DESIGN AND OPERATION OF A REMOTELY OPERATED PLUTONIUM

WASTE SIZE REDUCTION AND MATERIAL HANDLING PROCESS

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ABSTRACT

Noncombustible Pu-238 and Pu-239 waste is generated as a result of normal operation and decommissioning activity at the Savannah River Plant, and is being retrievably stored there. As part of the long-term plan to process the stored waste and current waste for permanent disposal, a remote size reduction and material handling process is being cold-tested at Savannah River Laboratory. The process consists of a large, low-speed shredder and material handling system, a remote worktable, a bagless transfer system, and a robotically controlled manipulator. Initial testing of the shredder and material handling system and a cycle test of the bagless transfer system has been completed. Fabrication and acceptance testing of the Telerobot, a robotically controlled manipulator, has been completed. Testing is scheduled to begin in 3/86. Design features maximizing the ability to remotely maintain the equipment were incorporated. Complete cold-testing of the equipment is scheduled to be completed in 1987.

BACKGROUND

Pu-238 and Pu-239 are produced at the Savannah River Plant (SRP) for use in the national defense weapons program and as a satellite heat source, respectively. Noncombustible plutonium waste is generated as a result of production, laboratory work, and decommissioning activities, and is being retrievably stored at SRP. In order to effectively process and dispose of this waste, the plant proposes to design and build a Transuranic Waste Facility in the late 1980's. Figure 1 is a schematic of the SRP TRU Waste Management Plan.

The Transuranic Waste Facility will process retrieved drums and large steel boxes containing Pu-239 waste for permanent disposal. The facility is designed for a later upgrade to process Pu-238, which may include decontamination and incineration modules (shown in light lines).

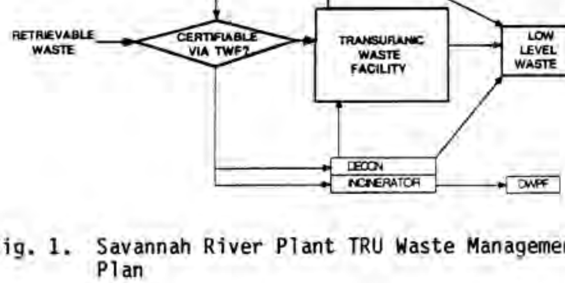

Fig. 1. Savannah River Plant TRU Waste Management Plan

PROCESS

The size reduction and material handling demonstration facility (Fig. 2) will demonstrate remote size reduction and material handling techniques to be used in processing plutonium-contaminated noncombustible items such as glove boxes, piping, valves, small process vessels, etc. Feed materials are prepared using a robotically controlled manipulator in conjunction with an electric worktable. Once prepared, the items are placed on the shredder loading door and raised into the shredder. Shredded material drops onto a conveyor and is carried into a drum hopper. A level sensing device shuts down the conveyor and shredder when the drum hopper is full, and the contents drop into a bagless transfer system for removal.

The robotically controlled manipulator, or Telerobot, utilizes a variety of specially adapted hand tools to prepare items for shredding. Items too large to fit into the shredder are partially size reduced with a plasma torch and placed in the shredder. The plasma torch is also used to size-reduce materials with material thicknesses greater than 1/4", or other unshreddables such as process vessels.

