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Revision 0

Plutonium Immobilization Can Loading Summary Report (U)

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Savannah River Site
Aiken, SC 29808

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DISCLAIMER

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INTRODUCTION

The U.S. Department of Energy will immobilize excess plutonium in the proposed Plutonium Immobilization Plant (PIP) at the Savannah River Site (SRS) as part of a two track approach for the disposition of weapons-usable plutonium. The Department of Energy is funding the development and testing effort for the PIP being conducted by Lawrence Livermore National Laboratory (LLNL), Westinghouse Savannah River Company (WSRC), Pacific Northwest National Laboratory (PNNL), and Argonne National Laboratory (ANL). The PIP will utilize the ceramic can-in-canister technology in a process that mixes plutonium and uranium with ceramic formers and neutron absorbers, presses the mixture into a ceramic puck-like form, sinters the pucks in a furnace, loads the pucks into cans, places the cans into magazines, and magazines into large canisters. The canisters will subsequently be filled with high level waste glass in the Defense Waste Processing Facility for eventual disposal in a geologic repository. This report discusses the Plutonium Immobilization Can Loading work the Savannah River Technology Center (SRTC) completed in Fiscal Year 2000 (FY00) and the first half of Fiscal Year 2001 (FY01).

BACKGROUND

The PIP Integrated Development and Testing (D&T) Plan describes the detailed development and testing tasks needed to provide technical data for the PIP design and operation. Past D&T work identified the process steps to immobilize surplus weapons-usable plutonium into an acceptable form. The three main process steps are; Plutonium Conversion, First Stage Immobilization, and Second Stage Immobilization. Plutonium Conversion includes unpacking shipping containers, removing container contents, converting plutonium metal to oxide via the hydox process, and preparing impure feeds. First Stage Immobilization includes blending the feed, adding uranium neutron absorbers, and ceramic precursors, granulating, pressing the pucks, puck sintering, and can loading. Second Stage Immobilization includes loading magazines and canisters, transporting canisters to DWPF, filling the canisters with high level liquid waste and glass, and canister storage.

The can loading task, in First Stage Immobilization, includes receiving sintered pucks on a transfer tray, loading the pucks into a stainless steel can, welding the can closed, inspecting the can, and transporting the can to the accountability area. Due to the personnel hazards associated with plutonium and other radio nuclides, all can loading operations will be performed remotely. The process to load the sintered pucks into the cans will be in a sealed glovebox and the can inspection processes will be in an enclosure.

The SRTC leads the PIP can loading D&T task. In FY98 SRTC completed several reports, see references 1 – 6, that document the puck can size selection process and the can loading conceptual design formulation. In FY99 SRTC demonstrated the can loading robot and associated systems, see reference 7. In FY00 SRTC demonstrated the can inspection robot and the can handling robot. This report documents the can loading work SRTC completed in FY00 and the first half of FY01.

FY00 MILESTONES

The following lists the FY00 Plutonium Immobilization can loading milestones and completion dates. Two milestones are also PIP Integrated Development and Testing (D&T) Plan milestones.

Date	Description
11/30/99	Compare Can Robots and Swiping Concepts
12/15/99	Complete Bagless vs. LANL Decon Report
2/1/00	Facility Deign Description (FDD) Input
2/7/00	Issue System Design Description (SDD) Draft A
2/24/00	SDD Design Review
4/30/00*	Issue SDD Draft Rev B
5/30/00	Place Inspection Robot Order
7/30/00	Complete 13 MT Concept Report
9/30/00*	Can Handling Robot and Can Inspection Robot Demo Complete

* D&T Milestone

FY00 SUMMARY

The following paragraphs describe each milestone listed above and the work SRTC completed in FY00 to meet each milestone.

Compare Can Robots and Swiping Concepts

This milestone compares commercial robots that can handle a puck can and perform the can swiping tasks. This comparison would lead to the final robot selection and the swiping method.

