BUILD IT FAST, USE IT FASTER

Fig. 1. Three-dimensional model of crawler.

The Story of the DWPF Melt Cell Crawler

By Clyde R. Ward, Montenius Collins, Thomas A. Nance, and Michael C. Prather

The Savannah River Site in Aiken, S.C., is a U.S. Department of Energy installation that began operations in the mid-1950s. There, at the Defense Waste Processing Facility (DWPF), high-level radioactive waste resulting from these operations is being immobilized in borosilicate glass.

When the DWPF began radioactive operations in March 1996, the glass melter in DWPF had a predicted life of only two years. However, a very successful program extended the life of the melter in radioactive operation to more than six years and resulted in more than 2 tons of radioactive glass being processed.

In September 2002, operations were halted to replace the ailing glass melter and repair or replace other vital equipment. There were glass particles, glass chunks, tools, and other debris on the floor of the melt cell resulting from efforts to extend the melter life, particularly the melter pour spout insert program. This material, if left on the floor, threatened to inhibit operation of equipment in the cell after operations resumed.

The DWPF had placed several Savannah River Technology Center (SRTC) engineers in their organization to help with the outage. Some of these engineers suggested a crawler to help clean the cell. In December 2002, SRTC engineers were asked to build a remotely operated crawler to assist in cleaning the DWPF melt cell floor. The crawler was to assist a vacuum system and grapple, acquired previously for cleaning the cell, to help assure that the cleaning was accomplished within the outage schedule.

Both the grapple and vacuum system would be deployed and powered by an impact wrench hook and power plug on the main process crane (MPC). The crawler would be transported within the cell by the melt cell crane with no restrictions on availability of the MPC. Power and control for the crawler were to be provided by wiring previously installed through the cell wall. This would bring continuous power and control to the crawler without using the MPC or melt cell crane.

The engineers had to design a crawler that would push glass and debris into piles so that the grapple could pick up the material and place it into waste bins. The crawler also must maneuver the end of the vacuum hose, if needed. In addition, the crawler had to clean areas on both sides of the cell that were inaccessible to the vacuum system and grapple. To maintain the outage schedule, the crawler had to be designed and built in 10 days and then had to clean the melt cell in 10 days.

