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EVALUATION OF OPTIONS FOR DISPOSITION OF DISPERSIBLE MATERIAL IN B-CELL

R. D. Tokarz
L. J. Defferding
M. D. Adickes
K. E. Keene
J. P. Pilger
J. M. Alzheimer
M. M. Paxton[a]

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Pacific Northwest Laboratory
Richland, Washington 99352

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SUMMARY

The radioactive contaminants in the dispersible material in B-cell of the 324 Building Radiochemical Energy (RE) hot-cell complex at the Hanford Site in southeastern Washington exceed the allowable level. Cleanup is required, and candidate technologies for cleaning up or otherwise addressing problems associated with the dispersible material are being evaluated by Pacific Northwest Laboratory (PNL).

The RE hot-cell complex in 324 Building was constructed in the late 1950s. From the early 1960s until today the complex has been the site for numerous research, development, and demonstration programs using radioactive and hazardous materials. In 1986, there was a spill of 1.3 million curies of concentrated cesium and strontium in B-cell. In mid-FY 1988, a program to clean B-cell was initiated. At present, dispersible material has been collected from 45% of the cell floor area, and 64% of the equipment and support racks have been removed from the cell.

The B-cell floor is littered with numerous large and small pieces of metals, plastics that have not yet degraded, and other unidentified debris that are reported to be from 3 to 16 in. deep. The debris includes feedstock, grout, tools, and anything else that has ever been dropped in the cell. This material remains in the cell because there is no easy way to pick it up.

This hot cell has been heavily used over the past 20 years and has completed all of the missions for which hardware was installed. The large hardware assemblies that cover more than 50% of the floor space are scheduled to be size-reduced and disposed of as low-level radioactive waste. As the equipment is removed, more of the floor space becomes available for cleanup of debris and dispersible material.

Draft Operational Safety Requirements (OSRs) limit the dispersible radioactivity in the 324 Building hot-cell complex to 23,000 curies strontium equivalent. Since B-cell alone has an estimated 1.5 million curies (590,000 curies strontium equivalent) of dispersible materials in the cell, it will be necessary to remove/containerize/fix a high percentage of the dispersibles in B-cell to eliminate the safety concern.

Because the radiation in this environment is extremely high and the debris is out of reach of cell manipulators, no commercial systems could be identified to clean up the dispersibles on the floor of the cell. This report defines the problem and identifies and illustrates alternative approaches to eliminate the safety issue as well as clean up the cell and place the dispersibles into suitable containers in anticipation of eventual disposal; however, when this project began, there was great concern over the possibility that the existing systems could not clean enough debris and dispersibles from the floor to meet the FY 1993 milestones. But in fact, the cleanout team has exceeded those milestones and cleaned the majority of the open floor space in the cell. At the present time, debris and dispersibles remain only along the edges and corners of the floor, under equipment that has not been removed, and in areas around equipment that are too narrow to be accessed with the clamshell devices.

In the current situation, it may be desired or required to reduce the safety risk at a rate faster than can be accomplished by waiting for each piece of the equipment in B-cell to be size-reduced and removed before the dispersible material under the equipment can be removed. If the decision is made to clean under the equipment, two approaches are recommended by the conceptual design team:

1. Design and fabricate a powered rake that can be extended and retracted to drag material out from under the existing equipment so that clamshells can pick it up. Installation of manipulators in basement locations may significantly improve operator access to the walls and corners as well as provide access to debris and dispersibles.

2. Develop an extension for the vacuum system to reach under the existing equipment and directly pick up the dispersible material. This extension could be directed by the overhead crane or by the basement manipulators.

We recommend that a vacuum system be developed to provide gross cleanup as well as final washdown of the floor and the walls. The team believes that once installed, the vacuum system could replace most of the other dispersible-gathering equipment.

CONTENTS

FIGURES

1.0 INTRODUCTION

The radioactive contaminants in the dispersible material in B-cell of the 324 Building hot-cell complex at the Hanford Site in southeastern Washington exceed the allowable level. Cleanup is required, and candidate technologies for cleaning up or otherwise addressing problems associated with the dispersible material are being evaluated by Pacific Northwest Laboratory (PNL).[a]

1.1 BACKGROUND

The hot-cell complex in 324 Building was constructed in the late 1950s. From the early 1960s until today the complex has been the site for numerous research and development test programs using radioactive and hazardous materials. In 1986, a spill of 1.3 million curies of concentrated cesium and strontium nitrate solution occurred in B-cell. This solution reached the cell floor but apparently did not flow beyond the dust and debris on the floor. After the solution dried, the radioactive cesium and strontium were left behind on the dust. The design of the cell and the intensity of the resulting radioactivity delayed the cleanup of this spill and the ongoing programmatic research in the hot cell.

This hot cell has been heavily used over the past 25 years and now has completed all of the missions for which hardware was installed. A number of large hardware assemblies cover more than 50% of the available floor space. These hardware assemblies are scheduled to be disposed of as low-level radioactive waste. As the equipment is removed, more of the floor space becomes available for cleanup of debris and potentially dispersible material. Before any new equipment is installed in the cell, it is prudent to clean the floor.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

1.2 DESCRIPTION OF CELL AND DEBRIS

The 324 Building B-cell is 22 ft wide, 25 ft long, and 33 ft high. The floors and walls are lined with 1/4-in. stainless steel. Three working windows and manipulators are located 15 ft above the floor. Two additional viewing windows are located on the west and south walls at the 26-ft elevation. An overhead gantry crane is rated at 6.5 tons. The crane hook will reach to about 2 ft from the floor and no closer than 18 in. to any wall. Therefore, all tools and materials used in the cell and subsequently dropped have never been recovered. The bridge crane access to the floor is limited only by the existing hardware in the cell.

Figure 1 is a recent photo of the condition of the B-cell floor. It is apparent that there are numerous large and small pieces of metals, plastics that have not yet degraded, and other unidentified debris. The debris on the floor is reported to be from 3 to 16 in. deep; it includes feedstock, grout, tools, and anything else that has ever been dropped in the cell. This material remains in the cell because there is no easy way to pick it up.

The debris also includes fine dust that has passed through the inlet air filters. In addition, all organic-based materials, such as rubber hoses, plastics, and paper, that have been dropped on the floor have been (or are being) reduced to fine powder from the intense radiation, thus adding to the dispersible material.

The cesium and the strontium solution that spilled in the cell is assumed to be distributed in the dispersible material.

1.3 RADIATION IN THE CELL

The principal radiation in the debris originated from the spill of 1.3 million curies of concentrated cesium and strontium. The radiation levels in the cell are too high to be accurately measured, but the calculated contact radiation level at the floor is approximately 10^7 to 10^9 R/h, depending on how the radioactive material is considered to be dispersed in the debris.

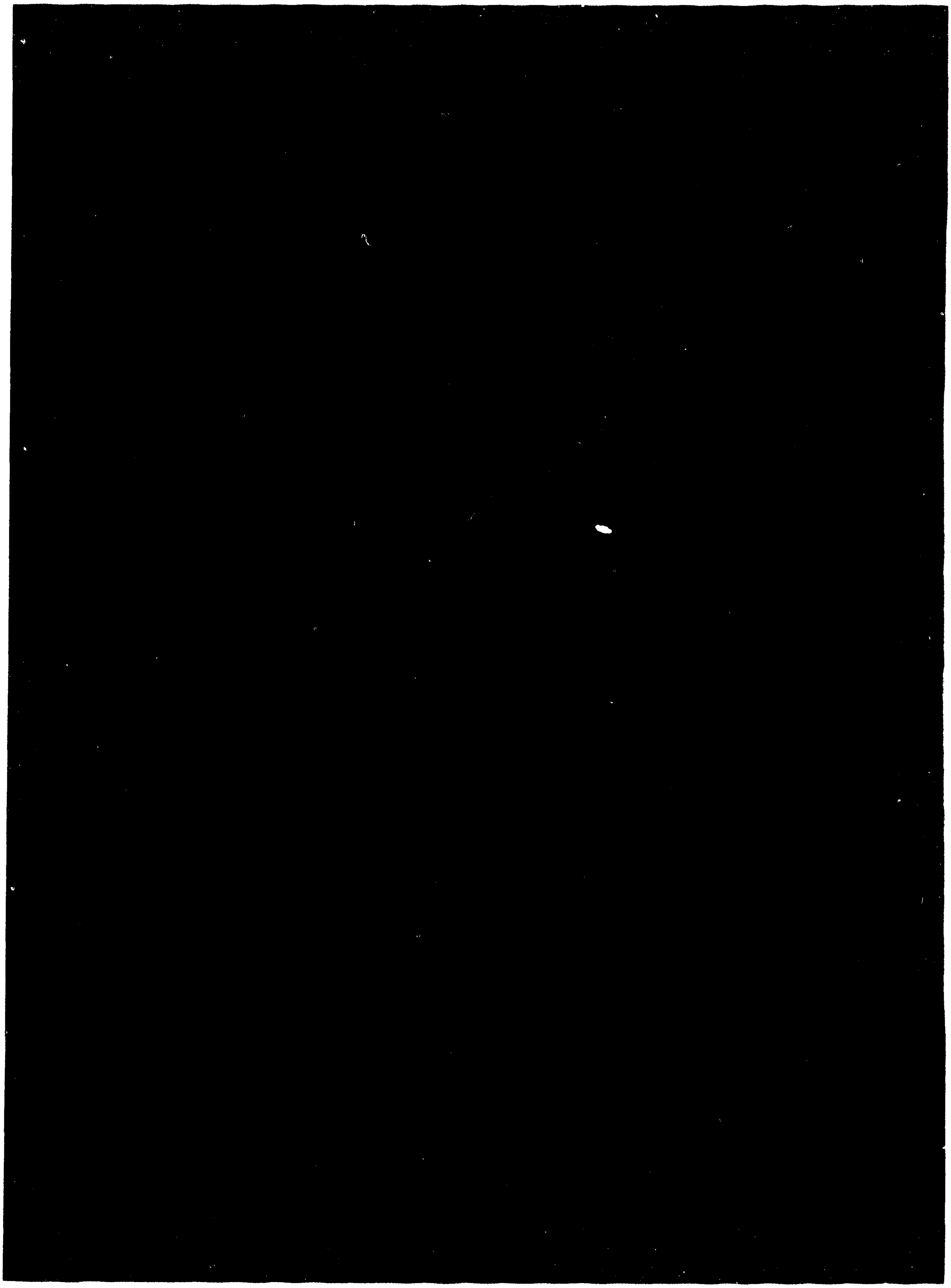


FIGURE 1. Current Cell Conditions

1.4 SAFETY ISSUE

Guidelines limit the dispersible radiation in the multiple hot-cell complex in the 324 Building to 23,000 curies strontium equivalent. Since B-cell alone has an estimated 1.3 million curies (590,000 curies strontium equivalent) of dispersible materials in the cell, it would be necessary to remove/containerize/fix a high percentage of the dispersibles in B-cell to eliminate the safety concern identified in the 1992 Safety Analysis Report for 324 Building Waste Technology Engineering Laboratory.[a]

1.5 PROJECT SCOPE

Primarily because of the extremely high radiation environment and the remote location (out of reach of cell manipulation), there are no commercial systems available to deal with the problem of dispersibles on the floor of the cell. This project was initiated to define the problem and identify acceptable approaches to eliminate the safety issue as soon as possible as well as to ultimately clean up the cell and place the dispersibles into stable containers in anticipation of eventual disposal.

(a) Safety Analysis Report for 324 Building Waste Technology Engineering Laboratory. 1992. PNL-7980, Pacific Northwest Laboratory, Richland, Washington.

2.0 ORGANIZATION OF THE DISPERSIBLES PROJECT

This project was established to provide a broad assessment of the technology that might be available and applicable to the problem of dealing with the dispersibles in B-cell. The project consisted of a problem definition team and a conceptual design team. Other project tasks involved discussion of cleanup options with vendors and with staff at other laboratories that have similar hot-cell cleanup needs.

2.1 PROBLEM DEFINITION TEAM

The main intent of the problem definition team was to characterize important aspects of B-cell in 324 Building and consolidate the information for use by the conceptual design team. This included making sure that there were no hidden surprises regarding information or characteristics of the cell that would preclude implementation of a design team idea in the cell. The scope also included gathering information about the cell, its contents, and the installed equipment used in it. This information was needed to give the conceptual design team an idea of the limits that the current B-cell environment could impose on potential approaches to cleaning up the cell.

2.1.1 Approach

The problem definition team split into two groups to gather the cell information. One group focused strictly on the cell and equipment used in it in every day operations. The other group focused on items that had been placed in the cell, their dimensions, and when they were scheduled for removal from the cell.

Information used in support of the problem definition team was gathered from a number of areas. Some information (e.g., location of manipulator arms) was gathered or confirmed by direct observation. Other information, such as crane speeds and room dimensions, was gathered from blueprints and architectural drawings or from interviews and conversations with people knowledgeable about B-cell. Finally, information regarding removal of items from the cell was obtained from a master schedule that reflects all activities taking place in the cell. The information gathered is summarized below.

2.1.2 Results

Detailed results of the problem definition team are outlined in Appendix A. There are two important aspects regarding the construction of the cell and associated machinery that have significant impact on cleanup activities in the cell. First, the three viewing windows on the first floor gallery to the cell are located 13 ft above the floor of the cell and are approximately 4 ft thick. The thickness of these viewing windows and their refraction index presents a perspective problem to the operator, especially when trying to look at the floor. Second, the manipulator arms for the cell enter 19 ft above the cell floor and have an effective reach only to about 8 ft above the cell floor. This is why they cannot be used by themselves to retrieve items that have fallen to the floor.

2.2 CONCEPTUAL DESIGN TEAM

The conceptual design team was chosen from engineers with broad backgrounds and experience. None of the team members had any long association with B-cell or even with hot cells. The project manager chaired the meetings and provided the detailed information received from the problem definition team in a sequential fashion as ideas and meetings progressed. Each member was responsible for developing and describing at least one proposed concept. The member then had to defend the concept and resolve issues raised in the review by fellow team members. One member of the problem definition team was also a member of the conceptual design team. In addition to working on the tasks of the conceptual design team, he helped integrate information received from the problem definition team.

2.3 LABORATORY CONTACTS

Staff from laboratories around the country have experience in hot-cell cleanup. Discussions were held with some of these individuals to determine if their tasks and experiences were relevant to the B-cell cleanup. A summary of these interviews is included in Appendix B.

2.4 INDUSTRIAL CONTACTS

In support of the B-cell cleanup, a survey was conducted to evaluate the different systems that could possibly be used to aid in the design of a unit or system to pickup and transport the debris and clean the floor of the hot cell. The survey method used for locating and contacting the different manufacturers was the 1992 Thomas Register and the Nuclear News 1993 Buyers Guide. Areas covered by this survey were

- material handling and transport equipment
- conveying equipment
- augers
- dust collectors and separation units
- mixers and blenders
- process filtration equipment
- vacuum systems.

Brochures and other literature have been received from many vendors and manufacturers. This information was be compiled and made available to the conceptual design team. A summary of this survey is included in Appendix C.

3.0 DESIGN CRITERIA

Design criteria were drafted for the proposed solutions for cleaning up the debris on the floor. The existing conditions in the cell and the design criteria are discussed here.

The large hardware assemblies in the cell prevent direct access to some portions of the floor. The metallic and other debris mixed in with the radioactive dispersible material limits the access to the dispersible waste. The manipulators are located well above the floor and cannot reach anywhere near the floor. There are ample numbers of penetrations through the walls. Water is regularly used in the cell, but in limited quantities. It is possible that the stainless steel floor has been breached. The air filtering systems in place at the cell air exhaust have been demonstrated to be effective during previous cleaning operations, so some entrainment of dust into the cell air is not a problem.

The very high levels of gamma radiation seriously limit operational approaches that require electronic control systems or the use of any materials that will degrade rapidly in the radiation. Some other materials are prohibited from being introduced into the cell for environmental or safety reasons. The conceptual design team proposed solutions to take into account the following concerns:

- Every piece of equipment taken into the cell must be considered to be contaminated and must be reduced to a size acceptable to be removed in grout containers or 55-gal drums of special case waste.
- The useful life of equipment or material in the cell radiation environment must be estimated, and replacement of components must be planned.
- All equipment work must be accomplished in front of the working windows, or the equipment must be removed to the airlock.
- Entrained dust must be kept to a minimum.
- Water use should be minimized.
- Water added to debris and then placed in 55-gal drums may accelerate corrosion of the drums and should be minimized.

- Systems that are not self-propelled must be positioned and operated by the overhead crane.

4.0 FIX-IN-PLACE APPROACH

Two options for mitigating the safety hazard of the radioactive dispersibles in B-cell are to fix the dispersible material in place or pick it up and package it. The fix-in-place option was evaluated by the conceptual design team.

Fixing the dispersibles in place on the floor with polymer-like material could reduce the safety hazard presented by dispersible material, but recent technical assessment indicates that 99% of the dispersibles would have to be fixed to meet the safety standard of no more than 23,000 curies of dispersible radiation in the 324 Building.[a] This makes it clear that partial coverage and/or partial soaking of the material on the floor would be unacceptable. Furthermore, if a method were developed to cover all the floor space and provide good penetration of the material on the floor, it would be impossible to prove that it had fixed 99% of the dispersibles. Another problem with this approach is uncertainty of the effects the fixing would have on subsequent collection and ultimate disposal of the fixed dispersibles.

Although the fix-in-place option does not now appear to be a workable solution, a PNL technical expert provided a dissertation on potential fixing materials. A summary of this dissertation on polymer systems to control particle entrainment is presented here.

Radiation degrades all polymers. This degradation occurs by cross-linking or chain scission. Crosslinking occurs as active radicals are formed that link with each other causing attachment of adjacent molecules to form a network. Crosslinking is directly related to the radiation exposure. As would be expected, the crosslinking causes the mass to shrink. This can significantly reduce the bond strength to a substrate. Gases are not given off during crosslinking. Chain scission occurs when the radiation causes the polymer molecules to break into smaller units. Solid polymers can turn to a soft sticky mass and eventually to liquids and gases.