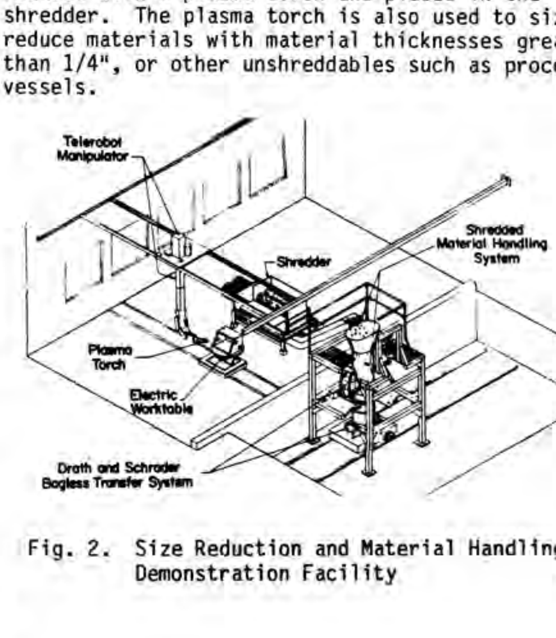

Fig. 2. Size Reduction and Material Handling Demonstration Facility

The Telerobot combines a gantry mounted industrial robot with nuclear hot cell manipulator technology. Capacity is 300 lb at the manipulator hand and 3000 lb at a hook beneath the shoulder pivot point. The support structure has a 18' span, 65' length, and is 20' high. A central computer is used to control all executive control functions, and a trajectory processor controls all linear interpolated movements. The Telerobot is controlled by a single operator sitting behind a special wrap-around control station which also contains the controls for all other equipment used in the demonstration. The Telerobot operates in either manual, semi-auto, or preprogrammed modes. Two 3-axis potentiometer joysticks are used for calculated rate control of the bridge axes and the axes of the manipulator arm in the manual and semi-auto mode operation. Removal of the arm is performed via a completely remote three-step process (push up, rotate, let down) with an arm removal attachment on the remote worktable.

The remote worktable is capable of precisely clamping, lifting, tilting, rotating, and moving back-and-forth items weighing up to 3800 lb. These motions are used by the operator during feed preparation for remote positioning of materials during plasma torch and hand tool operations.

The shredder is a Shred-Pax Model AZ-160, a low speed, 160 HP, electrically driven unit. The shredder hopper is completely enclosed during operation to avoid kickback of material and to reduce noise levels. Hopper inner wall construction includes steel backed rubber (with the steel facing in) to absorb the high impact forces of large, heavy items bouncing around during shredding. The shredder is able to accept items with external dimensions up to 3' x 4' x 5.5'.

The material handling system includes a hopper which measured, by volume, exactly one drum of shredded material using a time-delayed light sensor. The light sensor automatically shuts down the shredding process when the hopper is full, and then a clamshell at the bottom of the hopper opens, allowing the shredded material to fall into a bagless transfer drum below. The hopper is then tilted upward, allowing the bagless transfer machine to reposition the false lid onto the drum. The drum is then removed from the facility and a new drum is put in position.

The bagless transfer system is a converted German Drath and Schrader unit. The device is used to remotely remove contaminated waste, which lessens personnel by reducing hands-on contact. This system will eliminate the potential release of contamination by replacing the bagout technique currently used to remove TRU waste from contaminated environments, especially when removing sharp-edged shredded metals. The system was chosen since it had already proved reliable in over 10 years of operation in Europe. Improvements have been made to the unit in order to meet U.S. and Du Pont standards.

SHREDDER TESTING

A series of 4 tests of the large shredder and material handling system have been completed (Photo 1). Feed materials included both scrap and fabricated stainless and carbon steel boxes. These tests have shown that the system can consistently shred a 3' x 4' x 5'-1/4" enclosed stainless steel box in less than two hours with a two-by-two blade configuration installed in the shredder. The shredded material handling system, which conveys the shredded metal to a hold up hopper, has experienced no material handling problems. Approximately 475 lb of shredded metal fit into each drum without additional shaking or compaction. Volume reductions averaging 10:1 have been achieved using box configurations similar to glove boxes. Additional testing of the shredder and material handling system will be done in conjunction with the Telerobot and electric worktable in the demonstration facility during the last part of 1986 and through 1987.

