Shielded Cells D&D and Dismantlement System Requirements (U)

by

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System for Highly Radioactive Equipment Dismantlement:

Shielded Cell D&D and Dismantlement System
Requirements

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Summary

This document describes the basis for the development of the System for Highly Radioactive Equipment Dismantlement or SHRED. It is the result of a thorough investigation into current and past dismantlement practices at shielded cell facilities around the DOE complex. This information has been used to formulate the development requirements for the SHRED.

SHRED is a "toolbox" of remote dismantlement tools that can be selected for use as appropriate by anyone performing remote decontamination & decommissioning (D&D) operations. It is being designed primarily for use in shielded cell facilities, but will have application in any D&D operation where remote operation is desirable.

The unique characteristics of shielded cells are presented in this document along with their influence upon design requirements. In addition, a description of the proposed tooling and delivery systems that will make up SHRED is also described.

Background

This report is being prepared under Technical Task Plan number SR1-5-20-02 "Remote Disassembly of Highly Radioactive Equipment" for the DOE Office of Technology Development.

The contents of this paper are the result of an investigation into the needs of the DOE complex for future D&D of shielded cells, (also called hot cells). The investigation was made to help focus the development of specialized dismantlement tooling to assure that it will be useful and appropriate. The research was conducted during the period from January 1 to March 17, 1995. Telephone interviews were conducted with personnel from 9 sites. In addition, 6 shielded cell facilities at 5 different sites were visited. During each site visit, interviews were held with operators, engineers and managers that are experienced in shielded cell D&D. This paper is a result of discussions with some of the most experienced and knowledgeable D&D personnel in the DOE complex. An alphabetical listing of the people interviewed is included in Appendix A.

Past and Current Practices:

D&D operations have occurred and are occurring at several shielded facilities in the DOE complex. There are two basic approaches that have been and are being applied. The first involves the use of commercially available tooling in conjunction with existing mechanical manipulators (MSM's). Tools such as hand-held saws, grinders, and torches have been used effectively to dismantle and size reduce a variety of installed equipment. This type of operation has been employed successfully. It involves a low capital investment and takes advantage of the existing skills of MSM operators. However, there are two drawbacks: it

can be a slow process, and it is very damaging to MSM's. Both result in increased operating costs.

The other approach is the development of specialty tools and delivery systems. This method has also been used successfully, but it usually involves a large initial investment as most new developments do. In addition, the development effort is often duplicated at different sites.

(There is also a third approach that is actually a combination of the first two.)

As will be discussed later, the goal of this project is to enhance the cost effectiveness of both methods. Tools will be developed that perform better in the shielded cell environment and are more "manipulator-friendly" than existing industrial tools. Also, some of the expense of duplication of effort will be avoided. This project will develop generic tools that will address the basic needs at most sites. There will always be individual circumstances that dictate special development, but this project will reduce those cases by providing tools that meet the majority of dismantlement needs. Another goal is to provide tooling that can be deployed by a variety of delivery systems. This will further enhance the versatility and usefulness of the system.

The following report describes the aspects of shielded cell dismantlement that were uncovered during the research effort. In addition, it also describes the requirements and plans for developing tooling to address the most common needs for dismantlement and size-reducing. It also will discuss various concepts for tooling delivery. The tooling developed by this project along with the various delivery concepts will be referred to as the System for Highly Radioactive Equipment Dismantlement or SHRED.

Shielded Cells Comparison -- Differences and Similarities

Although there are differences between the shielded cells throughout the DOE complex, there are many general similarities in design. The key differences include methods of cell access, physical size, and the configuration of in-cell equipment. These will be discussed below with some detail. Similarities between cells will also be discussed. It is these similarities that make the development of a basic dismantlement system feasible. There are some elementary tools that can be useful to most shielded cell D&D operations.

