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# RADIOLOGICAL SURVEY STATION DEVELOPMENT FOR THE PIT DISASSEMBLY AND CONVERSION PROECT

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## 1. ABSTRACT

The Savannah River National Laboratory (SRNL) has developed prototype equipment to demonstrate remote surveying of Inner and Outer DOE Standard 3013 containers for fixed and transferable contamination in accordance with DOE Standard 3013 and 10 CFR 835 Appendix B. When fully developed the equipment will be part of a larger suite of equipment used to package material in accordance with DOE Standard 3013 at the Pit Disassembly and Conversion Project slated for installation at the Savannah River Site.

The prototype system consists of a small six-axis industrial robot with an end effector consisting of a force sensor, vacuum gripper and a three fingered pneumatic gripper. The work cell also contains two alpha survey instruments, swipes, swipe dispenser, and other ancillary equipment. An external controller interfaces with the robot controller, survey instruments and other ancillary equipment to control the overall process.

*Key Words*: SRNL, DOE Standard 3013, Robot, Radiological, Survey

## 1. INTRODUCTION:

The Savannah River National Laboratory (SRNL) is developing automated equipment for the Pit Disassembly and Conversion (PDC) Project that is slated for the Savannah River Site (SRS). The equipment being developed is automated packaging equipment for packaging plutonium bearing materials in accordance with DOE-STD-3013-2004. The subject of this paper is the development of a prototype Radiological Survey Station (RSS). Other automated equipment being developed for the PDC includes the Bagless transfer System, Outer Can Welder, Gantry Robot System (GRS) and Leak Test Station.

The purpose of the RSS is to perform a frisk and swipe of the DOE Standard 3013 Container (either inner can or outer can) to check for fixed and transferable contamination. This is required to verify that the contamination levels are within the

limits specified in DOE-STD-3013-2004 and 10 CFR 835, Appendix D. The surface contamination limit for the 3013 Outer Can (OC) is 500 dpm/100 cm2 (total) and 20 dpm/100 cm2 (transferable). This paper will concentrate on the RSS developments for the 3013 OC but the system for the 3013 Inner Can (IC) is nearly identical.

## 2. SYSTEM DESCRIPTION

The overall RSS consists of the subsystems and components described in this section. The system was installed at SRNL for development testing. Figure 1 is a photograph of the prototype work cell as installed at SRNL.