SRTC reviewed commercial robots that could handle a full puck can and perform the dexterous can swiping tasks. The full puck can weighs about 25 pounds and a gripper weighs about 10 pounds so the robot needed a 40 pound payload. The puck can swiping task requires the robot to maneuver a swipe pad in several orientations over the can exterior which requires a 6 axis robot or specialized tooling. After reviewing vendor literature and attending the Greenville Automation Show, SRTC determined that the commercially available 6 axis robots that can handle 40 pounds are too large to safely operate in the can loading bagless transfer enclosure. SRTC determined that a small 6 axis robot with a low payload capacity could perform the can swiping tasks and a small 3 axis robot could be built from commercial components to handle the puck cans. SRTC analyzed this option and determined that it was cost effective and would meet the PIP can loading requirements.

The can loading team developed a preliminary can swiping technique based on SRS swiping procedures and DWPF canister swiping methods. The can loading team then decided that an alpha survey would be acceptable to determine if the can exterior was free of contamination. There is a concern that a can alpha survey will not meet Health Physics criteria due to the radiation fields produced by the ceramic pucks. If this concern is true, an exterior can swipe will be required.

Complete Bagless vs. LANL Decon Report

This milestone ensures that SRTC thoroughly investigates, compares, and documents the bagless transfer systems and the LANL electrolytic decontamination system. The SRS bagless transfer, the BNFL bagless transfer, and the LANL decontamination system were included in the comparison. The comparison results would lead to the selection of a transfer method for the can loading glovebox.

SRTC designed and built the SRS bagless transfer system so information about the system was easily obtained. The puck can is held in a sphincter seal while the pucks are loaded into the can. After the pucks are loaded, the hollow plug is placed inside the can. A Tungsten Inert Gas (TIG) welder, outside the can and outside the loading glovebox, welds the plug to the can wall. Cutter wheels then cut the can in the middle of the weld area. This leaves the top half of the hollow plug welded to the top portion of the can in the sphincter seal. This stub maintains the glovebox seal. The bottom half of the hollow plug is welded to the can which is now welded shut and separated from the stub.

SRTC had previously visited Rocky Flats and toured the BNFL bagless transfer system. This system uses a hollow plug similar to the SRS bagless transfer system, but it uses a laser to weld the plug to the can wall and the same laser to cut the stub from the can. The BNFL system holds the can in a horizontal orientation. Due to the difficulties associated with loading pucks into a horizontal can, this technology was dismissed from further evaluation.

SRTC visited LANL and toured the Advanced Recovery and Integrated Extraction System (ARIES) to see the electrolytic decontamination system. This system welds cans shut in a radioactive environment, which potentially contaminates the can exterior, and then decontaminates the can. The electrolytic decontamination process includes placing the can in the electrolytic solution with an electrode on the can bottom. As DC current is passed through the can, it acts as an anode, and the vessel acts as a cathode. This process results in the outer can layers dissolving into the solution, which removes any contamination from the can exterior. The can is rinsed, dried, and inspected to verify it is not leaking and contamination free.

SRTC completed a report that describes each process in detail and compares the processes based on installed cost, glovebox floor space, waste generation, simplicity, reliability, and safety. The report recommends the SRS bagless transfer system for PIP, see reference 8.

Facility Design Description Input

This milestone provides support to the PIP Facility Design Description (FDD) authors. The authors were able to get a majority of the required information from early drafts of the can loading SDD and previously published can loading reports. SRTC also issued several PIP equipment layout options and the FDD authors used this information for the facility equipment layout and facility equipment list. SRTC did answer a few questions, but no formal report was required or issued for this milestone.

System Design Description Revisions

The System Design Description (SDD) milestones ensures the can loading SDD was drafted, reviewed, and comments were incorporated in the document. The SDD includes the can loading system functions and requirements, design description, operation, system limitations, upsets and recovery procedures, maintenance, and interface requirements.

