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USE OF A CUTTING AND CLEANING SYSTEM AT THE WEST VALLEY DEMONSTRATION PROJECT

March 1985—January 1986

By
L. W. Wiedemann
P. N. Standish

April 1986

Work Performed Under Contract No. AC07-81NE44139

West Valley Nuclear Services Company, Inc.
West Valley, New York

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Prepared for
U.S. Department of Energy
Assistant Secretary for Nuclear Energy

Prepared by
West Valley Nuclear Services Company, Inc.
West Valley, New York 14171

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ABSTRACT

This report describes the use of a commercially available ultra high pressure water cutting and cleaning system at the West Valley Demonstration Project (WVDP) Facility. This system, known as the Ultra High Pressure System (UHP), has been successfully used at the WVDP in such applications as removing concrete from the internals of a cement mixer drum, cutting conventional and high density concrete in both clean and radioactively contaminated areas of the Facility and underwater cutting of aluminum canisters previously used for storage of spent nuclear fuel assemblies.

The advantages of the system include savings in manpower, reduction in radiation exposure, adaptability to remote operations, and no structural damage to surrounding materials.

This report describes the equipment associated with the UHP System and the cost expected for the capital equipment, consumable materials and special tooling. Details of the various cutting and cleaning operations performed at the WVDP are provided as well as a list of future projects.

SUMMARY

The West Valley Demonstration Project (WVDP) is operated for the Department of Energy by the West Valley Nuclear Services Co., Inc. (WVNS), a subsidiary of the Westinghouse Electric Corporation. The WVDP is located in the town of Ashford, New York in Cattaraugus County at the facility where Nuclear Fuel Services, Inc. (NFS) reprocessed spent fuel from 1966 to 1972. The objective of the WVDP is to solidify the high level waste generated through fuel reprocessing and to decontaminate and decommission the equipment and facilities used. The Ultra High Pressure (UHP) cutting and cleaning system has been utilized in various applications at the WVDP to support this objective.

The UHP system has the following key components:

1. Diesel powered water pressurizing unit.

2. Hand held multiple jet cleaning tool.

3. Hand held single jet lance for cleaning and cutting.

4. Abrasive jet (Abjet) nozzle with grit feed system for cutting.

5. Linear tracking system for Abjet cutting.

Specific projects performed at the WVDP with the UHP system are:

1. Removal of built-up concrete from the internals of a cement mixer drum.

2. Removal of a concrete knee brace from the Cement Solidification System (CSS) Building.

3. Cut out of a concrete wall in a Contamination Control Area of the Process Building for installation of a pipe chase.

4. Enlargement of a radioactively contaminated concrete valve niche to accommodate installation of Liquid Waste Treatment System (LWTS) pumps.

5. Underwater cutting of aluminum canisters previously used for storing spent nuclear fuel to reduce the volume of radioactive waste.

Three concrete cutting projects are described in this report: the knee brace removal, the pipe chase cut out, and the valve niche enlargement. Two of these projects required contamination controls and the development of special equipment and methods for the cutting process. The pipe chase cut out project used a deflector/collector system for screening out radioactively contaminated concrete cuttings and grit from the water. The valve niche enlargement project used a method of cutting which left the contaminated concrete cuttings, grit and water contained inside the valve niche. In both cases, the residual contaminated waste was readily disposed of in accordance with WVNS policies and procedures.

An ongoing project at the WVDP utilizing the UHP system involves the underwater cutting of 6061-T6 aluminum canisters in the Fuel Storage Pool. These canisters are no longer needed since the spent fuel which was stored in the canisters has been returned to the utility owners. Because of their bulk, a system was designed by WVNS to section the canisters into compactible sizes. The cutting system designed consists of a tank, a lid, canister rotating wheels, Abjet nozzles and supporting arms and a water flow control system.

WVNS will be using the UHP system in the following future projects:

1. Cutting round and rectangular holes in a 61 cm (24") thick concrete vault roof.

2. Removing two 2.4 m (8') high x 2.4 m (8') diameter concrete pedestals from the radioactively contaminated Chemical Process Cell (CPC)

3. Sectioning test borosilicate glass logs from the vitrification system.

4. Decontaminating surfaces in the CPC.

The flexibility and efficiency of the UHP system have been demonstrated. This type of system should have many applications in the nuclear industry.

1.0 INTRODUCTION

The West Valley Fuel Reprocessing Plant was constructed in 1966 for Nuclear Fuel Services, Inc. (NFS) and licensed by the Atomic Energy Commission (AEC) to reprocess nuclear reactor fuel. Fuel receipt began in 1965 and reprocessing started in April 1966. Operation continued until early 1972 at which time the plant was shut down.

In July of 1976, NFS informed the AEC and the Nuclear Regulatory Commission (NRC), that it was no longer proceeding with the licensing application to expand and modify the plant. At that time, the plant was placed in a standby state with the minimum work force required to maintain safety systems. With the operating contract and lease between NFS and New York State Energy Research and Development Authority (NYSERDA) expiring on January 1, 1981, Congress enacted legislation to provide for takeover of the facilities by the United Stated Department of Energy (DOE). This legislation, signed into law by President Carter in late 1980, was called the West Valley Demonstration Project Act (P.L. 96-368). This Act authorizes DOE to carry out a demonstration program for the solidification of the liquid high-level radioactive wastes (HLW) at West Valley, operate the existing plant facilities, decontaminate and decommission certain facilities and perform program management. The DOE, through a process of competitive bidding, selected the West Valley Nuclear Services Co., Inc. (WVNS), a subsidiary of Westinghouse Electric Corporation, to act as operating contractor for the West Valley Demonstration Project (WVDP).

The primary objectives of the WVDP are to solidify the 2120 m^3 (560,000 gallons) of HLW remaining from the reprocessing of nuclear fuel and to decontaminate and utilize the existing reprocessing facility as much as possible in support of the solidification of HLW.

To achieve these objectives, major modifications to the existing facility are required. Large areas of the facility must be decontaminated and equipment prepared for disposal operations. One piece of equipment used to support these objectives is the UHP system. A description of the equipment and some of the tasks accomplished with it are described in the following sections of this report.

2.0 EQUIPMENT DESCRIPTION

2.1 General

The UHP equipment has been commercially used for cleaning ship hulls, brick buildings and heat exchanger tubes and for cutting concrete, rock and metals in the construction, mining and oil industries.

The UHP system expels water pressurized to 241 MPa (35,000 psi) through an orifice to form a high energy jet stream for cleaning hard materials (i.e., concrete, steel, glass, etc.) or for cutting soft materials (i.e., plastics, wood, cloth, etc.). When garnet grit is added to the stream of water exiting the orifice, the UHP system may then be used for wet grit blasting or for cutting hard materials.

The key components of the WVDP UHP system are:

1. Diesel powered water pressurizing unit.

2. Hand held multiple jet cleaning (water only).

3. Hand held single jet lance tool (water only or water and grit).

4. Abrasive jet (Abjet) nozzle with grit feed system for cutting.

5. Linear tracking system for Abjet cutting.

2.2 Power Unit

The self contained, portable power unit is a diesel driven "pumping" system that is capable of pressurizing water to 241 MPa (35,000 psi) at a maximum flow rate of 15.9 ℓ/min (4.2 gpm) (Figures 1 and 2). The ultra high pressure water [69 to 241 MPa(10,000 to 35,000 psi)] is transported from the power unit to the working tools (i.e., Abjet nozzle and cleaning nozzle) through a high pressure flexible hose. The power unit is also equipped with a branch hydraulic system that can operate equipment remotely i.e., the rotary drive on the rotary hand cleaning lance or the hydraulic drive motor on the linear tracker.

Oil is used to operate piston type pumps (intensifiers) which increase the water pressure to a maximum 241 MPa (35,000 psi) (Figures 3 and 4). By adjusting the hydraulic oil pressure to the intensifiers the output working water pressure can be varied to best suit the work being performed.

The power unit is contained in a skid mounted steel frame with protective side panels. The frame has an attachment to allow the power unit to be transported with a forklift or lifted with a crane. The unit is self protected from the weather; however, extra precautions must be taken during cold weather to prevent the water system from freezing. Therefore, a portable heated weather shelter has been designed and procured by WVNS to house the power unit during cold weather operation.

The only utility required for the power unit is a supply of clean water. The water cools the hydraulic oil operating the intensifiers and becomes pressurized in the intensifier. Once pressurized in the intensifier, the water is sent to the working tools for cleaning and cutting operations.

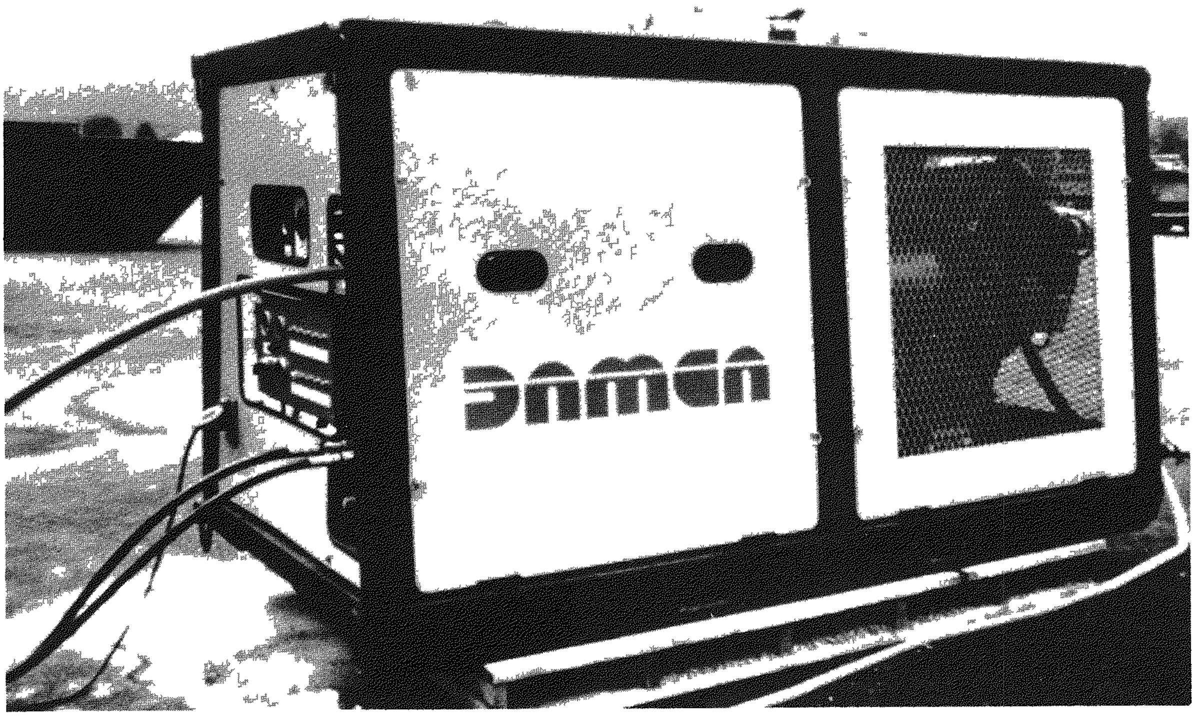


FIGURE 1
Power Unit

FIGURE 2
Power Unit with Side Panels Removed Showing Diesel Engine (left) and Three Intensifiers (top right)