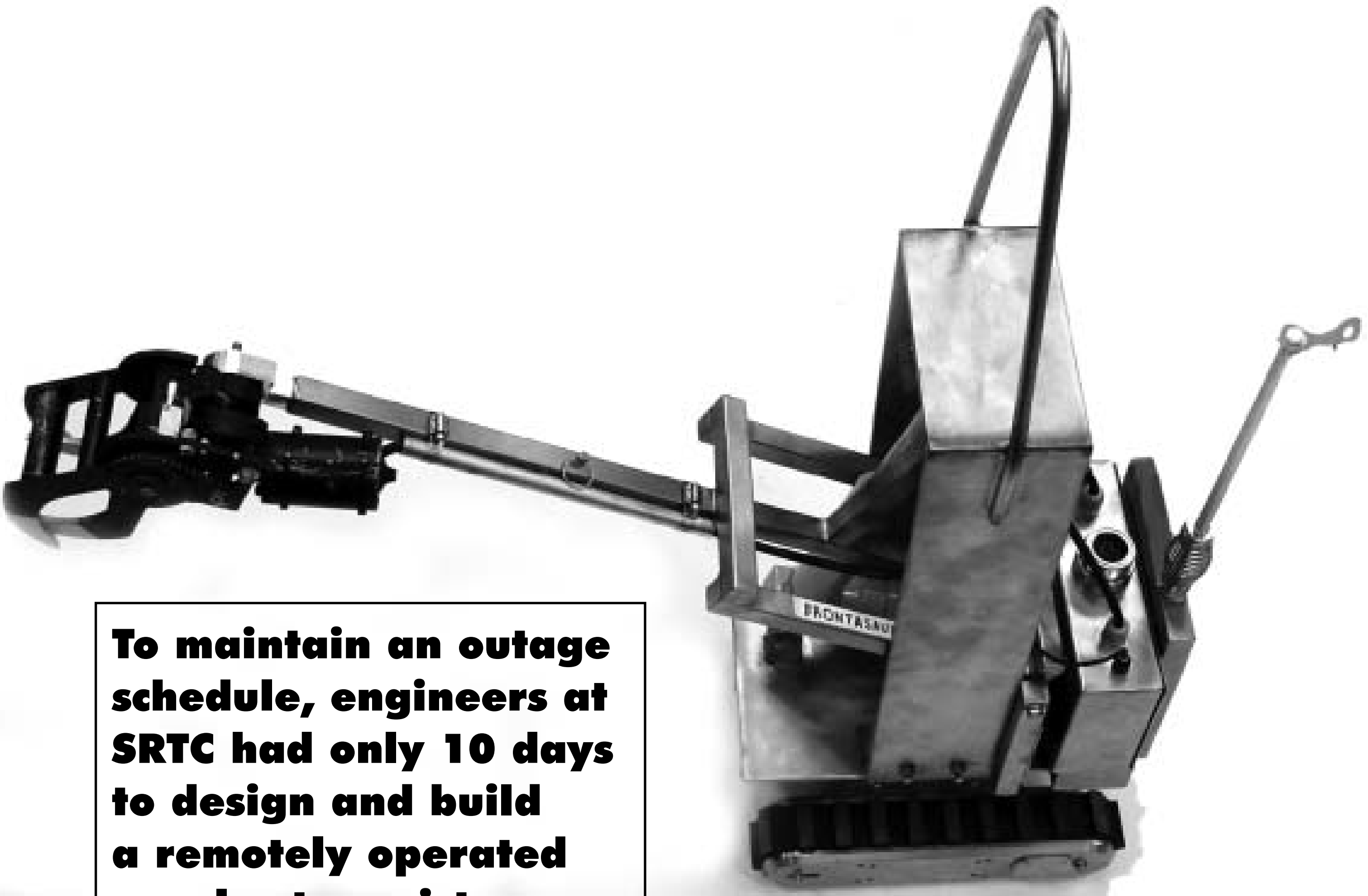

Fig. 2. Actual crawler.

To maintain an outage schedule, engineers at SRTC had only 10 days to design and build a remotely operated crawler to assist in cleaning the DWPF melt cell floor. And the crawler had only 10 days to clean the cell. How did they do? Read on.

DESIGNING THE CRAWLER

The DWPF Melt Cell Crawler team was composed of engineers, technicians, draftsmen, and machinist/welders. The technicians and machinist/welders worked with the engineers and draftsmen to design a crawler system that could be built in a short time with as many on-hand components and material as possible. Any other components or material would have to be available within a few days.

Based on the functions and requirements defined by DWPF, the team designed the crawler to be two-tracked with a lift arm and a gripper. The team selected Inuktun tracks, a Pedsco gripper, and a Pedsco arm motor, all of which were available at SRTC. Microvideo cameras with integrated lights were selected to allow front and rear views on board the crawler, since they also were on hand. The crawler was designed in three-dimensional (3-D) software (see Fig. 1) to eliminate any potential interferences with the motion of the arm or between components and to eliminate or minimize any other fabrication, assembly, or operation problems.

Only two heavy-gauge wires were available through the cell wall, so a custom control system was required. A variable direct current (dc) power supply provided speed control over the two heavy-gauge wires. The other wires were used to control the low-power relays that distributed, switched, and reversed power to the tracks, gripper, and arm motors on operator command. Since only one coaxial cable was available through the cell wall, another relay allowed the operator to switch the video signal coming from the crawler between front- and rear-view cameras. Five lifting bails were added to the Inuktun tether cable to allow the melt cell crane to assist with cable management. In brief tests at SRTC, the operator control box and relays, along with the variable dc voltage supply, successfully operated the tracks, arm, and gripper and selected the camera view before the crawler was shipped to DWPF.