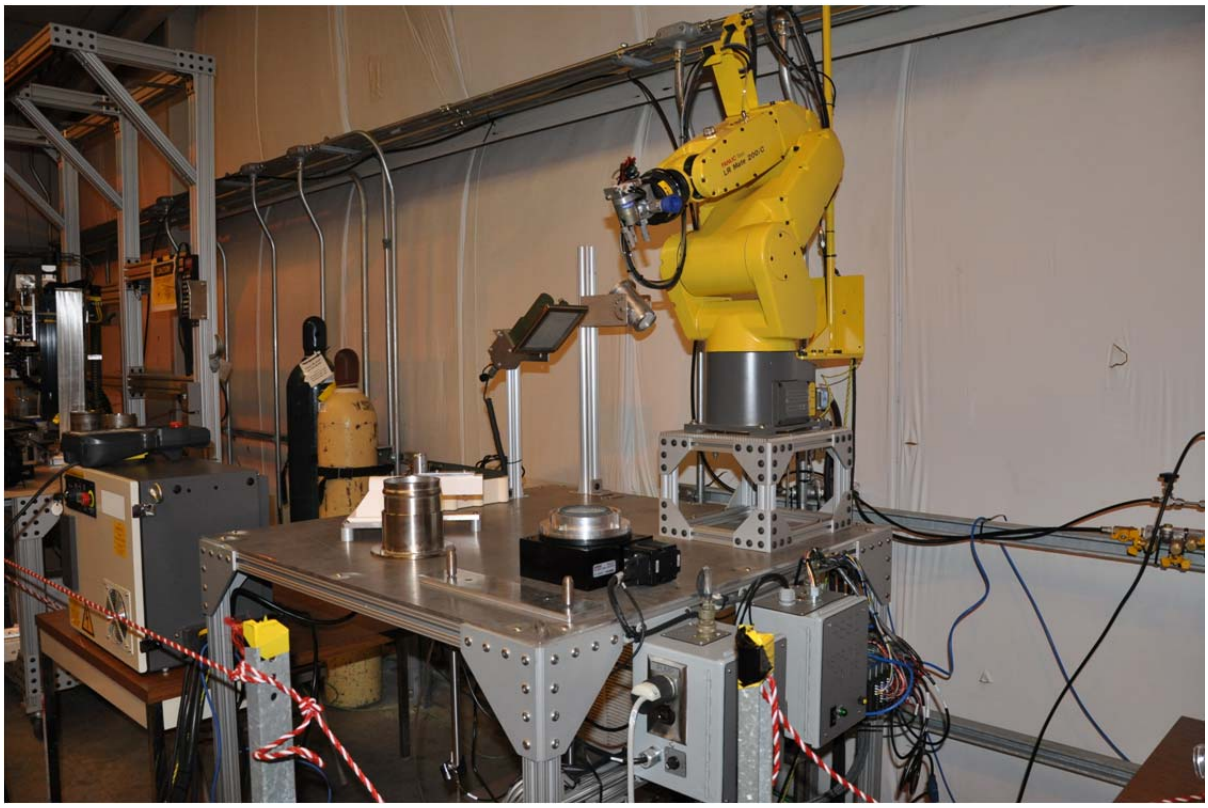

Figure 1 – RSS Prototype Work cell

The system is comprised of the following components: the robot, survey instrument, swipes, swipe dispenser, turntable, waste receptacle, GRS gripper targets, pneumatic and vacuum system and controller. Each of the components is described in more detail later in this section. The process of checking a 3013 OC for contamination will be automated in the sense that no hands-on tasks will be performed. There will be operators will be in the loop to provide permission to the controller to proceed to each a successive step in the process. In general, the process flow is as follows:

- The Gantry Robot System (GRS) will position the 3013 OC in the work envelope of the RSS and send a signal to the RSS controller that it is in position.

- The RSS controller will send a command to the robot to move to pick up the alpha probe, perform a “frisk” survey on the bottom of the 3013 OC and then return the probe to its storage location.
- The RSS controller will send a command to the robot to move to the swipe dispenser to retrieve a swipe, perform a swipe on the bottom of the 3013 OC and then take the swipe to the fixed survey instrument.
- The RSS controller will signal the GRS to position the 3013 OC on the RSS turntable.
- When the GRS positions the 3013 OC on the turntable the RSS controller will deploy the gripper targets to satisfy the GRS interlocks. This allows the GRS to release the 3013 OC. The RSS will also secure the 3013 OC on the turntable.
- The GRS releases the 3013 OC and moves to a position clear of the RSS work envelope.
- The RSS controller sends a command to the RSS robot to pick up the frisk probe and perform a frisk survey of the top and sides of the 3013 OC. When the frisk survey is complete, the robot returns the probe to its storage location.
- The RSS controller sends a command to the RSS robot to pick up a swipe disc (if necessary), swipe the top of the 3013 OC and then move the swipe to the survey instrument for counting.
- The RSS controller will then turn on the turntable to rotate the 3013 OC and the robot will swipe the side of the 3013 OC. After the side is swiped the RSS robot will take the swipe to the survey instrument for counting.
- The RSS robot positions the swipe over the waste receptacle and releases the swipe.
- The GRS will retrieve the 3013 OC from the turntable on the RSS station and take it to the leak test station.

This process flow assumes no contamination is found above any set points or alarm levels. If contamination levels are found above any set points or alarm levels these would be considered off normal events. RSS system actions or responses for off normal events will be defined as facility operation plans mature.

## 3. ROBOT

The robot used in the RSS is a FANUC LR Mate 200iC. It is a six axis industrial robot manufactured by FANUC Robotics. Some specifications for the FANUC LR Mate 200iC are:

| | |
|---|---|
| Payload (at wrist): | 5 kg (11 lbs.) |
| Reach: | 704 mm (27.7”) |
| Repeatability: | + 0.02 mm (+ 0.001”) |
| Weight (robot arm only): | 27 kg (59.5 lbs.) |

Figure 2 shows the LR Mate 200iC robot installed in the RSS work cell stand.