SRTC issued the can loading SDD draft A on 2/7/00 and participated in the formal PIP design review on 2/24/00. The design review team generated several comments, SRTC incorporated these comments into the SDD, and issued Rev B on 3/24/00, see reference 9. This SDD revision satisfied a PIP D&T milestone.

SRTC received comments about the SDD summary section from various PIP team members. These comments were incorporated and SRTC issued the SDD Rev C on 7/10/00, see reference 10.

Place Inspection Robot Order

This milestone intent ensures the can inspection robot was ordered early in the fiscal year. This would allow time for the procurement process and vendor delivery before the end of FY00.

SRTC wrote Purchase Order number 4B9591 that included required robot salient features and five required functional tests. Table 1 summarizes the 3 inspection robot bids that SRTC received.

Table 1 – Inspection Robot Comparison

	Required	Spectrum Systems	MotoMan	Staubli - Unimation
Model	-	Mitsubishi RV-1A	MotoMan SV3X	Staubli RX60
Cost	-	$27,000	$30,500	$45,910
Delivery	-	3 wks, demo unit	7 wks	12 wks
Min. Payload (pounds)	2	3.3	6.6	5.5
Reach (inches)	15 - 32	16.5	26.6	26.1
Max Repeatability (inches)	+/- 0.01	+/- 0.0007	+/- 0.001	+/- 0.0007
Number Axes	6	6	6	6
Pneumatic Gripper	Yes	Yes	Yes	No
Min. Serial Ports	1	1	1	3
Estop	Yes	Yes	Yes	Yes

SRTC placed the can inspection robot order on 5/10/00 with Spectrum Systems Inc. in Greenville, South Carolina. SRTC and NMS&S visited Spectrum on 5/18/00 to watch the required functional tests. Spectrum demonstrated four of the five required functional tests. The test to show that the robot could accept commands from the serial port couldn’t be demonstrated due to a lack of information from Mitsubishi about the serial port properties. SRTC visited Spectrum systems again on 6/15/00 and all five tests were successfully demonstrated. Spectrum delivered the robot and SRTC repeated the five functional tests.

Complete 13 MT Concept Report

This milestone documents the conceptual changes made to the can loading system when the PIP production requirement was changed from 50 to 13 metric tones (MT). With the production requirement decreasing, the PIP team also wanted to reduce the facility size and cost. The PIP team reduced can loading from three identical process lines to one line.

SRTC analyzed the new PIP requirements and determined the can loading system would require two bagless transfer units in the single process line to meet the production requirements. This changed the equipment layout, but didn't effect the equipment selection. The two bagless transfer systems occupy twice as much space in the lower enclosure and thus reduce the space to perform the can inspection and handling tasks. This reinforced the decision to use a small robot for the can inspection and a second small robot for the can handling. SRTC issued the report to meet this milestone, see Reference 12.

Can Handling Robot and Can Inspection Robot Demo Complete

This D&T milestone ensures the two robot systems would work properly in an integrated demonstration. This included designing and fabricating a simulated enclosure that included the two simulated bagless transfer units, the two robots, a simulated leak detection station, and a simulated cart.

SRTC designed the simulated enclosure and fabricated it using extruded aluminum members. The enclosure floor was made from aluminum plate and the walls and ceiling were omitted to allow easy access and visibility. SRTC installed the can handling robot and the can inspection robot in the simulated enclosure. One bagless transfer can holder was automated to move the puck can from under the simulated bagless transfer system to the enclosure center. A pneumatic cylinder provided this motion and a spare solenoid valve on the inspection robot controlled the cylinder. Stationary can holders represented the leak detection chamber and puck can cart. SRTC fabricated two simulated alpha probes based on a proposal from Alpha Spectra Inc., an alpha detector vendor. The first detector has a flat detector surface and is used to survey the can top and bottom. The second detector has a concave detector surface and is used to survey approximately 100 degrees of the can circumference. The inspection robot moves the detector up and down parallel to the can exterior in four quadrants to survey the entire can wall exterior. This D&T milestone was documented in report number WSRC-TR-2000-00430, which is reference 11.