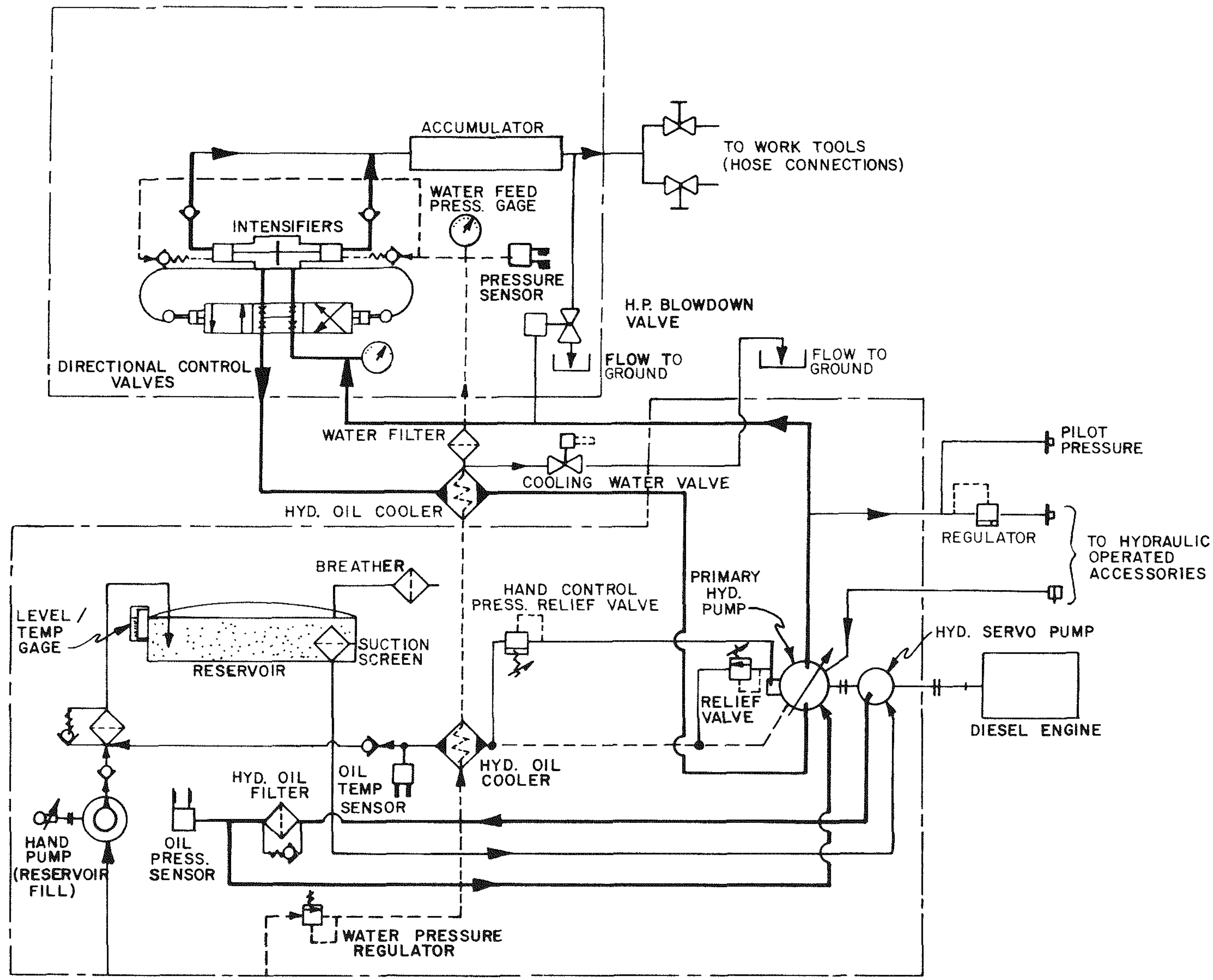
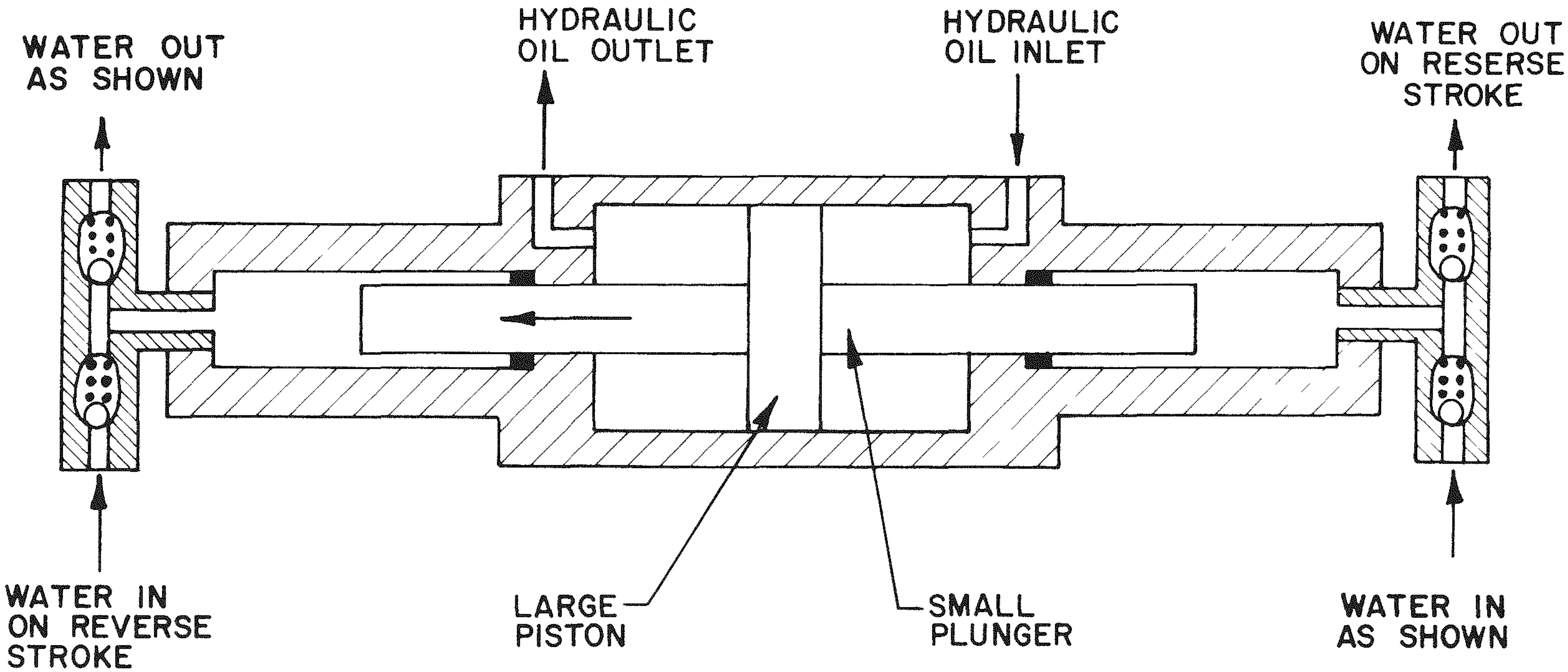


FIGURE 3
Power Unit Hydraulic Oil and Water Flow Schematic



AREA OF LARGE PISTON IS 13 TIMES
LARGER THAN SMALL PLUNGER
2,700 PSI (HYD. OIL PRESS.) x 13 = 35,000 PSI
18.6 MPa (HYD. OIL PRESS.) X 13 = 241 MPa

FIGURE 4
Intensifier Diagram

The flexible hoses which transport the high pressure water are available in a variety of lengths making it possible to operate the working tools over a hundred meters (several hundred feet) from the power unit. This feature has allowed projects to be completed inside a contaminated area with the power unit located in a distant uncontaminated area.

2.3 Abrasive Water Jet Nozzle System

The working tool used most frequently at the WVDP to date has been the abrasive water jet nozzle (Abjet) system. Its primary function at the WVDP has been for cutting aluminum canisters and steel reinforced concrete but it can also be used for wet grit blasting

The heart of the abrasive water jet system is the Abjet nozzle (Figure 5). The water from the power unit passes through an orifice with a diameter of 0.25 mm to 0.81 mm (0.010" to 0.032"), and forms a stream of water with a velocity of 701 m/sec (2,300 ft/sec). When the stream exits the nozzle body through the focusing/acceleration tube, it creates a vacuum in the nozzle body which draws air into the body through the grit supply tube. Grit is then metered into the air stream from a grit tank through the grit supply tube and carried into the nozzle body. As the grit is pulled through the focusing tube, it contacts the water stream and accelerates to the speed of the water. The result is a high energy, narrow stream of water and grit ranging in size from 1.14 mm to 2.29 mm (0.045" to 0.090") exiting the nozzle to perform the controlled cutting of objects. If remote operation is required for a task in a contaminated area, the small light weight nozzle can readily be adapted for such a purpose.

The flow of grit from the grit tank is manually controlled by a ball valve located on the bottom of the tank, and its flow rate is dependent upon the size of the orifice used in the tank discharge line. Orifices are available in a variety of sizes ranging 2.39 mm to 12.7 mm (0.094" to 0.5") in diameter.

A natural garnet grit is used for the various cutting operations. The size of the grit and its feed rate are variables which must be established for the type of material being cut, its thickness and the cutting rate desired. For example, a number 60 grit [0.41 mm (0.016") average particle grit size] fed at a rate of 0.45 kg/min (1 lb/min) will cut 3.17 mm (1/8") thick aluminum at a cutting rate of 45.7 cm/min (18 in/min); and a number 36 grit [0.71 mm (0.028") average particle size] fed at a rate of 1.4-1.8 kg/min (3-4 lb/min) can be used to cut 43.2 cm (17") of concrete at 25.4 mm/min (1 in/min).