(a) Safety Analysis Report for 324 Building Waste Technology Engineering Laboratory. 1992. PNL-7980, Pacific Northwest Laboratory, Richland, Washington.

Curable polymers that could be used for consolidating the debris on the B-cell floor include epoxy, polyester, polyurethane, silicone, and polyamide. When they are mixed with a curing agent they will have a viscosity that ranges from about 20-weight to 90-weight motor oil. They will cure in various times from less than 1 h to 2 days. During the cure period the viscosity continues to increase. If the polymers are heated, the viscosity may decrease slightly, but the cure rate is usually increased significantly so that penetration into a particulate mass is reduced.

These materials are all crosslinked when exposed to radiation. Consequently, they will get harder and more brittle as the exposure increases. The epoxy, polyester, and silicone will begin to crack and crumble at about 10^9 R. The polyurethane reaches the same state at about 10^{10} R, and the polyamide probably will begin to crack at about $3x10^{10}$ R.

The combination of heat and radiation makes it unlikely that any of the above materials would soak in far enough to stabilize the whole mass before it becomes solid. The radiation levels in the cell would immediately begin to break down the bonds, and in a few months, most materials would be reduced to powder and off-gases.

The effects of radiation on cyanoacrylates are not well known. However, methyl methacrylates break down and give off gases. If the cyanoacrylates behave the same, they will not be acceptable.

4.1 ALTERNATIVE APPLICATION

4.1.1 Organic Materials

The debris on the floor of B-cell could be sprayed with a polymeric fluid, such as a silicone oil. This fluid would continue to "soak in" and coat the under layers of material over time. This process would contain small particles that would normally be entrained in the air during cleanup. The recommended fluids will crosslink under radiation and eventually become solid. The available data indicate that the polymer fluids become solid at the following radiation levels:

- silicone oils - 10^8 R
- mineral oils - 5 x 10^9 R
- alkyl aromatics - 10^{10} R.

All three of these fluids are available at low viscosities (just above the range of water). Also, their viscosity will be lowered by increasing the temperature above ambient. Since they are not chemically crosslinking, they should be fluid enough to soak all the way through before the radiation has a significant effect. After that occurs it should not matter if they become solid. In fact, a solid that is easily broken would probably be easier to clean up than a gummy substance. In either case, a high-pressure hot water stream should cleanup everything but a thin film that may be left if the oil was not solidified.

One of the questions that will have to be answered is whether the fluids will wet the surface of the debris. If the "dust" is not wetted and, if it is tightly packed, the fluid may not soak in at all.

4.1.2 Inorganic Materials

Inorganic materials such as Cabosil (silicon dioxide), Ludox (colloidal silica) and water glass (sodium silicate) were considered and some samples were obtained. These materials are immune to radiation, so if they could fix the dispersibles in place they would represent a viable solution to the immediate problem. Test of samples and additional reports from materials experts quickly dissuaded us from further considering of these products, because none of the materials have sufficient gelled or cured strength. These materials form very weak bonds and could not be expected to maintain the material in a non-dispersible state in the base case earthquake scenario.

4.2 PRELIMINARY EVALUATION

The fix-in-place option does not appear to be viable. There are questions regarding the ability of the polymer-like materials to soak in far enough to stabilize the whole mass before it becomes solid. Also, in a few months at best, they would be destroyed and add to the dispersible debris. Even if the technology were perfected, it is unlikely that the materials could be dispersed in the cell adequately to stabilize 99% of the dispersibles as required to meet the 23,000 curie dispersible radiation limit for all 324 Building cells.

5.0 CHANGE IN CONTAINER SPECIFICATION

When this project started, it was expected that the dispersible material to be picked up would be placed in 55-gal drums. Most drawings were prepared showing the receptacle as a 55-gal drum. Subsequently, we were informed that the material will ultimately be placed in 2R containers. These are stainless steel containers that are 12 in. in internal diameter and can be 4 to 8 ft long. They have various closure methods, but basically are closed at the top.

The change in the type of container impacts the potential cycle time or duty cycle for some options. In the clamshell and the Mexican dragline approaches, tools and metallic debris below a fairly large size were expected to be picked up along with the dispersible material and dumped into the 55-gal drums. These approaches, to be acceptable with the 2R container, must be modified to reduce the size of debris that is picked up to sizes small enough to drop into the 2R containers. Another approach to resolving this problem would be to screen the debris out as the dispersible material is dumped into the 2R container. This has been factored into the weighting of the decision matrix table. However, this problem and many others will be addressed in subsequent design considerations and may influence the approach taken in detailed design.

6.0 PICKUP AND PACKAGE APPROACHES

The conceptual design team identified several approaches that could be considered for picking up the dispersible materials and placing them in containers. They also proposed approaches for separating the debris from the dispersible material in preparation for picking up the dispersibles and approaches for cleaning under hardware assemblies.

6.1 PREPARATORY CLEANUP FOR PICKUP AND PACKAGE APPROACHES

The existing conditions in the cell must be considered when selecting one or more of the proposed approaches to picking up the dispersible material on the floor. The existing large hardware system as well as the debris strewn on the floor present obstacles to cleanup. In addition, material dropping during size reduction of the systems adds continually to the debris on the floor.

The system presently used to pick up some of the debris consists of a custom clamshell device. This system is not capable of picking up all the debris, particularly the larger pieces. In addition, the operators indicate that it is not user friendly or fast. Continued use of this device may be adequate, but whatever technology is used must address the problem of cleaning up the two types of materials that exist on the floor: the debris and the dispersibles. There is no system proposed or known that would be capable of dealing with the dispersibles and the debris at the same time. Also, it is desirable to separate the debris from the dispersible material because the debris can be rinsed off with water and placed in grout containers for disposal as low-level waste.

The conceptual design team proposes the device shown in Figure 2. The device is a form of the Mexican dragline approach (see Section 6.2); it includes a pitchfork-like design to be dragged along the floor to scoop up debris while leaving the dispersibles. It can be made in any size to optimize the pickup operation, and the contents can be dumped into a grout container with a device similar to that shown in Figure 3. This device, designed

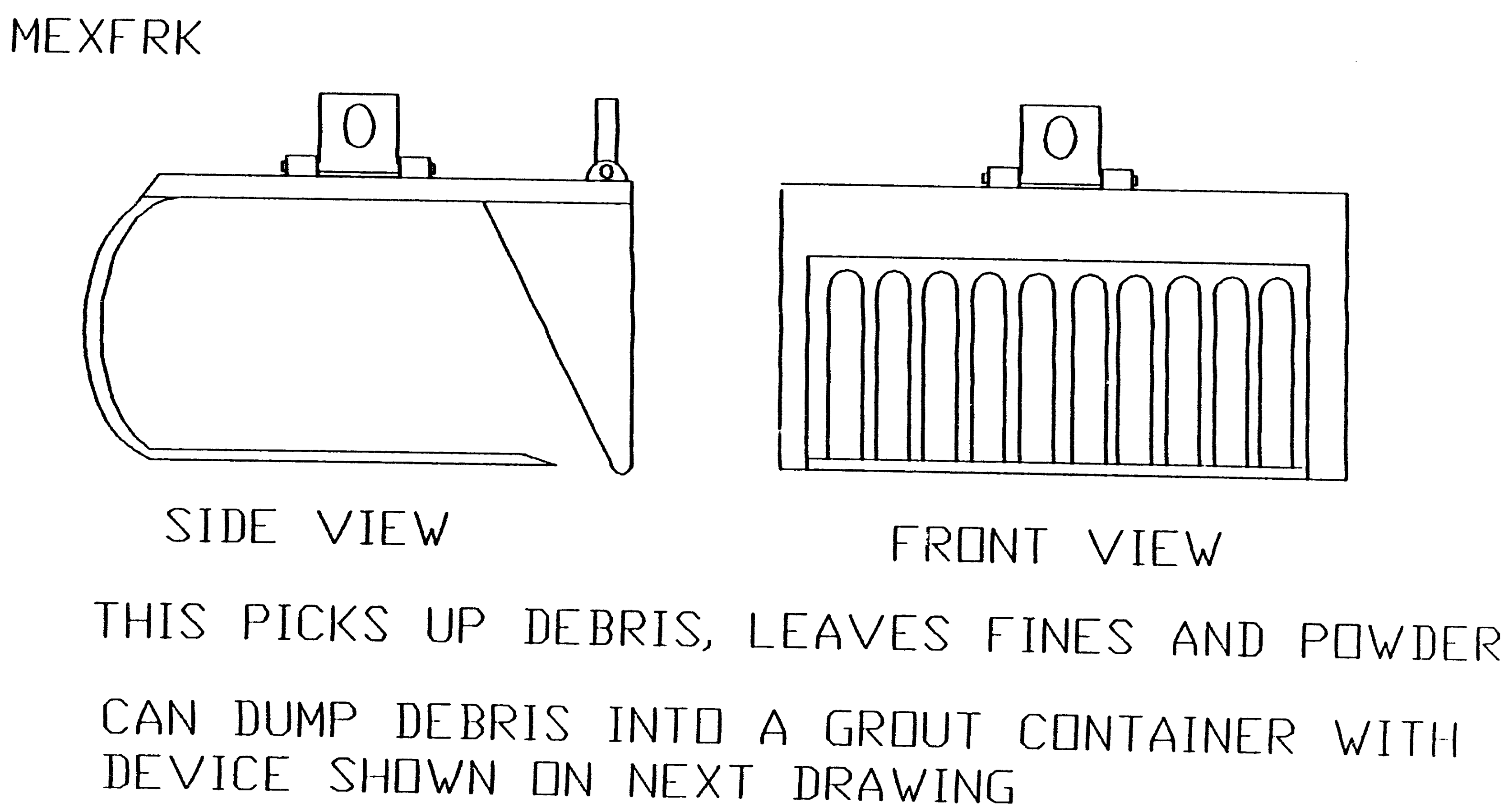
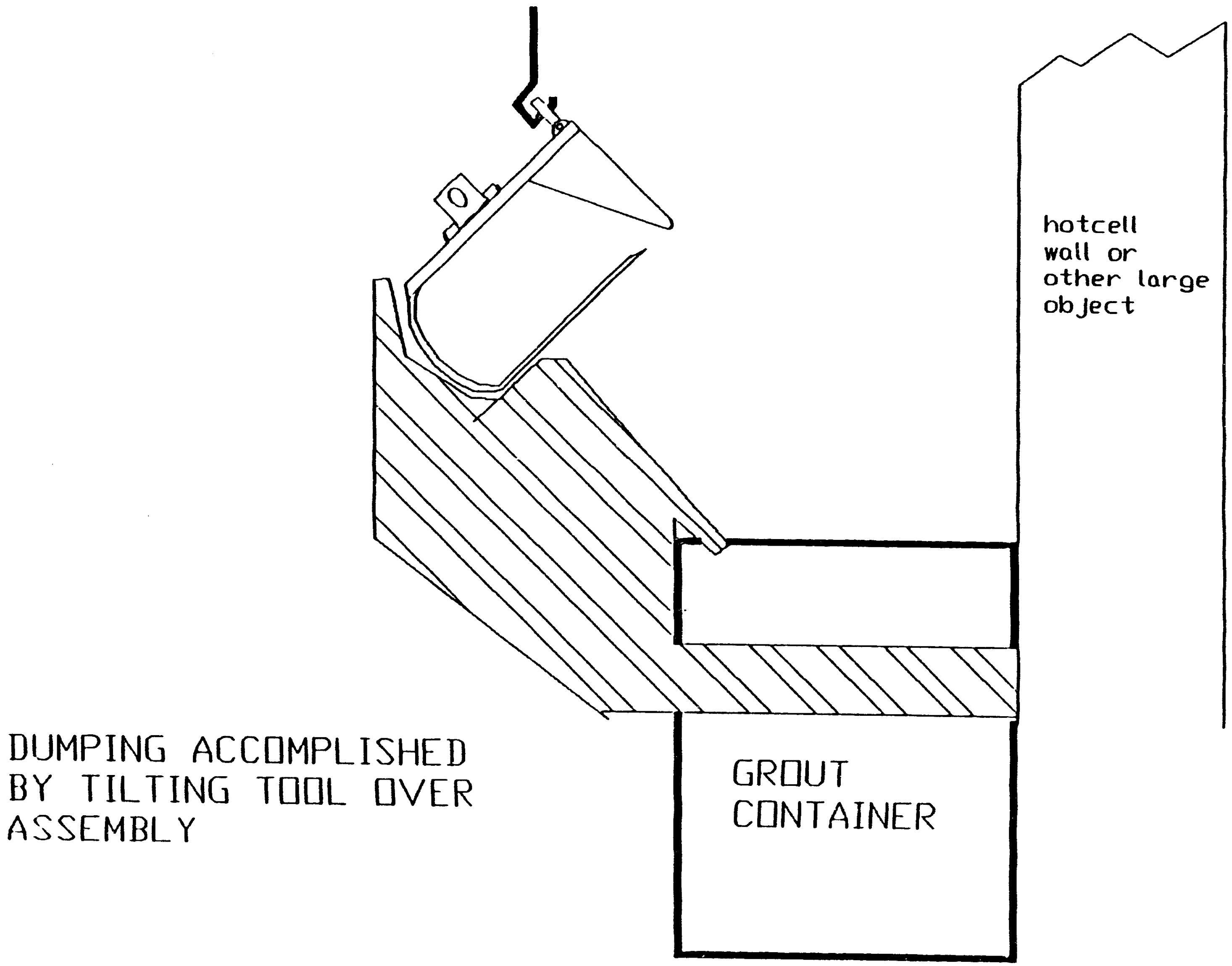


FIGURE 2. Mexican Dragline Fork for Preliminary Cleaning



<u>FIGURE 3</u>. Mexican Dragline Fork Dump Design

properly, can pick up most of the debris above some selected size and thereby reduce the problems associated with picking up the dispersibles.

Regardless of which approach is used to pick up the dispersibles, some debris will be present during the operations and after the dispersibles are removed. Therefore, for optimal cleanup, it may be necessary to pick up the remaining debris before final cleanup, or to integrate the operation for picking up the debris and dispersibles.

6.2 MEXICAN DRAGLINE

The Mexican dragline consists of a rectangular box with one end open. It requires two cables to operate. One cable is attached to the top of the box between the loaded center of gravity and the open end; the other cable is attached to the vertical midway point at the open end of the box. The latter cable is used to pull the box along when collecting dirt into the box and to maintain the box horizontal when moving a loaded box from the pickup point to the dump point. The cable is released to permit the load to be dumped. The cable attached to the top of the box is used to lift and transfer the box to the load position, to control the angle of attack during loading, and to translate the loaded box to the dump site. From this description, the generic device cannot be used in the B-cell because there is only one overhead crane available. With the addition of the second bridge crane, this approach may work if both bridge cranes can be used at the same time and if one of them can be used at the anticipated loads to provide the function of the horizontal cable.

6.2.1 Alternative Application

Because the B-cell has a flat stainless steel floor, the Mexican dragline device can be operated with only one bridge crane. However, one dragline device will not be sufficient. The conceptual design team proposed to provide two variations of this approach to satisfy the requirements for cleanup of the dispersibles in the cell. These two devices are identified as MD-1 and MD-2 and are shown in Figures 4 and 5.

