Automation in a Material Processing/Storage Facility

by
K. Peterson
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808
J. Gordon


DOE Contract No. DE-AC09-89SR18035

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ABSTRACT

The Savannah River Site (SRS) is currently developing a new facility, the Actinide Packaging and Storage Facility (APSF), to process and store legacy materials from the United States' nuclear stockpile. A variety of materials, with a variety of properties, packaging and handling/storage requirements, will be processed and stored at the facility. Since these materials are hazardous and radioactive, automation will be used to minimize worker exposure. Other benefits derived from automation of the facility include increased throughput capacity and enhanced security.

The diversity of materials and packaging geometries to be handled poses challenges to the automation of facility processes. In addition, the nature of the materials to be processed underscores the need for safety, reliability and serviceability. The application of automation in this facility must, therefore, be accomplished in a rational and disciplined manner to satisfy the strict operational requirements of the facility.

Among the functions to be automated are the transport of containers between process and storage areas via an Automatic Guided Vehicle (AGV), and various processes in the Shipping Package Unpackaging (SPU) area, the Accountability Measurements (AM) area, the Special Isotope Storage (SIS) vault and the Special Nuclear Materials (SNM) vault. Other areas of the facility are also being automated, but are outside the scope of this paper.

I. FACILITY CONTAINER HANDLING

Figure 1 depicts a simplified flow of containers through the facility and into the storage vaults. The various shipping package containers will be handled by a fleet of AGV's, a pick-and-place robot, a gantry crane robot in the AM area and a material handling robot in the SIS vault. All material destined for the SNM vault will be repackaged into Interim Term Storage Containers (ITSC's), whose geometry is different from that of any shipping package container.

Figure 1. - APSF Container Flow

Overhead handling of containers is required by certain processes in the AM room and by the storage method used in the SIS vault. An additional consideration is that containers will be hung on engineered pegs in the SNM vault by the AGV. The container hanging strategy is being developed for the vault so that it can accommodate possible future container geometries without modification to the vault.
II. CONTAINER HANDLING STRATEGIES

Figure 2 depicts some of the container geometries to be handled in the APSF. After taking into account the handling requirements imposed by all containers and facility areas, an integrated strategy for container handling was devised.

![Figure 2 - Samples of Container Geometries]

A. AGV’s

AGV’s will be used to transport containers between most areas of the facility, to place ITSC’s in the SNM vault, and to perform routine surveillance and inventory evaluations. Increased security and reduced worker exposure are the incentives for this strategy. Each AGV will be directed and monitored over a wireless link by the facility control room. The use of several AGV’s will ease scheduling demands, permit ongoing operations during AGV maintenance and allow an AGV to retrieve a failed AGV from worker-restricted areas. The AGV system will consist of the vehicle fleet, the control system, peripheral equipment (bar code reader, video camera, etc.) and the generic container handling system.

Because containers will be shuttled between virtually all container processing/storage areas by AGV’s, the AGV’s must be capable of handling all container geometries. In addition, the AGV’s must be capable of hanging the ITSC containers vertically in the SNM vault. Since all containers have a cylindrical profile, the AGV’s will be equipped with a universal gripper which grasps all containers from their side. Figure 3 depicts a conceptual gripper design to accommodate the container geometry variations.

![Figure 3 - AGV Gripper Conceptual Design]

B. Pick-and-Place Robot

The stationary pick-and-place robot shuttles containers between the adjacent SPU and the AM areas. Like the AGV’s, the pick-and-place robot must handle all container geometries. It will employ a universal gripper like that on the AGV’s, handling all containers from their side. It will also utilize positioning stations to access and deliver containers.