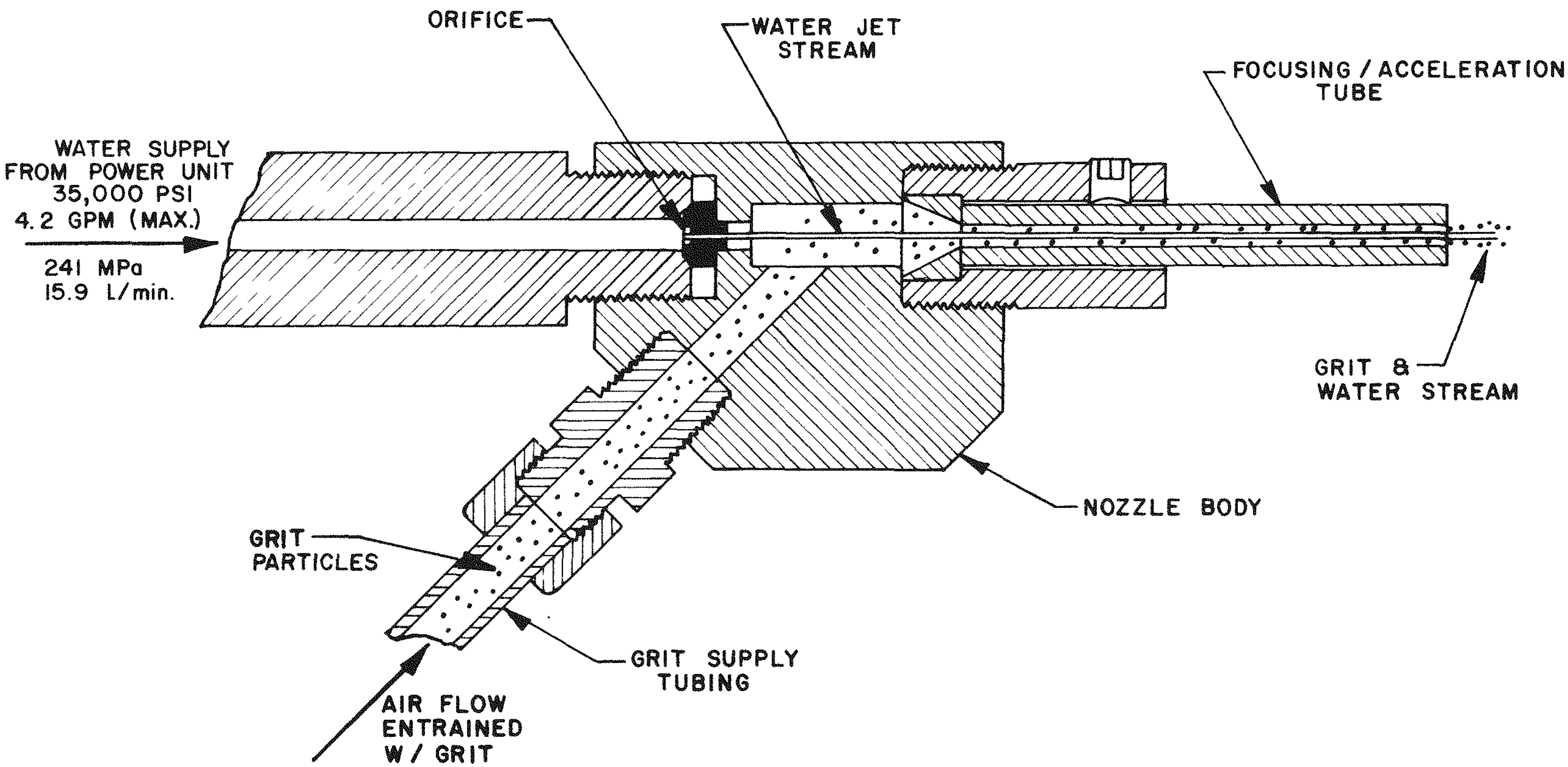


FIGURE 5
Abrasive Jet Nozzle Assembly

2.4 Linear Tracker

A linear tracking device can be mounted and set for remote straight line cutting with the Abjet nozzle. The tracker has a hydraulically driven "cart" with a variable speed drive motor for controlling the travel rate of the Abjet nozzle. The tracker can be mounted in any position (horizontally or vertically) to make the required cuts. Once the tracker is mounted and the nozzle aligned, the cutting operation can be remotely accomplished from any convenient location (Figures 6 and 7). This is a valuable feature when work must be performed in a radioactively contaminated area in which water and grit must be controlled and operator presence in the immediate area is not desired.

A circular tracker is also available for cutting circular holes in concrete with the Abjet nozzle. The circular and linear tracker provides WVNS with the flexibility to make almost any size and type of cut required.

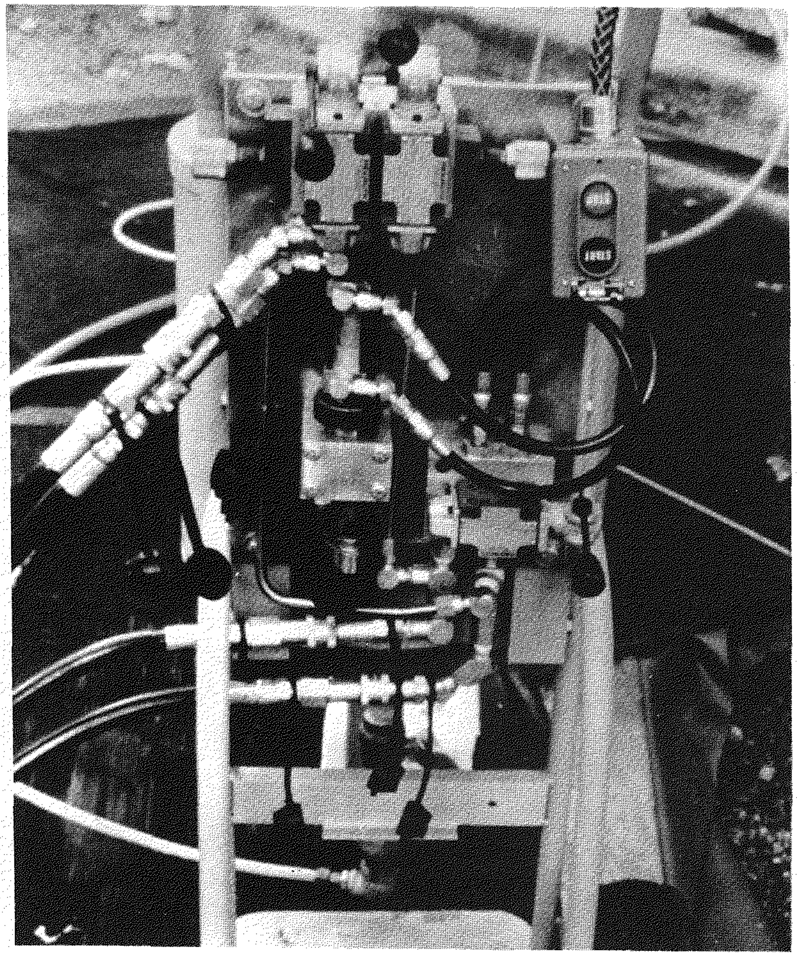


FIGURE 6
Tracking System Controls Located on Grit Tank Cart

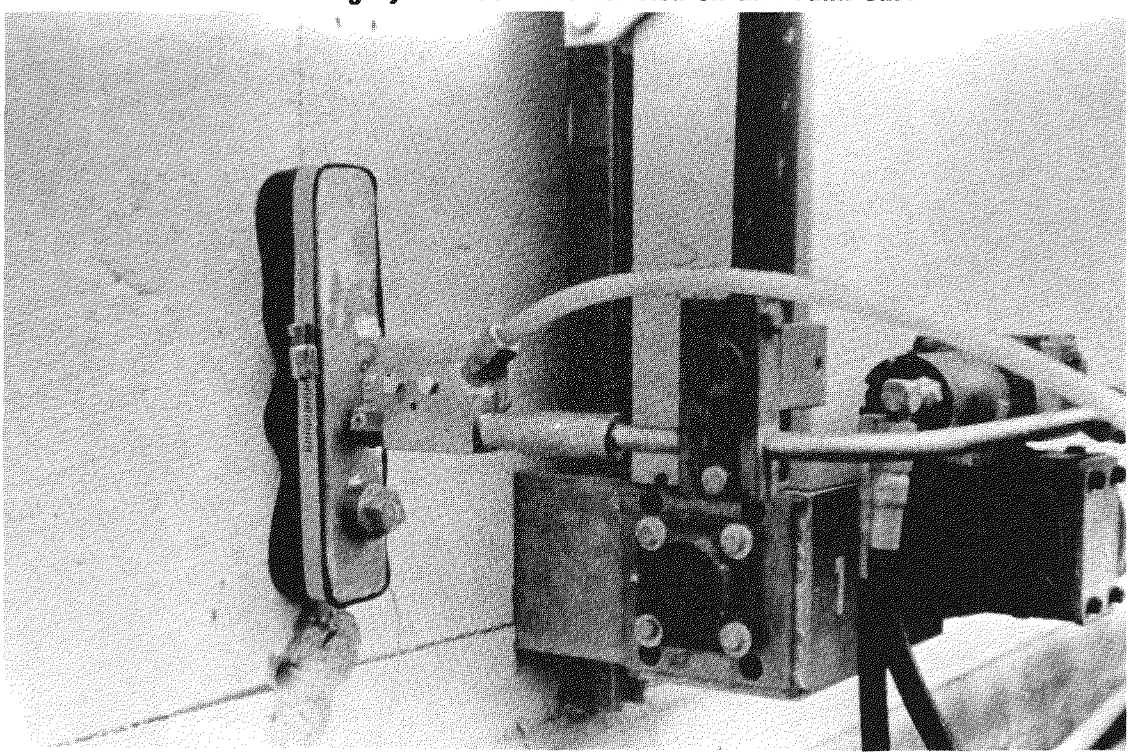


FIGURE 7
Abjet Nozzle Mounted to Hydraulically Operated Tracker (with Water Deflector Guard)

2.5 Hand Held Multiple Jet Cleaning Tool

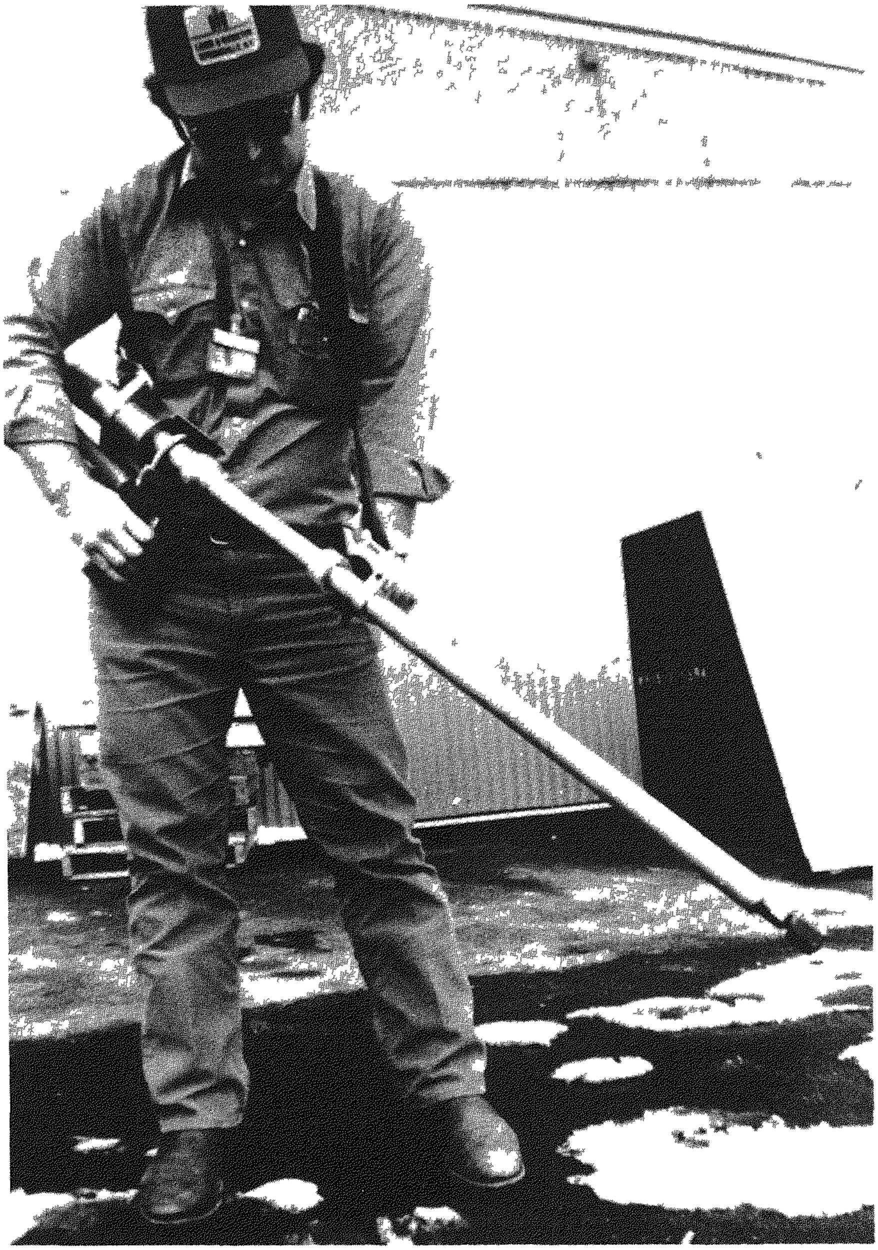
The hand held multiple jet rotary water lance is a working tool which cleans or scarifies materials using UHP water (Figure 8). The hand held lance at the WVDP has a hydraulic motor driven nozzle head. The nozzle head has two orifices separated at a 45 degree angle, through which UHP water from the power unit passes. The nozzle head is rotated at 500 rpm by the hydraulic motor which is powered by the power unit. This rotation produces a "cone" of water capable of cleaning or scarifying a path several 8 cm (3") wide (depending on stand-off distance and material being removed).