Figure 2 -– FANUC LR Mate 200iC

A FANUC FS-10iA force sensor was integrated into the robot arm and robot controller. The tri-axial force sensor allows the robot to apply a pre-set force to the 3013 OC while performing the can swiping. This force approximates the force a Radiological Control Inspector applies when conducting a manual swipe operation.

The controller for the robot arm is a FANUC R-30iA Mate Controller. This is the standard controller that comes with the robot. For the application in SRNL, a standalone controller with the optional 110-120 VAC input option was selected. For the PDC facility installation, the optional rack mount configuration and standard 200-230 VAC power input may be preferred. Programming and jogging of the robot is via the teach pendent.

## 4. ROBOT END EFFECTORS

### 4.1 Pneumatic Vacuum Gripper

A vacuum gripper attached to the force sensor allows the robot to pick up and hold the individual swipes. The gripper is a Schmalz Bellows Suction Pad model number SAB 30 NBR-60 G1/4-IG. This suction pad is rated for 30 N (6.7 lbf) of suction force and can conform to an object with a rounded surface (minimum radius of 40 mm). Several different suction pad designs were tested prior to selecting this particular one. This particular cup was selected because it provided the best holding power and conformance to the cylindrical surface on the 3013 OC.

### 4.2 Three Fingered Gripper

A pneumatically operated three finger gripper was added to the robot end effector to allow the robot to pick up the probe of the survey instrument. This is needed to perform the "frisk" portion of the 3013 OC survey. The Schunk gripper used is an MPZ 38. The gripping force (O.D. gripping) of this gripper with 1" long fingers and a supply pressure of 80 psi is approximately 15 lbs. Stroke per finger is 0.157". The fingers designed for this gripper incorporate positive engagement pins so the probe is securely held by the gripper. This gripper is set up as a separate tool in the FANUC controller configuration settings. Figure 3 shows the three finger and vacuum gripper mounted on the end effector.

