Mobile Work Platform – A Fluor Fernald Innovative Dismantlement Technology

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June 16, 2000

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For Presentation at the
Fourth U.S. Department of Energy International
Decommissioning Symposium
June 12 – June 16, 2000, Knoxville, TN

*Fluor Fernald, Inc. with the U.S. Department of Energy under Contract NO. DE-AC24-92OR21972

DISCLAIMER

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Abstract

The Department of Energy's (DOE) Office of Science and Technology Decontamination and Decommissioning (D&D) Focus Area, led by the National Energy Technology Laboratory, has been charged with finding new and innovative D&D technologies and then validating through field demonstration that the technologies are safer, faster and/or more cost-effective. The D&D Focus Area's approach to verifying the benefits of the improved D&D technologies is to use them at DOE sites in large-scale demonstration and deployment (LSDD) projects.

The DOE's Fernald Environmental Management Project (FEMP), near Cincinnati Ohio, was host for a LSDD Project overseen by the D&D Focus Area. The FEMP was formerly engaged in the production of high quality uranium metal; and is now currently undergoing active environmental restoration, including removal of major process facilities.

As observed during the D&D of Fernald's Plant 1, the baseline method for removing piping required laborers to work above the floor on ladders, scaffolding, and/or man-lifts with hand-held power tools. The pipe must first be rigged to prevent falling when cut. After cutting, the pipe is manually lowered to the ground and placed in a storage/disposal container. The Mobile Work Platform (MWP) consists of a mobile chassis, an articulating, telescoping arm and a dual crimper/shear "end-effector". It has the capability to grab and hold a pipe, crimp and shear the pipe (up to a ten-foot section) on either side of where it is being held and then lower and place the pipe section into a storage/disposal container. The MWP can crimp/shear up to a 6-inch diameter, schedule 40, carbon steel pipe. A single operator using a radio remote control operates the MWP.

The paper will describe the results (productivity, safety advantages and lessons learned) during the Mobile Work Platform demonstration at Fernald.

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Introduction

The Fernald Environmental Management Project (FEMP) is a United States Department of Energy (DOE) facility that once produced uranium metal products for use in the U.S. defense programs. The site is now engaged in a cleanup program to address environmental problems associated with the former production mission. Together, the DOE and Fluor Fernald place their highest priority on the health and safety of the Fernald work force and the public. The DOE continually seeks safer, faster and more cost-effective remediation technologies for use in the Decontamination and Decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology (OST) sponsors Large-Scale Demonstration and Deployment Projects (LSDDPs) in which developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, accelerated schedule, and decreased cost.

The Operable Unit 3 Record of Decision (Final Record of Decision) for Final Remedial Action for DOE FEMP requires the removal of piping and electrical conduit as part of the overall decontamination and dismantlement of structures and components at the site. This report describes a comparative demonstration between the innovative Mobile Work Platform (MWP) technology and the baseline, a manual, labor intensive, removal method.

The Problem

At the FEMP and throughout the DOE complex, a typical activity is the removal of piping and conduit when decommissioning a process facility. During the D&D of Plant 1 at Fernald, pipe/conduit removal methods were labor intensive, time-consuming, costly and often represented a significant challenge. Because of personnel safety issues, the "cut and drop" approach to piping and conduit removal was not permitted at Plant 1.

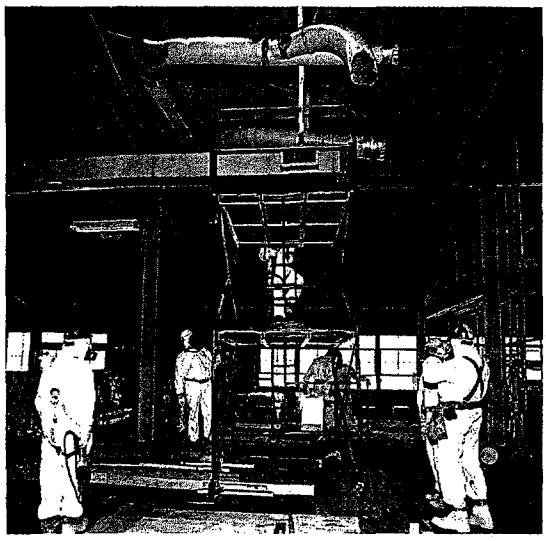

Figure 1. Crew staging scaffolding to remove overhead pipe.