There are two valves located on this hand held lance that allow the operator to have on/off and speed control of the water at the work site. One valve is located on the hydraulic motor to control nozzle head rotation and the other is located on the pistol grip of the lance to control water flow.

Hand grips and shoulder straps are available on the hand held lance to allow the operator better control of cleaning or cutting operations. This feature also provides support against 222 N (50 lbs) of reaction force produced when the unit is operating at full power. The supplied force is variable and depends on the size of the nozzle used.

2.6 Hand Held Single Jet Cleaning Tool

The Hand Held Single Jet Lance is a light weight and portable working tool which can be used with the power unit for cleaning, scarifying, wet grit blasting or cutting materials. With a single stream of water it is possible to clean small areas (i.e., paint removal for weld inspections) without affecting surrounding areas. Due to the concentration of energy in a single stream, it is also possible to penetrate small areas and remove undesirable material (i.e. remove contamination from cracks in concrete). With the attachment of an Abjet nozzle (Figures 9 and 10), the tool can also be used with garnet grit for the wet grit blasting and cutting of materials.



***NOTE:** It is possible to use the rotary lance mounted to a tracking device (rather than hand held) to allow for accurate control, particularly if scarifying concrete.*

FIGURE 8
Hand Held Rotary Water Lance

FIGURE 9
Hand Held Single Jet Lance with Abjet Nozzle

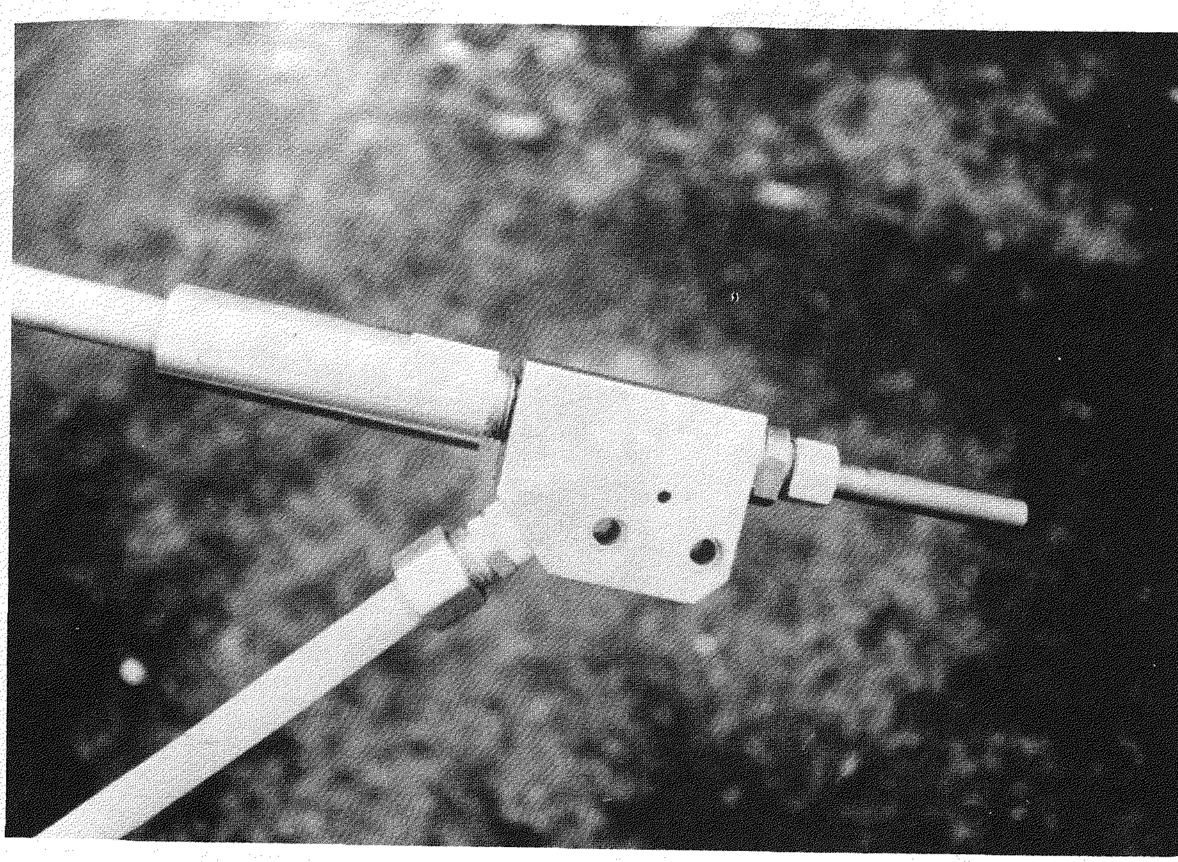


FIGURE 10
Close-up of Abjet Nozzle on Hand Held Lance

3.0 TECHNICAL OBJECTIVES

The overall objectives of this program are to:

1) Adapt a commercial UHP cleaning and cutting system for Decontamination and Decommissioning (D&D) projects at WVNS.

2) Evaluate the effectiveness of the equipment on several specialized projects.

3) Demonstrate the cost savings and reduction in radiation exposures brought about by using the UHP system.

4) Test the effectiveness of remote operation of this unit in contaminated areas.

5) Train operators for safe use of the equipment.

6) Develop precision cutting techniques.

4.0 OPERATOR AND MAINTENANCE TRAINING

Initial training of operators and Facility Engineers using the UHP equipment was completed at the West Valley site by a representative from the manufacturer. The training included four (4) hours of classroom training and four (4) hours of hands-on training with the UHP equipment. Additional operators have since been trained at the site by the Facility Engineering and Training Departments.

In addition to operator training, the factory representative also trained maintenance personnel on troubleshooting and repair of the equipment. Due to the specialized nature of this equipment, it was essential that qualified mechanics perform the equipment maintenance.

5.0 INDUSTRIAL SAFETY

Industrial safety has been considered at both the factory and the WVDP. Some of the safety features built into the equipment at the factory to protect operating personnel and equipment are:

1) All moving parts on the engine are covered with guards.

2) The UHP System has a bleed down valve that automatically drains the system after the power unit is shut down.

3) All high pressure hose and threaded tubing connections have bleed holes to prevent a buildup of pressure behind the threaded joint in case of leakage.

4) All high pressure hoses are covered with an additional hose shield. Therefore, any leakage from the pressure carrying hose is captured in the shield hose and directed out through the open end of the shield hose. If a pressure carrying hose fails, the low flow of water [15.1 ℓ/min (4 gal/min)] from the hose does not have enough energy to cause any harm.

In addition to the safety features built in at the factory an emergency kill switch has been installed on the power unit controls by WVNS. This switch is located at the work site so that the power unit can be immediately shut down by the tool operator in an emergency situation. This is particularly important when the work site is remote.

All WVNS training classes emphasize industrial safety. A separate section is provided in the training handout material that addresses the "dos and don'ts" of safety around the UHP equipment. Prior to using the equipment, a WVNS industrial work permit is issued after a safety engineer reviews the job and determines the additional safety requirements needed to perform the job safely (i.e., hearing protection, steel toe shoes, eye protection, roping off the area, safety watchman, etc.).

6.0 DESCRIPTION OF OPERATION

6.1 Cleaning

The Cement Solidification System (CSS) at WVNS encapsulates low-level waste (LLW) in cement for waste disposal. During cold testing of the CSS, several inches of residual concrete built up and hardened on the internal surfaces of the High Shear Cement Mixer Drum. After attempts to remove the buildup with hammer and chisel failed, the UHP system was used for cleaning the mixer.

Since access to the mixer internals was limited to several pipe connections on top and the pump/mixer connection on the bottom, the rotary lance was the only instrument which could access the internals and clean the mixer. The rotary hand lance with an orifice diameter of 0.61 cm (0.024") and an operating pressure of 241 MPa (35,000 psi) cleaned the vent pipe to like-new condition.

6.2 Concrete Cutting

6.2.1 Knee Brace Removal

The glass melter to be used for encapsulating HLW in glass has an off-gas system with a blower in Building 01-14. The new pipe chase connecting the Vitrification System to the off-gas blower ties into an existing pipe chase outside the CSS Building. At the tie-in, a supporting knee brace had to be removed to allow installation of the new off gas pipeline from the melter.

The brace was 61 cm (24" thick), 20.7 MPa (3,000 psi) (minimum) concrete reinforced with 19.0 mm (3/4") and 28.6 mm (1 1/8") diameter rebar and weighed approximately 2948 kg (6,500 lbs). Both horizontal and vertical cuts were required for the brace removal, and since the walls of the new pipe chase were already installed, access to the side of the brace was limited. (See Figures 11 and 12 for the pipe chase locations before and after the knee brace removal).

The abrasive jet cutting system was selected as the most efficient means for removing the brace. The linear tracker was used and a submount designed and fabricated to allow mounting of the tracker directly to the brace. Forklift mounts were also designed, fabricated and mounted to the brace to allow a forklift to be used to support the brace during final cuts. (See Figure 13 for the knee brace after removal and Figure 14 for the quality of cut made by the UHP system).

The job was accomplished using the Abjet nozzle with a 0.81 mm (0.032") orifice and a 2.29 mm (0.090") inside diameter focusing tube (Table 1). A number 30 grit [0.93 mm (0.0365") average particle grit size] was used at a flow rate of 1.59 kg/min (3 1/2 lb/min). The Abjet cutting nozzle was able to cut 43.2 cm (17") deep traveling at a rate of 2.54 cm/min (1 in/min). As rebar was encountered this rate was reduced to 1.27 cm/min (1/2 in/min). Since the brace was 61 cm (24") thick, cuts were required to be made from both sides (see Table 1).