The crawler tracks were approximately 17 inches long (see Fig. 2). For maximum maneuverability, the base was designed to stay within the circumference of a circle when turning about the base center with these treads. The available linear actuator (screw jack) from the Pedsco dictated

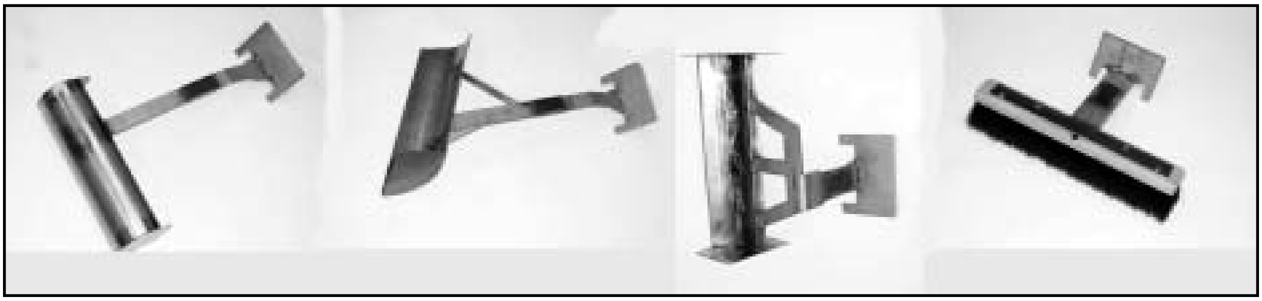

Fig. 3. Initial tools (hoe, angled snowplow, double blade, push broom).

a maximum reach of approximately 26 in. from the front of the base to accommodate the desired 35-pound lift capacity. A stainless steel counterweight was bolted onto the back of the crawler to prevent the crawler from tipping forward when lifting 35 lb.

Initially, three tools with blades were designed and built for cleaning the melt cell floor (Fig. 3). All three had identical adapter plates that allowed them to be picked up off of the floor and grasped firmly with the Pedsco standard claw gripper. One was a "hoe" with a long handle for pulling glass and debris. Another was an "angled snowplow" for pushing glass ahead and to one side. The third was a "double blade" with two curved blades, back to back, for pushing or pulling glass and debris. After testing at SRTC with glass fragments and particles, similar to the glass on the melt cell floor, plates were added to the ends of the blades to retain even more glass.

After using a push broom to clean up after the tests, designers decided to modify an 18-in. push broom head by adding an adapter plate for the gripper, making an additional cleanup tool in the melt cell. The push broom turned out to be one of the most useful tools. It was used to move most of the glass on the floor into piles or into a dustpan.

A scoop tool was added to the arsenal to scoop up the glass and place it into a waste bin. The crawler gripper could grasp the scoop tool and hold it in the horizontal position for scooping. When the gripper was released, the scoop would pivot and dump its contents but not fall off the gripper. The scoop could be pivoted back to the horizontal position on the floor and regrasped to make another scoop or released to disengage the gripper. In the end, this tool was used to remove the bulk of the glass from the floor of the melt cell.

Fig. 4. Crawler using push broom.

The crawler system was delivered to DWPF on December 12, 10 days after the project was initiated, as required.

THE CRAWLER IN USE

Due to the tight schedule, SRTC engineers changed to the DWPF 12-hour shift schedule to operate the crawler. The engineers attended all of the shift turnover meetings to discuss progress, plans for the next shift, and the support needed for melt cell cleanup. This helped form a very successful team of SRTC and DWPF personnel during the deployment. DWPF personnel provided outstanding support during this 24-hour-a-day operation. The crawler began cleaning on December 14.

All nonglass objects were placed in one set of standard DWPF bins, and all glass was placed in new bins specifically designed for the glass. Objects included melter-cleaning tools, can plugs, manipulator plug holders, can throat protectors, throat protector bails, manipulator sleeves (boots), melter pour spout inserts, melter sight glass holders, melter pour spout liners, insert expanding rings, an insert deployment tool, gaskets, and temperature probes. The segregation of objects and glass would allow the objects to be dispositioned as normal waste and would retain the option of placing the glass inside a canister in the future for disposition.

The crawler started by removing many of the objects in the center of the cell using the gripper. After most of the objects had been removed from this area, glass was moved into piles with the blade tools for pickup by the grapple. The hoe and the double-bladed plow moved objects and large particles of glass quite well. Both, however, left a significant amount of small glass particles behind. The broom could push and pull all the material into the piles with just a few passes (Fig. 4), so it was used for the rest of the job.