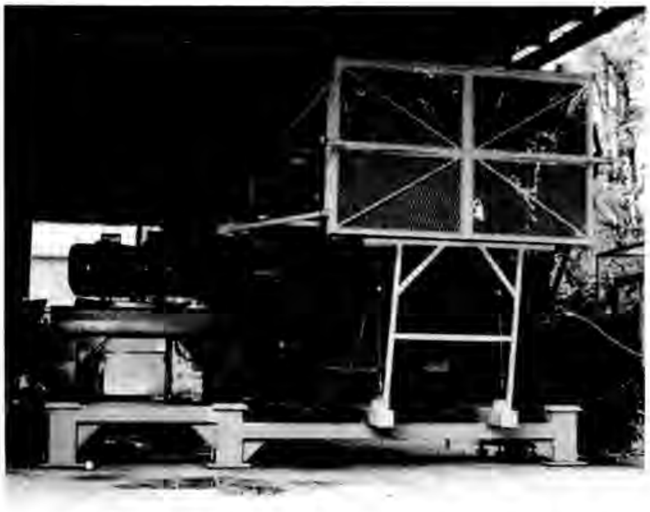

Photo 1. Shredder and Material Handling System

In the initial testing, scrap materials were used as the feed material (Table I). In the first of the initial tests a scrap stove was used. The stove, which was fabricated of very thin (1/16") carbon steel, was shredded too quickly and produced unacceptably long (14") pieces. The feed rate was also too rapid for the material handling system, which was designed for a slow, steady feed from the shredder. A variable reversing timer was installed which controlled both problems. The timer was set to allow control of the amount of time that the shredder blades would rotate in the forward direction, at which point they would reverse. In the second of the initial tests, a similar stove was used, and the reversing timer was set for 5 seconds. Feed rate was more controlled, and each piece size was reduced to acceptable levels. In the third test, a scrap refrigerator was shred with similar results.

Table I
Test Results - Shredding of Scrap Materials

TEST #1	
Size:	42" high x 24" wide x 40" high (scrap stove)
Material:	1/16" carbon steel with fiberglass insulation
Shredding Time:	2 minutes
Final Volume:	2 (3/4 full) lined 55 gallon drums
Piece Size:	2" wide x 14" long
TEST #2	
Size:	42" high x 24" wide x 40" high (scrap stove)
Material:	1/16" carbon steel with fiberglass insulation
Shredding Time:	5 minutes
Final Volume:	1 (3/4 full) lined 55 gallon drum
Piece Size:	2" wide x 9" long
TEST #3	
Size:	66" high x 33" by 26" (scrap refrigerator)
Material	1/16" carbon steel with fiberglass insulation
Shredding Time:	15 minutes
Final Volume:	2 (3/4 full) lined 55 gallon drums
Piece Size:	2" wide x 9" long
TEST #4	
Size:	80" x 50" x 34" (scrap air handling duct)
Material:	1/8" stainless steel
Shredding Time:	1 hour 50 minutes
Final Volume:	1 (3/4 full) lined 55 gallon drum
Piece Size:	2" wide x 5" long
TEST #5	
Size:	80" x 50" x 34" (scrap air handling duct)
Material:	1/8" stainless steel
Shredding Time:	2 hours 15 minutes
Final Volume:	1 55 gallon drum
Piece Size:	2" wide x 5" long

In tests #4 and #5, the scrap materials closely resembled glove boxes typically found in TRU waste. Both items were constructed of 1/8"-thick stainless steel. Fabrication was both bolted and welded, corner and side bracing were found on the interior, and they were enclosed on 5 of 6 sides. In both cases, the items shredding times were within acceptable levels (2 hours), piece size was very good (5" long), volume reductions of 10:1 were achieved, and material flowed smoothly through the material handling system. Before and after shots of test #6 are shown in Photographs 2 and 3, respectively.

Photo 2. Stainless Steel Air Handling Duct Used in Test #5

Photo 3. Shredded Material from Test #5

In the second stage of testing (Table II) a series of enclosed rectangular boxes fabricated out of 1/8" and 1/4" carbon and stainless steel plates were used for feed material. These large boxes were used to test the ability of the shredder to grab large rectangular shapes without appendages (to grab onto) and to further assess the ability to shred 1/8" and 1/4" steel. Photo 4 shows several of the boxes used in the second stage of testing.