FY01 MILESTONES

The following lists the FY01 Plutonium Immobilization can loading milestones and completion dates. The PIP project was placed into suspension in March 2001. Due to the suspension, the internal WSRC milestones were changed to closeout and documentation activities. Two milestones are also PIP Integrated Development and Testing (D&T) Plan milestones.

Date	Description
12/30/00*	Provide Draft SDD, Revision E
1/15/01	Complete IGRIP Video of 13 MT Concept
2/28/01	Demonstrate Can Inspection with Empty Can and Automated Can Holder
3/23/01	PIP Suspension
5/30/01	Summary Report (this report)
6/30/01	Document Vision Software
7/30/01	Update Job Folder
8/30/01*	Demonstrate Loading Variable Height Pucks
9/30/01	Issue Can Loading Closeout Reports

* D&T Milestone

FY01 SUMMARY

The following paragraphs describe each FY01 milestone listed above and the work SRTC completed in FY01 to meet each milestone.

Provide Draft System Design Description, Revision E

This milestone ensures the System Design Description (SDD) is complete. The SDD was revised for several reasons including; incorporating new information and formatting the document to the new PIP format. SRTC completed this SDD revision, see reference 13.

Complete IGRIP Video of 13 MT Concept

This milestone ensures that an IGRIP (3 dimensional computer simulation) video would be completed that showed the new can loading concept for the 13 MT case. SRTC completed this video and distributed copies to the team members.

Demonstrate Can Inspection with Empty Can and Automated Can Holder

This milestone ensures that improvements were being made to the can inspection system. SRTC fabricated an empty puck can and modified the control software to include the empty can in the demonstration. SRTC also added a pneumatic actuator to the bagless transfer can holder. SRTC controlled the actuator with a spare solenoid valve on the inspection robot. Again, the control software was modified to include the automated can holder in the demonstration.

Summary Report (this report)

This milestone documents the can loading work completed in FY01 and the beginning of FY02. Before the suspension, this milestone was two reports, an FY01 summary and a FY02 summary. Due to the suspension, these were combined into one can loading summary report. SRTC completed the report.

Document Vision Software

This milestone ensures that SRTC documents the can loading vision software. Dr. Gregg Hovis wrote the can loading vision software. He left WSRC in November of 2000 and was contracted through SRTC to deliver the can loading vision system documentation, see reference 14.

Update Job Folder

This milestone ensures all the can loading information is retained for use after the suspension. SRTC reviewed and organized the documents in EES Job Folder # 22629.

Demonstrate Loading Variable Height Pucks

This milestone improves the can loading system by allowing the system to handle pucks of varying height. SRTC purchased a pressure sensor and installed it on the vacuum line that feeds the puck lifting tool. The sensor changes state when the pressure is below a setpoint. The sensor output was integrated into a spare digital input channel on the robot controller. The robot software was able to read the change in sensor output when the vacuum was on and no puck was on the tool and when the vacuum was on and a puck was on the tool.

A simple test program was written to move the robot over a puck, lower the puck lifting tool 0.1 inch, delay 2.0 seconds while checking the sensor output, and move down again if the puck was not on the tool. If the puck was on the tool, the program used the robot position to calculate the puck thickness and used this thickness to stack variable height pucks. The simple program worked well with pucks that ranged in height from 0.5 inches to 1.25 inches. The calculated puck height error was +/- 0.1 inches, which was the creep distance. This distance was too large. The desired puck height error was calculated to be 0.0125 inches. This was derived from 0.25 inches total error for 20 pucks, and 0.25”/20 = 0.0125”. More tests were run with shorter delay times and smaller creep distances. When delay time was 0.1 seconds and the creep distance was 0.0125 inches, the calculated puck height was +/- 0.0125 inches.