Differences in Shielded Cells:

(Including their impact on SHRED design requirements)

1. Method of access:

Access to shielded cells varies with individual design. While having minimal influence upon the design criteria for tooling, access requirements will impact the selection of delivery methods. Some cells have overhead covers as in the SRTC F-wing facility in

Bldg. 773-A. Removed by a crane, these covers allow equipment to enter and exit the cells through the ceiling. (See Figure 1a) Other cells have sliding or swinging shielded doors in the back or side of the cell. One example of this design is the Isotope Facility at ORNL. When the radiation levels inside these cells are low enough, these doors are opened to allow cell entry. (See Figure 1b) Some cells have airlocks requiring equipment to pass through two sets of doors in order to enter or exit the cell. The B-Cell at PNL is an example of this type of design. (See Figure 1c)

Figure 1: Variations in Shielded Cell Access Methods

While there are many variations from the designs shown in Figure 1, these represent the general categories of cell access provisions.

There are two variations to the designs described above that are worth mentioning. First, many cells of types 1.b. or 1.c. have a rail system installed in the floor. These rails could be very useful when deploying the SHRED on a cart. Another feature present in some cells is a small transfer port used to introduce small items into the cell. (Figure 1.a.) This would be helpful for supplying tools, blades, and grinding wheels into the cell.

2. Size:

The size of DOE shielded cells varies significantly. They range from small analytical cells that measure approximately 2m cubed to large canyon-style facilities that exceed 10m in height. This wide variation in size will have a great deal of impact upon the delivery method of choice, but little influence over the design of tooling.

3. Radiation levels:

From a few hundred mR/hr to 500,000 R/hr, the radiation dose rates vary widely in shielded cells within the DOE complex. All in-cell components must be designed with radiation tolerance in mind.

4. Flammability requirements:

Some shielded cells can tolerate flame- and spark-producing cutting methods. Some cannot. For this reason, tools will be developed that employ cold-cutting methods (such as slow saws) and tools will be developed that use hot-cutting methods (such as grinders and torches).

5. Installed equipment:

There is also a variety of types, sizes, and weights of equipment resident in the shielded cells. Equipment sizes vary from small tubes and pipes to large tanks and structural members. This will be one of the main influencers of tools that are selected for development. The ability to dismantle and size-reduce equipment of all sizes must be provided.

6. Lined vs. unlined:

The last major difference in shielded cell configuration that will be discussed is the area of liners. Some cells have steel or stainless steel liners, while some, with no liners, have exposed concrete walls. The cell liners present a unique dismantlement challenge. Many liners are welded to reinforcing and structural steel elements that are embedded in the concrete walls. If the cell is being completely dismantled (as opposed to just removing the contents and deconning the interior of the cell), then detaching the liner from the wall becomes a difficult task. Tools will be needed to remove sections of the liner and to dig into the concrete in order to cut the reinforcing steel.

Similarities in Shielded Cells

The previous section dealt with the differences in shielded cells across the DOE complex. This section will focus on the similarities that exist. As mentioned earlier, the fact that there are a lot of similarities is the main reason that this project is feasible. The goal of the SHRED is to become a basic set of tools that meets some of the common needs of all or most of the different facilities. The key similarities are discussed below along with a brief mention of their effect on tooling selection and design.

1. Remote access:

All shielded cells are, by the nature of the work performed within them, designed for remote operations. This fact makes the use of a remote dismantlement system like the SHRED necessary and natural. The cells already have built-in provisions for supporting remote work. Also, the operators of these cells are familiar with, and good at, performing work remotely. Tooling designs should be simple, reliable, and easy to use with remote handling methods. Since these are remote areas, operations that normally are performed hands-on, such as changing blades, must be performed remotely.

2. Cell design:

While cells come in many shapes and sizes, their basic designs are similar in several ways. First, all cells have shielding walls. The vast majority of walls are concrete. A few use a steel shell filled with water. Most are several feet thick. Within the walls of most cells are viewing windows that will allow line-of-site viewing for the operators. Cells without windows are equipped with in-cell cameras. All cells have in-cell lighting that is necessary for viewing remote operations. There are penetrations for electrical and pneumatic lines that can be used to power tools. The vast majority of cells have manipulator tube penetrations of essentially the same diameter. These tubes can be used in one of the delivery scenarios that will be discussed later.