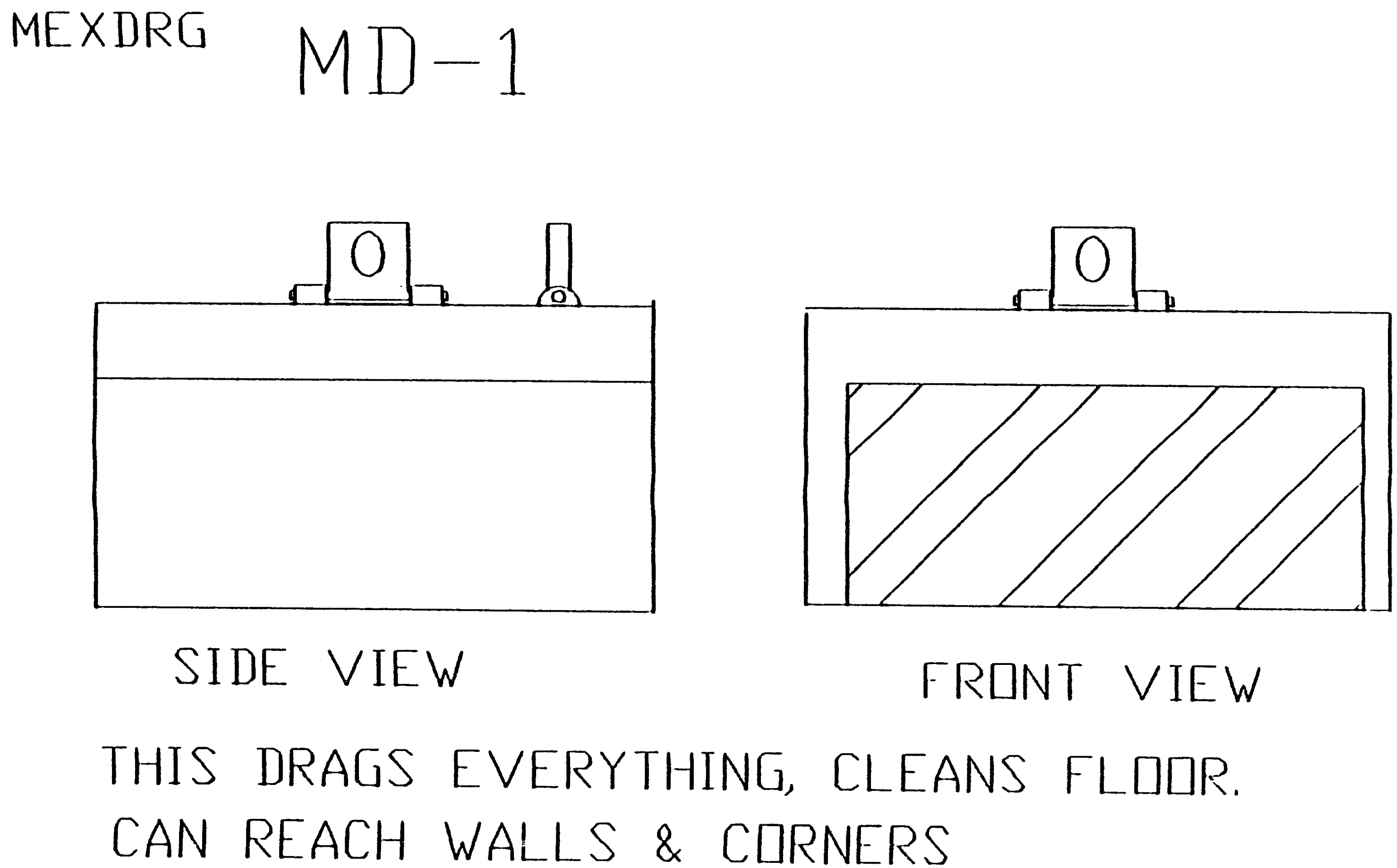


FIGURE 4. Mexican Dragline Device for Collecting Dispersibles (MD-1)

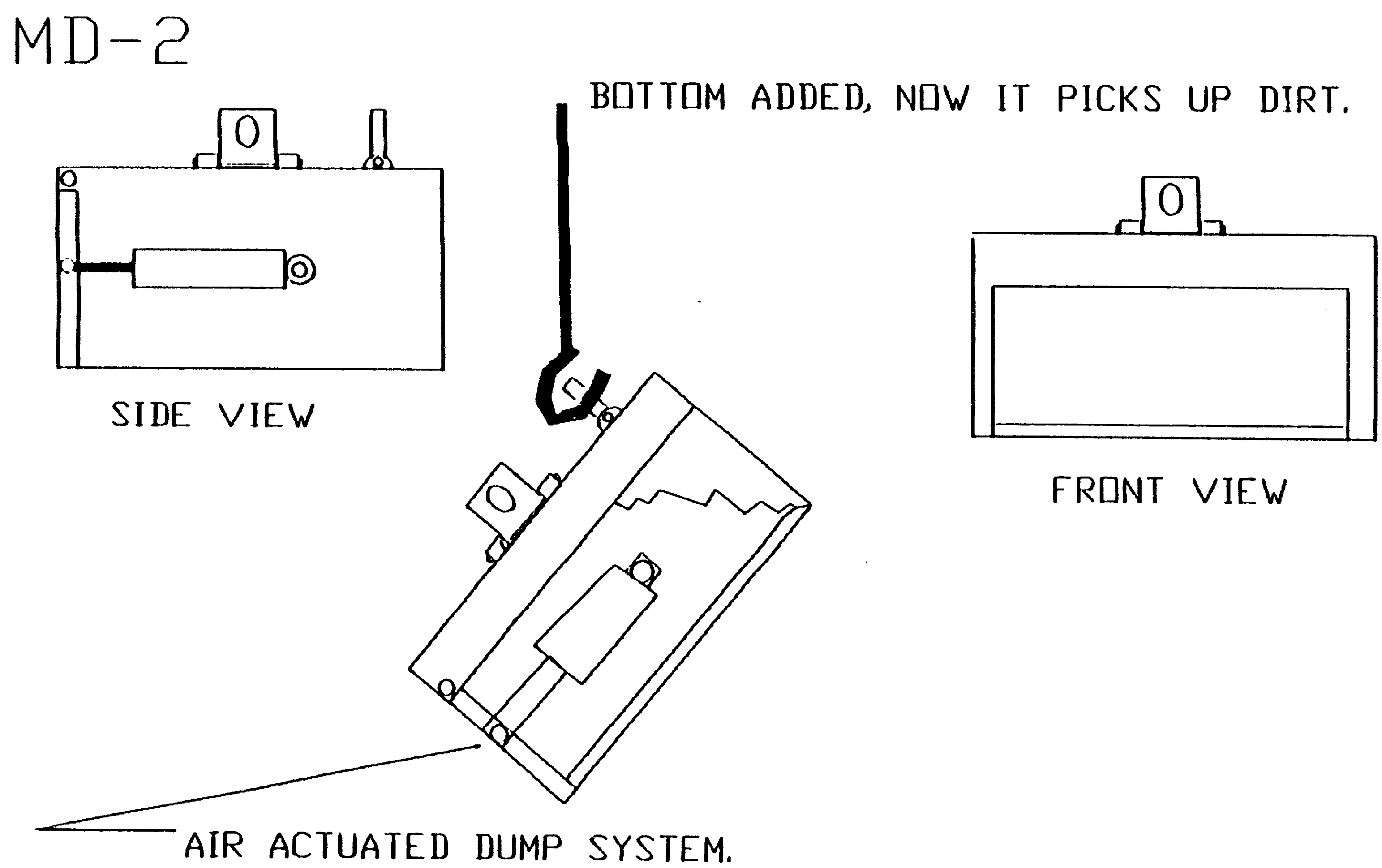


FIGURE 5. Mexican Dragline Device for Picking Up Dispersibles (MD-2)

The MD-1 (Figure 4) is used exclusively to remove debris from the walls and corners and close to existing equipment and to bring the debris to a convenient location or configuration to be picked up by MD-2.

As shown in the drawings, MD-1 is a Mexican dragline turned upside down. It is constructed in segments small enough to be separated and disposed of in the appropriate low-level waste containers. It is heavy enough to ensure that, when placed in a corner or against a wall, it will remove compacted debris from the floor; and designed to be light enough to ensure that it will not damage the stainless steel floor. The location for attaching the bridge crane hook is directly above the center of gravity, while the drag hook location is near the open end of the inverted box. Both hook locations can be rotated using pressurized air cylinders. This feature permits fine control of the box orientation so it can be placed up against a wall or in a corner.

The hook eyes are designed to facilitate easy mating and release of the bridge crane hook. The size of this tool will be related to how close the bridge crane hook can get to the wall and to the efficiency of movement of material. This device could be limited to getting the dispersible material just far enough from the walls to be picked up. It could move the debris much farther if the quantity of dispersible material were only 3 in. deep.

In summary, the MD-1 is used to move debris from the walls to a location where larger quantities of dispersible material can be picked up with MD-2. MD-2 (Figure 5) is the classic Mexican dragline modified to operate with one bridge crane. It is expected to be lighter than MD-1 and would use the same two hook locations and design.

To operate the MD-2 device, the bridge crane hook is placed in the center-of-gravity eye, and the MD is lifted and moved to the location where it can be dragged into the pile of dispersible material. Before the dragline is placed on the floor, the bucket is rotated into the proper orientation with the air-operated swivel system. After it is place on the floor, the hook is detached from the center eye and relocated to the forward eye. The bridge crane is then manipulated into the proper location to drag the bucket into the pile of dispersible material.

The material is expected to be very light and may not efficiently enter the bucket. If this proves to be true, the bridge crane operator (before positioning the bucket) can pick up the 5-ton steel container that is already in the cell and place it in position to act as a backstop behind the pile of dispersible material.

Once the bucket is loaded, the operator can pick it up and move it to the drum and its attached receiving assembly (to be described later). This bucket requires another design feature. When the bucket is picked up using the forward eye, the bucket will swivel and the open end will be pointed up; from this configuration, the contents can be dumped through the dump system.

It is also important to dump the dispersible material from the bucket into the drum with a minimum of material becoming airborne. This could be accomplished by using an air-operated door in the back of the bucket as shown in Figure 5. The proposed assembly is shown in Figure 6. As the loaded bucket hangs from the forward eye, the lower portion of the bucket is matched to the top of the assembly fitted over the drum. With the bucket in this configuration, the door is ratcheted open, minimizing flow to reduce dust entrainment into the exhausting air from the drum. If this is inadequate to prevent airborne contamination and for other possible considerations, another approach to reduce or eliminate the airborne contamination may be considered.

The material that can be handled is limited by the design of this bucket. At present, in addition to the dispersible material on the floor of the cell, there also exists a large quantity of debris. Some of this debris cannot be accommodated by the bucket and some of it could not pass through the dump door in the bucket. Therefore, pieces of debris would have to be removed before this approach could be considered fully functional. As discussed earlier, this may require additional steps; however, the debris is low-level waste and can be collected and placed in grout containers, thereby reducing the quantity of special-case waste to be generated.

6.2.2 Preliminary Evaluation

The Mexican dragline is capable of replacing existing clamshell systems to pick up dispersibles from open areas of the floor. The equipment can be designed and fabricated on site and could be operational in a short time.

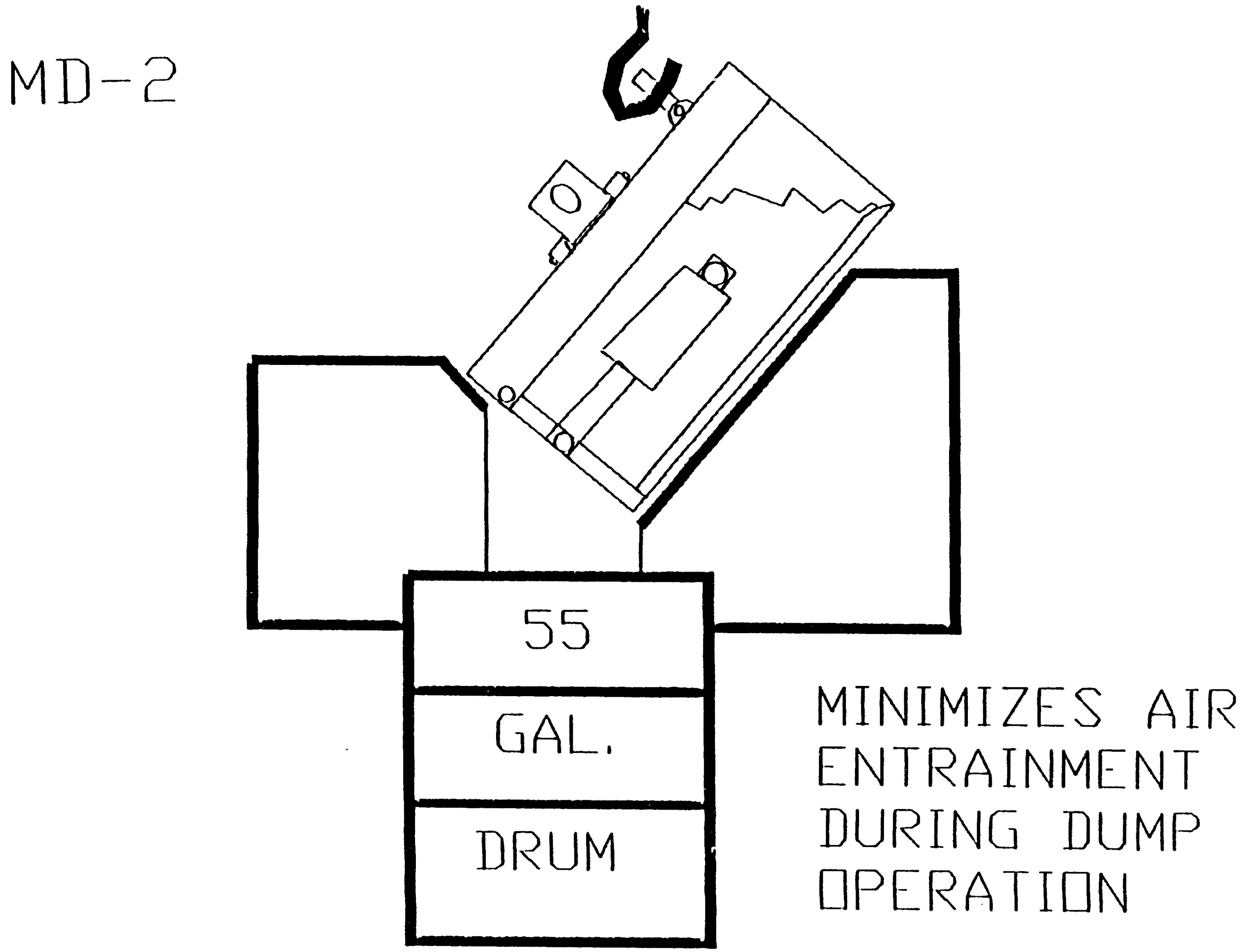


FIGURE 6. Mexican Dragline Dump Assembly

Whether it should be is a question requiring consideration of other factors, such as, can the existing equipment adequately do the remaining cleanup and how much dispersibles are left and can the material be removed from under the existing equipment at a rate that warrants added cleanup equipment in the cell. It should be noted that neither the clamshells or the Mexican dragline will ever provide completely clean floor space and that one or more alternative approaches to final cleaning must be provided.

6.3 CLAMSHELL CONCEPT

A clamshell is a device commonly used in materials transfer applications such as digging, dredging, or transferring materials from piles to transport vehicles or mechanisms. The clamshell consists of two opposing similar or identical scoops that have a common hinge point typically located above and between the buckets. A clamshell bucket (single device--two scoops) is lowered or, in some cases, dropped to initiate a bite onto the surface of the material to be scooped into the bucket. The opposing scoops are then drawn together, gathering and lifting the material between the scoops into the closing bucket. Upon closure of the bucket, the enclosed material is lifted and transported to a discharge location, where the clamshell is opened and the contents of the bucket fall onto or into an appropriate pile or container. In such applications, the clamshell device is typically attached to the working end of cables manipulated by a crane operator.

Clamshell operations require manipulation of two active cables. Takeup of the primary cable actuates closure of the clamshell bucket, provides lifting, and maintains closure of the bucket. When the bucket is positioned over the dump location, takeup of the secondary cable opens the bucket, discharges the contents, and maintains the bucket in the open position. The clamshell is then repositioned for the next load using the secondary cable. A tag line attached to the bucket is used to maintain bucket orientation.

6.3.1 B-Cell Application

A clamshell device is proposed as a mechanism for picking up the dirt and debris that is found on the floor of B-cell. A graded approach, wherein the more massive pieces of debris are removed first, is suggested. A clam-shell bucket specifically designed for separating the coarse debris from the less coarse dirt would first be employed to sift and separate. This approach is being employed, to a limited extent, as a part of the current B-cell cleanup activity.

A clamshell concept is illustrated in Figure 7. The bucket shown in this figure is typical of one more applicable for picking up dirt as compared with one for picking up coarser debris. This concept replaces the primary and secondary cables, described above, with a cylinder to open and close the bucket. Since only a single crane hook is available, it will be used primarily to provide lifting and positioning functions for the clamshell. Note that the illustrations show a single center cylinder to articulate the bucket and fixed length links attached to the bucket scoops. This geometry ensures that both scoops close at the same rate toward the bucket parting line, an important feature for operational stability.

A clamshell is not very effective at removing material from a shallow layer on a planar surface. A better approach would perhaps be to use some kind of raking or grading device to gather the debris/dirt into one or more piles of greater depth. The increased depth of a pile would permit more of the bucket volume to be used during each lift and would require fewer total trips. Piles would also make more effective use of a graded clamshell approach. It is also possible to use the clamshell as a raking/grading device as explained below.

Figure 7 shows the bucket in the open position with the cylinder rod extended. The tag line is shown extended and will be held with a master/slave remote manipulator to maintain rotational orientation of the bucket during placement. If the initial activity is to rake or grade the cell floor, the bucket is positioned such that a vertical edge (bottom) of the scoop reaches the cell wall. The scoop/bucket is sized by design to reach from the crane hook limit centerline to the wall. To rake or grade the cell floor, one transfers the crane hook from the clamshell lifting eye to the tag line eye. The overhead crane is then used to pull the open bucket across the floor moving debris/dirt along in front of both vertical surfaces. This "raking/grading" activity is assumed to be a multiple-pass operation.