The motivation to seek out and utilize a remote controlled machine capable of holding, crimping, then cutting sections of pipe and conduit is to reduce the hazard of exposures to personnel that are experienced during the baseline manual removal process. As pictured in Figure 1, the baseline method requires a crew consisting of 5 people to erect scaffolding, to rig the section of pipe/conduit to be removed, then cut it using hand held power tools and finally lower the pipe section to the ground. The next step is to transport the segmented pipe sections to the waste container. This last step was often performed manually.

Often a sling and pulley system is used to lower the pipe section safely to the ground. When the pipe to be cut is located high above the ground, the danger to personnel using power equipment is increased. Advantages of using the MWP include removing personnel from "harm's way," reducing the quantity of labor intensive work, eliminating the need for rigging activities and eliminating the need for personnel to work at elevated heights, by allowing a machine, specifically designed for the work, to do the job.

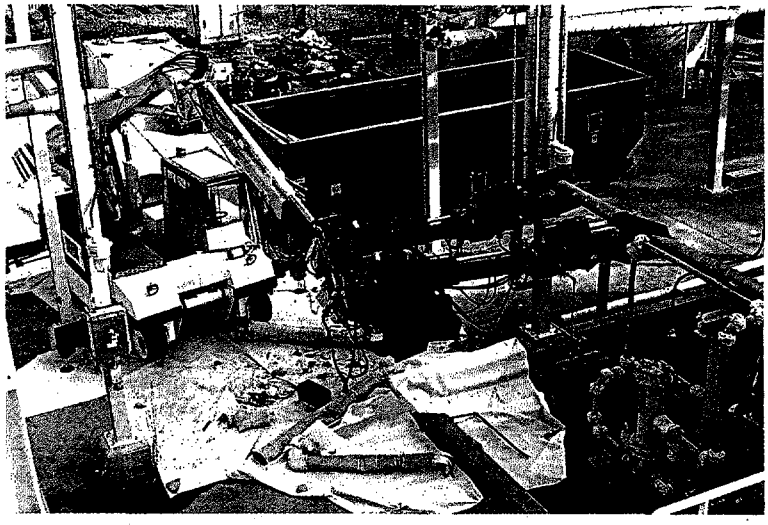

Figure 2. Mobile Work Platform removing pipe at Fernald.

How it works (Mobile Work Platform)

The MWP shown in Figure 2, supplied by Eagle Tech, has a four wheel chassis, Model No. 1500, a multi-articulating folding main boom attached to the chassis by means of a 360-degree rotating turret assembly. Attached to the telescoping end of the main boom are two independently operable arms that are mounted on a common articulating and rotating support platform base called the rotator. The rotator enables both arms to pivot around a common point. The rotator allows both arms to work at a 90-degree angle off either side of the main boom arm. Each arm is able to independently telescope outward or retract to assist in final positioning of the shear blade. Each arm is also able to independently articulate right, left, up, and down and also roll to position the shear blade in any position between horizontal and vertical. Both end-effectors have the ability to grab, hold in place, crimp, and shear pipe/conduit and lower the segmented section to the floor, waste container, or a predefined staging area.

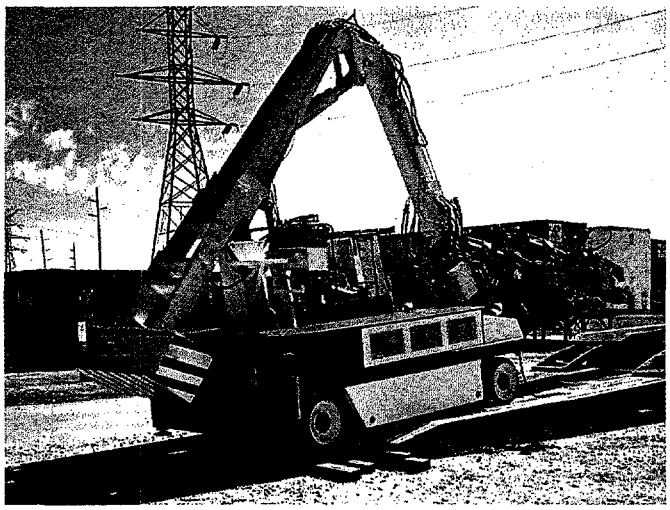

Figure 3. MWP driving off the transport trailer.