Since this method worked for all the delay times and creep distances, the program was modified to move the robot over a puck, lower the lifting tool at a constant speed, check the sensor output, stop the robot when the sensor found the puck, and calculate the puck height. Several tests were run with pucks that ranged in height from 0.5 inches to 1.25 inches and a creep speed that ranged from 0.113 inches/sec to 0.263 inches/sec. When the creep speed was 0.188 inches/sec, the calculated puck height was within the +/- 0.0125 inch specification. Slower creep speeds didn’t show improvements in the calculated puck height and faster creep speeds yielded larger errors in the calculated puck height. For this reason, the creep speed of 0.188 inches/sec was chosen as the optimal speed. All the variable puck height data can be found in the can loading robot 3 ring binder, which is located in the EES Job Folder # 22629.

The can loading robot demonstration was modified to include the pressure sensor, calculated puck height software, and variable puck height stacking. The integrated demonstration was tested several times and was working properly. This demonstration completed a PIP can loading milestone, see SRT-RSE-2001-00028.

Issue Can Loading Closeout Report

This milestone generates a document that will help to restart the PIP can loading task after the suspension. SRTC issued the closeout report, see SRT-PIP-2001-033.

ERROR RECOVERY

The following sections list some potential errors that may occur in the can loading system and possible recovery procedures from each error. This list is not meant to be a complete list of all possible errors, but rather an indication of how errors could be handled.

Error 1 – The Puck Transport Tray Falls off the Transport Cart

The first step to recover from this error will be to use the can loading robot to move the tray back onto the transfer cart. If this fails, the second step will be to remotely remove all radiation sources from the can loading system. The can loading robot will load all available pucks in a puck can and all cans will be processed normally. If the cart is available, it will move the second tray of pucks to the elevator and the material transport system (MTS) will move this tray to the tray storage area. The MTS will bring an empty puck transfer tray to the can loading glovebox and operators will use long handled tools to place the remaining pucks on this tray. The MTS will move this tray to the tray storage area. After the radiation sources are removed, operators will correct the puck transport tray failure, the equipment will be tested to ensure the problem will not recur, and operations will continue.

Error 2 – The Can Loading Robot Drops a Puck

The first step to recover from this error will be to try to correct the problem with the can loading equipment. If the puck lands on the puck transfer tray, the vision system will locate it and the can loading robot can automatically pick it up. If the puck lands off the tray, an operator can manually operate the robot to pick the puck up and place it back on the tray. If neither option works, the procedure to remotely remove radiation sources described in Error 1 will be used. Once the sources are removed, operators will grab the dropped puck and place it back on the puck transfer tray. The MTS can remove this puck, the equipment will be tested to ensure the problem will not recur, and operations will continue.

Error 3 – The Can Loading Robot Drops a Tool

The first step to recover from this error will be to manually operate the robot to pick the tool up with the can loading robot. Due to the can loading robot limited degrees of freedom, this will be difficult. If this option doesn’t work, the procedure to remotely remove radiation sources described in Error 1 will be used. Once the sources are removed, operators will manually move the dropped tool to the appropriate tool holder, the equipment will be tested to ensure the problem will not recur, and operations will continue.

Error 4 – The Helium Hood Drops a Hollow Plug

The first step to recover from this error is to use the can loading equipment to correct the problem. If the plug is accessible by the helium hood, operators can manually operate the robot to recover the plug with the helium hood. If this doesn't work, the can loading robot can use the puck lifting tool to place the plug in a location that is accessible by the helium hood. If those options don't work, the MTS will bring a new plug to the can loading glovebox and the can loading robot can use the helium hood to grab the new plug. If all these options fail, the procedure to remotely remove radiation sources described in Error 1 will be used. Once the sources are removed, operators will manually correct the plug failure, the equipment will be tested to ensure the problem will not recur, and operations will continue.