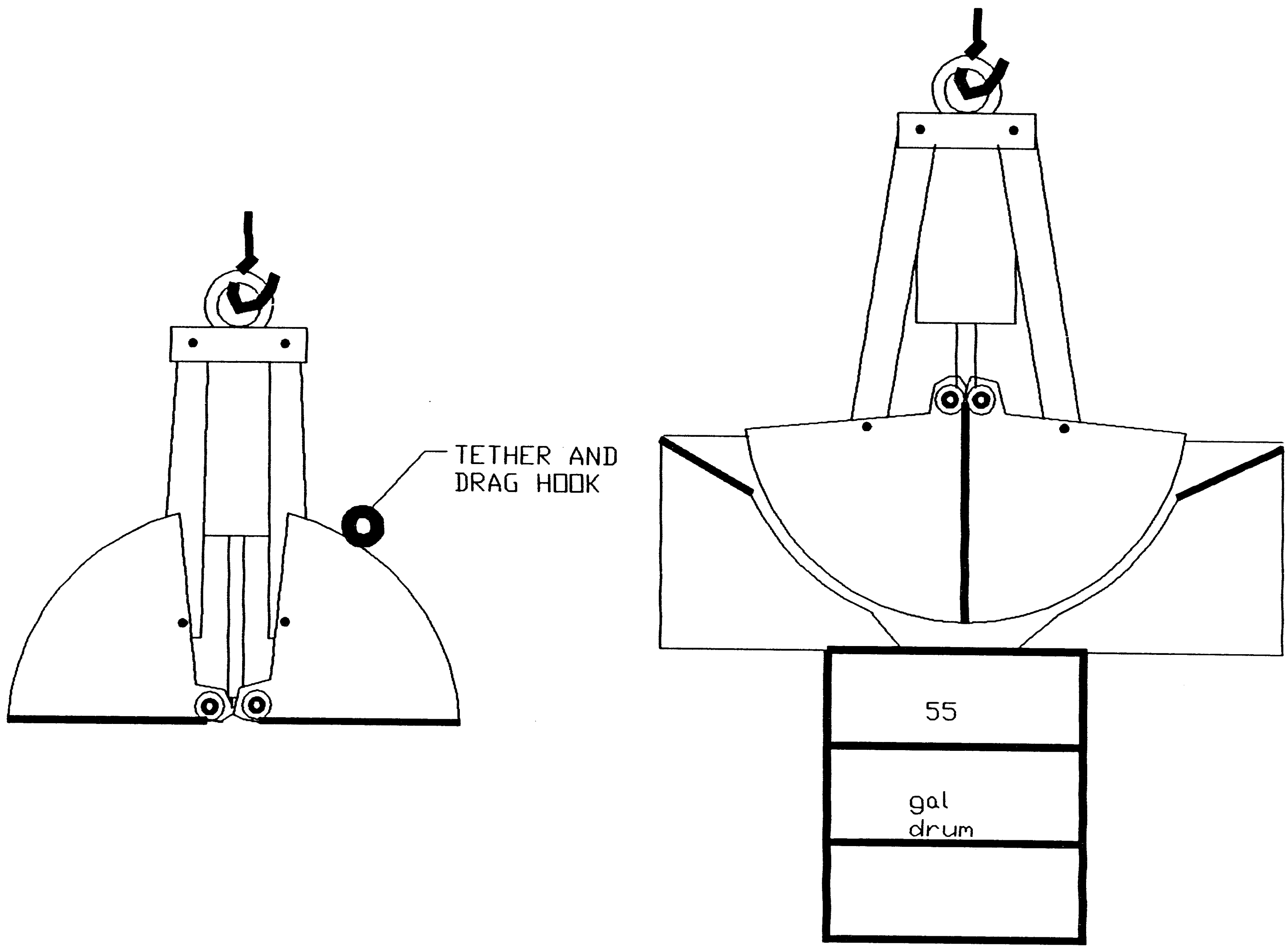


FIGURE 7. Clamshell Concept

After the debris/dirt has been consolidated into piles or mounds, the tag line is removed from the crane hook and stored. The crane hook is attached to the clamshell lifting eye and the bucket is lowered over the material to be picked up. The bucket is placed on the cell floor with only a slight amount of slack in the crane-lifting cables (the hook should have 0 to 2 in. free travel before picking the load). The cylinder rod is retracted at a controlled rate, drawing the jaws of the bucket together.

Following closure, the clamshell is lifted by the crane and transported to the dump hopper over a 55-gal drum. The dump hopper has a rectangular opening sized to accommodate the bucket with minimal clearances. The bucket is lowered partially into the dump hopper, and the cylinder rod is extended at a controlled rate in stepped increments, with a predetermined pause after each incremental step, discharging the contents of the bucket into the hopper and the 55-gal drum. To minimize the spread of dust during the dumping operation, the clamshell bucket is fitted with a dust containment bag. As shown in Figure 7, the bag (material to be determined) can be loosely shaped to the closed-bucket geometry and allowed to blouse when the bucket is open. Although there will still be dust escape paths between the hopper and bucket, the bag may provide adequate dust abatement for this concept.

A significant problem associated with the clamshell concept is the potential for entrapment of debris between the bucket jaws. Because of the beveled jaws, entrapment of material such as bolts, hose fittings, etc. is most likely to occur at the sides of the bucket. Entrapment of such debris is likely to cause some local deformation of the bucket jaw faces. An option for this occurrence is to provide replaceable jaw faces of more durable material (hard alloy steel). The replaceable jaw concept is also useful for changing the scoops from clamshell operation (dirt removal) to raking and sifting operation (debris removal).

6.3.2 Alternative Approaches

If the dusting problem at clamshell discharge cannot be adequately abated by the bag solution, or if the bag is unacceptable for other reasons, spray misting should be explored as an alternative approach.

Alternative approaches for powering the motion cylinder are compressed air and water hydraulics. Water hydraulics will provide the highest closing forces and the most precise motion control.

6.3.3 Preliminary Evaluation

The clamshell approach described above represents a workable approach to pick up dispersibles and can help meet future milestones. It would take approximately 4 months to design, fabricate, and test on an aggressive schedule.

6.4 AUGER APPROACH

The basic function of an auger is to drill holes in wood, dirt, or even rock. However, an additional function is to carry the debris from the cutting area to some other location.

This approach can be used in B-cell to pick up the debris and elevate it to a point high enough to be dumped into a 55-gal drum, or rather into a collection bag for later insertion onto a 55-gal drum. The basic approach is illustrated in Figures 8 and 9. A vendor-supplied auger 4 or 6 in. in diameter is proposed. Standard lengths can be welded together to obtain the necessary length.

The auger would be placed inside a steel tube and driven by an air motor as shown in Figure 8. This figure shows the basic system, including a collection bag on the back and a collection head on the front that is used to bring the debris to the auger. The entire system is supported and moved by the overhead crane. Directional control in addition to the movement of the crane can be accomplished by adding rotational control at the crane hook or between the crane hook and the device. Another approach to this control may be to operate tethers from two cell windows with manipulators to pull the system into proper position. Figure 8 shows the outlet of this device going directly into a 55-gal drum in a dust-free mode. This configuration would permit driving the auger until the drum has been filled and the slip clutch on the drive engages. At that point, the cover to the drum is removed and the balance of the drum is filled with material that remains in the downspout.

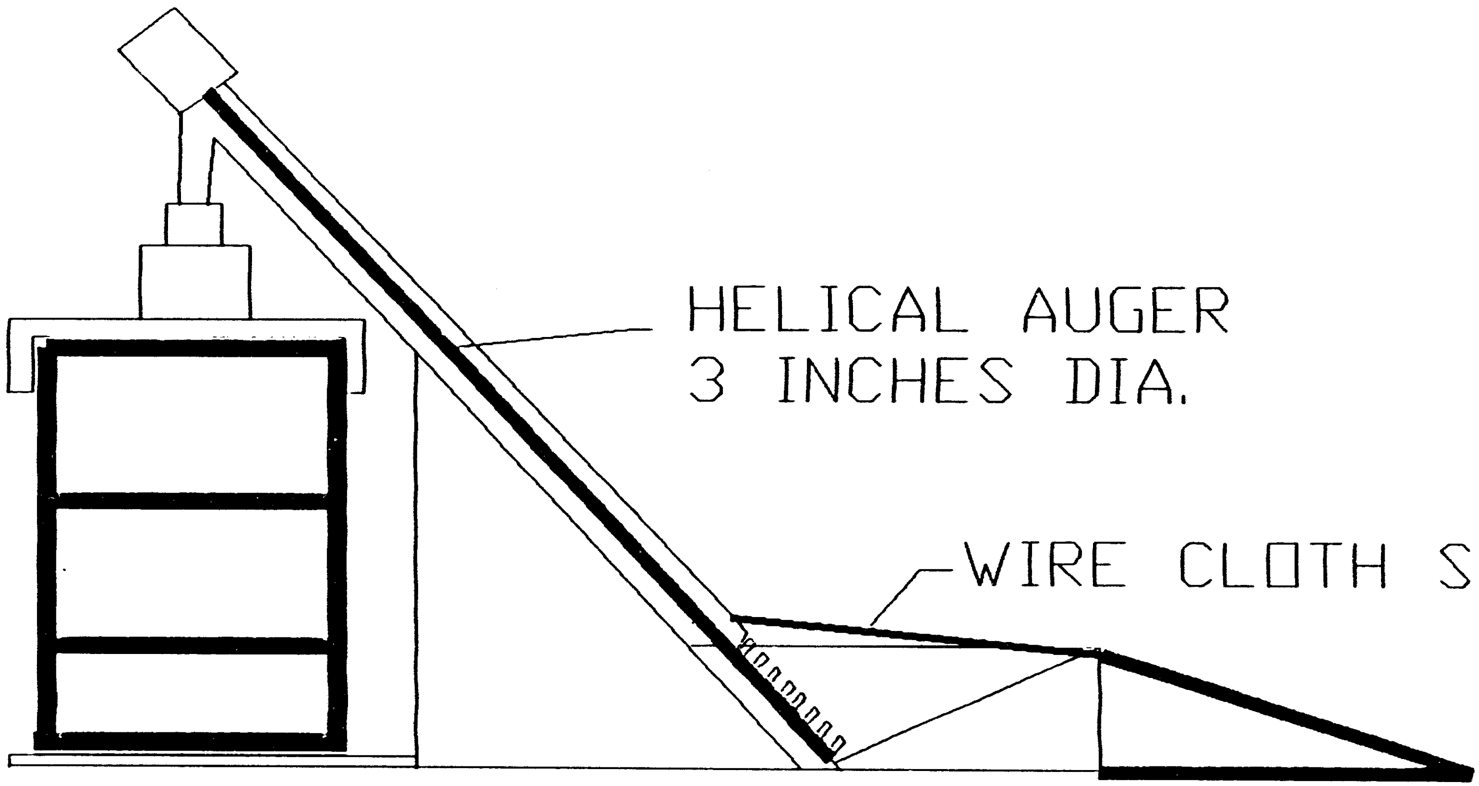


FIGURE 8. Auger Configuration

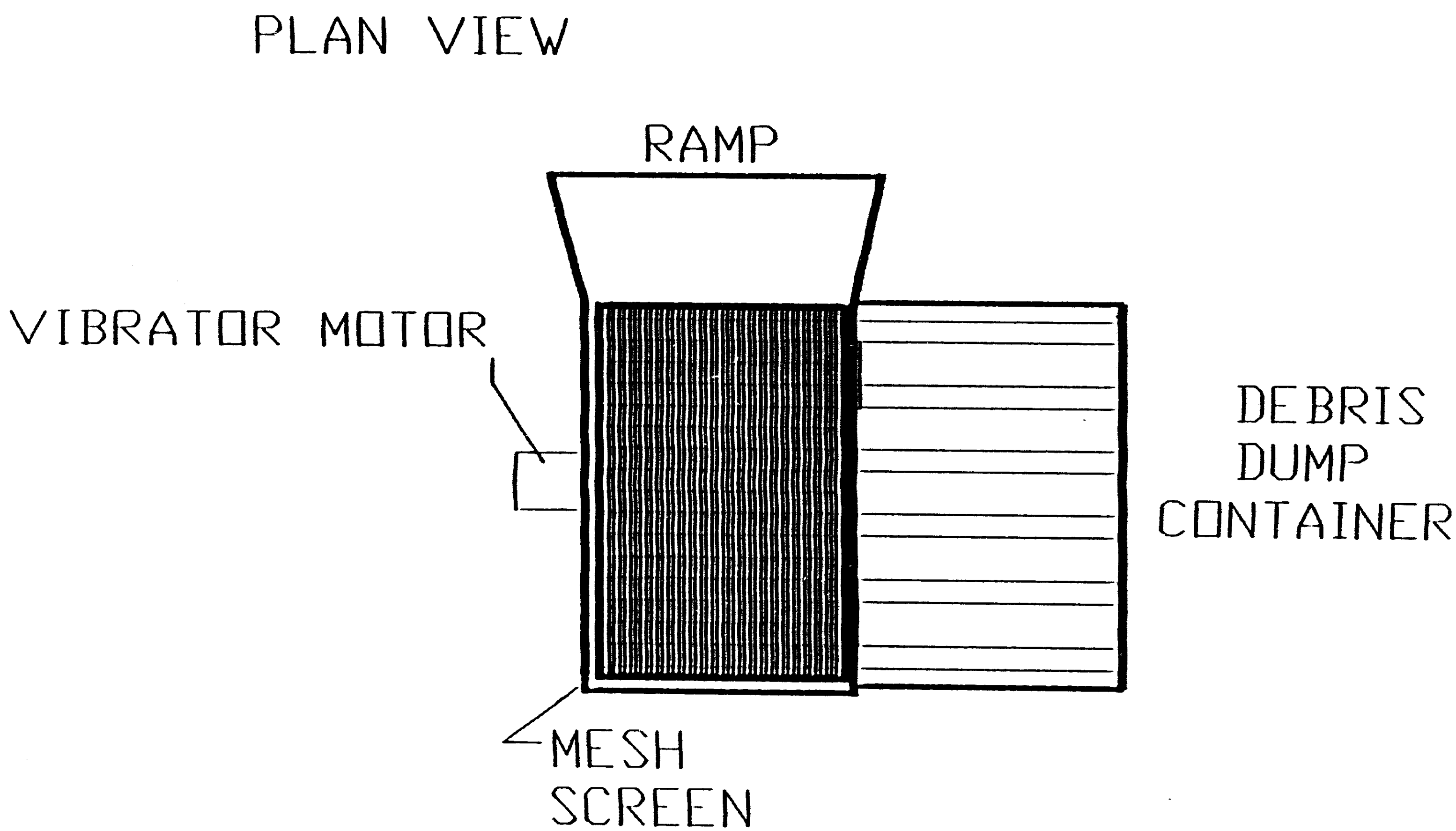


FIGURE 9. Auger Plan View

An extension added to the basic device could add the capability to clean under existing hardware. This approach represents the most dust-free approach to picking up the dispersibles, and perhaps provides an additional benefit: placing the dispersible material in bags to aid handling later.

6.4.1 Alternative Application

This approach has a possible option as follows: the auger could be 12 in. in diameter, housed in a schedule 120 steel seamless pipe, and powered by a very high torque air motor. In this mode, it may be capable of devouring any trash in its path as well as picking up major large chunks of metal. This means the auger could probably perform the major cleanup job as a single tool, eliminating the need to pick up the solid debris before using it.

6.4.2 Preliminary Evaluation

This is one of the top choices for cleaning requirements, and one of two approaches that may promise to clean under existing equipment. There are no show stoppers for this approach, but dealing with random pieces and parts would be an annoyance. The auger may not be able to get some places because solid debris may pile up in front of the pickup head. The bag and the system to attach and remove it will have to be determined, but this can be done.

This approach requires no serious design and development. If it were the prime choice, it could possibly be ready for cell installation within weeks. Placing the auger in service has three prerequisites:

- sufficient floor space must be available
- large debris must be separated or removed
- the bagging operation must take place in the cell.

6.5 VACUUM CLEANER SYSTEM

A vacuum cleaner system for cleaning B-cell would consist of two major components: a modified commercial vacuum cleaner and water traps for treating the exhaust. The commercial vacuum cleaner would be designed to fit over a 55-gal drum, or similar transition container in the case where the final container is to be a 4-gal drum or a 2R container. This setup is shown in

Figure 10. It is a standard commercial vacuum except that the filter is much larger and the service-free life of the unit is extended by making the filter a rolled paper assembly that can be changed during use. The end of the roll filter is cut into ribbons and fed into the container so that no cleaning or changing of filter paper is necessary.

Because of the fine nature of the debris to be vacuumed, it will be necessary to treat the vacuum exhaust to prevent loading of the cell exhaust high-efficiency particulate air (HEPA) filters. This can be accomplished by passing the vacuum exhaust through a sufficient number of water traps connected in a series. There are numerous designs for water traps, and tests will be required to select the best design for this application. Each water trap can be equipped with a fill and drain spigot to facilitate changing the water when necessary. If the pressure drop across the water trap(s) is too large, it could reduce the efficiency of the main vacuum cleaner. This situation can be overcome by making each water trap a water-trap vacuum cleaner. The inlet to the water-trap vacuum cleaner would be connected to the exhaust of the main vacuum cleaner or the exhaust of the previous water-trap vacuum cleaner.

The second component, a series of water traps for treating the exhaust from the vacuum unit is shown in Figure 11. This figure shows a commercially available water-filter vacuum device which, when coupled in series with the primary unit, will provide very good final filtering of the highly soluble cesium and strontium. The water can be cleaned by adding the drain, fill, and level piping as shown. One filter system may not be adequate, so Figure 12 shows a system with one main vacuum system in the center that includes the paper filter and the collection container, surrounded by six smaller water-filter systems in series.