Because this was the first concrete cutting work performed by WVNS, the set up time prior to cutting took considerably longer than the cutting. The tracking device for the cutting nozzle had to be mounted to the concrete and aligned with the line of cut. It was also necessary to protect the new pipe chase concrete during cutting. While it took approximately one (1) week to set up the equipment for the cut, the actual cutting time for this block removal was only eight (8) hours. In comparison, an outside contractor estimated a cost of $34,000 with a four (4) week completion time to remove this knee brace.

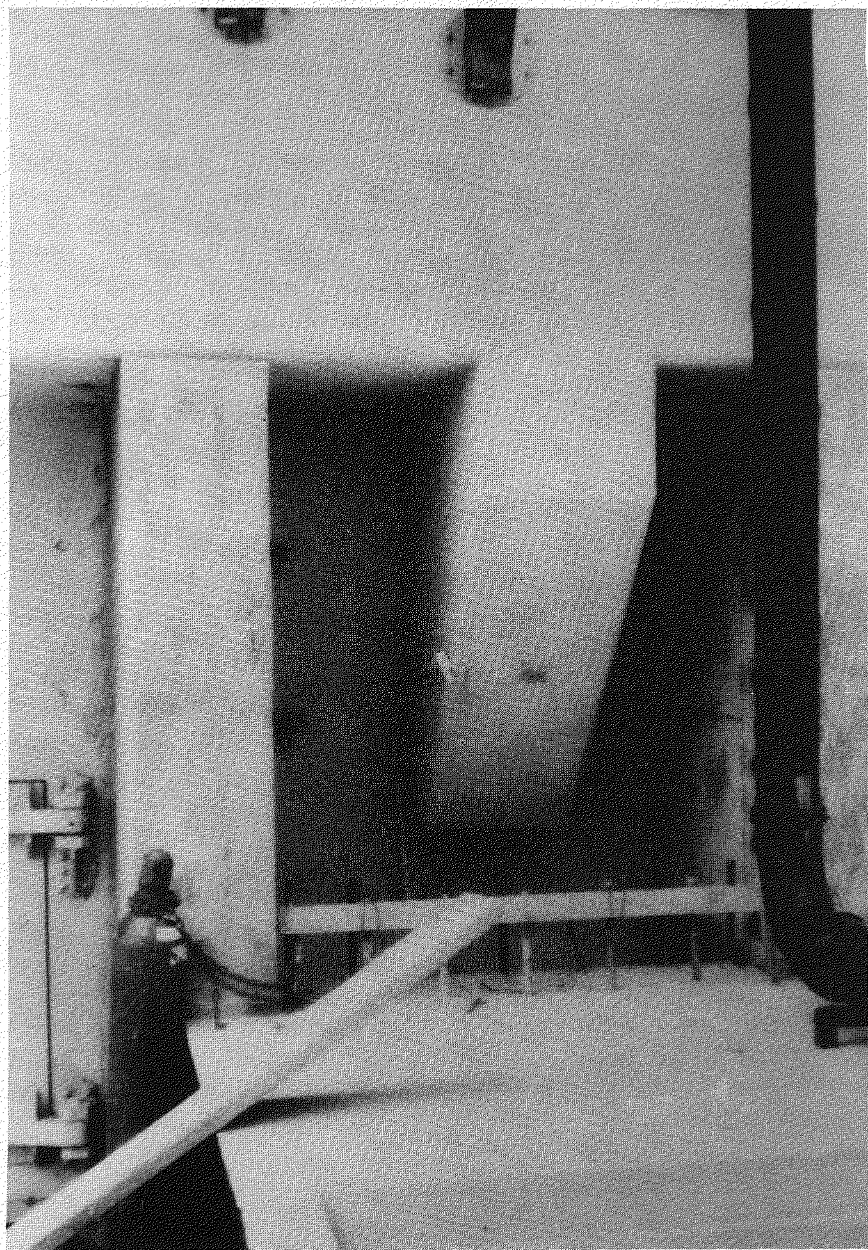


FIGURE 11
Knee Brace Removal Location

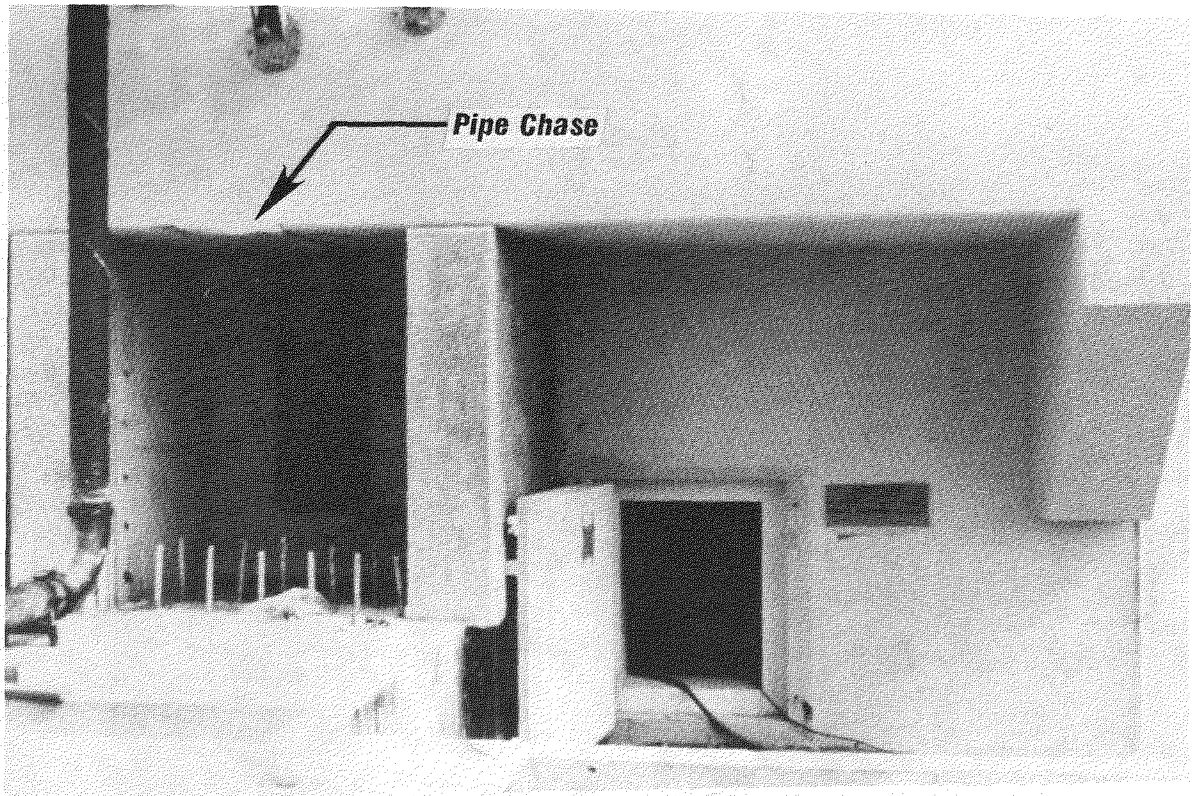


FIGURE 12
Pipe Chase after Knee Brace Removal

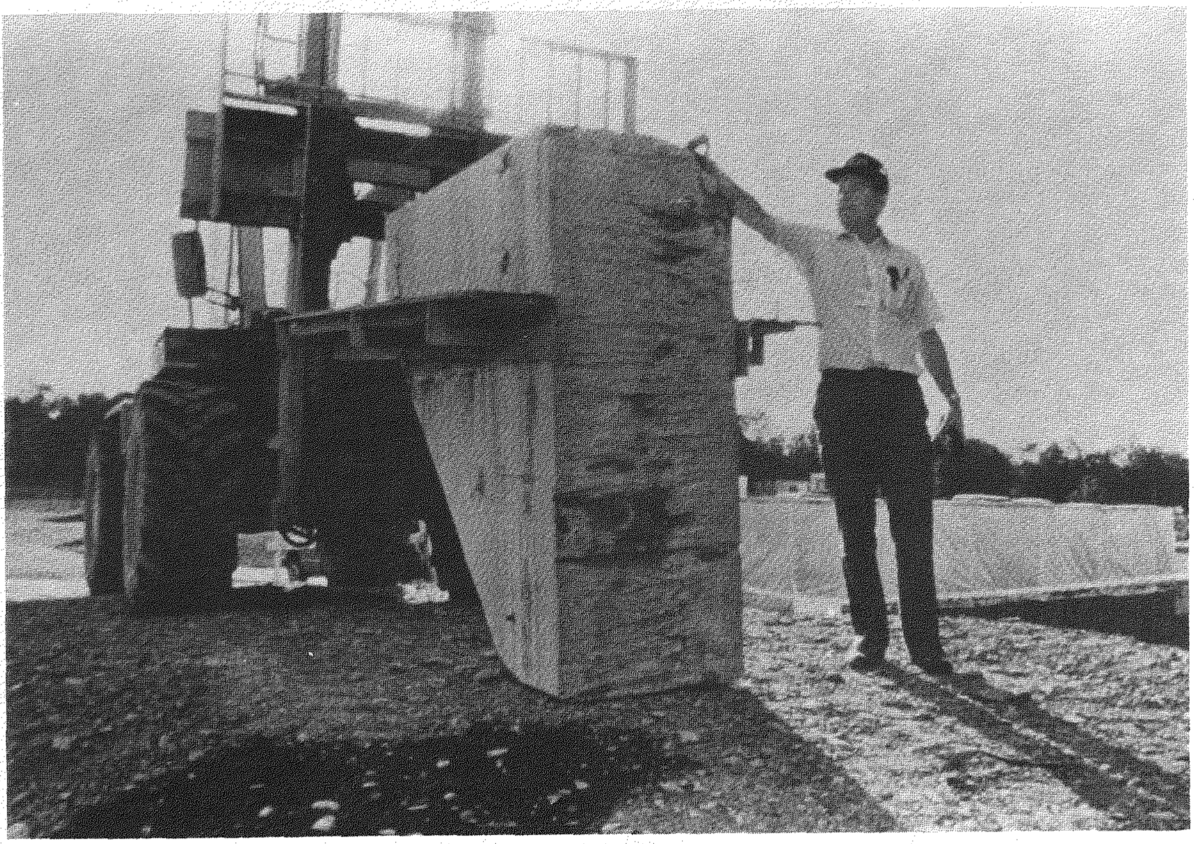


FIGURE 13
Knee Brace after Removal with Abjet Cutter

FIGURE 14
Quality of Cut Made by Abjet Cutter

Table 1

CONCRETE KNEE BRACE REMOVAL - ABJET SETUP AND OPERATION

A. CUT-OUT SIZE

1) Triangular brace cut into two pieces.
Each piece: 1.7 m (5 1/2') length x 0.61 m (2') thick.

2) Calculated weight: 2,948 kg (6,500 lbs).

3) Reinforced with 19.1 mm (3/4") and 28.6 mm (1 1/8") diameter rebar.