The MWP was built to satisfy the following specifications:

- Grab, support, crimp, shear then lower in a controlled manner a schedule 40, carbon steel pipe up to 6 inch (in) diameter with an additional 2 in of aluminum jacketed insulation.

- Reach and cut pipe up to 30 feet (ft) above the ground.
- Hold 1000 pounds (lb) with the main boom positioned parallel to the ground.
- Hold a load with the engine off, and provide a means to lower the load in a controled manner.
- Fit in and operate within an 8 ft wide by 9 ft tall entrances/asiles.
- Radio remote controlled operation up to 100 ft away.
- Place pipe sections directly into waste container.
- Travel 90-degrees in either direction from a stationary starting position.

The greatest feature of the MWP is the fact that it removes the D&D worker from "harm's way." Use of the Mobile Work Platform will eliminate the need to require workers to operate at heights up to 30 ft off the ground. These severe working conditions are often labor intensive and can jeopardize worker safety.

The uniqueness of the MWP is in the robustness of its design. With the capability to hold a 10 ft section of 6 in diameter, schedule 40, carbon steel pipe (weighing more than 200 lb), the MWP is able to manipulate and safely lower sections of pipe after cutting. During the demonstration at the FEMP, the MWP removed a single section of 4 in diameter, carbon steel pipe wrapped in aluminum jacket insulation, measuring 29 ft long. The MWP was able to lower the pipe and then further segment the sections into less than 10 ft long pieces directly above the waste disposal container.

Figure 4. MWP removing overhead pipe.

During the pre-acceptance testing of development, the MWP was tested with a 1,000 lb weight prior to working at the FEMP.

Initially, the operator is seated in the on-board cab and drives the MWP off the tractor-trailer transport vehicle to the work area, see Figure 3. The MWP is self-propelled and has the ability to steer each of the four wheels independently, increasing the maneuvering proficiency. While en route, the end-effector assembly is secured to the chassis to provide added stability during transport.

Once at the work area, the four outriggers are extended laterally and the outrigger jacks are deployed to stabilize the chassis. Then, the operator can leave the vehicle cab and utilize the belt supported radio remote control unit to manipulate the boom and end-effector functions of the MWP. In a typical application of overhead pipe removal, the end-effectors are manipulated via remote control to make final adjustments necessary to properly position the shear jaws around the pipe to be cut, see Figure 4.

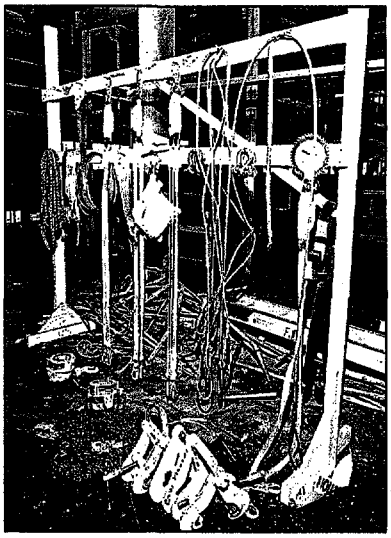

Figure 5. Examples of rigging equipment

The identically designed end-effectors allow the MWP to hold or cut by varying the amount of force applied to the pipe segment. Both end effectors can perform the same functions. The proportional remote control allows the operator to vary the speed and force of the individual functions, giving the operator precise control.

Using an example of a straight section of pipe/conduit, the right shear is moved into position to grasp the pipe, then the left shear is positioned to crimp and cut. Next the left shear is opened and positioned to hold and support the pipe section while cutting with the right shear. Now that the pipe section is separated from the rest of the pipe length, the left shear lowers the section to ground elevation. The next step is to position the end-effector shears for the next pipe section to be removed, and the process is repeated.

Figure 6. D&D worker assembling scaffolding.

How it works (Manual Removal)

During the D&D of the FEMP's Plant 1, the contractor utilized portable electric band saws, and heavy duty electric reciprocating saws combined with scaffolds, scissors lifts, safety harnesses, fall protection devices and other various rigging equipment to perform the pipe and conduit removal task. Some of the rigging equipment required is shown in Figure 5.