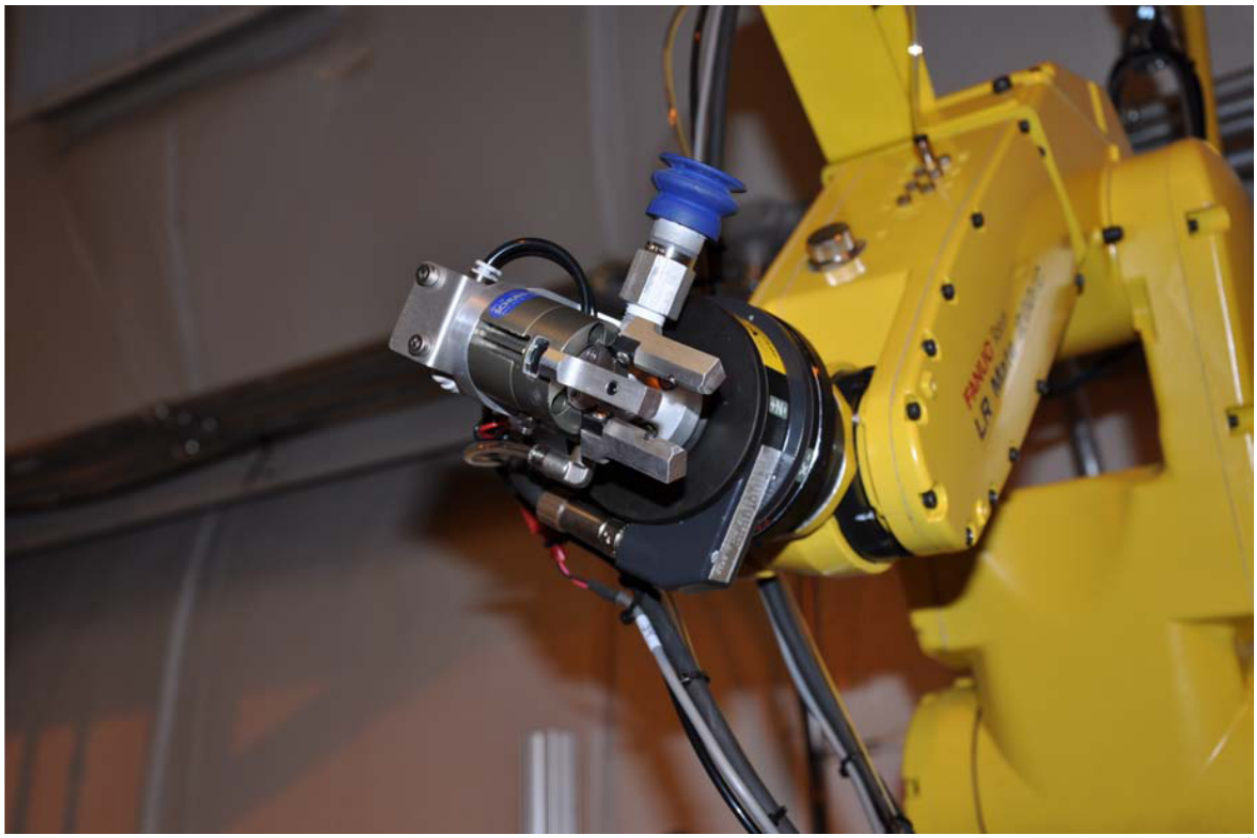

Figure 3 – Three Finger and Vacuum Grippers

## 5. SURVEY INSTRUMENTS

### 5.1 Swipe Survey Instrument

A Ludlum Measurements 43-5 alpha probe connected to a Ludlum Model 2200 Scaler/Ratemeter is used for counting the swipes. To eliminate gamma sensitivity of the probe, the operating voltage is lowered to ~ 550 Volts. Testing by the SRS Health Physics Services group confirmed that gamma sensitivity is eliminated by reducing the operating voltage. Data from the Scaler/Ratemeter is transferred to the RSS controller via the RSS232 port.

### 5.2 Frisk Survey Instrument

As with the Swipe Survey Instrument, the frisk survey instrument is a Ludlum 43-5 alpha probe connected to a Model 2200 Scaler/Ratemeter.

## 6. SWIPE DISC

A cotton swipe that Radiological Control Inspectors use for conducing manual swipes to check for transferrable contamination is used by the RSS. The swipe disc is a 1.75” diameter cotton smear cloth with an adhesive backing. The swipe is attached to a backing material to facilitate handling by the robot.

The backing material is a 2” diameter x 1/16” thick piece of Teflon. The purpose of the backing material is to provide some rigidity to the cotton swipe and to provide an impervious material for the vacuum gripper to grip, while allowing enough flexibility so the swipe can conform to the outside diameter of the inner 3013 container.

The cotton discs and Teflon backing material are assembled into the swipes prior to being placed into the swipe dispenser.

## 7. SWIPE DISPENSER

The swipe dispenser holds the new swipes prior to use. It is a simple tube design with an end cap to retain the swipes, but allows the robot to slide individual swipes out of the dispenser. The dispenser is angled off of vertical by 45$^{o}$ to permit easier robot gripper access. A weight inside the tube provides a constant force to force the swipes to the bottom of the dispenser. The capacity of the dispenser is 50 individual swipes. Figure 4 shows the robot removing a swipe from the dispenser.