Because the radiation level in the cell is very high, life cycle and serviceability are important. The equipment will last longer and be easier to service if it is suspended high in the cell. This setup provides some additional advantages as shown in Figure 13. The suction nozzle is suspended with a flexible steel pipe directly under the vacuum system, and the entire

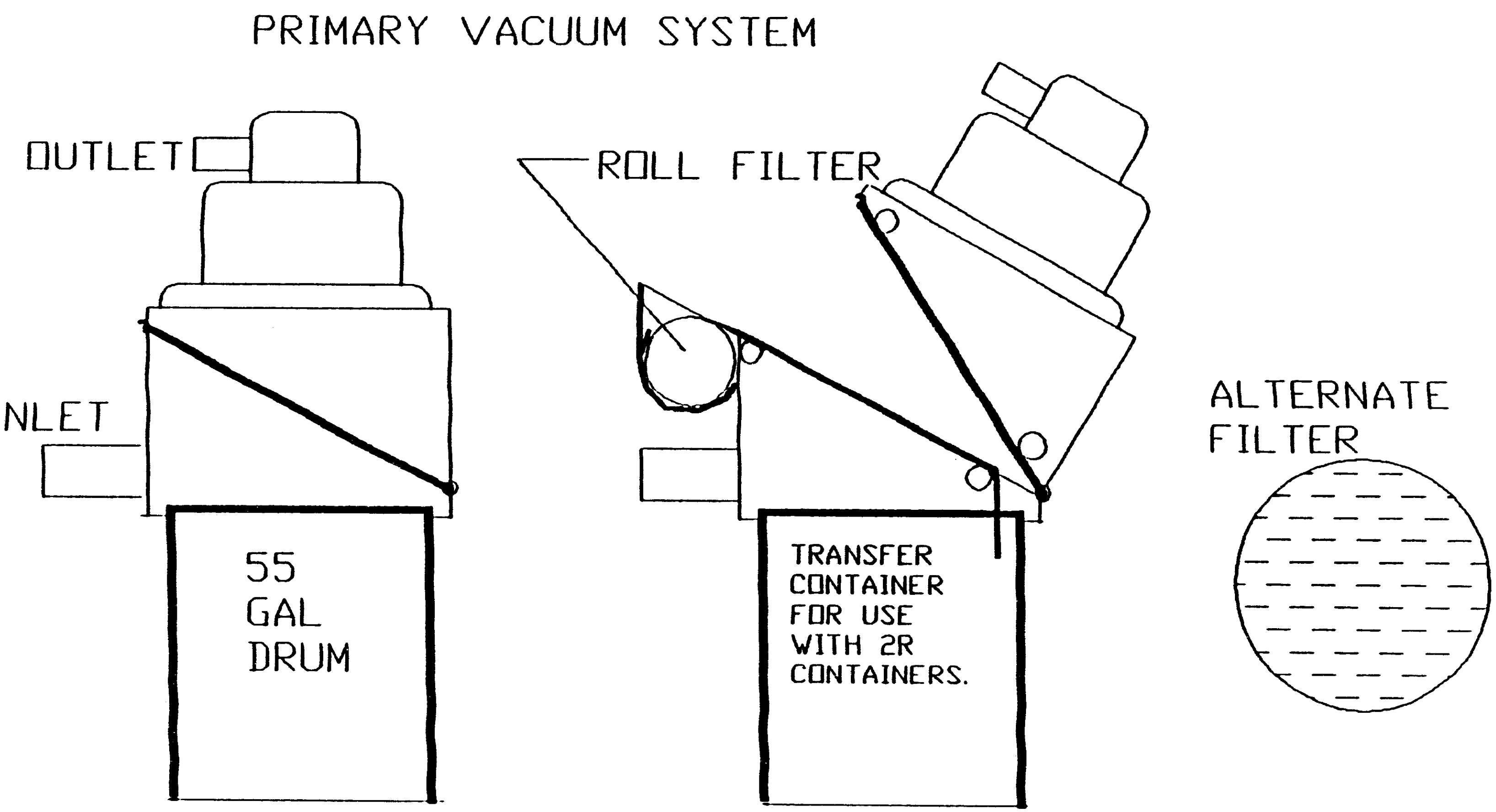


FIGURE 10. Vacuum Cleaner

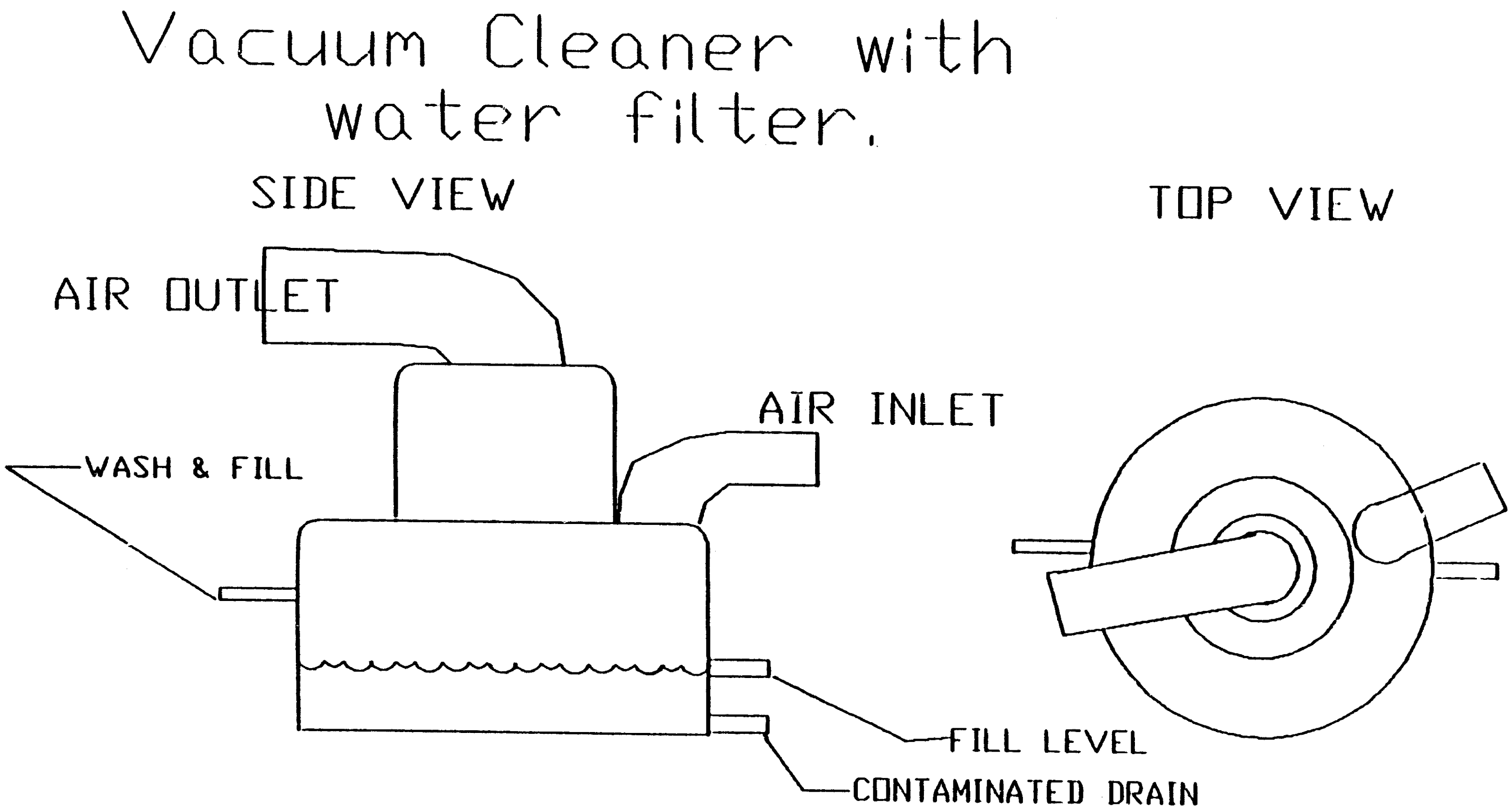


FIGURE 11. Commercial Water Filter Device

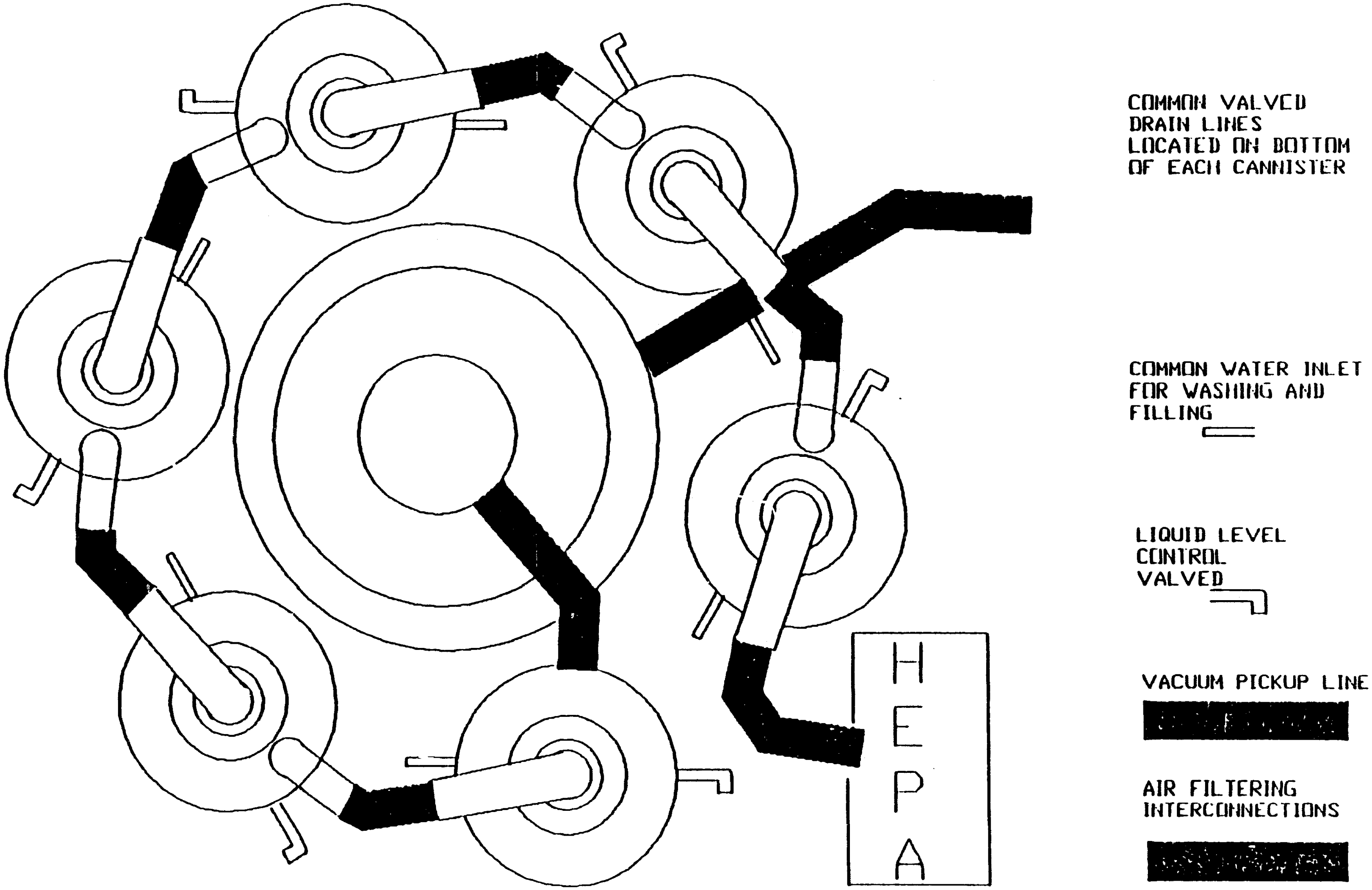


FIGURE 12. Augmented Filter System

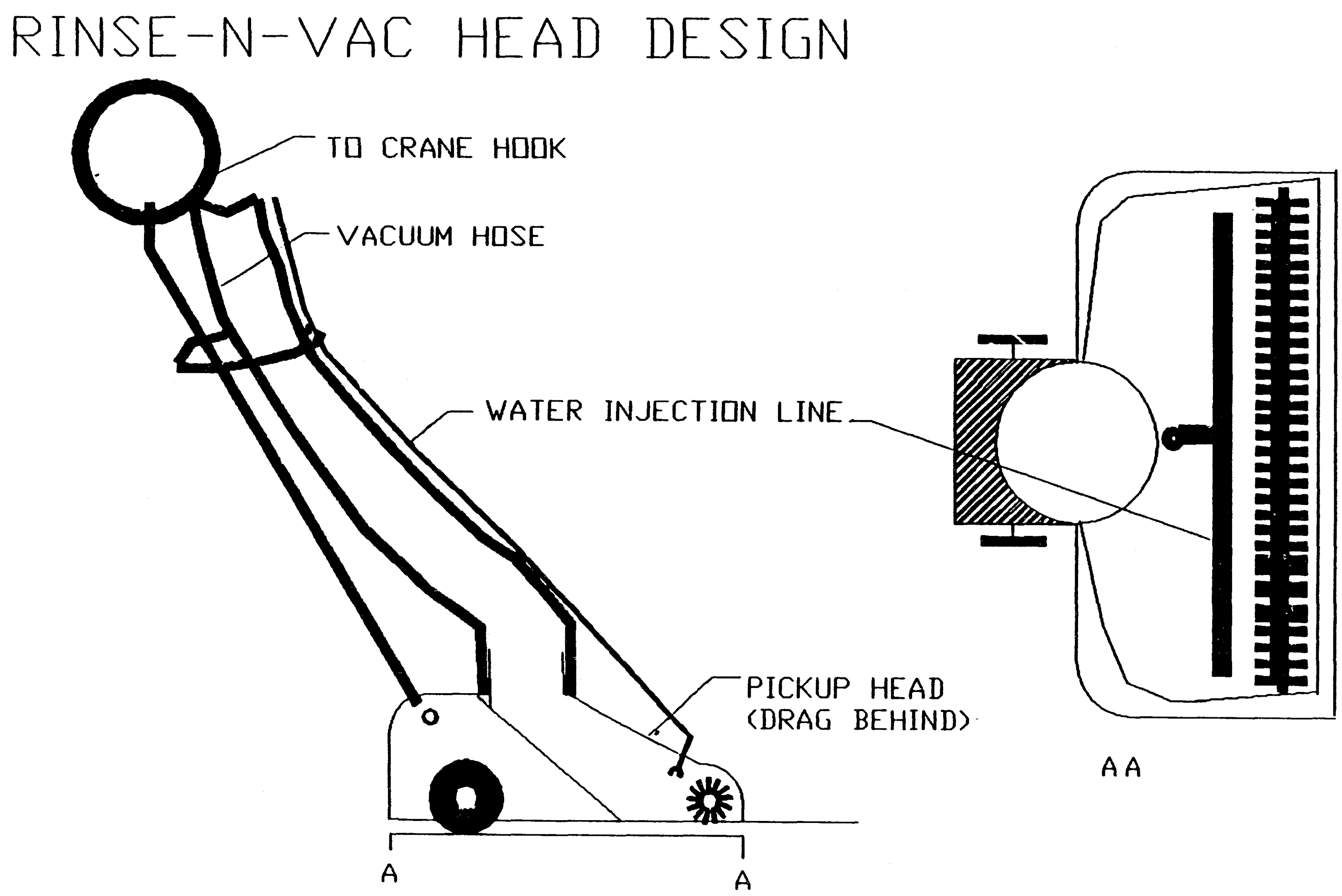


FIGURE 13. Vacuum System Suspended from Crane

system can be manipulated with the bridge crane. Additional benefits are that 1) the system will tolerate the radiation much longer, 2) the working visibility will be much better, and 3) the system can be used with 55-gal drums, 4-gal drums, or 2R containers.

Figure 14 is an enlarged view of the pickup head for the system shown in Figure 13. It includes pulsed air lines to entrain the dispersibles so that the vacuum hose in the center can pick up more material from a single location and do a better job even with debris under the head. Figure 15 shows the head design for the final (wet or dry) cleaning operation. This head design is used in the rinse and vacuum operation to provide the final cleaning of the floor and perhaps the walls of the cell.

6.5.1 Preliminary Evaluation

This vacuum system is capable of meeting the FY 1994 milestone provided sufficient cell time is made available. No cell cleanout is required before this system can be implemented, but additional cleanup of debris uncovered during vacuuming or debris that is too large to be picked up by the vacuum system will have to be dealt with by other cleanup systems.

6.6 TELESCOPING RAKE OR SCRAPER

A rake is an implement equipped with projecting prongs to gather material (such as grass) or for loosening or smoothing the surface of the ground. A scraper is used to remove or dislodge material from a surface. These are usually hand implements with long, rigid handles. In the telescoping raker or scraper concept, the rigid handle has been replaced with a handle whose length can be varied. The handle is firmly held by the "upper" end, and the rake or scraper head is dragged across or through the material by extending and contracting the handle.

A conceptual sketch of the telescoping rake/scraper is shown in Figure 16. The telescoping rake/scraper would be used to move material on the floor of B-cell to a central location to be picked up by some other method. This device would be used with the handle nominally in the horizontal orientation. The upper end of the handle would be firmly attached to either its own massive anchor or to one of the in-cell pieces of equipment. The motive force