TABLE II

Test Results - Fabricated Steel Boxes

<u>TEST #6</u>	
Size:	3' x 4' x 4'
Material:	1/8" carbon steel
Shredding Time:	2 hours 15 minutes
Final Volume:	1 (3/4 full) lined 55 gallon drum
Piece Size:	2" x 6"
<u>TEST #7</u>	
Size:	3' x 4' x 5' (reinforced)
Material:	1/8" carbon steel
Shredding Time:	3 hours 10 minutes
Final Volume:	1-1/3 (3/4 full) lined 55 gallon drums
Piece Size:	2" x 6"
<u>TEST #8</u>	
Size:	3' x 4' x 5'
Material	1/4" carbon steel
Shredding Time:	1 hour 10 minutes (time spent trying to grab box, then discontinued and used for Test #4)
Piece Size:	2" x 5"
<u>TEST #9</u>	
Size:	3' x 4' x 5' with a 2' x 3' window and 2 - 7" diameter holes cut in one side
Material:	1/4" carbon steel
Shredding Time:	2 hours 30 minutes (discontinued after 15% of box had been shredded due to slow shredding speed)
Piece Size:	2" x 5"
<u>TEST #10</u>	
Size:	3' x 4' x 4'
Material:	1/8" stainless steel
Shredding Time:	5 hours
Final Volume:	1 (3/4 full) lined 55 gallon drum (shown in Photo 5)
Piece Size:	2" x 5"
<u>TEST #11</u>	
Size:	3' x 4' x 5'
Material:	1/8" stainless steel
Shredding Time:	5 hours 40 minutes
Final Volume:	1-1/4 (3/4 full) lined 55 gallon drums
Piece Size:	2" x 5"
<u>TEST #12</u>	
Size:	1/4 of a 3' x 4' x 5' box (1/5' x 2' x 2.5')
Material:	1/4" stainless steel
Shredding Time:	35 minutes (for 10% completion)
Problems:	Slow shredding
Piece Size:	2" x 5"

Photo 4. Boxes Used in Second Stage of Testing

In test #6, a 3' by 4' by 4'-1/8"-thick carbon steel box was used. Although some difficulty was experienced in getting the shredder to take the initial bites out of the box, shredding became rather smooth after this. Total shredding time was 2 hours 15 minutes. In test #7, a 3' by 4' by 5'-1/8"-thick carbon steel box with reinforcing bracing (welded between the interior walls) was used. The internal bracing simulated internal piping of glove boxes which would tend to limit the ability of the shredder to crush and fold the box. Results of this test were similar, with about a 50% increase in shredding time due to the internal bracing. In tests #8 and #9, the same 1/4"-thick carbon steel box was used. After over 3-1/2 hours of shredding, 85% of the box remained. It had become apparent that the shredder was unable to handle 1/4"-thick material.

In tests #10, #11, and #12, 1/8" and 1/4" stainless steel boxes were used. Although the piece size and volume reduction were very good (1/8" material), with 85% of the material less than 5" long, the shredder jammed frequently. The shredder was unable to shred 1/4" material. Unjamming of the shredder was performed remotely by pulsing the motors in the reverse direction until the steel which jammed the blades backed out.

Photo 5. Shredded Material from Test #10

The following problems had been seen in the first two tests, which were later corrected by changing the blade configuration from one-by-one to two-by-two:

The shredder was unable to shred 1/4"-thick material
Shredding times were slow
Jamming was frequent
The shredder motors were overworked

In the two-by-two configuration, two blades are stacked next to one another rather than singly, resulting in cuts twice as wide. Since only half as many cuts are made across the shredder, twice as much power is delivered to each cut. This results in much faster shredding speeds and the ability to cut thicker materials. The main drawback is larger piece size, which could be controlled by the reversing timer.

After installation of the two-by-two blade configuration, several tests (Table III) were made using fabricated steel boxes similar to those used in the second set of tests. Results were dramatically improved. The initial test (#13) shred the 85% complete 1/4" carbon steel box used in tests #8 and #9 in 1 hour and 45 minutes. Previously the box had been only 15% completed in 3-1/2 hours with the one-by-one blade configuration. In test #14, a 2.5' by 3' by 6'-1/4" stainless steel box section was shredded in 1-1/2 hours with no problems. Tests #15 and #16 shred 3' by 4' by 5'-1/8" stainless steel boxes in just over an hour each. Due to the poor shape of the feed hopper after these series of tests (damage occurring from boxes slamming into thin hopper walls and loading door), further testing was suspended until a new, stronger hopper could be made.

