaborative effort between the TMFA and RBX under EM-50's focus area centered approach. The TMFA acts as the lead in the development effort and relies upon the RBX to act as the expert or contractor in the field. The system, which was originally being developed by one site, is now a multi-site team. In the past year, three new organizations have been brought into the development effort. The CBFO is now co-managing the focus area and its interests related to TRU waste. The IUoOE is performing both radiological and industrial safety analyses for the project. MSE at WETO will integrate and demonstrate the system. With the numerous sites and organizations involved in this development, a communication plan was essential. To maintain communication, the development team meets 3 times a year and has bi-weekly video-conferences. The team leads, project manager and TMFA also hold conference calls twice a month. Communication outside the communication plan must be documented and distributed to all interested parties.

Also unique to this development effort is the level of involvement by SRS. SRS has provided a consistent team member since becoming the end user of the technology. The end user representative is active in all team communications, technology review processes and acts as the site liaison. SRS has initiated General Plant Projects (GPP) funding to prepare the HANDSS-55 deployment site, build the second and third level of containment for the glovebox and provide utilities for the system. SRS is also providing half of the funding for the HANDSS-55 glovebox.

The demonstration of HANDSS-55 at WETO and the deployment at SRS will be an example of successful joint cooperation between many EM-50 organizations and EM-30.

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2. Marzolf, D., Fogle, R., Prather, M., Milling, R., and Harpring, L., "Advanced Technology for Repackaging TRU Waste", WSRC-MS-2000-00903, December 2000.