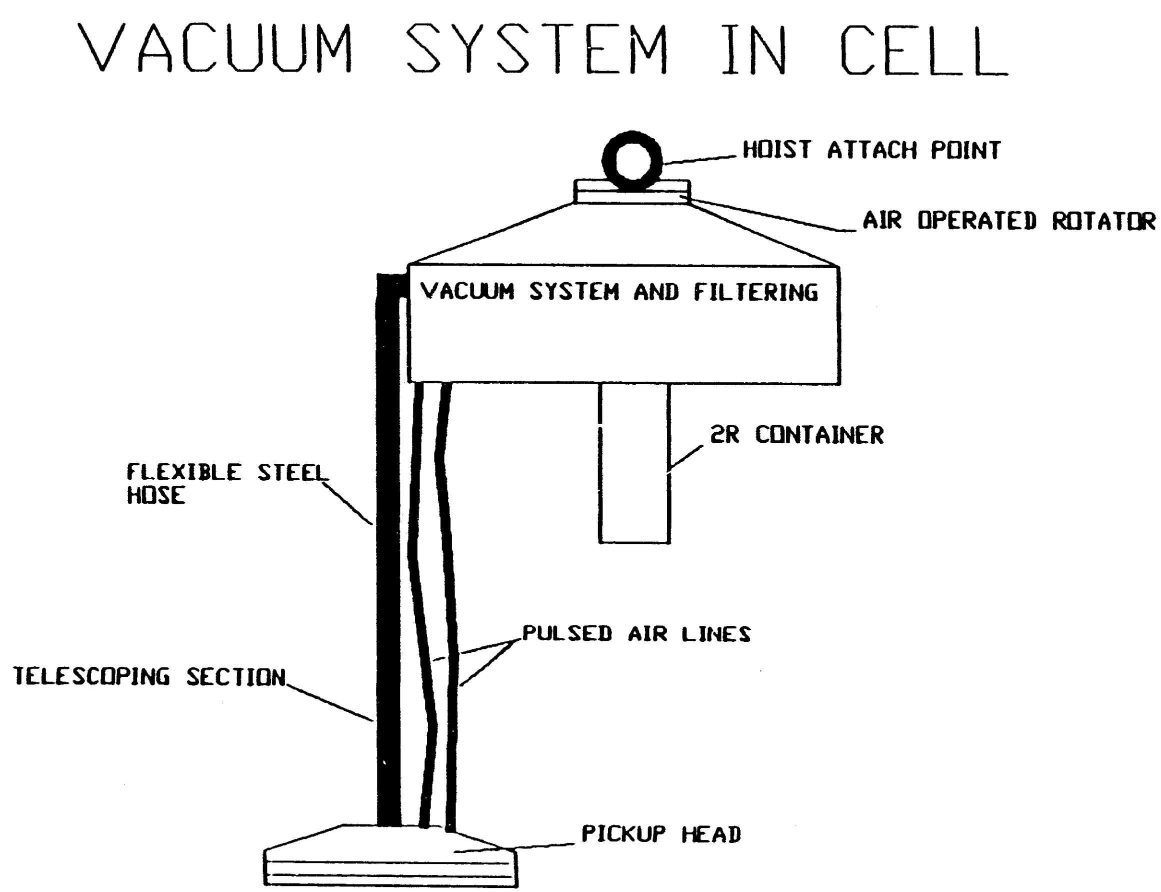


FIGURE 14. Vacuum Pickup Head

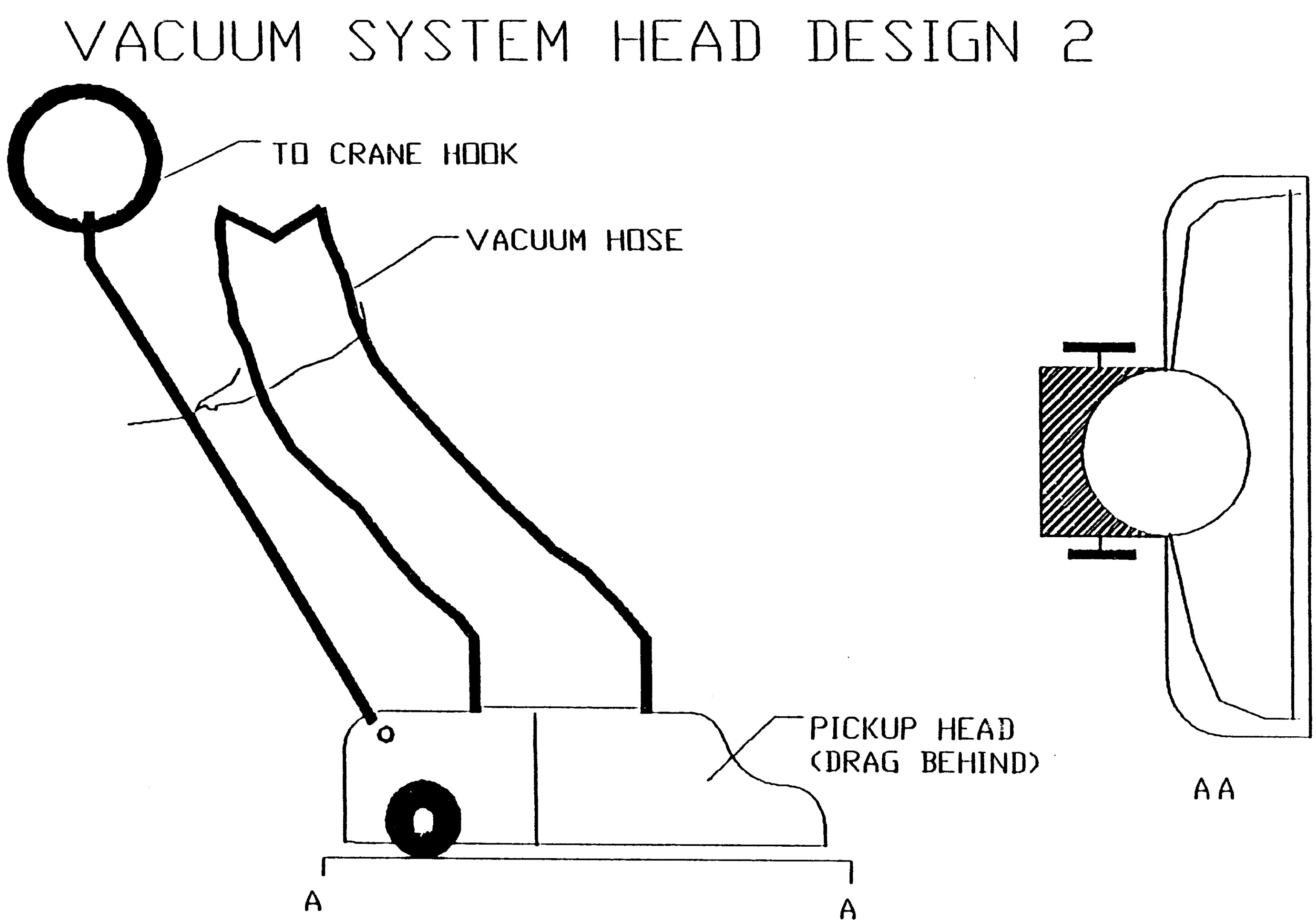


FIGURE 15. Head Design for Final Cleaning

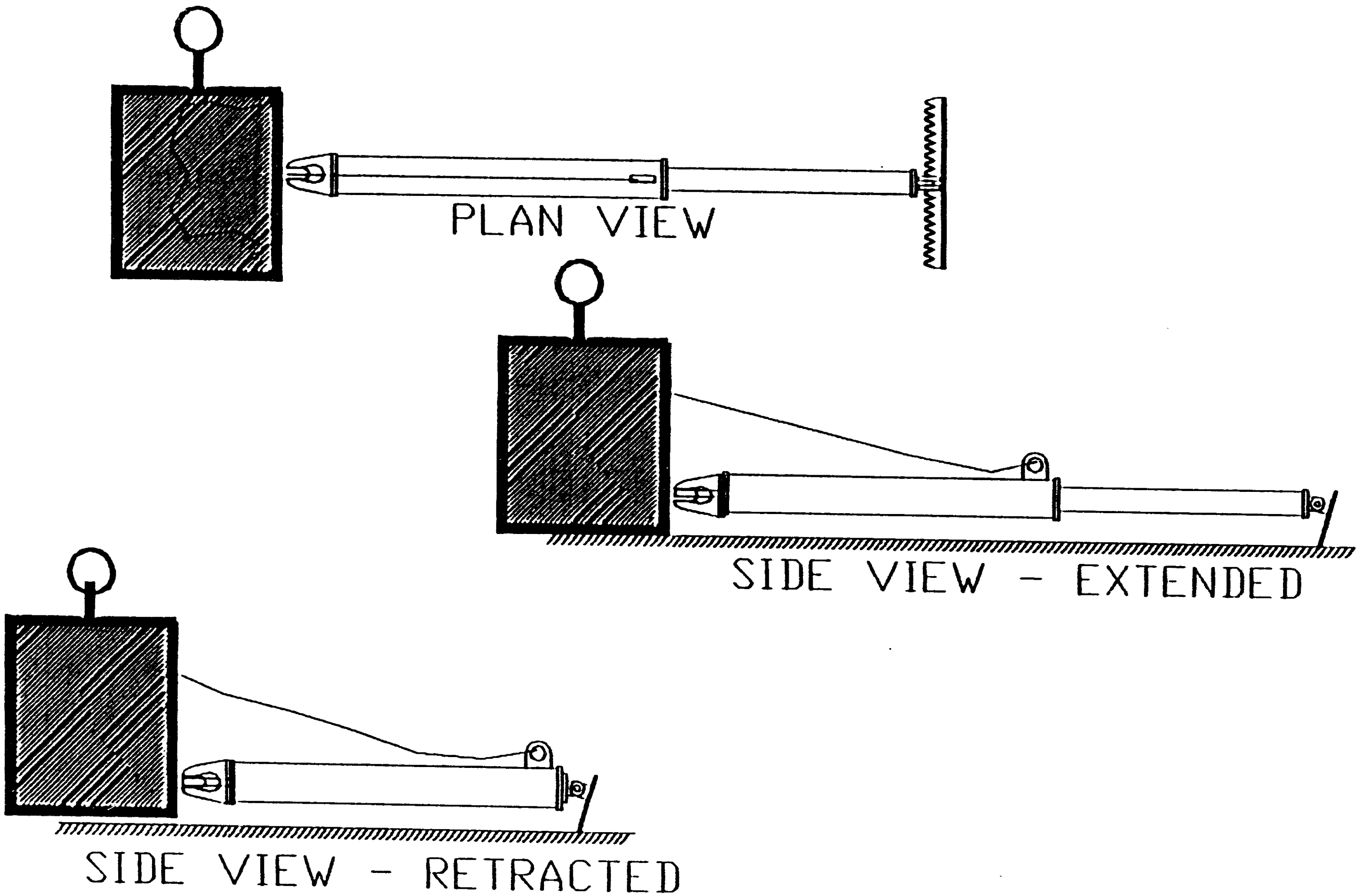


FIGURE 16. Telescoping Rake/Scraper Design

for the device could be either pneumatic, water hydraulic, or mechanical screw. The device would be placed into the cell with the overhead crane. The crane would also be used to orient the pointing direction of the device.

In operation, the rake/scraper would start in the fully retracted configuration. The device would be pointed in the desired direction with the overhead crane and the telescoping handle would be extended. The rake/scraper head would pivot in such a way that it would slide over the top of most of the material while extending. When extended to the desired length, the telescoping handle would be retracted to drag material. The rake/scraper head would pivot against a stop that would maintain an angle adequate to have the head dig into the material. Depending on the amount of material that was moved with each stroke, the device could be operated several times in one orientation. The crane would then rotate the device out of the way and the accumulated material would be picked up by another device.

The rake could be used to reach under equipment as well as to move material from the open floor space. The stroke of the device, the width, and the configuration of the head would be selected during the design phase to best handle the geometric needs of the B-cell configuration and the properties of the material to be collected.

Optionally, the head could be equipped with actuators to actively control the orientation. This would permit more flexibility in operation. The advantages of this approach are as follows:

- This device is relatively "low tech." Although a telescoping rake/scraper of this configuration, to our best knowledge, has not been made, the components are either commercially available or simple to fabricate.
- The rake/scraper can remove a large amount of material from a large percentage of the floor. It can remove material from under equipment almost as easily as elsewhere. The head of the device can be designed to remove almost all the material on the floor within the reach of the head. Rake teeth could be replaced with a straight blade to clean the fines from the floor.
- This concept does not pose significant potential to plug or jam, which might be problematic with some other concepts.

This approach also has some disadvantages:

- The device must be held at the handle end. This will require attachment to a large object at floor level in the cell. Attachment to such an object may be difficult with use of only the overhead crane. A special "anchor" weight could be added to the design, but this would add to the material to be disposed of at the end of cleanup.
- Water or pneumatics can be used for powering the cylinder. The cylinder will have seals that may be damaged rather quickly by the radiation.
- Dragging the rake/scraper through the dirt on the floor presents some potential to generate airborne contamination and other dust. This potential is related to the speed of operation. The amount of such airborne material can be reduced by operating at a slower speed.
- This device does not move material into waste containers. It must be used with another device.

6.6.1 Preliminary Evaluation

The rake/scraper will allow material to be removed from most parts of the floor, not just those with clear overhead clearance. It is a simple concept that would not be difficult to implement. The technical risk for success of the development is low.

The ease of use is somewhat of a question. Until a mockup or prototype is developed, operational characteristics can only be estimated. The device could be ready for use within the constraints of our schedule. Detailed design could be completed in approximately 2 weeks. Fabrication of parts could be completed in 2 weeks if adequate priority can be obtained. The greatest unknown is in the availability and delivery of the required cylinder. An estimate is a 2-month delivery of such a cylinder if one needs to be fabricated, less if one is available off the shelf. Procurement will add 2 to 3 weeks to the delivery time unless special priority can be obtained. Testing would take about 1 week. The total time from start of detailed design until the end of testing is estimated to be 2 to 3 months.

6.7 RINSE-N-VAC

A rinse-n-vac cleaning system (Figure 15) works on the principle of using a wetting agent that typically contains some chemical cleaner as a transport medium to pick up fine dirt in or on an object via vacuuming. The rinse-n-vac system has an applicator nozzle for the fluid as part of the same attachment that does the vacuuming. As the nozzle/vacuum attachment is pulled, the nozzle wets the area and the vacuum attachment picks up the debris. The stream of solution emitted by the nozzle is heavy enough to completely wet the area, yet not heavy enough to flood it. The vacuum attachment picks up both regular debris (nuts and bolts, small objects, etc.) and the very fine debris (dirt and dust) that is suspended in the fluid. Rinse-n-vac systems typically work best on flat areas of uniform consistency or height, where only small quantities of debris are present.

6.7.1 B-Cell Application

It is envisioned that the rinse-n-vac system would be used primarily for final cleanup and water washing of the cell floor and/or walls after most of the material on the floor has been removed.

6.7.2 Preliminary Evaluation

There are several potential show stoppers regarding use of the rinse-n-vac system in B-cell. One is the problem caused by using water. Although vast quantities of water will not be dumped on the floor, when a drum gets filled up, the water needs to be evaporated out before the waste can be interred. Interim storage of barrels may pose a problem. Maintaining the connection from an anchored can to the vacuum head is also a design issue that needs to be well thought out. Another problem is the time required before the rinse-n-vac system could be implemented.

Despite these potential show stoppers, this device would be very effective for a final cleanup of the floor. The wetting action would keep dispersibles to a minimum, and the water provides the capability to put any loose cesium on the floor into a solution, where it can be transported and contained more easily.

6.8 ICE CAN CONCEPT

This concept would remove the waste from the floor in a manner similar to a cookie cutter. It would be lowered by the crane onto the material on the floor, cut a hole in the waste, and capture the material within it. It would then be raised by the crane, moved to a waste container, and the material would be released into the waste container.

6.8.1 Mechanical Configuration

The unit has no motors of any kind that the radiation could deteriorate. It would consist of a thin metal inner cylinder, the inside diameter of which would be equal to or slightly smaller than the inside diameter of the waste container (55-gal drum).

Surrounding the inner tube would be a spirally wound coil of thin wall, small diameter tubing. As shown in Figure 17, both ends of the coil would be located at the top of the unit.

Insulation would be packed between the outside of the coil and the inside diameter of the outer jacket. The outer jacket would be another thin metal cylinder. The inner cylinder and the outer jacket would be connected by flat, thin, metal closing rings at the top and bottom.

Around the lower few inches of the outer jacket and extending a short distance beneath the bottom closing ring would be a thicker metal containment skirt. Beneath the lower closing ring, above the bottom of the containment skirt, and within the inside diameter of the inner cylinder are water jets. They would be aimed to create a circular water flow within this area. The jets would connect to water tubes which run vertically along the outer jacket through grooves in the containment skirt, bend, and penetrate through the skirt. At the upper end, on top of the upper closing ring, the vertical water tubes would connect to a circular manifold with a single inlet.

Connections to the coiled tubing and water tubing would be made with metal connectors, and all tubing would be of flexible metal. The connection to the inlet end of the coil will lead to a 3-way valve, outside the cell, which will allow either a refrigerant or heated air to flow to and through the coil.

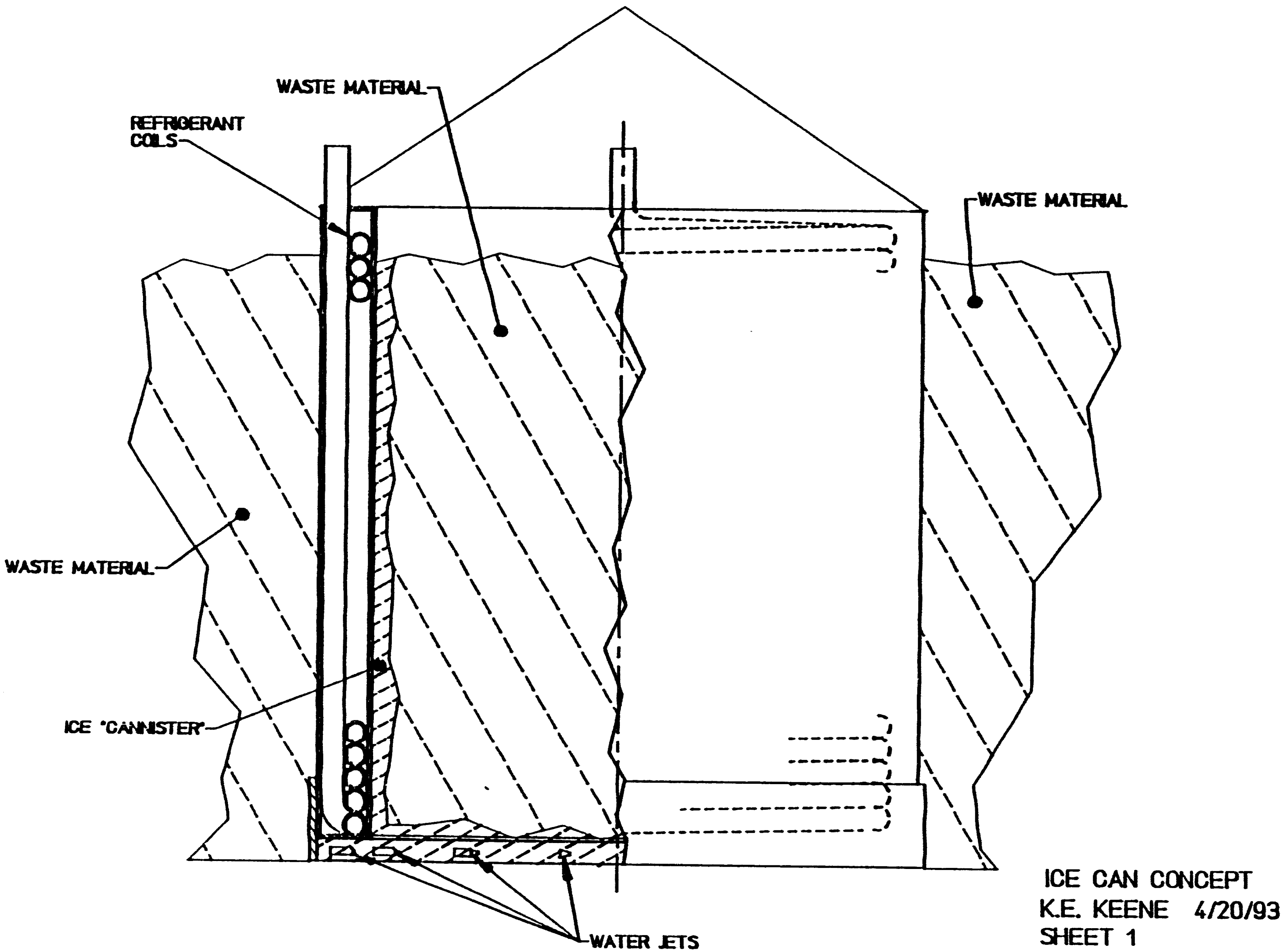


FIGURE 17. Ice Can Concept

The connection to the outlet end of the coil would either allow dispersal of the refrigerant within the cell or return of the refrigerant to the area outside the cell. The determination depends on the type of refrigerant and the effect it would have on air balance.