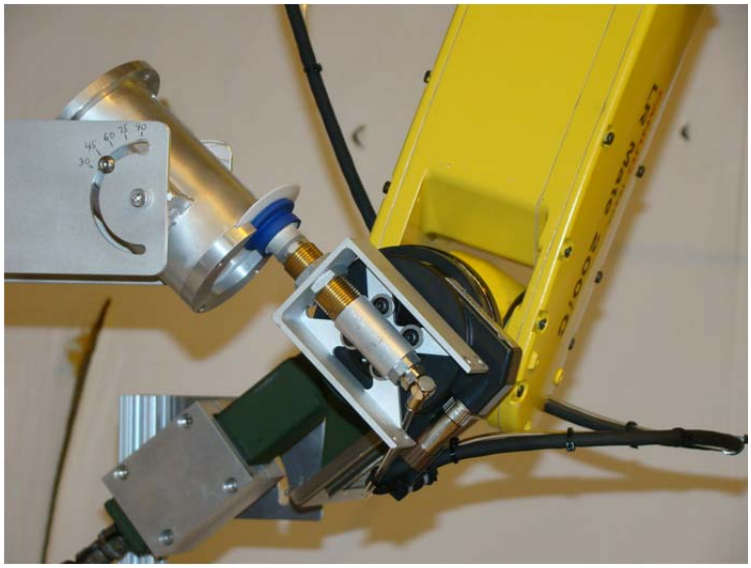

Figure 4 - Robot Removing Swipe from Dispenser

## 8. TURNTABLE ASSEMBLY

A turntable is integrated into the system to rotate the can for swiping its entire circumference. A vacuum plate and rotary joint are integrated into the turntable so the can is securely held on the turntable when the robot is applying a radial force to the can. Figure 5 shows the turntable assembly.

The turntable is a Lintech 300 series unit, model number 306180-1-S-M02-C001-L09. This model has a 6” diameter stage and a load capacity of 225 lbs (dynamic) and a maximum speed of 10 rpm. The drive motor for the turntable is an Animatics SmartMotor #2316DT-PLS2. This is a NEMA 23 framed servo motor operating at 24 VDC with a nominal continuous power rating of 204 watts.

A Schmalz vacuum plate model number SPK 80 MOS-15 G1/4-IG and Rotary Systems rotary swivel model number 007-10211-BT were incorporated into the turntable to provide vacuum to hold the can in place.