Typically, a crew will build a section of scaffolding, see Figure 6, to support the piping to be removed and attach a clamping device to the building's structural beam The beam clamp, shown in Figure 7, is used to hold the pipe section to be cut. But first, two areas of the pipe must be prepared, so the worker removes the aluminum jacket and insulation if necessary. Qualified riggers then secure the pipe before cutting begins. Once one end is cut through, the saw is carried over to the other side of the pipe and cutting resumes. After the cutting phase has segmented a pipe section from the remaining pipe run, it is carefully lowered to ground level via a sling and pulley system. Then, laborers must move the pipe sections to the disposal container. Often, the pipe section has to be manually handled by laborers to maneuver the pipe into the waste disposal container. Sharp edges and fragments of steel commonly protrude from the ends of the pipe section increasing the risk of personnel injury.

Figure 7. Beam clamp with nylon strap.

Mobile Work Platform Advantages

While the manual removal methods have been in existence for a long time, the MWP has the advantage of removing workers from 'harm's way'. By eliminating the need to elevate workers above ground level and minimizing the quantity of work performed with powered hand tools, the MWP is safer than baseline removal methods.

History shows that the FEMP has an excellent safety record, however accidents may happen and whenever steps are taken to reduce the danger to workers, the project is heading in the right direction.

The Demonstration Sites and Descriptions

The MWP technology was demonstrated at two locations that are similar to conditions found at Fernald and other places across the DOE complex. For demonstration purposes at the FEMP, an outdoor location and an indoor location were selected which presented a minimum risk of radiological contamination of the equipment. The MWP technology was first demonstrated outside at the former Maintenance Tank Farm Area (MTFA) for a period of 10 working days, then moved inside to Plant 6's North-West corner, also known as the Waste Water Treatment Facility (WWTF) for 3 working days.

The MTFA is an outdoor location, containing horizontal and vertical overhead pipe rack with electrical conduit, carbon steel insulated and non-insulated pipe with various diameters from 6 in to 3/4 in. The largest diameter pipe in the MTFA was a 6 in diameter, carbon steel, aluminum jacketed fiberglass insulation fire suppression line. Several carbon steel steam and condensate return lines with aluminum jacketed fiberglass insulation were located within the same pipe rack. In addition, various sizes of smaller diameter conduit and pipes were in the rack as well. The MTFA pipe rack

elevation was approximately 20 ft above ground level. The pipes were mounted via saddles, "U" bolts, and angle brackets in the MTFA.

In contrast to the relatively open area of the MTFA, the WWTF presented a narrow entrance (8 ft wide, 9 ft tall), indoor location with low (9 ft high) overhead catwalk flooring within the working area. The MWP was able to reach underneath several nitric acid tanks to remove stainless steel pipe with insulation.

In the WWTF, the MWP was used to safely remove plastic conduit, carbon steel non-insulated pipe, 3 to 4 inch diameter insulated stainless steel pipe and a series of "U" shaped, galvanized steel channel supports measuring 6 in by 2 in. These items were located on either side of the narrow aisle within the WWTF. The close quarters of the WWTF tested the ability of the MWP to operate in tight areas with low overhead clearance. Figure 8 shows the MWP working within the WWTF.

The purpose of having the MWP demonstrated at two locations at Fernald, was to determine the overall flexibility of the machine using the two extremes, a wide open area versus a tight quarters area, while documenting the resulting production rates. During the demonstration at the FEMP, the