The connection to the water inlet will lead to a 3-way valve that allows high-pressure water or refrigerant (only if the refrigerant may be released to the cell atmosphere).

6.8.2 Sequence of Operation

1. The unit is picked up by the overhead crane, using a commercially available sling, and attached to lifting eyes on the unit (see sketches).
2. The unit is lowered onto material on the floor.
3. A high-pressure water valve, located outside the cell, is turned on to allow the unit's water jets to disperse a ring of the material from beneath the unit and guide the material toward the inside of the inner cylinder. The containment skirt will keep a large amount of the water and material from escaping to the cell.
4. The unit will settle to the floor of the cell, having cut through and captured a cylinder-shaped volume of material.
5. It is not likely that the material will be saturated by the water cutting process. Most of the water in the material will be located between the material and the inner cylinder inside wall and also at the bottom of the material (between the material and the floor).
6. The water valve is turned off.
7. The refrigerant valve is then opened to the coil inlet and, if used, to the water jets, freezing the water beneath and around the waste material and thereby capturing it within a "can of ice."
8. The crane then lifts the unit with the captured material and moves it over the top of a waste container.
9. The refrigerant valve is then turned off and the hot air is valved to the coils, thereby melting just enough of the ice to allow the ice/waste mixture to drop into the waste container.

6.8.3 Preliminary Evaluation

The advantages are that there is a low likelihood of material becoming airborne and that the system requires no electric motors, air motors, or moving parts that would be affected by the high level of radiation.

One disadvantage is the introduction of water into the cell. If there are leaks in the floor, as suspected, the water would aid migration of the material. If there is one single disqualifying factor for this approach, it would have to be this possibility of leaks in the cell liner on the floor. The solubility of cesium in water would aid the cesium in migrating out of the cell.

Even if there are no leaks, water could react with chemicals in the cell. In addition to creating more waste and taking up room in the waste containers, water would also create a rust problem in the waste containers.

The second disadvantage is that the time it takes to freeze a mass of water this size is unknown. Educated guesses are from "a few minutes" to "hours." This would necessitate a "development project" and affect the schedule.

6.9 WATER STREAM TRANSPORT CONCEPT

This concept uses large amounts of water to move material, somewhat like using a garden hose to clean the driveway. The water and entrained material would be washed to a pickup location and pumped up and into the 55-gal drums. The use of significant amounts of water could improve the way the material is transported through hoses. The ability to use a water stream to remove material from under equipment is a plus of this system. A water stream will be most effective when moving the lighter material. Since the fine particulate material is the problem of most immediate concern, this might be used as a method of segregating the fine material from the coarse material. If an initial area could be cleaned and surrounded with a "fence" capable of keeping out large pieces of debris, the finer material could be washed through the fence and sucked up leaving the coarser, less-dispersible material for other collection methods.

6.9.1 Preliminary Evaluation

An advantage of this concept is that the debris would not necessarily have to be removed from the material on the floor before cleanup. The material under equipment could be removed without removing the equipment.

There are several disadvantages to this concept. The use of copious amounts of water could result in a leak through the floor if a hole or crack is present. The stainless steel plates of the floor may have been damaged by the moving heavy equipment or the dropping of items. However, with the debris on the floor, there is no way to look for damage until the floor has been cleaned.

The use of water has several other disadvantages. A lot of water evaporating inside the cell could lead to condensation on the windows and camera and limit vision for cleanup operations, and the HEPA filters could also be ruined. Water will flow to the low spots in the floor, which may not be desirable.

This concept does not merit further consideration for the cell floor cleanup efforts this year, although it may be useful during final cleanup of the cell floor.

6.10 DIRECTED VEHICLE/ROBOT

Following are several potential missions for a remotely operated vehicle: 1) a vehicle mounted manipulator to pick up items, 2) a small, remotely controlled bulldozer used to push the debris into piles, 3) a remotely operated vehicle with a camera to provide very useful views of the situation from a ground-level perspective, and 4) a means to position sensors such as radiation probes under equipment or into the debris.

A remotely operated vehicle with a manipulator arm and camera could be used to supplement the work being done by the manipulators. While some work could be done at floor level using manipulators with extended reach, this work might be better done by a remote vehicle. The direction of attack might be better and the other manipulators could be used for other tasks.

A remotely operated vehicle with a blade or other device to move debris could be useful. The vehicle could access parts of the floor potentially not reachable with the manipulators. Another system would pick up the debris.

A remotely operated vehicle equipped only with a video camera might be very useful, not for picking up debris, but for improving the visual data available to plan or execute clean up tasks.

Disadvantages to using a remotely operated vehicle are as follows:

- The life of the equipment is potentially short because the radiation levels are high.
- Remotely operated vehicles would be required to be very heavy if they were to be able to move much material.
- We are not currently aware of a remotely operated vehicle or robot that is readily available to perform or could be readily adapted to do this task. Time is not available to develop one.
- An inspection robot might not be able to navigate around on the top of the debris. The surface of the debris and the ability of the debris to support a remotely operated vehicle are items that would have to be characterized.

6.10.1 Alternative Approach

The use of a long-arm robotic manipulator that was hung from one of the overhead cranes or attached elsewhere in the cell might present other options. These manipulators would most likely be telerobotic. Depending on the need, these manipulators could improve and complement the capabilities of the present in-cell manipulators. They could be more dexterous and have higher payloads.

6.10.2 Preliminary Evaluation

While robotic/remotely operated vehicles or long-reach manipulators have definite advantages in remote cleanup tasks such as the job at hand, there does not appear to be an off-the-shelf device that could be used. No robotic or remotely operated devices could be available during FY 1993. Since any in-cell applications would require development and unless this development were to start immediately, it is unlikely such equipment could be available in FY 1994. Cost and time for development indicate that this is not a viable approach. In addition, the radiation levels in the cell are so high that the useful life of a robotic device would be unacceptably short.

6.11 APPROACHES FOR CLEANING UNDER EXISTING HARDWARE SYSTEMS

Some or all of the large hardware systems in the cell have floor stand-offs that may permit access to clean the floor under them, rather than waiting for the system to be removed. For systems that have 6 in. or more of clearance between their superstructure and the floor, some level of cleanup under the hardware is possible.

The device proposed for this job is shown in Figure 16. It is depicted as a mechanical rake, which is extended forward, under the system and to the back wall, then pulled back out from under the system, bringing some dispersible material and perhaps some debris with it. This mechanical system cannot clean the area thoroughly but can probably retrieve 60% of the material under the hardware.

Alternatively, the rake head could be replaced with a vacuum pickup head. The vacuum device can do a much better job of cleaning areas under the hardware that it can access, but it would have no capability to retrieve or clean around pieces of debris that may be under the hardware. Therefore, as a stand alone device, neither the rake nor the vacuum head can provide completely effective cleaning under hardware. Together the two devices can do an excellent job, but not the final cleanup. The prime difficulty of working under the hardware is the inability to see where further cleaning is necessary. In addition, working against the back wall and around the feet of the hardware would be very difficult. It would be impossible to confirm visually that the cleanup was complete, although it might be easy to confirm that some areas had not been cleaned.

7.0 CONCLUSIONS

The conceptual design team could not conceive of a single system or device that would clean up both the debris and the dispersibles at the same time. The mechanical approaches considered would pick up the debris but would leave some dispersibles on the floor, and the vacuum system would clean much of the dispersible material and leave much of the debris on the floor.

It is possible and practical to clean, to some extent, under existing hardware systems if that becomes important. This could be accomplished using the mechanical rake or a similar device with a vacuum pickup head rather than a rake.

When this project began, there was great concern over the possibility that the existing systems could not clean enough debris and dispersibles from the floor to meet the FY 1993 milestones. In fact, they have exceeded those milestones and cleaned the majority of the open floor space in the cell. At the present time, debris and dispersibles remain only along the edges and corners of the floor under equipment that has not been removed and in areas around equipment that are too narrow to be accessed with the clamshell devices.

There are two possible approaches to continue the cleanup operations in B-cell: 1) Proceed with the scheduled removal of equipment and subsequent removal of debris and dispersibles, or 2) attempt to remove the debris and dispersibles from under the existing equipment.

The first approach requires no immediate development of equipment other than what we have been using, but will require the eventual development of final cleaning systems, such as the wet-vac system to pick up the last vestiges of dispersible material.

The second approach, to attempt to remove the debris from under and around existing equipment calls for immediate development of a method for removing the those materials. The rake approach (operated from the bridge crane) is one viable method. This can be a powered device or a static device moved entirely by the bridge crane. Another approach to this problem would be to gain access to the floor through the manipulator ports at the basement level in the cell and use the rake method operated by the manipulators.

7.1 COMPARATIVE EVALUATION OF ALTERNATIVE APPROACHES

A comparative evaluation of alternative approaches is provided in Tables 1 and 2.

7.2 APPROACHES RECOMMENDED FOR FURTHER DEVELOPMENT

Of the concepts proposed for the floor cleanup, the Mexican dragline, the auger, and the clamshell concepts would deserve further consideration if the existing equipment and the diligence of the cell staff had not reduced the need for continued development of gross removal equipment.

The problem now involves the removal of debris and dispersibles from under the existing equipment. This fact forces the prime consideration to shift to techniques of collecting the debris and dispersibles from under the existing racks. Cleaning along the walls and in the corners must also be addressed. The rake approach may assist with this problem; however, consideration should also be given to using floor access through the manipulator ports located in the lower level of the B-cell. Installation of existing manipulators in these locations may significantly improve operator access to the walls and corners as well as providing access to debris and dispersibles under existing equipment. Manipulators operated from these locations with the addition of rakes designed to be operated by these manipulators may be able to gather much of the remaining debris and dispersibles into locations where the clamshells can pick it up.

The vacuum system concept is recommended as the final alternative. There is a concern that the vacuum system has a potential for plugging and for possibly recycling dispersible contamination if the filter system is not adequate to capture the fine dispersible material. The plugging problem can be solved, if it occurs, by restricting the inlet and not creating restrictions in the rest of the line before it reaches the container. The problem with airborne contamination can be solved with the proper filtering systems. The vacuum system proposed is different from any commercial system because it has a disposable paper filter and a final water washing system. Commercial vacuum systems have only fixed filters and do not provide both filtering approaches in a single system. This approach requires no actual development, just adaptation of the vacuum equipment for use in our particular situation and testing to determine efficiency and operating parameters. The airborne contamination should not be a problem if this system is properly designed and operated. This vacuum system can be adapted to a wet-vac system and used for final cleaning and washing of the floor and walls of the cell.

It is expected that some tooling and hardware has been dropped and resides under the equipment. This could make it difficult or impossible to access some areas. Another concern is that the pickup head could become caught under the equipment. These concerns will have to be addressed.

7.3 PROPOSED FINAL SYSTEM SOLUTION

It may be desired or required to reduce the safety risk at a rate faster than can be accomplished by waiting for each piece of equipment to be reduced and removed from the cell before the dispersible material under it can be removed. If the decision is made to clean under the equipment, the conceptual design team recommends two approaches that they consider acceptable and possible. The first approach is to design and fabricate a powered rake that can be extended and retracted to drag material out from under the existing equipment. Installation of manipulators in basement locations may significantly improve operator access to the walls and corners as well as providing access to debris and dispersibles under the equipment. Manipulators operated from these locations with rakes designed to be handled by these manipulators may be able to gather much of the remaining debris and dispersibles into locations where the clamshells can pick it up.

We recommend that the vacuum system be developed to assist with the cleanup. The vacuum system can provide gross cleanup as well as final wash-down of the floor and the walls, if necessary. The vacuum system requires somewhat more development than the other systems: it will have to be designed and tested to survive the radiation and filter all the dispersibles out of the effluent air flow. Although it will take longer to prepare for installation into the cell, once installed, a vacuum system could replace most of the other dispersible-gathering equipment.

The second approach is to develop an extension for the vacuum system to reach under the existing equipment and directly pick up the dispersible material. This extension could be directed by the overhead crane or by the basement manipulators.

APPENDIX A

PROBLEM DEFINITION INFORMATION

APPENDIX A

PROBLEM DEFINITION INFORMATION

The questions below were asked by the problem definition team in order to define the high level characteristics and information about the B-cell. Where available, the source of the information and a confidence rating as to the validity of the answer have been provided. Confidence ratings range from 0 (low confidence) to 10 (high confidence).

A.1 CRANE INFORMATION

Question: What is the current crane configuration in B-cell?

Answer: Current configuration is reeved for 6-ton lifting; it can be changed to a 10 1/2 ton mode. There are no plans at present to change the configuration back to 10 1/2-ton mode.

Reference: Original crane blueprints, Sam Morris

Confidence rating: 10

Question: What does it take to change the crane configuration?

Answer: The crane must be moved into the hot cell airlock, decontaminated, and then re-reeved to desired configuration. The process of decontaminating, refitting, and reinserting crane into the hot cell may take up to 2 days to complete.

Reference: Sam Morris

Confidence rating: 9

Question: What is the traverse time for x, y and z travel in the 6 1/2-ton mode?

Answer: Hoist, trolley, and bridge motors are direct current motors and are controlled in 5-speed steps by varying the field excitation voltage to a 10 HP motor generator set. In the 6-ton mode, travel in any direction ranges from 0 to 20 ft/min. In the 10 1/2-ton mode, lift and trolley speed are reduced by half.

Reference: Original crane blueprints, Rod Jones

Confidence rating: 10

Question: How close to each wall can the hook be placed?

Answer: The main hook can be placed as close as 12 in. to the west, north, and south walls. It can touch the east wall because the rails that the crane run on continue into the hot cell airlock.

Reference: B-cell blueprints, Rod Jones

Confidence rating: 7-8. This figure has not been actually measured.

Question: Can the crane be operated with angular loads?

Answer: No. The Hanford Hosting and Rigging manuals prohibit any angular pulling vertical, and there is only enough cable to the drum to reach to approximately 2 ft from the floor bottom. Limit switches prevent hook from touching the floor or going too high. Shives on the trolley are fixed and would rub against the cable if the cable was angled. The brakes on the crane have also been disabled as a safety precaution, so there is no way to anchor the crane for pulling.

Reference: Hanford Hoisting and Rigging Manual, Rod Jones

Confidence rating: 9

Question: Could a smaller cable be placed on the drum that could allow angular pulling?

Answer: No. Grooves in cable drum are set for current cable size/configuration. If a new cable could be found, it would have to go through acceptance testing, etc. before installation. In addition, a limit switch prevents the hook from touching the floor would need to be disabled.

Reference: Rod Jones

Confidence rating: 10

Question: Can the crane be operated from any window?

Answer: yes

Reference: Visual inspection, Rod Jones, hot cell operators

Confidence rating: 10

Question: What is the current reach of the crane in the 6-ton mode?

Answer: The crane has a working height available of 17 ft. Floor to beam truss height is 20 ft 6 in.

Reference: data provided by Frank Haun.

Question: When is the new 3 1/2-ton crane going in and where in relation to the existing crane?

Answer: The new crane is currently on site and finishing acceptance testing. It is scheduled to be installed December 1993/January 1994. It will be placed in the cell first (i.e., west of the 6-ton crane) to allow 100% accessibility to all parts of the cell.

Reference: Rod Jones

Confidence rating: 10

Question: Can both cranes be tied or operated together?

Answer: Yes, provisions have been made to join the cranes to make a single crane with an increased lifting capacity. This means that there would be no need to re-reeve the 6-ton crane.

Reference: Rod Jones

Confidence rating: 9

Question: What is the traverse time for x, y, and z travel on the new 3 1/2-ton crane?

Answer: NA at this time, but expected to be similar to the 6-ton crane. New crane has 500-lb boom on it to allow access to all parts of the cell.

Reference:

Confidence rating: 5

MANIPULATOR INFORMATION

Question: How many manipulators are there?

Answer: There is one set of manipulators at each of the three first-floor viewing windows in the B-cell.

Reference: Visual inspection

Confidence rating: 10

Question: What are the reach limits of the manipulators?

Answer: Manipulators can be operated in any position, although overhead maneuvers are difficult due to the positions the operator controls take in the viewing gallery. Manipulators penetrate the cell wall 19 ft above the cell floor and have an effective reach from 8 ft to 30 ft above the cell floor. They can also be placed into penetrations on the second floor gallery by the South and West windows. The volume of space each manipulator can operate in is cone shaped, with the apex of the cone towards the center of the cell. Manipulators are able to hand items off across the cell to each other. There are three types of manipulators available for use in the cells (current configuration is model F) with heights ranging from 7 ft 6 in. to 10 ft 0 in. Maximum reaches range from 9 ft 2 in. to 12 ft 4 in., and the manipulators are rated to carry loads from 65 to 100 lbs.

Reference: Sam Morris, Operations Data Sheet

Confidence rating: 9

Question: What are the load limits of the manipulators?