3. Manipulators:

Almost all shielded cells are equipped with mechanical manipulators. These are usually located in pairs and penetrate the shielding wall above the viewing windows. These manipulators are similar in design and operation, and there are very skilled operators at all facilities. These manipulators will be invaluable in deploying and servicing tools, in material handling, and in connecting hoses and wiring to the tools. Any tooling and delivery concept should include the use of these manipulators, because they are a great asset. However, past experience has proven that using mechanical manipulators for dismantlement work is hard on both manipulator and operator. Because of reactive forces produced by saws and grinders, the mechanical manipulators have suffered high failure rates when used to hold these tools. A sound dismantlement concept should call for tools to be deployed by some other method. The manipulators should be used only in a support role.

Some of the larger cells have electro-mechanical manipulators (EMM's) mounted on overhead, moveable bridge cranes. They have sufficient lift capacity that they could be used for holding tools. While this is an ideal delivery method, the percentage of facilities with EMM's is small. The EMM's can also become high-maintenance items when used for rigorous D&D work as experience has shown.

4. In-cell cranes or hoists:

Most shielded cells are equipped with cranes and/or hoists that are remotely operated from outside. These will be very useful for supporting and positioning tools, moving materials to and from the dismantlement operation, and removing the tools and delivery system for maintenance when necessary.

Dismantlement System Requirements

The research into similarities and differences in shielded cells have led to the development of a set of design requirements for the SHRED. These are discussed below.

1. Versatility in delivery options:

Since there are so many variations in shielded cell designs, there is no single delivery option that would work in all cases. While it is not within the scope of this project to develop the delivery system per se, it is necessary to present some concepts that can be used to design tooling around. Several concepts are presented in the next section of this report. All tooling will be developed to be adaptable to all of the concepts presented, and probably many others as well.

2. Standard "basic toolbox" concept:

The need for special tooling development will always exist because of the individual needs of each facility. However, it will be the goal of this project to develop a "toolbox" of basic tools that will have widespread application. The D&D program manager will have a standard set of tools from which to choose. He will also have the ability to incorporate special or modified tooling as his particular situation dictates.

3. Must address flame and non-flame cutting methods:

As discussed earlier, there must be tools available that are not spark- or flame-producers for use in those cells where flammability is a concern. Other, more aggressive methods will be developed for use in cells where this is not a concern.

4. Components must be rugged and reliable:

Because of the problems associated with remote maintenance and the costs associated with decon, the tools must be simple and rugged. The resulting reliability will increase productivity and decrease the costs of D&D operations.

5. Operation must be easy and intuitive for existing operators:

In order to be successful, this project must produce tools that are easy to use. The tools will be straightforward and require little if any special training for their use. Cutting operations should be automated to the extent possible without adding unnecessary complexity. Tools should be designed with compliance so that a low level of precision is required. Tools that are easy and intuitive will reduce operator fatigue and speed up operations.

6. High radiation tolerance:

Tools will be designed with radiation tolerance in mind.

7. Maintenance requirements:

Because maintaining equipment in shielded cells is a difficult and costly endeavor, tooling must be designed with the following criteria in mind:

- High frequency activities will be performed remotely (i.e., changing blades, grinding wheels, etc.).
- Easy hands-on maintenance in protective clothing
- Inexpensive tools can be considered "throw-aways"

SHRED Design Concept

System Description:

As mentioned before, the SHRED is a "toolbox" of basic dismantlement tools that will be available to the shielded cell operators who need them. The tools will be designed to meet the requirements that were defined in the previous section. They will also be readily adaptable to any of several delivery methods to increase their versatility and usefulness. These delivery methods will be discussed in detail later in this section.

All tools will be powered by and controlled with 110 vAC and/or 100 psi air whenever possible to take advantage of the existing energy sources available in most cells. There are a couple of exceptions. The plasma arc tool, which will probably use 220/440 vAC, and the hydraulic shears. The shears will be designed to use non-hazardous, synthetic fluids to avoid mixed-waste problems.