When the melt cell crane was available, it could adjust the position and elevation of a bail to keep the tether off the floor but still long enough to allow movement of the crawler over a large area. Without the crane, engineers had to be careful to avoid running over the tether with the crawler or wrapping the tether around the crawler.

"All Right, I'll Do It Myself"

After the crawler placed the glass in piles, the grapple was used for picking up the glass and putting it into the proper bin. However, the grapple could pick up only a small amount of glass, and it failed after only three grasps. The vacuum picked up small glass particles, but the hose clogged frequently with large glass chunks. Furthermore, the grapple and vacuum required the MPC for deployment, but the crane was not available all the time.

The crawler, on the other hand, could operate independently 24 hours a day. Because of these problems with the grapple and vacuum and their lack of availability, the crawler was used to complete the cleaning by itself.

Getting the Boot

The crawler used the scoop tool (Fig. 5) to collect the glass from the piles and deposit it into the bins (Fig. 6). After the engineers used the scoop for a while, they found that they could bring the scoop into the horizontal position after dumping by pulling it against the near side of the bin wall and then regrasping, aided by views from the onboard camera and one of the melt cell cameras. This sped up the operation.

After cleaning the center of the cell, the crawler was moved to the area on the near side of the cell. Care had to be taken in this area, because here the melt cell crane could neither hold the tether in the air nor could it retrieve the crawler from most sections of this area if it became stuck or failed.

Again, the crawler was used to remove most of the objects in this area (Fig. 7), and then the broom and scoop were used to clean up the glass. There was a large pile of debris at the south end of this area.

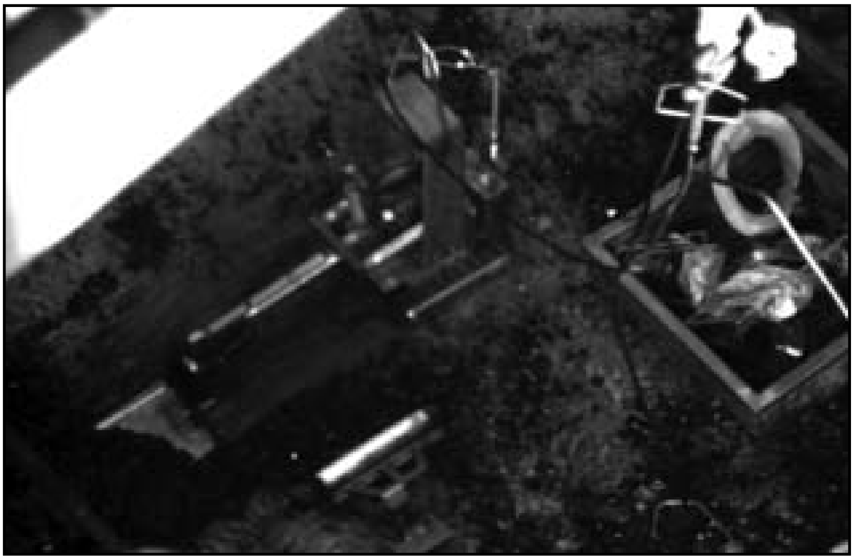

Fig. 5. Crawler using scoop to pick up glass.