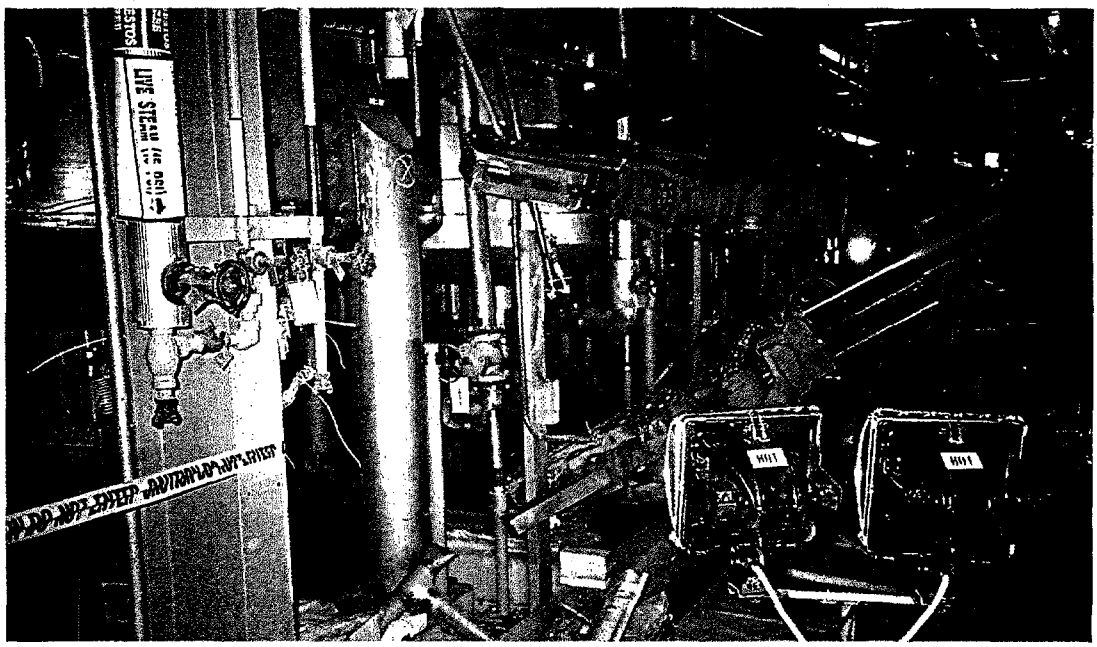

Figure 8. MWP removing pipe and conduit within the

MWP was able to remove all of the pipe and conduit identified for removal during the demonstration. A total of 844 lin ft of pipe and conduit were removed over the period of 13 working days.

Key Results

The key results of the demonstration are as follows:

- Best Feature: Removes workers from "harm's way". During the demonstration a vertical pipe was cut that had residual water (~1/4 gal.). If this unexpected event had occurred with hand-held power tools, the personnel may have been exposed to contaminated hazardous material. However, all personnel were outside the building during the shearing phase pipe removal and due to the crimping feature of the MWP, no one was sprayed with the liquid.

- Unit cost for the demonstrated application: $4.94/lin ft

- The MWP removed 844 lin ft of pipe and conduit during the 13 day demonstration.

- Successfully removed all pipes and conduits attempted regardless of geometric configuration, including supports (hangers, U-bolts, saddles, posts, channels and other supporting mechanisms).

- The longest single section of pipe removed with bends: 29 lin ft (4 in carbon steel, with 2 in insulation). Largest diameter of pipe removed was: 6 in carbon steel (14 lin ft length, 22 ft above ground level) with an additional 2 in of aluminum covered insulation.

Table 1. MWP Demonstration Material Summary Table.

	Maintenance Tank Farm Area		Waste Water Treatment Area	
Material[1]	Linear Feet	Aluminum jacketed insulation[2]	Linear Feet	Aluminum jacketed insulation[2]
Carbon Steel Pipe	620	Yes	61	Yes
Stainless Steel Pipe	0	No	79	Yes
Plastic Conduit	9	NA	52	NA
Galvanized Steel Channel	0	NA	23	NA
Total	629		215	

[1]U-bolts, pipe hangers, and other supporting brackets.
[2]Aluminum covered pre-formed fiberglass, asbestos-free insulation 2 in thick.

Table 2. Production Rate Summary

Production Rate	
Average	20 lin ft/hr
First 6 days	13 lin ft/hr
Last 7 days	28 lin ft/hr
Highest single day	36 lin ft/hr

Technology Description

Baseline approaches to removing former process piping and conduit materials at the FEMP include power tools like: portable band saws, reciprocating blade saws, and open flame cutting torches. Each of the aforementioned pipe and conduit D&D methods all involve locating people in the immediate vicinity of the cutting process. Each of these methods has drawbacks, such as slow production rates, generation of airborne contamination, creating fire ignition sources, inherent dangers of operating hand held cutting tools, requiring personnel to handle pipe and conduit sections, and large crew requirements.