All tools will have several handling options. This is made necessary because a variety of delivery options must be supported. If being supported by a crane or hoist, the tools must

be fitted with lifting rings or bails. If by manipulator, then a special handle is needed. Some tools will clamp on to the equipment being cut.

An important aspect of this program is commercialization. When it is appropriate, we will select industrial partners to participate in the tooling development. The goal is to develop commercial suppliers of these products. We are currently exploring CRADA's and other partnership arrangements.

Tool List:

The following list is the result of conversations with experienced D&D personnel around the DOE complex. Universal usefulness was the main criteria for selecting these tools. The tools are ranked in order of their priority. A discussion of each tool is included.

1. Reciprocating Saw

Description:

The reciprocating saw is the first tool chosen. It was selected for its ability to cut many materials and shapes, and it produces no sparks. It can be used in cells with flammability concerns. It can cut pipes, structural elements, tanks, plate, etc. This type of saw was used in almost every D&D job investigated by the author. The operation of feeding the blade into the work can be difficult when performing the work remotely. It is difficult to "feel" the pressure being applied to the blade. These saws will be developed with simple, automatic feed systems to avoid this problem.

Advantages:

- Cuts many materials
- Cuts many shapes & sizes
- Non spark producing

Disadvantages:

- Slow
- Requires frequent blade changing
- Reaction forces are hard on manipulators

2. Hydraulic Shears

Description:

Hydraulic shears were chosen next because of their speed and simplicity. They are rugged and produce no sparks or flames. A powered manipulator that is equipped

with shears could rapidly remove and size-reduce large amounts of pipe, conduit, small structural elements, and other items. This tool will be most effective mounted to a hydraulic manipulator with a built-in tool interface. In this arrangement, the hydraulic hoses are routed through the manipulator and therefore protected from snagging and pinching. Hydraulic shears in several sizes will be investigated.

Advantages:

- Fast
- Simple, easy to use
- Rugged
- Clean -- produces no particles

Disadvantages:

- Limited to cutting small components
- Requires hydraulic supply
- Relatively heavy
- Requires clearance around object being cut

3. Abrasive Wheel Grinder

Description:

Grinders are very effective in cutting metals -- even hardened steels. They are relatively fast and can cut almost any shape in any orientation. They produce sparks and a lot of fine debris from the metal being cut and the disintegration of the wheel. Grinding wheels must be changed frequently and remotely. We will equip the grinder tool with a self-feed mechanism similar to that of the reciprocating saw. This tool will be useful in cutting cell liners for removal.

Advantages:

- Aggressive cutting of metals
- Can cut almost any shape and size in any orientation
- Easy to use
- Rugged

Disadvantages:

- Produces sparks
- Produces fine debris
- Require frequent wheel changes

4. Circular Saw

Description:

The circular saw is similar to the grinder, but has a toothed metal blade instead of an abrasive wheel. It is limited to cutting wood, plastic, and soft metals. It is relatively fast and aggressive and cleaner than the grinder because the cutting blade doesn't disintegrate. Blades dull quickly when cutting metals. A non-liquid method of cooling the blade could be used to increase blade life. Circular saws can "kick" and/or bind when the blade encounters resistance.

Advantages:

Relatively fast
Cleaner than grinder
Simple

Disadvantages:

- Some sparking
- Can produce high reaction forces
- Not good for hard metals

5. Plasma Arc

Description:

The plasma arc is a torch-type tool that is very effective in cutting metals. It uses a high-current electrical arc to burn its way through metals. A high temperature gas (plasma) is used to conduct the current from the tool tip to the work. This method is fast and good for large objects such as tanks, structural steel, and possibly cell liners. Most plasma arc torches require a 110 to 440 vAC power supply and a nitrogen (N₂) and/or argon supply. The material being cut must be grounded. Plasma arc cutting produces airborne particulates that will plug HEPA filters. An electro-static precipitator can be installed upstream of the HEPA filters to extend their life. The arc is bright and requires eye protection similar to that used for arc welding.