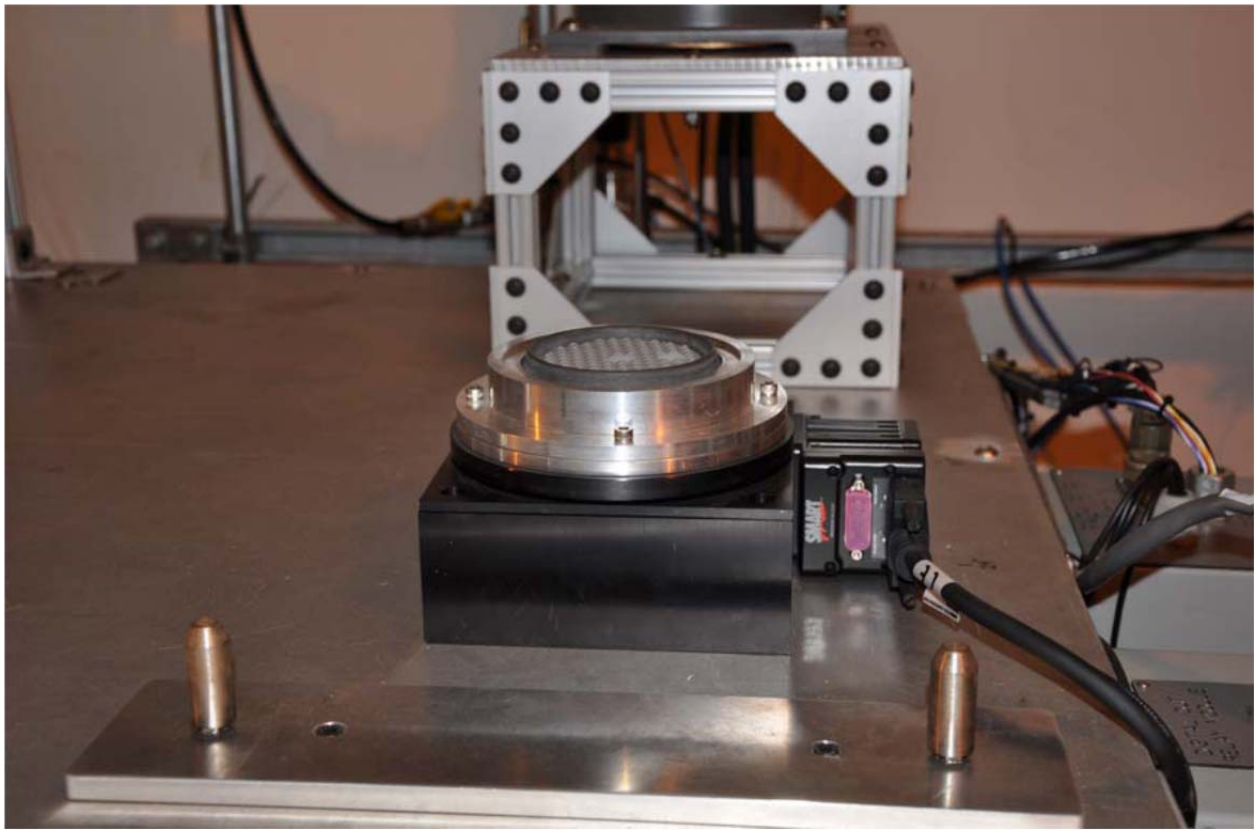

Figure 5 – Turntable Assembly

## 9. GANTRY ROBOT SYSTEM (GRS) GRIPPER INTERLOCK TARGETS

A Gantry Robot System is used to move the 3013 OC from one station to the next in the canning process. The GRS has a pair of sensors integrated into its gripper that, combined with the permissive logic in its control system, will prevent the gripper from opening unless a pair of carbon steel "targets" is in close proximity to the sensors. These targets will be located at positions in the canning room work envelope where the GRS will release the 3013 can (either inner or outer as applicable).

The targets for the RSS work cell are cylindrical carbon steel pieces threaded on to the end of a pneumatic cylinder. The pneumatic cylinder allows the targets to be deployed when needed and retracted out of the way when not needed. The pneumatic cylinders used for the targets in this application are Bimba model MRS-0210.5-D. Bimba MSSX solid state switches are mounted to the cylinder to provide a signal to the controller that the cylinders are deployed.

## 10. PNEUMATIC SYSTEM

Plant air at 80 psig and 15 psig and a vacuum pump mounted on the RSS system provide air and vacuum to operate the three fingered gripper, vacuum gripper and turntable vacuum plate.

## 11. WASTE RECEPTACLE

A small receptacle on the workcell holds the used swipes. It is a Medegan 1 quart stainless steel jar (Medegen # 88010). The same jar is used elsewhere in the facility as a waste receptacle.

## 12. SYSTEM CONTROLLER AND PROGRAMS

The entire process is controlled by a PC based LabView™ (a National Instruments product) virtual instrument (VI) program. The LabView program controls the turntable, pneumatic system (valves and pump), FANUC robot, and reads data from the pressure transducers, microswitches, and survey instruments (frisk and swipe). The control program interfaces with the turntable and the survey instruments via RS-232.

The control program interfaces with the Compact RIO (cRIO) System (National Instruments product) via Ethernet. The cRIO system is an 8-slot rack which accepts various modules. In this application an analog input module is used to read the pressure sensors, a digital output module is used for the solenoid values, a relay module (24-V) is used to switch the vacuum pump, and an eight channel digital input module and eight channel digital output module are used for two-way communication with the FANUC controller. The LabView VI interfaces with the FANUC controller via the digital I/O. The cRIO also allows the control program to be downloaded to an on-board processor so that the entire system can run without a PC attached. The user interface can be viewed remotely through an Ethernet connection on the Workcell Integrated Control System (WICS), which is the overall PDC canning equipment process control system.

The LabView control program uses a "Queued State Machine" approach that executes commands from the front of a command queue. This style of programming offers a flexible structure for user input as well as future changes and scalability. Most commands are from a

predefined list of inspection operations. Other commands may be user inputs and may be inserted at the front of the queue or at the end of the queue. Yet other commands may be conditional. For example, disposal of a swipe disk may occur only if the count rate is above a preset threshold level. The user interface for the RSS Control program is shown in Figure 6. The user interface shows an "active" P&ID which indicates the current state of valves, vacuum pump operation, pressures, status of can, state of robot and GRS gripper permissives. The current operation is also displayed with text based information. Manual controls are also provided which may be executed when the system is not running the automated inspection sequence. The manual controls offer the means to recover from off-normal events.