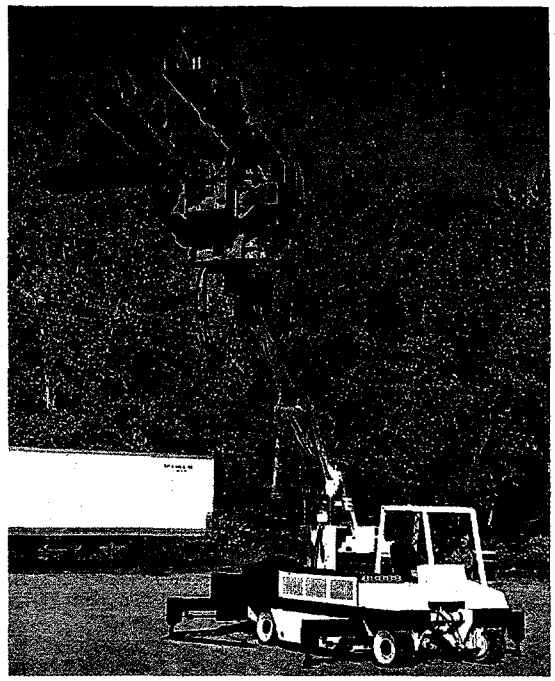

Figure 9. MWP holding a 1,000-pound weight at the vendor's facility.

In an effort to find a better method of removing former process pipe and conduit, the MWP technology was demonstrated at the FEMP. It was demonstrated in a real-world environment. It was utilized within an area that required the removal of pipe and conduit. The MWP was assessed to determine its ability to satisfy the following objectives:

- Reduce the health and safety hazards to the D&D laborers from:

  –The need to work at heights when cutting pipe, conduit and other components.
  –Equipment or pipe segments being lowered or moved may shift and/or fall suddenly, injuring personnel.
  –Sharp edges left from manual cutting methods and subsequent hands-on handling of cut segments.
  –Manual cutting methods may increase the potential for airborne contamination problems.

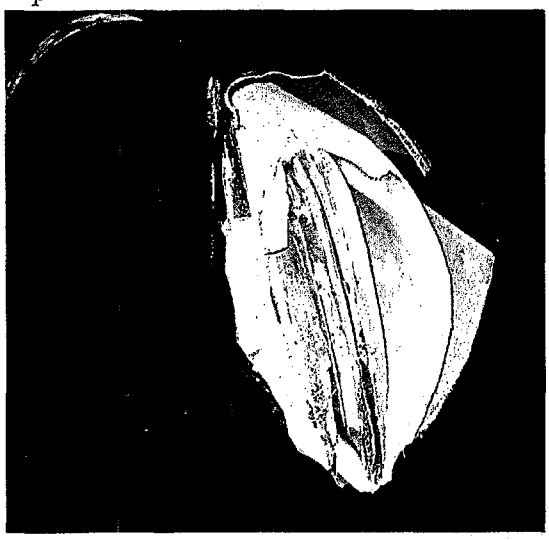

Figure 10. 6 in, carbon steel pipe with insulation is crimped by the MWP.

- Provide a cost-effective alternative for pipe and conduit removal.

- Provide a comparison to baseline pipe and conduit removal technologies.

The MWP technology has three integral systems: the chassis system, the arm system and the end-effector system. Within the chassis system is housed a propane fueled, 302 cubic

inch displacement, V-8 motor that drives a set of hydraulic pumps that provide pressure to move the various articulations of the unit. The hard rubber tires have four wheel 90 degree radius steering and are powered by hydraulic pressure and controlled from standard steering controls within the on-board cab.

The chassis measures 72 in wide by 148 in long and 93 in high. The complete vehicle weighs 30,400 lb as configured for the demonstration at the FEMP. The rear pair of outriggers can extend away from the chassis and all four of the outriggers can be telescoped outward away from the sides.

The arm consisted of a main boom and jib boom are constructed of high tensile strength steel. The jib boom can telescope outward and extend to reach 30 ft above the ground and reach 30 ft out laterally from the chassis. Each end-effector can grab, hold, and cut pipe and conduit into sections ranging in length of about a ft long up to 20 lin ft. During the demonstration at the FEMP, a 29 lin ft, a 4 in diameter, carbon steel pipe with insulation was removed in one piece. The aforementioned pipe section included several 90-degree bends forming the steam line expansion loop.