Error 5 – The Bagless Transfer Weld Fails

Recovering from a bagless transfer weld failure will be accomplished with the can loading equipment. This recovery is a can loading requirement and is included in the can loading process block flow diagram, see reference 6 for details. The summarized procedure is as follows; raise the damaged can up into the can loading glovebox to expose the weld area, use the can loading glovebox can cutter to cut the can below the weld area, use the can loading robot to remove the pucks from the can, remove the pucks from the glovebox, manually repair the welder and sphincter seal, test equipment, and continue operations.

Error 6 – The Can Inspection Robot Drops a Tool

The first step to recover from the can inspection robot dropping a tool is to manually operate the robot to recover the tool. Since the inspection robot has 6 axes, it is able to reach and manipulate objects in many locations and orientations. If the tool is within the robots reach, an operator can manually operate the robot to grab the tool and replace it in the tool holder. If this option fails, operators can use long handled tools to remove the radiation sources. Once the sources are removed, operators will manually replace the tool in the tool holder, the equipment will be tested to ensure the problem will not recur, and operations will continue.

Error 7 – The Can Robot Drops a Can

The first step to recover from the can robot dropping a can will be to remove the radiation sources as described in Error 1. Once the sources are removed, operators will manually place the can on the can transport cart. Due to the high source term associated with each can, temporary shielding and/or special tools may be required to manually complete this task safely. The equipment will be tested to ensure the problem will not recur, and operations will continue.

SYSTEM MAINTENANCE

The can loading components must be designed for glovebox maintenance. Glovebox maintenance is defined as maintenance with the reach and dexterity restrictions from working through gloveports. The following lists the can loading major components and some features that will help with glovebox maintenance.

Puck Transfer Tray Cart and Lifts

The primary glovebox maintenance feature for the puck transfer tray cart and lifts are the magnetic couplings. The cart motor and actuator are located outside the glovebox and the cart is located inside the glovebox. A magnetic coupling links the actuator to the cart. The motors for the lifts are located outside the glovebox and the lift actuator is located inside the glovebox. In both cases, most maintenance for these components can be performed outside the glovebox. The cart will be replaced when the cart needs maintenance. No tools are needed since the magnetic coupling is the only thing holding it to the rails. The lift assemblies will be replaced when a lift needs maintenance. SRTC recommends using two bolts and two guide pins to attach each lift assembly to the glovebox. The bolt heads can be oversized and tapered to allow for quick and easy removal. The guide pins will ensure the lift assembly is in the proper location without operator adjustments.

Can Loading Robot

The primary glovebox maintenance feature for the Cartesian style can loading robot is the fact that it is made from parts that are small enough to be handled through gloveports. The glovebox layout was modified to ensure the maximum width is 48 inches. This will allow operators to reach all the components from gloveports, see reference 7, attachment 5, for the can loading equipment layout. Maintenance to the can loading robot will not be easy since the entire robot must be inside the glovebox and it contains many parts. Maintenance can be simplified if quarter turn or push/pull electrical connectors, oversized tapered bolts, and guidepins are used where appropriate. Motor replacement will require disconnecting two electrical cables and dismounting the motor. A replacement motor will be installed in reverse order. Actuator replacement will be more difficult since many parts must be removed before the actuator can be replaced. SRTC recommends that broken or damaged can loading robot parts be replaced rather than repaired in the glovebox.

Helium Hood and Puck Lifting Tool

Since both of these tools will fit through a standard 8 inch bag-out port, SRTC recommends replacing them via the bag-out port when maintenance is required rather than performing maintenance inside the glovebox.

Bagless Transfer System

The primary maintenance feature for the bagless transfer system will be large doors in the enclosure next to each system. These doors allow access to the bagless transfer welder, cuter, and motors. Experience and lessons learned from the SRS and Hanford bagless transfer units should be incorporated into the PIP bagless transfer systems to ensure maintenance is simplified. Maintenance can further be simplified if quarter turn or push/pull connectors are used for the electrical connections, oversized tapered bolts are used, and guidepins are used when appropriate. The bagless transfer systems will require periodic maintenance to replace welding tips and cutting wheels, which are consumed during regular operations.