TABLE III

Test Results
Two-by-Two Blade Configuration Fabricated Steel Boxes

TEST #13	
Size:	3' x 4' x 5' with a 2' x 3' window and 2 - 7" diameter holes cut in one side
Material:	1/4" carbon steel
Shredding Time:	1 hour 45 minutes
Final Volume:	1 (3/4 full) lined 55-gallon drum
Piece Size:	4" x 6"
TEST #14	
Size:	2 1/2' x 3' x 4' x 6'
Material:	1/4" stainless steel
Shredding Time:	1-1/2 hours
Final Volume:	1 1/3 (3/4 full) lined 55-gallon drums
Piece Size:	4" x 6"
TEST #15	
Size:	3' x 4' x 5'
Material	1/8" stainless steel
Shredding Time:	1 hour 10 minutes
Final Volume:	1 (3/4 full) lined 55-gallon drum
Piece Size:	4" x 8"
TEST #16	
Size:	3' x 4' x 5'
Material:	1/8" stainless steel
Shredding Time:	1 hour
Final Volume:	1 (3/4 full) lined 55-gallon drum)
Piece Size:	4" x 8"

Sound levels were measured and found to be as high as 116 db. This was corrected by a total redesign of hopper, loading door, and some additions between the hopper and conveyor. The new design used the same concept but is much stronger, completely enclosed, and lined with 1-1/2" of Armaplate® (Goodyear), a steel backed rubber plate. This was used to absorb the energy of the items as they were bounced into the walls. The new hopper design is complete and will be installed when the shredder is reinstalled in the integrated demonstration.

BAGLESS TRANSFER SYSTEM TESTING

Cycle testing of the Drath and Schrader Bagless Transfer System was performed and the system proved highly reliable and durable.

A plexiglas cover was installed to obtain a seal during leak testing. Leak testing was scheduled before and after cycle testing, under 2" H_2O positive pressure. After the first leak test proved successful, a 24-volt control system was designed and installed to permit continuous cycling. Cycle testing was scheduled to run for 2000 cycles. However, because the cycle testing served as a reliability test, the number of cycles run was determined by the successes or failures in the unit. Minor problems with limit switches occurred erratically. Therefore, to accumulate large numbers of successive runs, the number of cycles was increased twofold. A total of 4142 cycles were completed. Results are shown in Table IV.

TABLE IV

Bagless Transfer System Cycle Test

Date	Cycles Complete	Notes
10/07/85	281	Drum gasket fell into drum, no mechanical problems
10/08/85	398	Gripper limit switch not working, on/off switch broken
10/09/85	413	Troubleshot limit switch for gripper and repositioned until in working order, on/off switch replaced, impression switch not working - need internal access for repair, drum replaced
10/14/85	648	Impression limit switch repositioned until working (435 cycles)
10/15/85	858	Lock limit switch not working, repositioned until working (750 cycles)
10/21/85	1757	Circuit tripped, but no mechanical problems occurred
10/28/85	2707	Repaired gasket, no mechanical problems
10/29/85	2756	Gripper limit switch not working, E&I unavailable for repair
10/30/85	2829	Gripper limit switch repositioned by E&I until working
11/04/85	2951	Lock switch not activated - adjusted screw controlling position until running
11/08/85	3787	Air pressure low, but no mechanical problems

No mechanical problem signifies that a system problem interfered with cycling, however, no mechanical problems were involved.

The minor problems caused by faulty limit switches occurred during cycling, in the gripper, lock, and impression stages. Also, because of vibration, screws became loose in various locations in the unit causing system interlocks to be activated. Once lock washers were added on test screws, and the limit switches were repositioned, the unit proved reliable for notable periods of 1169 and 1768 cycles. A leak test using DOP smoke was conducted after completion of cycle testing. Results verified that the unit maintained a good seal with no leaks.

FUTURE TESTING PROGRAM

The intended goals of future testing will be to determine the performance of the integrated process to handle a large variety of noncombustible waste including piping, valves, glove boxes, and discarded process equipment. The performance of each individual component will be assessed for reliability and maintainability. The following is the projected timeline for future testing:

1)	Telerobot - Initial Testing	
	Arrives at SRL	1/20/86
	Temporary installation and testing	2/86 - 5/86
2)	Integrated demonstration	
	Building completed	6/86
	Equipment installed	8/86
	Startup	10/86
	Demonstration and testing	10/86 - 12/87

CONCLUSION

Based on tests performed to date on the shredder, material handling system, and bagless transfer system, the proposed process appears to be an acceptable, reliable means of processing large noncombustible waste items. Design of the SRP Transuranic Waste Facility will incorporate this process upon successful completion of the integrated demonstration in 1987.