As part of the pre-acceptance criteria, the Model 1500 was tested with a weight of 1,000 lb at the manufacturing facility before arriving at the site as shown in Figure 9. The test included lifting the test weight with one end-effector to the maximum height above ground and then rotating the turret 360 degrees. In addition, the shear blade holding the test weight was rolled 90 degrees each direction and the Rotator was rotated 90 degrees in each direction to prove the capability of the MWP.

The end-effectors are designed with a curved shear blade to provide a crimp prior to the shear cut, (Figure 10) to reduce the potential to releasing contaminants within the pipe. The blades (Figure 11) can be easily changed in the field to provide less crimping effect on the pipe, if an inspection of the pipe interior is necessary.

Although not required for use at the FEMP, the MWP was initially equipped with cameras to allow for remote viewing of the operations. The cameras supplied for the demonstration consisted of an on-board receiver video monitor, which can be removed from the MWP and placed at some distance away for remote operation, While on-board the MWP, DC electricity is converted to AC current to power the cameras. The chassis and arm are proven technologies in use at various industrial applications and may be supplied in various chassis

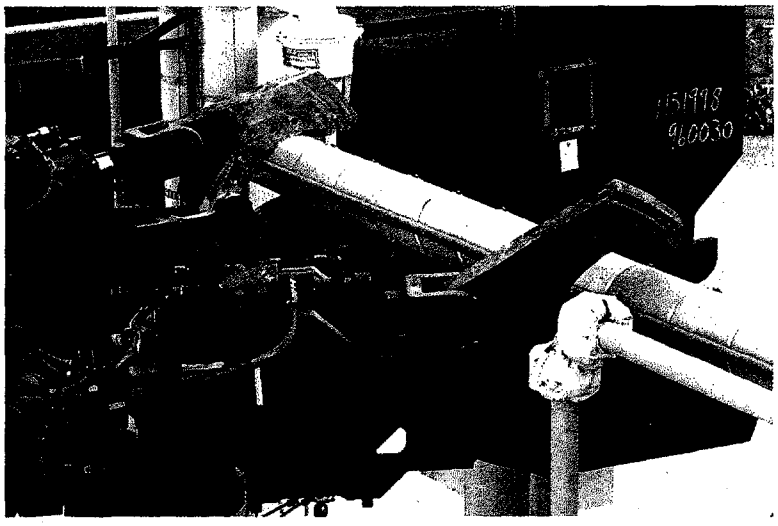

Figure 11. MWP removing pipe at the FEMP's Maintenance Tank Farm.

sizes, lift capacities and power trains. Currently, the MWP can be operated outside or inside a facility, on concrete floors or may be modified for rough terrain.

Commercial Availability

Both technologies and their components are commercially available. However, the vendor has performed modifications to the MWP technology and its components to enhance efficiency and productivity. The MWP is available as a vendor provided service or rental.

Future Plans

As a result of the demonstration debriefing, the vendor for the MWP technology, is making modifications to the unit to increase flexibility and productivity. Eagle Tech is examining the possibility of deploying a "teach and learn" system to automate repetitive maneuvers once within the working area. Eagle Tech is also exploring the efficacy of additional end-effectors other than a shear.

Licensing

The Mobile Work Platform is currently available for purchase or as a vendor provided service from Eagle Tech.

More Information

All published Innovative Technology Summary Reports are available on the OST Web site at http://em-50.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST Reference number for the MWP is 2243.

Demonstration Site Description

The demonstration of the MWP technology was conducted in accordance with the approved *Mobile Work Platform Work Plan 2500-WP-0036, Rev. 1.* The MWP technology was demonstrated at two very different areas at the FEMP, however both locations had a low potential for radiological contamination. The first was an outdoor location consisting primarily of an extensive overhead pipe rack known as the Maintenance Tank Farm Area (MTFA). The MTFA pipe rack consisted of various pipes and electrical conduit ranging in size from 6 in to 3/4 in diameter carbon steel, galvanized steel, also pipe supports and insulation. The pipe rack was elevated approximately 20 ft above the ground. This location was chosen because of the close similarity in size and layout of "process piping" found within process areas throughout Fernald. The path leading up to the MTFA was as narrow as 9 ft wide.