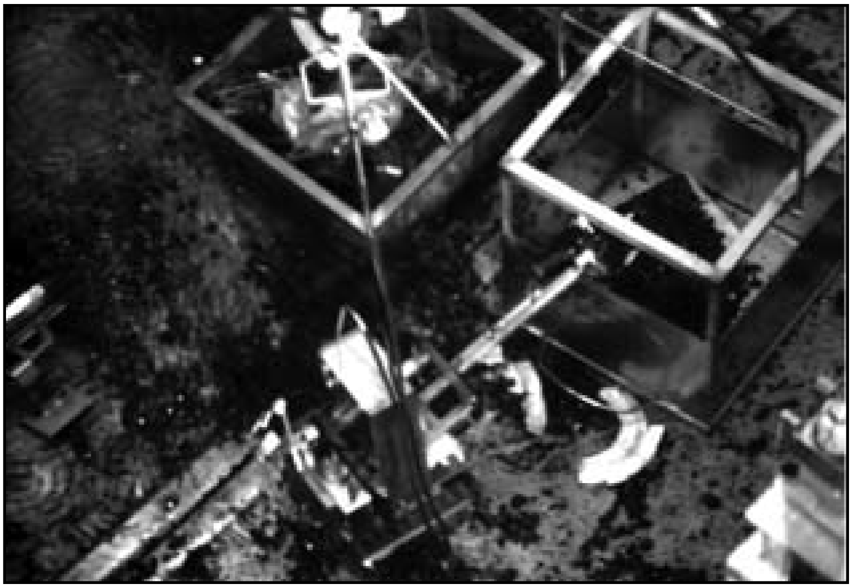

Fig. 6. Crawler dumping glass from scoop into bin.

Fig. 7. Picking up object on near side of cell.

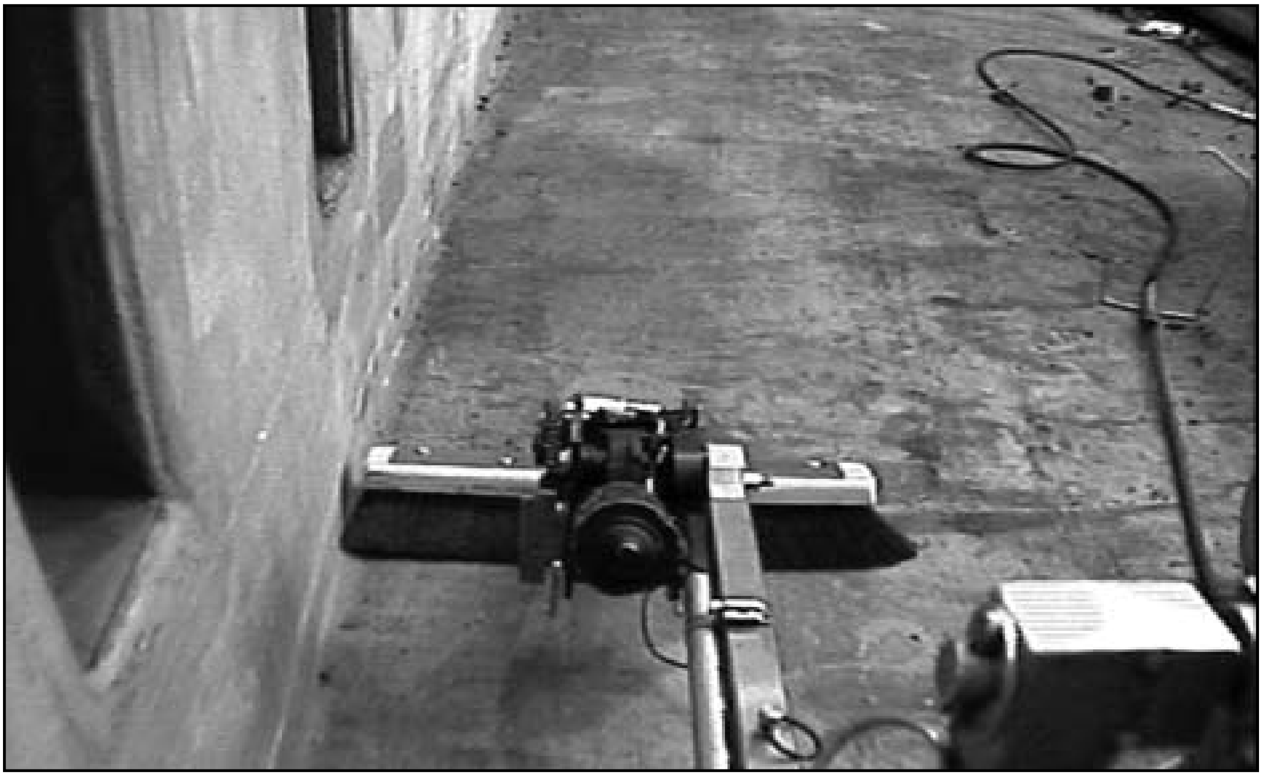

Fig. 8. Area on near side of cell after cleaning.

The objects from this pile were placed in the bin designated for nonglass material. Eventually, this bin was filled and removed and a second bin was brought in.