Can Inspection Robot

The primary maintenance feature for the can inspection robot will be a jacket or boot that covers the entire robot and internal air pressure. The jacket and internal air pressure will reduce the chances of contaminated particles from entering the robot. Since this robot is outside the glovebox, no contamination is expected. The jacket concept needs further analysis to determine if it is cost effective. When maintenance is required, the jacket can be removed and maintenance can be performed in place or the entire robot can be removed from the enclosure. SRTC recommends a spare inspection robot be on hand so it can be installed and used while repairs are performed on the original robot.

Can Handling Robot

The primary maintenance feature for the can handling robot will be the modular robot design. Due to the size and weight of the robot, it can't easily be jacketed or removed from the enclosure for maintenance. All maintenance will be completed in place. Maintenance can be simplified if quarter turn or push/pull connectors are used for the electrical connections, oversized tapered bolts are used, and guidelines are used when appropriate. Motor replacement will require disconnecting two electrical cables and dismounting the motor. A replacement motor will be installed in reverse order. Actuator replacement will be more difficult since many parts must be removed before the actuator can be replaced. SRTC recommends that broken or damaged can handling robot parts be replaced rather than repaired in the glovebox.

Puck Can Transfer Cart

The primary glovebox maintenance feature for the puck can transfer cart is the magnetic coupling. The cart motor and actuator are located outside the enclosure and the cart is located inside the enclosure. A magnetic coupling links the actuator to the cart and most maintenance for these components can be performed outside the enclosure. The cart will be replaced when the cart needs maintenance. This requires an access panel or door for the cart. No tools are needed since the magnetic coupling is the only thing holding it to the rails.

FUTURE ACTIVITIES

The can loading task can be broken into two major systems, can loading and can inspection. The following can loading system and can inspection system items should be completed after the PIP suspension.

Can Loading System:

- Improve the vision system software. The vision system currently is operational, but the following improvements should be made. The system now finds black blobs that have an area similar to the area of a puck. This method has potential for false puck findings or missing pucks. For example, if two pucks are touching, the blob area is greater than one puck and the system will not find either puck A correlation algorithm compares a puck image to the entire image. Preliminary testing showed the correlation algorithm would find regular pucks and touching pucks, but it was not integrated with the robot system. The correlation algorithm should improve the systems reliability. The system currently requires several operator inputs to be calibrated. The operator input could be removed and an automated calibration routine should be included.

- Integrate the helium hood operation. The helium hood was successfully demonstrated on a test stand, but never operated with the can loading robot. To ensure this process will be successful, this should be tested.
- Add puck weigh and dimension station. These steps are in the can loading concept, but still need to be integrated into the can loading system. The PIP puck handling task uses a similar system.

Can Inspection System:

- Improve the control software. Currently the control system uses a timer to determine if can handling robot motions are complete. Every half second the control system asks the robot if it is moving. If the robot is not moving the control system issues the next command. This method uses constant communications between the control system and the robot, and that isn't the optimal choice. The can handling robot should tell the control system that it has completed a move, then the control system can issue the next command. SRTC completed initial tests with the Smart Motors and proved the system can operate in this manner. The system improvement must be integrated and tested.
- Integrate the leak detector. An automated remote leak detector will have several issues to resolve before it meets the PIP requirements, and thus should be integrated.
- Determine if can survey is acceptable or if can swiping is required. This issue has not been resolved by the PIP team and an answer is needed.
- Test can swiping. If the previous item requires can swiping, then this task should be demonstrated. Previous remote swiping operations have proven to be difficult and this needs to be demonstrated. The DWPF uses a master-slave manipulator to perform remote canister swiping.

SUMMARY

This report documents the FY00 can loading milestones, the work SRTC completed for each milestone, and work completed in FY01 before the PIP suspension. The report also describes the recovery procedure for several possible errors and recommends features for the major components that will simplify maintenance activities.

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