B. ABJET NOZZLE SET UP

- 0.81 mm (0.032") diameter orifice [15 ℓ/min (4 GPM) water flow].
- 2.29 mm (0.090") inside diameter focusing tube - 7.6 cm (3") length.
- Number 30 Garnet Grit: 1.6 kg/min (3 1/2 lb/min) flow.
- Cutting Rate: 25.4 mm/min (1 in/min) for concrete.
  12.7 mm/min (0.5 in/min) for rebar.

C. CUTTING TIME, GRIT and WATER CONSUMPTION

1) 1.65 m (65") length cuts [30.5 cm (12") average depth].

- Cutting time: 2 hours per cut (including recutting as required)
- Grit consumption: 190.5 kg/cut (420 lb/cut).
- Water consumption: 1,817 ℓ/cut (480 gal/cut).

2) Total Time and Consumption

- Cutting time: 8 hours
- Grit consumption: 726 kg (1,600 lb).
- Water consumption: 7,268 ℓ (1,920 gal).

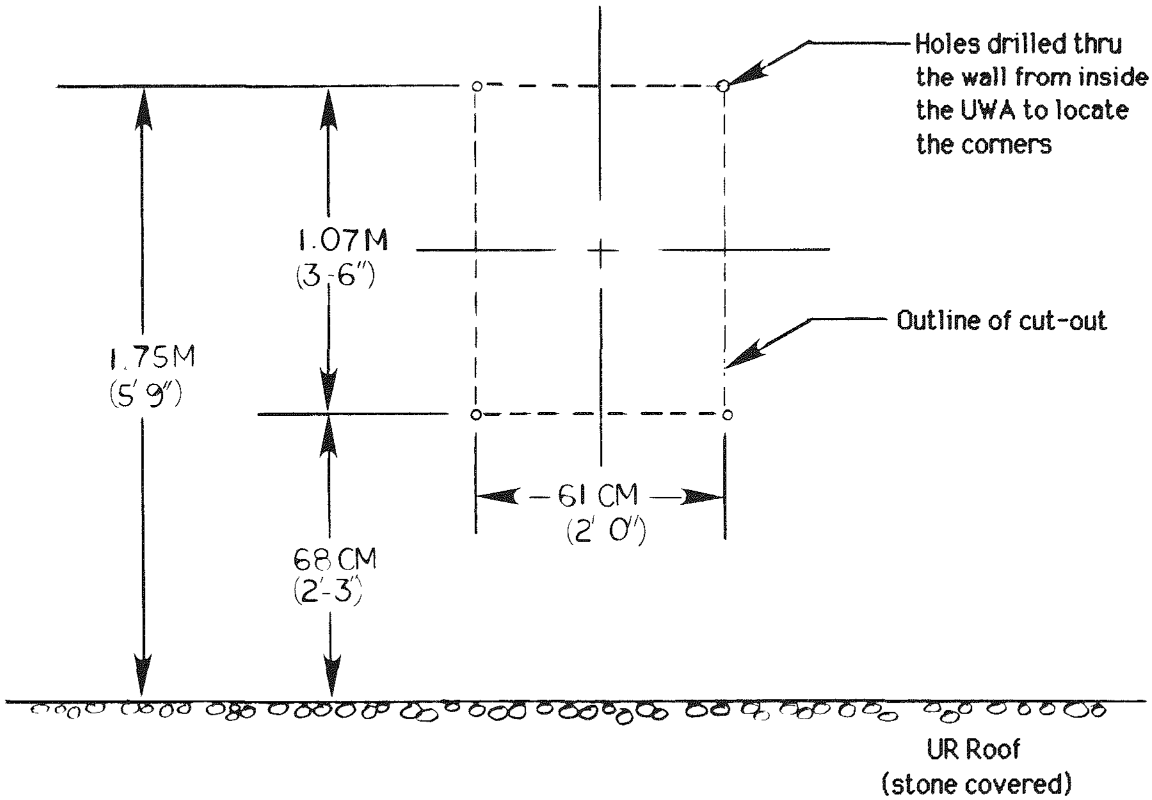
6.2.2 Pipe Chase Cut Out

To allow for installation of a pipe chase for process lines to the CSS, a 61 cm x 107 cm (2' x 3-1/2') hole was required in the wall of the Process Building in the Upper Warm Aisle (UWA). The wall was 30.5 cm (12") thick poured concrete reinforced with 12.7 mm (1/2") diameter rebar (Figure 15). The same equipment used for removal of the knee brace was used for this cut out operation. The tracker was attached to the concrete wall with anchors (Figure 16) and was mounted between the parallel cuts to be made to reduce the setup time between cuts. This way, only the Abjet nozzle and supporting hardware needed to be moved when moving from the left vertical cut to the right vertical cut.

For this application, the Abjet nozzle was set up with a 0.81 mm (0.032") diameter orifice and a 2.29 mm (0.090") inside diameter focusing tube. A number 36 garnet grit size [0.71 mm (0.028") average particle grit size] was used at a flow rate of 1.36 kg/min (3 lb/min). The cutting rate through the 30.5 cm (12") thick concrete was 5.1 cm/min (2 in/min). As rebar was encountered, the rate was reduced to 19 mm/min (0.75 in/min) (see Table 2).

Since the inside of the wall to be cut was in a contamination control area of the plant, control of water, grit and concrete cuttings during the cutting operations was essential to avoid spreading contamination. A carbon steel deflector/collector system was fabricated and attached on the contaminated side of the wall which totally enclosed the block to be removed (Figure 17). Water and grit catch drums were connected to the bottom of the deflector. Screened decanting lines allowed the water to drain from the drums to the floor drain but retained the grit in the drums. A water separating vacuum system was connected to the top of the deflector to remove the vapors from the air within the deflector. After removal of the water, the air was discharged to the plant's filtered ventilation system. Following completion of the cuts, the pipe chase hole was covered with an aluminum plate for ventilation control and weather protection (Figure 18).

This project successfully demonstrated some unique capabilities of the UHP system: remote precision cutting of reinforced concrete, remote operation without structural damage to the surrounding areas and remote operation in a contaminated area without spreading contamination. The experience gained from this critical cutting operation and the new hardware developed will not only significantly increase the efficiency of future work but will also lead to the implementation of the UHP system for more complex projects.

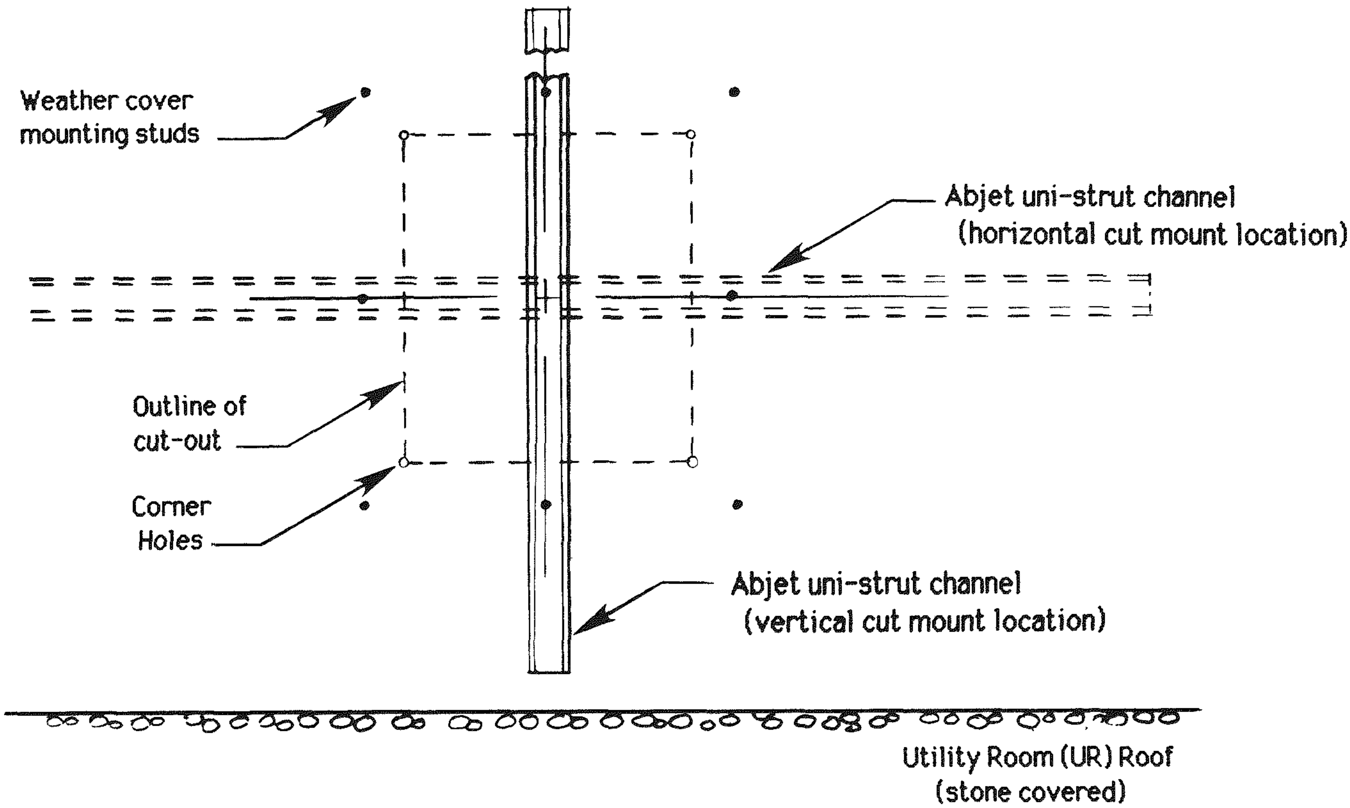


Notes:
1. Wall thickness is 30.5 cm (12")

2. Location and layout of the cut-out is in the Upper Warm Aisle (UWA). Holes drilled in the four (4) corners are to locate the cut-out outside on the Utility Room (U.R.) Roof and to assist with cutting the block

3 Cutting done from the U.R. Roof into the UWA.

FIGURE 15
Size and Location of UWA Pipe Chase Cut-Out



Notes:

1. The uni-strut channel for mounting the linear tracker is mounted to the wall with the weather cover mounting studs located on the center line of the cut out.
2. Holes are drilled in the channel to match the mounting studs in both the horizontal and vertical mounting position.
3. The channel is mounted in the vertical position parallel to cut lines for the first set of cuts.
4. The linear tracker is mounted to the channel with the spring load uni-strut mount bolts. The hydraulic motor is in the down position.
5. Upon completion of the vertical cuts, the tracker and channel are removed and remounted in the horizontal position.