Some of the most difficult objects to get into the bin were the manipulator boots. When they were pulled, they would stretch out to 20 feet long or more. Patience was required to grab the boots, one part at a time, and get the entire boot into the bin.

When the melt cell crane was available, it could adjust the position and elevation of a bail to keep the tether off the floor but still long enough to allow the crawler to move over a large area. Without the crane, engineers had to be careful to avoid running over the tether with the crawler or wrapping the tether around the crawler.

Pit Stop

As the final cleanup of the near side (Fig. 8) was under way, one of the Inuktun tractors failed. Even though the crawler could move only in an arc, the crawler was maneuvered to an area where the melt cell crane, with some difficulty, could retrieve it. The crawler was remotely transported into the contact maintenance cell, where DWPF electricians in plastic suits worked to replace both tractors. Since one tractor had failed after many hours of service in the melt cell and both tracks had the same hours of service, both tracks were replaced. The mechanics sent the repaired crawler back to the melt cell to complete the cleanup.

Sweeping Clean

After finishing the cleanup in the area on the near side, the crawler was moved into the north end of the center of the cell. After operators removed objects in this area, they used the broom to sweep the glass into a new tool, a dustpan, that was built at SRTC during the cleanup. The dustpan was fairly heavy, which kept it in position. When the melt cell crane picked up the filled dustpan, it automatically tilted back to retain the glass. When the crane lowered the dustpan into the glass bin, a channel on the back of the dustpan would catch on the side of the bin and dump its contents into the bin. The dustpan was also sized to fit in a small area between a guardrail and a turntable track that was to be cleaned next. The crawler used two side-brush tools, also built during the cleanup, to push glass in this area into the dustpan for removal.

The far side of the cell, which previously had looked clean by comparison to the center of the cell, now looked poor compared to the cleaned center area. The SRTC team was asked to clean this area as well. The crawler cleaned this far side with the broom and dustpan. Great care had to be taken to avoid driving the crawler into a drainage gutter next to the wall. The crawler's short turn-

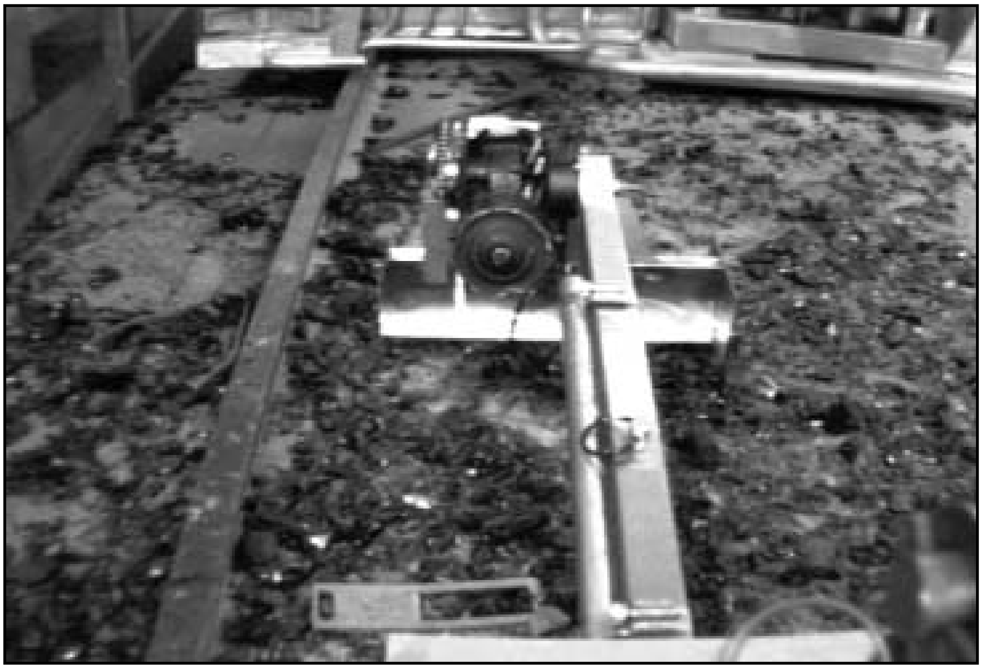

Fig. 9. Before cleaning the center area.