Advantages:

- Fast
- Simple
- Cuts large, thick metal objects
- Can be easily held by MSM's

Disadvantages:

- Produces flames
- Can plug HEPA filters
- Requires N₂ and/or argon supply
- Requires eye protection

6. Impact Chisel

Description:

The impact chisel was selected for its ability to chip away at concrete. This will be necessary in some D&D operations to expose embedded objects that must be removed. This tool will not be large enough to rubblize the shielded cell facility. Facility demolition is outside the scope of this project. This tool produces severe reaction forces that will certainly damage MSM's and probably powered manipulators. A fixture will be developed to help isolate the manipulator from these forces.

Advantages:

- Can chip small amounts of concrete

Disadvantages:

- Limited in usefulness
- Damaging to MSM's

7. Vacuum Cleaner

Description:

A vacuum cleaner tool will be very useful in collecting particles, small objects, and contamination produced by cutting operations. While this is not a dismantlement tool per se, it is a needed element in the overall D&D scenario. This project will not design an appropriate vacuum cleaner. It will, however, generate a concept for using commercially available, HEPA-filtered vacuum cleaners in conjunction with the proposed tooling and delivery systems.

Delivery Concepts:

There are many ways to deploy the dismantlement tooling. Several are discussed here. The selection of a delivery system is left up to the individual user. The tooling is designed to accommodate the methods described below, or they can be adapted for use with other systems.

Possibly the delivery system with the most universal application is shown in Figure 2.a. This concept couples a powered thru-wall manipulator with the dismantlement tooling. This type of manipulator is currently available. The manipulator is designed to be installed in a standard MSM port. The beauty of this concept is that it can be used in almost all facilities without modification to the cell. The manipulator is rugged enough to handle the forces generated by the tools. If the manipulator is fitted with a tool-changer (quick disconnect interface), then all wiring and hoses can be routed through the manipulator. This prevents cable management problems like snagging and pinching. This configuration may not be useful for large cells because of the limited reach of the manipulator.

2.a. Thru-wall manipulator

2.b. Manipulator on cart

2.c. MSM and in-cell crane

Figure 2: Miscellaneous deployment concepts

The next delivery concept is shown in Figure 2.b. This concept involves holding the dismantlement tools with a powered manipulator that is mounted to a cart, skid, or other vehicle. Cells with rails in the floor are good candidates for this approach. The concept also includes the use of powered manipulators that may already exist in some cells. Most of these are mounted on an overhead crane. The manipulator can move around the cell to position the tools where they are needed. This delivery option is ideal for large cells. The MSM's are used in a support role for changing blades, making connections, and otherwise servicing the system.

Figure 2.c. shows the simplest deployment concept. The tools are supported by the in-cell crane or hoist and held in place by the MSM's. While this is the cheapest solution in terms of initial cost, it is not necessarily the most cost effective approach in the long run. Expect a high percentage of MSM downtime and repair cost when choosing this method. Past experience has shown that MSM's suffer a high failure rate when used with powered tooling.

Conclusion

As indicated by the investigation that preceded the writing of this paper, there is a need for a system such as the proposed SHRED. The D&D of shielded cells offers a unique set of requirements that are currently not addressed on a DOE complex-wide basis. The SHRED will hopefully become the standard building block for future D&D operations. The design criteria set forth in this document will guide the development of standard tools that can be used for the majority of shielded cell dismantlement operations.

Glossary of Terms

D&D	Decontamination and Dismantlement
DOE	Department of Energy
EMM	electro-mechanical manipulator (electrically powered manipulator)
MSM	mechanical manipulators typically used in shielded cell operations
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OTD	Office of Technology Development (DOE)
PNL	Pacific Northwest Laboratory
SHRED	System for Highly Radioactive Equipment Dismantlement
SRTC	Savannah River Technology Center
WSRC	Westinghouse Savannah River Company
WVNS	West Valley Nuclear Services

Appendix A -- Acknowledgments

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