The second location was Plant 6G's Northwest corner which contained the Waste Water Treatment Facility (WWTF). The entrance leading into the building was 8 ft wide by 9 ft tall while the average overhead clearance within the 'hallway' was less than 9 ft. Pipes and conduit were located overhead and to either side of the hallway. The pipes and conduit included 4 in stainless steel insulated and non insulated pipes, a 6 in "U" shaped galvanized channel support, and carbon steel pipes. Figure 12 shows the MWP working within the close quarters of the WWTF.

Demonstration Objectives

The primary reason for demonstrating the MWP technology was to assess its ability to remove pipe and electrical conduit in a safer, more efficient and cost effective way as compared to the manual/baseline method. The objectives of the demonstration were to:

- Hold, crimp, cut, and lower to the ground up to 6 in diameter, schedule 40 thickness, carbon steel pipe and de-energized electrical conduit with minimum labor and risk to personnel.
- Determine cost effectiveness.
- Evaluate safety improvements and capability of the MWP.

Results

The Demonstration was successful in safely achieving all of the aforementioned demonstration objectives. However, the operator did not have a great deal of experience with the remote control interface prior to the demonstration at the FEMP. As the demonstration progressed, the operator became more proficient with the controls. However, the Integrating Contractor Team concurred that the MWP could have been operated much faster using an experienced operator. After the demonstration FDF and the vendor conducted a system by system critique of the individual components of the MWP.

Competing Technologies

The MWP has no known directly competing technology because of its robust size, strength and unique ability to hold, crimp, cut and then lower sections of pipe in a controlled manner. The MWP performs a process that can be compared to manual removal methods. Other companies have previously built robotic arms with a variety of end-effectors that have been deployed in demonstration decommissioning programs. However, none of them have the capability to hold, crimp, cut and lower in a controlled manner. Since the cut and drop approach is unacceptable at the FEMP these products while reviewed were not selected for demonstration.

Technology Applicability

The MWP is useful in many applications where elevated pipe and conduit are required to be safely removed across the DOE sector. By reducing the risk of injury to personnel, the MWP will lower overall cost of D&D projects. With proper modification, the MWP would provide the most benefit in an environment that is high in contamination, high in radiation, and presents a high industrial hazard.

The MWP technology demonstrated at the FEMP was designed, manufactured, and assembled by Eagle Tech of Solon, Ohio. The MWP can be purchased or is available as a vendor provided service. The MWP technology was sponsored by the DOE's Office of Science and Technology, Large Scale Demonstration and Deployment Project. No regulatory permits were required to demonstrate the MWP at the FEMP.

Technology contacts:

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Ph. 440-542-0440

Lessons Learned

The MWP technology is a commercially available system. Hands-on training can be provided by the vendor and is recommended to familiarize the operator with the uniqueness of the remote controls. To date only one of these units exist; therefore a truly experienced operator does not exist. Based upon the data collected during the demonstration, a graph shown in Figure 13 illustrates that with operating time and experience an operator can significantly improve the production rate.

Technology Limitations and Needs for Future Development

The MWP technology demonstrated at the FEMP could benefit from the following design improvements.

- Provide an improved operator interface (i.e. joystick controls) would increase production rate.
- Employ a "teach and learn" computer system to assist the operator with repetitive manipulations.
- Utilize a laser range finding to assist placement and fine-tune maneuvering of end-effector would automate the final positioning of the shear head.
- Provide an electrical and hydraulic swivel to improve flexibility and reduce the loops of electrical wiring and hydraulic hoses.
- Provide a locking quick connect hydraulic fittings.
- Provide an indicator to view the direction of the individual wheels of the MWP.

- Utilize a telescoping, articulate counter weight.

- Provide flexible boot coverings around hydraulic cylinders, and removable surface paint coatings to enhance decontamination of the unit.

Technology Selection Considerations

Ideally, the MWP is most useful in high radiation areas where personnel are performing pipe and conduit removal tasks. In such areas, the MWP may be an enabling technology. The additional savings in personnel exposure are not applicable at the FEMP as may be encountered at other facilities within the DOE complex.