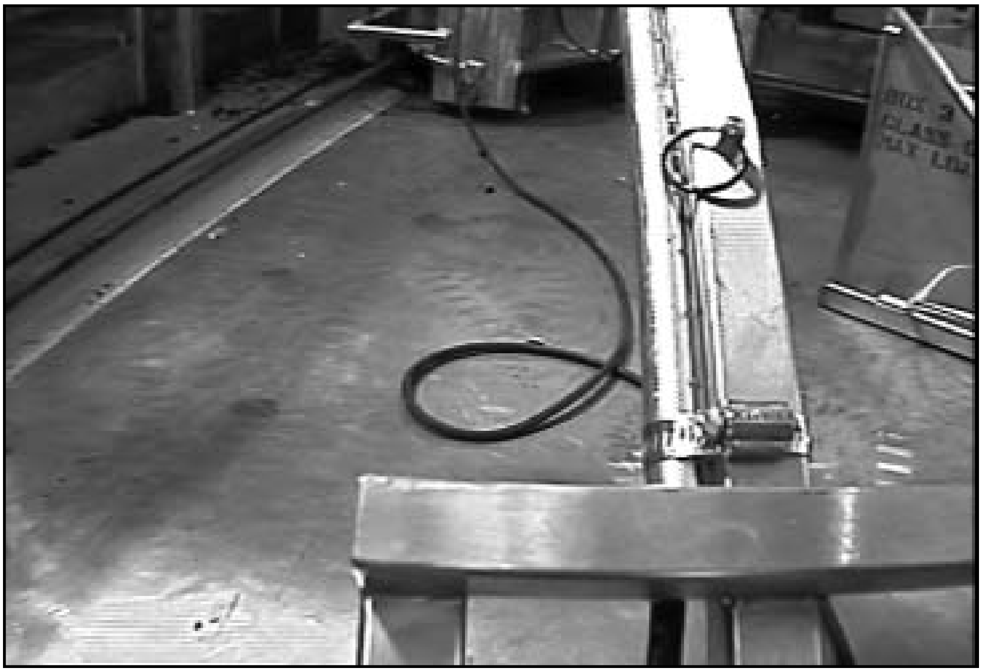

Fig. 10. After cleaning the center area.

ing radius proved to be perfectly suited for this area of the cell, allowing the crawler to turn around without falling into the gutter.

Two Days to Spare

On December 21, *eight days* after the cleanup began, the melt cell floor that had been covered with debris (Fig. 9) was now thoroughly cleaned (Fig. 10). During the cleanup, the SRTC team used the unique crawler, designed and built in only 10 days, and met several challenges with outstanding support from the DWPF personnel. The cleanup was completed ahead of schedule, and the outage schedule was maintained.

THE WRAPUP

The crawler and associated tools, designed and built in 10 days, cleaned the melt cell quite well in a short time. The crawler was to assist the vacuum and grapple with the melt cell cleanup, but due to initial problems with those tools, the crawler completed the cleanup by itself—and did it in only eight days. Designing the crawler in 3-D software prevented problems that could be expected with 2-D design in such a short time. The tools also worked quite well considering the limited time available for design, fabrication, and testing. Additional tools, designed and built during the crawler deployment, proved to be valuable, because the scope of the tasks for the crawler increased significantly after it was deployed. With a variety of tools available for a unique, first-time, remote task, the right tools were found to work very well in completing the cleanup on schedule.

Having experienced personnel on the crawler team aided in the quick design, as they offered such creative solutions as the tether bails that eliminated potential damage to the crawler system and accelerated the cleanup. Components on hand—such as the tracks, gripper, and arm motors—were critical to completing this work with such an aggressive schedule. Having the engineers who developed the crawler also operate the crawler meant that operators had strong ownership of the system and also intimate knowledge of the capabilities and limitations of the system. With the full support of DWPF personnel during deployment, this proved to be a winning combination. ■

Clyde Ward is a senior advisory engineer at the SRTC. Montenius Collins is a senior engineer, Thomas Nance is a principal engineer, and Michael Prather is a senior engineer, all at SRTC.