FIGURE 16

UWA Pipe Chase - Abjet Tracker Set-Up

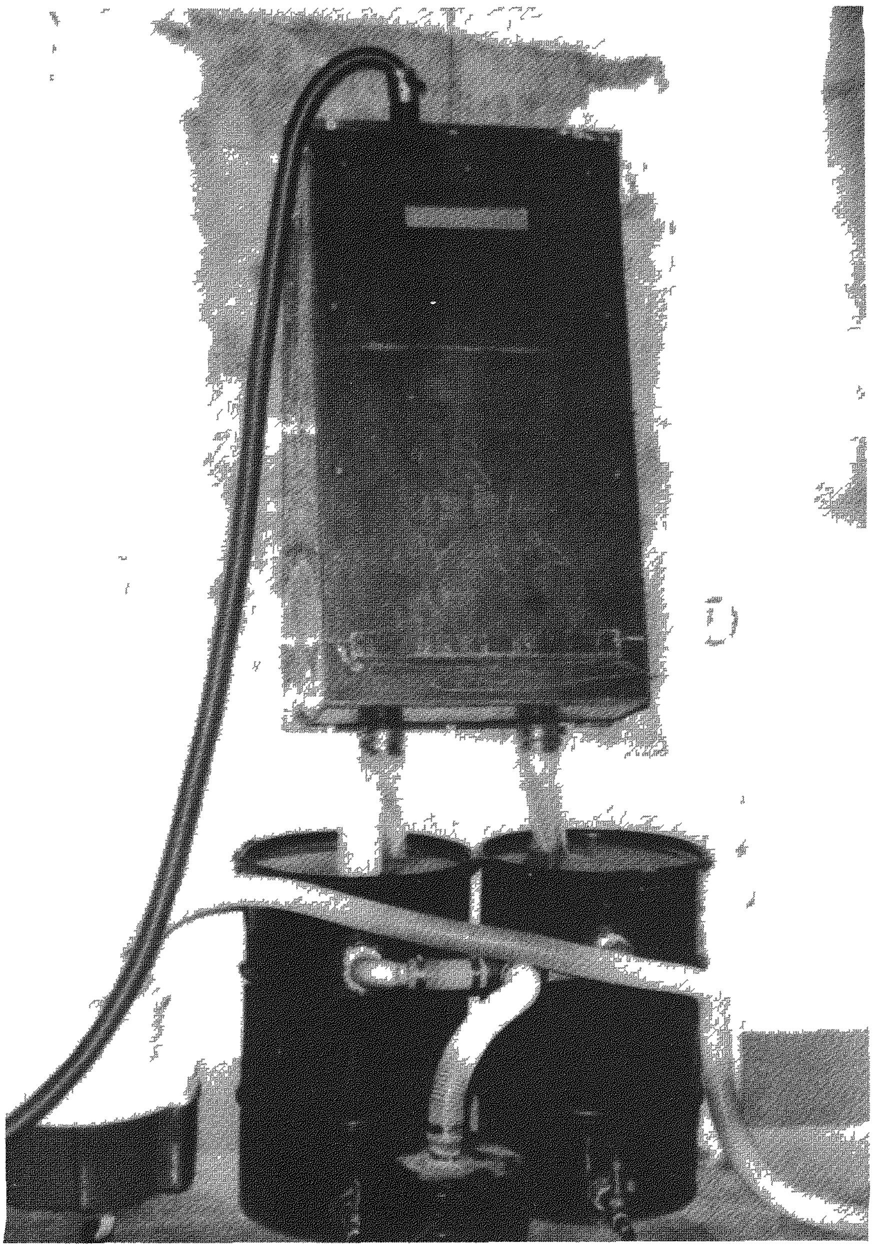


FIGURE 17
UWA Pipe Chase Collector/Deflector System

FIGURE 18
Pipe Chase Cut-Out in UWA Wall

Table 2

UPPER WARM AISLE PIPE CHASE - ABJET SET-UP AND OPERATION

A. SOUTH WALL CUT-OUT SIZE

1) 61 cm (24") wide X 107 cm (42") high X 61 cm (12") thick.

2) Calculated weight: 476 kg (1050 lbs).

3) Reinforced with 12.7 mm (1/2") diameter rebar.

B. ABJET NOZZLE SET UP

- 0.81 mm (0.032") diameter orifice [15 ℓ/min (4 GPM) water flow].

- 2.29 mm (0.090") inside diameter focusing tube - 7.6 cm (3") length.

- Number 36 Garnet Grit: 1.4 kg/min (3 lb/min) flow.

- Cutting rate: 5.1 cm/min (2 in/min) for concrete.
  19.0 mm/min (0.75 in/min) for rebar

C. CUTTING TIME, GRIT AND WATER CONSUMPTION

1) 61 cm (24") length cut.

   Cutting time: 15 minutes per cut
   Grit consumption: 20.4 kg/cut (45 lb/cut).
   Water consumption: 227 ℓ/cut (60 gal/cut).

2) 1.07 m (42") length cut.

   Cutting time: 25 minutes per cut.
   Grit consumption: 34 kg/cut (75 lb/cut).
   Water consumption: 378 ℓ/cut (100 gal/cut).

3) Total Time and Consumption.

   Time: 1.33 hours.
   Grit consumption: 109 kg (240 lbs).
   Water consumption: 1211 ℓ (320 gal).

6.2.3 Valve Niche Wall Removal

To enlarge a valve niche to accommodate a pump for the new LWTS, a 30.5 cm (12") thick high density [4,486 kg/m^3 (280 lb/ft^3)] concrete wall on the existing valve niche had to be removed. The niche was lined with 9.5 mm (3/8") thick stainless steel (Figure 19). The wall was 2.06 m (6'-9") long and 1.22 m (4'-0") high with a calculated weight of 3402 kg (7,500 lbs) (Figure 20). Due to the weight of the wall and the size of the handling equipment, the wall was removed in two pieces.

Since this wall was in a radioactively contaminated area, it was necessary to control the water, grit and concrete cuttings. To do this, the initial cuts were made only half way through the concrete from the niche side of the wall. During the cutting operation the water, grit and cuttings splashed back into the niche. Complete final cuts were made from outside the niche so that the water, grit and cuttings passed through the original cut into the niche. The water in the niche was sampled for radioactive contamination and later pumped to the floor drain for treatment in the existing liquid waste treatment facility. The grit and cuttings were placed into two 114 ℓ (30 gallon) drums and disposed of as radioactive waste.

The vertical cuts were made by mounting the linear tracker in a vertical position on the wall. The horizontal cuts were made by mounting the tracker on top of the wall. The location and sequence of the cuts are shown in Figures 21 through 23.

The Abjet nozzle set-up, grit size and feed rate were the same as had been used on the pipe chase wall cut out (Table 3). The high density concrete in the valve niche wall was expected to be harder to cut than conventional concrete however, this was not the case. Instead of using cutting rate of 2.5 - 5.1 cm/min (1 to 2 in/min) to make a 15.2 cm (6") deep cut as originally estimated, the high density concrete was cut at a rate of 10.2 cm/min (4 in/min). The niche and Abjet nozzle of the UHP system were completely covered to contain the water, grit and cuttings inside the niche. Since the operators could not see the rebar when it was encountered to make adjustments in the tracking speed, a uniform tracking speed was used. As a result, a more conventional method (reciprocating hacksaw) was utilized to cut the rebar.

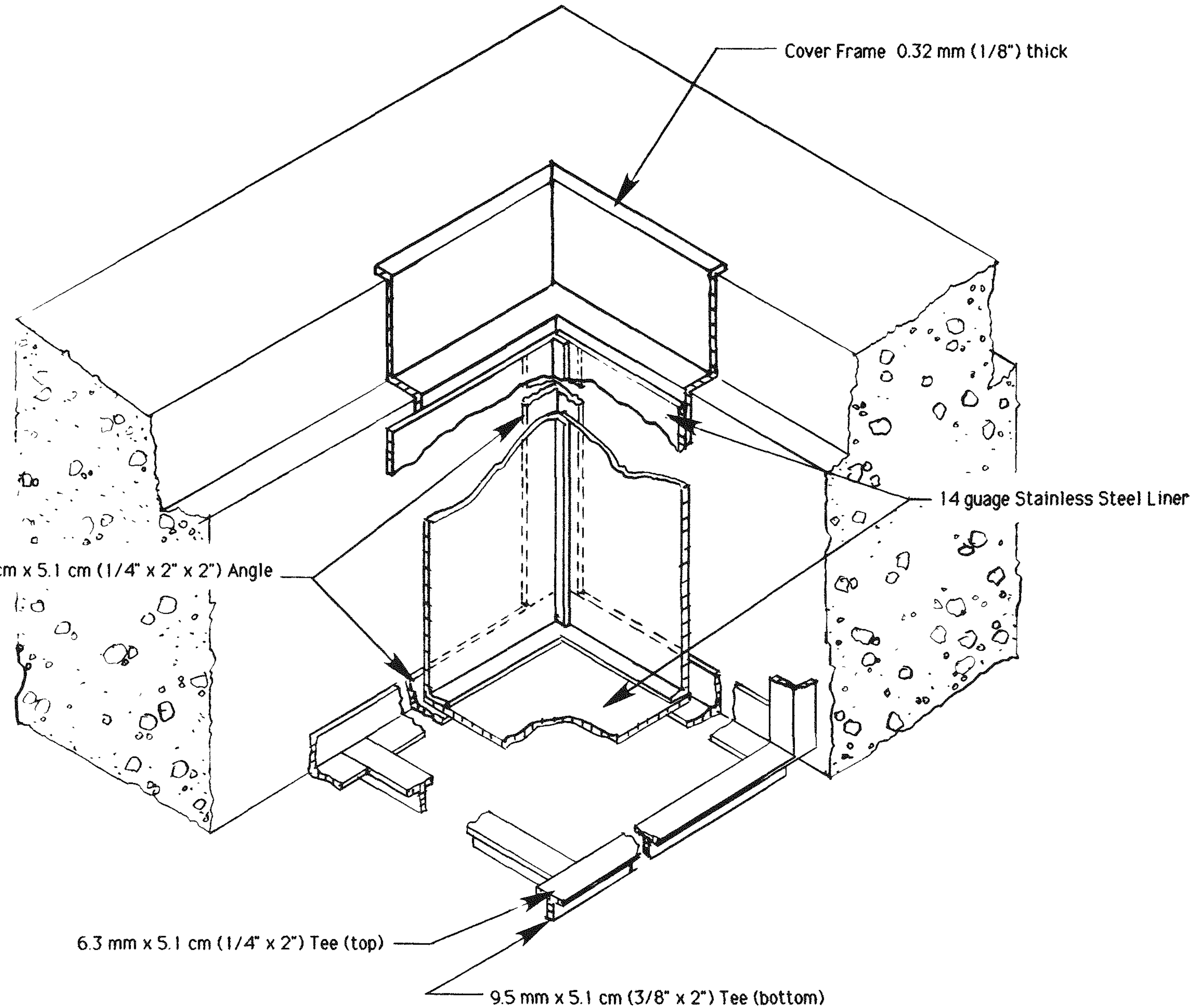
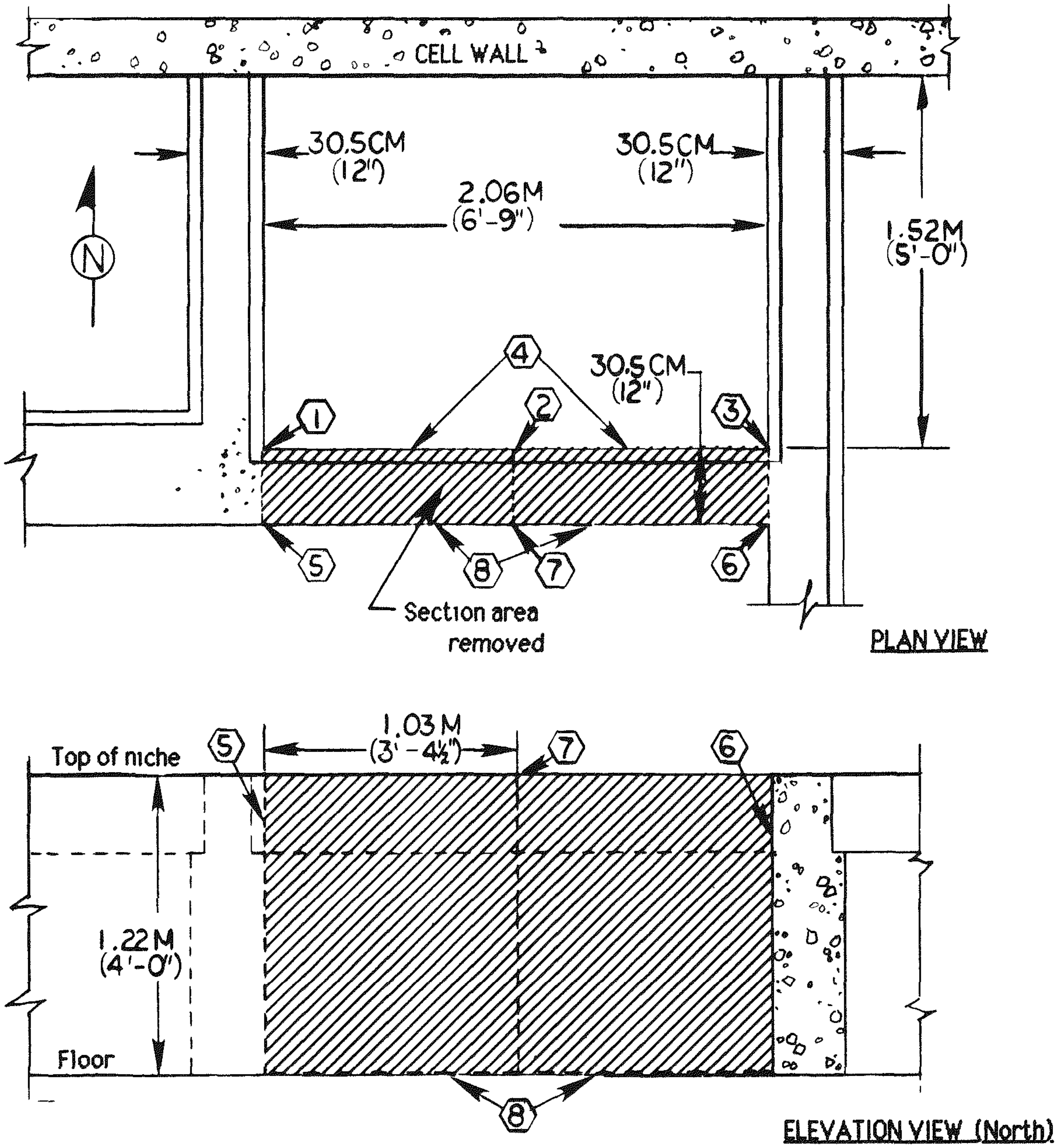