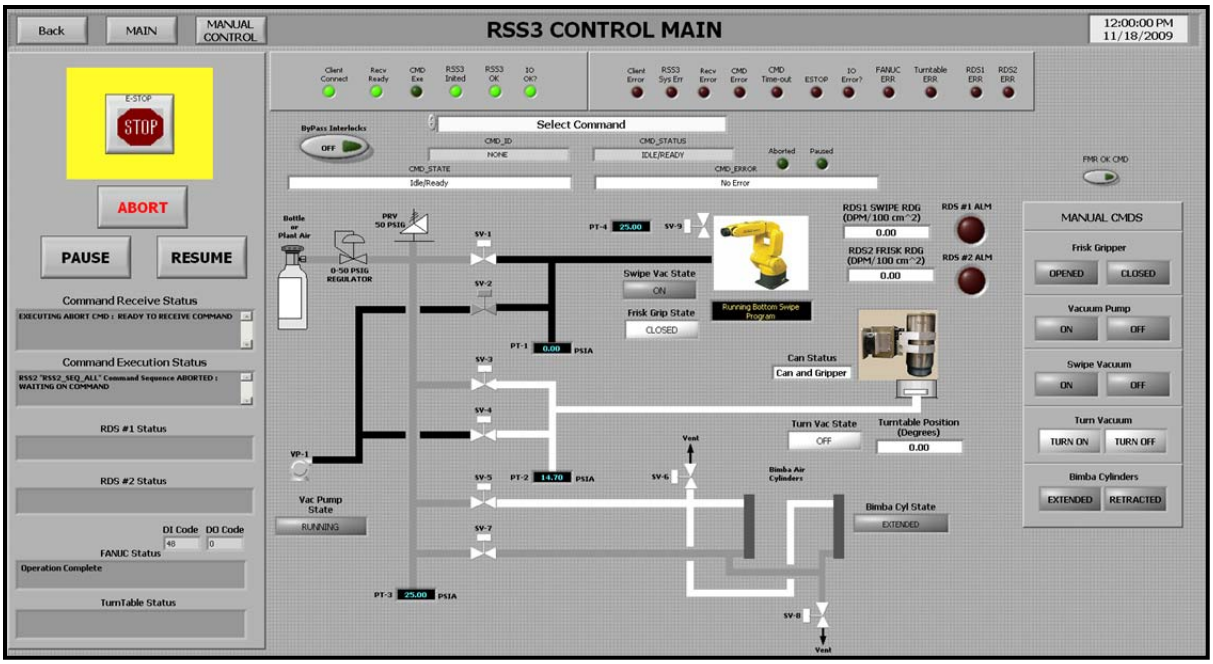


Figure 6 – RSS Control User Interface

## 13. FANUC CONTROL PROGRAMS

The main program for the FANUC controller is a program that continually loops looking for a digital input from the LabView VI. When an input is received, the program calls a macro (essentially a sub-routine) program to execute the specific task associated with that input. Through the I/O the status of the particular macro is communicated from the FANUC controller to the LabView VI.

The tool setup in the FANUC controller allows the controller to account for and utilize different geometries for the different tools. Two different user frames and two tools are used in the FANUC programs. The world coordinate system is used for some of the programs and a defined coordinate system is used for the macros that swipe the bottom, top and sides of the 3013 OC. The world coordinate system is defined with respect to the robot, and the user frame one is defined with respect to the turntable. The two tools defined are for the vacuum gripper and for the three fingered pneumatic gripper.

## 14. CONCLUSIONS

SRNL has developed a prototype Radiological Survey Station that can perform a frisk and swipe of a 3013 OC to check for fixed and transferable contamination in accordance with DOE-STD-3013-2004 and 10 CFR 835, Appendix D. The system, in conjunction with the GRS, will frisk and swipe the bottom of the 3013 OC before it is placed on the survey station, then frisk and swipe the top and side of the 3013 OC.

This system along other systems being developed by SRNL will provide the Pit Disassembly and Conversion Project automated equipment to package plutonium bearing materials in accordance with DOE Standard 3013.

## 15. ACKNOWLEDGMENTS

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## 16. DISCLAMER

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