C. SIS Robot

Figure 4 depicts the SIS vault, where certain materials with unique storage requirements will be stored. Since routine personnel entry in SIS will not be allowed, a robotic system within the SIS will accept containers from an AGV via a portal equipped with a positioning station, and place them in a sarcophagus with individual capped storage wells. The robot will eliminate the personnel exposure to radiation that would otherwise be incurred in the storage of these containers, and will also enhance the security of the storage vault by eliminating the need for personnel access to the vault on a routine basis.
Control of the SIS robot will be performed remotely from the facility control room. The SIS robot will only handle a single container geometry, so its gripper will be a dedicated design for handling SIS containers from overhead. Caps on each storage well will be equipped with fixtures that allow the robot to remove and replace them. An ultrasonic sensor will also be employed on the robot’s end effector to confirm that a storage well is unoccupied prior to placing a container in it.

The initial SIS robot concept featured a generic robot mounted on a track system to access all the storage wells in the SIS vault. Extended-reach robots have been identified which may eliminate the need for a track system. Benefits of a stationary robot include reduced cost and complexity, better repeatability, and simplified installation and removal of the system for servicing.

D. AM Gantry Robot

Unpackaged primary containers will undergo several analytical processes in the AM area. The AM gantry robot will handle containers from overhead to shuttle them between assay stations, and it must be capable of handling the full complement of containers. Fitting containers with adapters to create a universal handling interface for the AM robot would result in increased material/labor costs, operator exposure and inventory logistics. Adapters might also interfere with assay process within the AM area. For these reasons, a set of custom interchangeable grippers which attach to universal tool changers are being developed for the AM gantry robot. The tool changers are equipped with several pneumatic ports and electric lines to permit operation of the gripper and any end effector sensor. A gripper station will allow the robot to automatically select the appropriate gripper for the specific container to be handled.

E. SNM Vault

ITSC containers will be hung on engineered pegs in the SNM vault by the AGV. This system must meet seismic requirements. Since the ITSC geometry does not lend itself to being hung directly, especially in light of seismic requirements, a basket is being developed which will accept the ITSC from the AGV, and can in turn be hung on a peg in the vault by the AGV. Since the AGV will be able to handle ITSC’s and SNM baskets directly, and can also load and unload ITSC’s into and from the basket, the SNM vault inventory can be surveyed, sampled and reconfigured as needed using the AGV in place of workers. Decreased worker exposure and enhanced security are among the benefits of this strategy.

II. SHIPPING PACKAGE UNPACKAGING

A. SPU General Description

Shipping packages are opened in the SPU, and the inner primary container is removed for subsequent processing. This process is labor intensive and presents significant opportunity to reduce worker exposure, increase processing throughput and enhance safety.

An enclosure is required to shield operators from the radioactive materials inside the containers and provide containment of any possible contamination encountered during the unpackaging operation. Remotely operated equipment inside the enclosure will expedite the opening of shipping packages and the removal of containers, while minimizing the safety hazards associated with these tasks.
Shipping package outer containers are typically 30, 35 or 55 gallon drums, but other special geometries will also be handled. Shielding and packing components typically surround the inner vessels, some of which must be removed to access the interior. Primary vessels will also need to be removed from a secondary vessel with certain packages. After being unpackaged, the primary vessel is sent to other facility areas for assay and repackaging. The remaining components of the shipping package are reassembled for reuse. This stage of the operation is primarily performed manually, with basic automation employed to enhance worker safety and increase throughput.

To accommodate shipping package geometry variations, a flexible system for unpackaging is required. Other considerations in the design of the SPU include protecting the operator from radiation and potential radioactive contamination, worker safety, worker ergonomics and throughput.

The SPU enclosure concept shown in Figure 6 is based on an existing SRS facility design, but fundamental changes to the original design are being made to address current facility needs. Although it is not expected that contamination will normally be encountered, two complete enclosures will be required in the SPU to ensure that throughput requirements are met and to maintain a nominal processing capacity in the event that one enclosure does become contaminated. Each enclosure will provide adequate containment during decontamination operations to permit ongoing routine unpackaging in the remaining unit.