Answer: They are capable of lifting up to 100 lbs in a straight vertical lift. However, as the arm is rotated to an extended horizontal position, the mechanical advantage of the arm is seriously reduced. At full extension, it is capable of lifting only 3 to 5 lbs.

Reference: Sam Morris

Confidence rating: 7. No one has really maxed out the manipulators to test these numbers.

Question: Can extensions be used or are they available to get closer to the floor?

Answer: The manipulators can not be extended, however the hot cell operators have devised a number of tools to extend their reach and dexterity.

Reference: Sam Morris

Confidence rating: 9

FLOOR SCHEDULE

The following schedule details when the various items in the B-cell are scheduled to be removed. All dates for removal were taken from the B-cell restoration schedule supplied by Randy Thornhill.

Task: 13
Item: 3B feed tank rack (SW corner)
Removal date: May 1993

Task: 18
Item: 4A and Floor
Removal date: September 1993

Task: --
Item: ESP filters
Removal date: June 1993

Task: 10
Item: Ceramic Melter/turntable
Removal date: June 1994

Task: 15
Item: 1A rack (SE corner)
Removal date: March 1995

Task: 16
Item: 1B rack (SE corner)
Removal date: October 1995

Task: 19
Item: 7B fuel storage rack
Removal date: November 1995

Task: 17
Item: 2A rack (NE corner)
Removal date: July 1997

Task: --
Items: Work tray and tank 119
Removal date: October 1997

CELL CONTENT SPECIFICATION

The following list details high level cell information as well as the area of floor each item scheduled for removal in the hot cell covers. Where available, the clearance available underneath the item is also given. Dimensions are given to the nearest inch, and all items are treated as having rectangular shapes. All dimensions were taken from hot cell blueprints.

B-cell liner: 11 ga. stainless steel floor and liner up to elevation 17 ft 2 in.

Slope of floor: West to East, floor elevation at West side of cell is (-)10 ft 0 in., elevation of floor at East side of cell (-)10 ft 6 in. Sump area located in NE corner of cell, bottom of sump at (-)11 ft 0 in.

B-cell dimensions: 22′ - 0 " x 25′ - 0" (550 sq. ft.)

1A rack : 3′ - 6" x 8′ - 4" (29.16 sq. ft.) clearance: to be determined

1B rack: 3′ - 4" x 8′ - 4" (27.78 sq. ft) clearance: to be determined

2A rack: 4′ - 9" x 8′ - 6" (40.38 sq. ft.) clearance: to be determined

3B rack: 3′ - 5" x 7′ - 10" (26.76 sq. ft.) clearance: to be determined

4A rack: 4′ - 0" x 7′ - 10" (31.33 sq. ft.) clearance: 9"

Ceramic Melter/turntable: 6′ - 0" x 10′ - 6" (63 sq. ft.) clearance: to be determined

7B fuel storage rack: 4′ - 6" x 6′ - 6" * (29.25 sq. ft.) clearance: 16"

Work tray & Tank 119: 4′ - 0" x 4′ - 0" (16 sq. ft.) clearance: to be determined

ESP filters: 2′ - 0" x 8′ - 0" (16 sq. ft.) clearance: to be determined

APPENDIX B

LABORATORY CONTACTS

APPENDIX B

LABORATORY CONTACTS

Battelle, Columbus Division

Dr. Wayne Carbiener

Dr. Carbiener discussed the hot cell cleanup that they are starting. He said they were just completing a cell characterization and had not started the cleanup process yet. Since Battelle did some private work in the cells, the U.S. Department of Energy (DOE) is funding 90% of the cleanup cost and Battelle private is funding the rest. Dr. Carbiener said that he is really out of the loop on this effort and referred us to either Ken Borg or Ed Castleberry.

Ed Castleberry

Mr. Castleberry is in charge of the hot-cell cleanup campaign at Columbus. He confirmed that they were just completing the cell characterization. Their cells have debris and dispersible materials, but not to the extent found in B-cell. They are now starting the planning phase of the cleanup, they have not actually started removing material from the cell. Ed said he was interested in cooperating with PNL and suggested we visit each other's sites. Periodic information exchanges should be beneficial to both sites.

Savannah River

Nevyn Rankin would be interested in working with us to review our approaches, but he doesn't have a similar problem or experience.

(EG&G - Idaho)

Scott Altmeyer has no comparable experience.

Scientific Ecology Group (SEG)

Information was sent to Pat Rencken. She sent literature relating to a remote vacuum head drive system for radiation environments.

Ogden Environmental

Ray Dalbert (946-8484) worked in 324 Building and states that he is fully aware of the cell and the problem. He can map the floor for radiation dose. It would take 6 wks to set up and 16 h to complete.

DOE-Idaho

Howard Cummings referred us to Mike O'Brian at Argonne West, in WIPP. He referred us to Mike Vaughn, who referred us to Scott McBride. They are using a commercial vacuum to pick up tiny quantities of radioactive materials in glove boxes. He provided make and model numbers, phone numbers, etc., but nothing that we would be able to use. DOE-Idaho has no other relevant experience. Sampling WIPP waste containers is the primary function of these people.

Idaho National Engineering Laboratory (INEL-WINCO)

Ron Smith - no comparable situations.

APPENDIX C

INDUSTRIAL CONTACTS

APPENDIX C

INDUSTRIAL CONTACTS

Search for Cleaning Equipment

The following companies were contacted in an effort to find off the shelf equipment that could be used to clean the floor in the 324 B-cell. The equipment was to be off the shelf and ready to use. Several companies did not have any equipment on the shelf, but were willing to develop a cleaning system for us.

After receiving information, and talking with the following companies, we found no item or device that would perform the cleanup without further development. This is due, in part, to the very high radiation levels in the cell. All of the air suction devices (vacuum systems) that are readily available are not built for remote operation. Other systems require drastic measures that are simply not acceptable, such as flooding the floor with water.

Companies Contacted

The following companies provided information and expressed an interest in assisting with the project:

ABB Combustion Engineering Nuclear Power
(203) 285-4188
Person Contacted: Ed Siegel
FAX - (203) 285-9521
Discussion Results: They do not have anything off the shelf that would work for us, but they would be happy to develop a remote cleaning system.

Air Systems Inc.
(800) 866-8100
Person Contacted: Ray Ellis
Discussion Results: This company has produced a stainless steel vacuum system that has been used as Sandia, Fernald, and Alabama Power for radioactive applications. The vacuum system has a .03 micron HEPA filter on it, with a remote exhaust.

Alaron
(412) 847-6210
Person Contacted: Mike Shuma
Discussion Results: Mr. Shuma, a project engineer with Alaron, thinks our best bet is to buy a commercial HEPA Vac and design handling components that will work with the manipulators. Although Alaron could sell a vacuum to us, Mr. Shuma thinks we would be better off just buying an off-the-shelf unit. They may be able to help us with the design of the handling hardware if we need the technical support.

Alliance Inc.
(616) 637-5915
Person Contacted: Mike Wilson
Discussion Results: This company does not appear to have any off-the-shelf equipment suited to remotely cleaning the cell.

Applied Radiological Control Inc.
(404) 429-1188
(800) 241-6575
Person Contacted: Dave Carr, Robert Plant
Discussion Results: This company is currently doing decontamination at a cell in Oak Ridge. Steve Landecker from Battelle Columbus has gone to look at the ice blast method they are using. In our case with dust, Mr. Carr thinks some sort of vacuum system would be effective. He is going to have one of his experts give me a call.

Arbill Inc.
(215) 228-4011
(800) 523-5367
Person Contacted: Wayne Gotta (referred by Steve Wyjadka)
Discussion Results: This company deals with the Hako line of vacuum cleaners. The X700 series cleaners are air motor driven, the 6-gal unit costs from $900 to $1200, is made of stainless steel for dry material, and has a HEPA filter. The static vacuum has a suction of 180 inches of water at 166 CFM.

ARD Corp.
(410) 997-5600
(800) 969-ARDI
Person Contacted: Jim Richley
Discussion Results: Mr. Richley has a "Super Scavenger" robot that will crawl around on the bottom of the cell. The robot has a blade and may also use a vacuum system. They used this robot to clean a resin tank in a radioactive environment at SECO. As long as we can use cameras somewhere in the cell, the device can be used. The vehicle is hardened at least to 10 to the 7th rad/hr. Note: If the radiation readings at the floor are in fact 10 to the 9th, this system would fail very early.

Container Products Corp.
(919) 392-6100
(800) 635-5647
Person Contacted: Jim Grantham
Discussion Results: Mr. Grantham is sending information on their abrasive vacuum system that may be used for decontamination. He is sending a fax, followed by a mailer and a videotape. They also have leasing programs and a mobile decontamination unit that can operate where there is no water or power. He has sent Bruce Sasser (PNL) complete decontamination information already.

Decon Systems Inc.
(803) 847-1990
(900) 473-3266
Person Contacted: Jim Petty
Discussion Results: Mr. Petty suggested the use of a "Super Scavenger" device -- a remote crawler robot to which we can attach a vacuum hose. He is faxing information on this and whatever else he thinks will work for us. He is not sure if the crawler if radiation hardened. He referred me to the ARD Corp. This is the company that actually makes the Super Scavenger. Note: It is not radiation hardened.

Euroclean
(708) 773-2111
(800) 545-4372

Person Contacted: Robin Zavoli
Discussion Results: This company has only one vacuum unit that may be useful to us. It is for dry use only. Remote operation may be a problem, they have one customer using the vacuum remotely by vacuuming with the hose through a door, but with the vacuum unit itself outside the room. Mr. Zavoli is faxing information on the system. After receiving the information, it is apparent that this is not nearly what we are looking for.

Federal Industrial Services Inc.
(313) 533-9888
(313) 521-1066
Person Contacted: Mike Hadwinn
Discussion Results: Mr. Hadwinn is supposed to call and talk about what his company has available. Their equipment is mostly sandblasting and metal spraying equipment, but they do deal with vacuums as well. Mr. Hadwinn called and discussed the possibility of flooding the cell, getting the material in suspension, and then pumping water through the filters. I have a feeling that this is not acceptable.

Fisher Scientific
(412) 562-8300
(800) 766-7000
Person Contacted: Bob Briggs
Discussion Results: Mr. Briggs is in the technical service department in this company. He stated that he does not know of any product that they sell that would help us clean the cell floor.

Hazard Technology Co. Inc.
(800) 852-3698
Person Contacted: David Levinson
Discussion Results: The products that are available from this company are vacuum systems for hazardous cleanup and for power tools. They would also sell us a vacuum from Euroclean. None of these systems are suitable for remote operation.

R Houston and Sons Inc.
(513) 367-5252
Person Contacted: Roger C. Houston
Discussion Results: This company does not have any off-the-shelf hardware that would be ideal for our use. Their main business is sandblasting. They do carry some high performance vacuum cleaners made by the Tornado Company.

Inventive Machine Corp.
(216) 874-4222
(800) 325-1074 or (206) 767-9880
Person Contacted: Raffael or Chuck Thorton
Discussion Results: This company does have vacs, but we need to contact the Seattle distributor. The distributor is United Wester Supply Co.

Kleiber and Schulz Inc.
(516) 293-6688
Person Contacted: Don
Discussion Results: This company will custom engineer a system to work with us. The system they use now involves spraying water at high pressure to remove contaminants into the water, then the slurry is vacuumed up. Don will do his best to fax me some information regarding their capabilities, but he was unwilling to promise anything. The staff member most knowledgeable about decontamination is in Oak Ridge. The normal marketing information is sent through the mail, and Don will send us one of those packages.

NFS
(203) 434-0660
Person Contacted: Mark Greenleaf
Discussion Results: This company does custom engineered filtration systems. Dexter Balyeat (ba-le-a), from NFS, is working with Westinghouse. He will probably call and talk about our application. I received information on their systems in the mail. The equipment looks nice, although nothing is available off-the-shelf.

Nikro Industries Inc.
(708) 530-0558
Person Contacted: Jim Nicholson
Discussion Results: Mr. Nicholson is unsure about the vacuum system surviving in the cell at our high levels. He is faxing information on a vacuum unit.

Nilfisk of America Inc.
(215) 647-6420
(800) NIL-FISK
Person Contacted: Cory Peffer
Discussion Results: Mr. Peffer will be faxing information on their vacuum systems. These use 55-gal drums as collection containers.

Non Destructive Cleaning
(818) 761-0264
Person Contacted: Keith Dufalt
Discussion Results: This company does not have anything that would help us to clean out the cell. The company specializes in blasting with CO2. This eliminates the cleaning carrier as the CO2 becomes a gas.

Nuclear Power Outfitters
(815) 455-3777
Person Contacted: Charisse Zeff
Discussion Results: This company has a couple of vacuum systems. A fax is being sent. The fax shows a couple of vacuum systems. I don't think any of these systems is really what we want.

Pentek Inc.
(412) 262-0725
Person Contacted: Nancy Moore
Discussion Results: This company has a remote system that has a vacuum, as well as a more aggressive system that they use to "scabble" the floor. A representative is going to be at the TRICIPE show on Aug. 11 and 12. Information is being faxed. They have used this system at a superfund site in Yakima, and also with the Bud. Co. cleanup of the Manhattan Project site. Martin Marrietta has also used the system.

Power Products and Services Co. Inc.
(804) 525-8120
Person Contacted: Tim Montgomery
Discussion Results: Mr. Montgomery is facing information on the company's vacuum systems. What he would like to propose is to use a vacuum that is placed outside the cell. The contaminate would be filtered out before it exited the cell. We would have to figure out a way to manipulate the suction end. This company's vacuum systems cost about 5K, have a suction of 307 inches of water at 189 CFM.

Safety Equipment Co.
(813) 621-4921
(800) 226-1126
Person Contacted: Judy Hart
Discussion Results: This company is a distributor for Abatement Technology Co. vacuum cleaners. Ms. Hart could only find systems for asbestos fibers in her information, but she did give me the contact for Abatement Technology Co.

The Spencer Turbine Co.
(203) 688-8361
(800) 232-4321
Person Contacted:
Discussion Results: The company had done just a few jobs with radioactive materials, and most of their systems are custom-manufactured units. They do not have anything off-the-shelf and ready to go. Information is being faxed.

Taprogge America Corp.
(516) 921-5200
Person Contacted: Robert Pollaski
Discussion Results: This company builds cleaning systems for power plant condensers. They do not have any equipment to clean a cell.

Townsend and Bottum Services Group Inc.
(313) 761-3440 or (313) 761-1855 or (612) 983-0873
Person Contacted: Jerry Heppburn or Len Tepper
Discussion Results: This company will have someone from their decontamination group call us. They deal with water; they are diving contractors.

Transnuclear Inc.
(914) 347-2345
Person Contacted: John Mangussi (general manager)
Discussion Results: This company does not have any equipment to help clean up the cell. They deal with shipping containers for radioactive materials. Mr. Mangussi knew of a company here locally that did that kind of work, but he couldn't think of the name of that company.

United Western Supply Co.
(206) 767-9880
Person Contacted: Chuck Thorton
Discussion Results: Thorton is a distributor for the Inventive Machine Corp. He said he doubts that this vacuum is up to our specifications. The filter is rated at somewhere around 10 to 100 micron. It is a drum vac though, and he is faxing information.

WOMA Corp.
(206) 258-1356
(800) 258-5530
Person Contacted: Frank Bob
Discussion Results: This company deals with water jet technology and probably would not get involved with cleaning the cell. They may have some other contacts, so they will have another person call back.

The following companies could provide no assistance or expressed no interest in the project:

U. E. Systems Inc.
(914) 592-1220
(800) 223-1325
Person Contacted: Gary Moore
Discussion Results: This company works with ultrasonic equipment for leak detection. They do not have any equipment that we can use.

Abatement Technology
(800) 634-9091

ABESCO
(212) 473-1300

Alconox Inc.
(212) 473-1300

Alyn Corp.
(714) 641-8021

Apex Technologies Inc.
(813) 445-1500

The Atlantic Group
(804) 857-6400
(800) 446 8131

Bartlett Nuclear Inc.
(508) 746-6464
(800) 225-0385

Boride Products Inc.
(616) 2100
(800) 662-2131

Butterworth Jetting Systems Inc.
(713) 644-3636
(800) 231-3628

B&W Fuel Company
(804) 385-3662

B&W Nuclear Service Company
(804) 385-2310

Clean Room Products
(516) 588-7000

Cloverleaf Cleaning Systems
(313) 982-7400
(800) 533-5236

Conco Systems Inc.
(412) 828-1166
(800) 345-3476

Environmental Alternatives Inc.
(603) 357-8814

Enviro Pak/Tech Oil Products Inc.
(318) 367-6165
(800) 737-5533

Flowmore Services Corp.
(713) 351-7979
(800) 356-9667

Foster-Miller Inc.
(617) 320-8900

Framatome USA
(703) 527-4747

Frahm Safety Products Inc.
(615) 254-0841

Hako Minuteman Inc.
(708) 627-6900
(800) 323-9420

Hot Cell Services Corp.
(206) 854-4945

Hydro Services
(713) 499-8611
(800) 231-6913

Lechler Inc.
(708) 377-6611
(800) 777-2926

Mainstream Engineering Corp.
(407) 631-3550

Master-Lee Engineered Products Inc.
(412) 537-6002

Mid Atlantic Diving Contractors
(410) 461-1155

NLB Corp.
(313) 624-5555

Nuclear Associates
(516) 741-6360

Nuclear Energy Services
(203) 796-5273

Nuclear Shielding Supplies and Service Inc.
(602) 748-9362
(800) 528-7086

Oceaneering International Inc.
(504) 395-5247

Refueling Services Inc.
(410) 267-6670

Serfilco Ltd.
(708) 559-1777
(800) 323-5431

Siemens Nuclear Power Services
(615) 499-0961
(800) 628-8268

Sioux Steam Cleaner Corp.
(605) 763-2776

Spraying Systems Co.
(708) 665-5000

Uni-Chem Chemicals
(714) 992-2728

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