The overall conceptual design of each enclosure consists of an upper and lower section which are connected by a pneumatically-actuated sphincter type seal assembly. The lower section is used for preparation and monitoring of the various shipping packages, while the actual unpackaging operation takes place in the upper section. This strategy protects the equipment in the upper section from possible contamination during shipping package preparation in the lower section, and protects the equipment in the lower section, and most of the shipping package exterior, during unpackaging operations in the upper section.

Figure 6. - SPU Enclosure Concept

Both upper and lower sections of the enclosure will feature sealing access doors and connections to the facility HEPA exhaust system to provide overall containment of the shipping package and its contents in the event that contamination is encountered during unpackaging. Access to both section interiors during unpackaging is provided via gloveports to maintain containment. Cross contamination of the two sections is discouraged by the presence of a removable plug in the sphincter seal void during package preparation, or by the presence of the container itself in the sphincter seal during unpackaging operations in the upper enclosure.

B. SPU Enclosure - Lower Section

Shipping packages are brought into the lower enclosure section through an access door which will also permit bagging out of materials as required. The lower enclosure section includes a slide-out shelf attached to a rotating lift table to accept the shipping package for preparation and to partially raise it into the upper enclosure for unpackaging. A pallet will be attached to the lift table's slide-out shelf to accept the shipping package and then position it within the lower section. A variety of shipping packages can be accommodated using interchangeable pallets.

Other equipment to be contained in the lower section are shipping package preparation tools, radiation monitoring equipment and decontamination materials.

Preparation operations in the lower section include removing the drum ring or other components as needed and verifying that the currently-accessible surfaces of the shipping package are not contaminated. All of these operations will be performed manually via the enclosure gloveports.
C. SPU Enclosure - Sphincter Seal

The sphincter seal discourages migration of possible contamination between the lower and upper enclosure sections throughout the unpackaging process. While the shipping package is being prepared in the lower section, the seal is inflated against a barrier plug. When the shipping package is ready to be unpackaged, the barrier plug is removed, the package is lifted partially into the upper section, and the seal is inflated against the perimeter of the top of the shipping package.

Several sphincter seal assemblies will be required to accommodate the various shipping package geometries. Packages will be processed in “campaigns” to minimize the expense and incurred downtime associated with hardware changeouts. The hoist will be used to assist in removing and placing the sphincter seal assemblies.

D. SPU Enclosure - Upper Section

The upper section will be used to perform the actual unpackaging operations and to prepare the primary containment vessels for delivery to the AM room via a pick-and-place robot. The upper enclosure will include a powered trolley type chain hoist, a lid lifting mechanism, other unpackaging equipment, radiation monitoring instruments and decontamination materials.

A sealed access door will be included in the upper enclosure to allow general access to the upper section, to allow changeout of the sphincter seal assemblies, and to permit bagging out of materials as required. Safety switches will prevent operation of any enclosure equipment whenever any gloveport is occupied, or when the access door is open. An automatic door with a shielded passage will be used to transport the PCV from the SPU enclosure to the AM room using the pick-and-place robot.

Once the prepared package has been elevated to the upper section and the sphincter seal inflated, the lid will be removed and held out of the way using a vacuum cup attached to a powered pivoting arm. Vacuum cups were chosen for this operation because they are not dependent on the composition of the lid for attachment, as would be magnets. The entire lid removal process can be controlled from outside the enclosure unless the lid-to-drum seal needs to be broken manually.

Interior packing will then be removed from the package and set aside using the chain hoist and custom tooling. Since exterior controls for the hoist will be provided, worker exposure will be minimized. Other custom tooling will allow the hoist to lift the primary container from the package and deliver it to the SPU positioning station for delivery to the AM area by the pick-and-place robot.

SUMMARY

Significant benefits will be achieved by the application of automation to the APSF processes in terms of safety, worker exposure, security and throughput. The variety of shipping packages and inner container geometries makes it important, however, to apply automation judiciously so that initial costs and maintenance costs are minimized while optimizing reliability, throughput and security. The strategies presented in this paper with regard to container handling and shipping package unpackaging reflect these goals.