FIGURE 19
Detail of Niche Liner



Notes

1 The sequence of cuts is noted by ⬡

2 The wall was removed in two (2) sections Each section weighed approximately 907 kg (2,000 lbs)

FIGURE 20
UWA Valve Niche Sequence and Location of Cuts

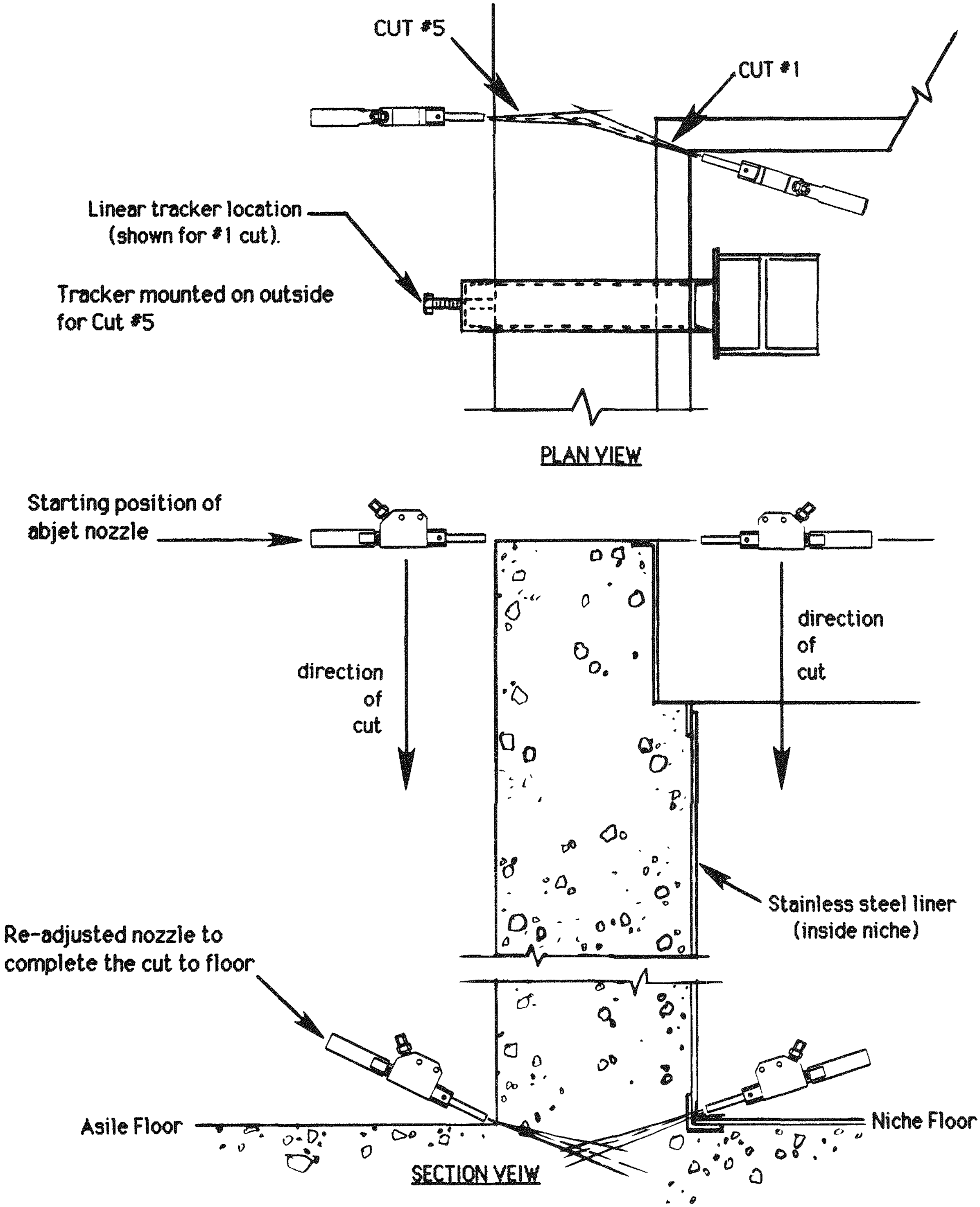


FIGURE 21
UWA Valve Niche Nozzle and Tracker Locations

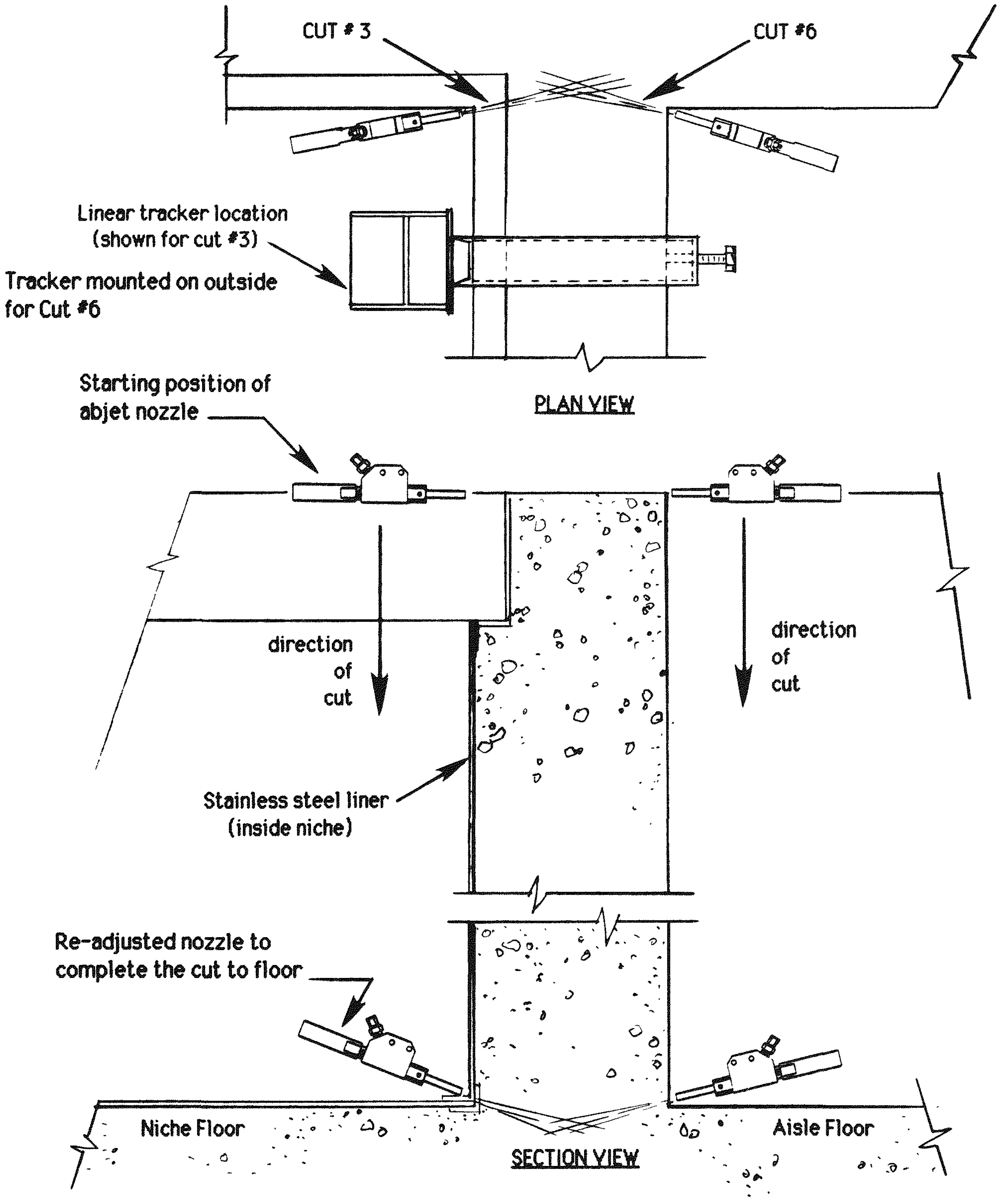


FIGURE 22
UWA Valve Niche Nozzle and Tracker Locations

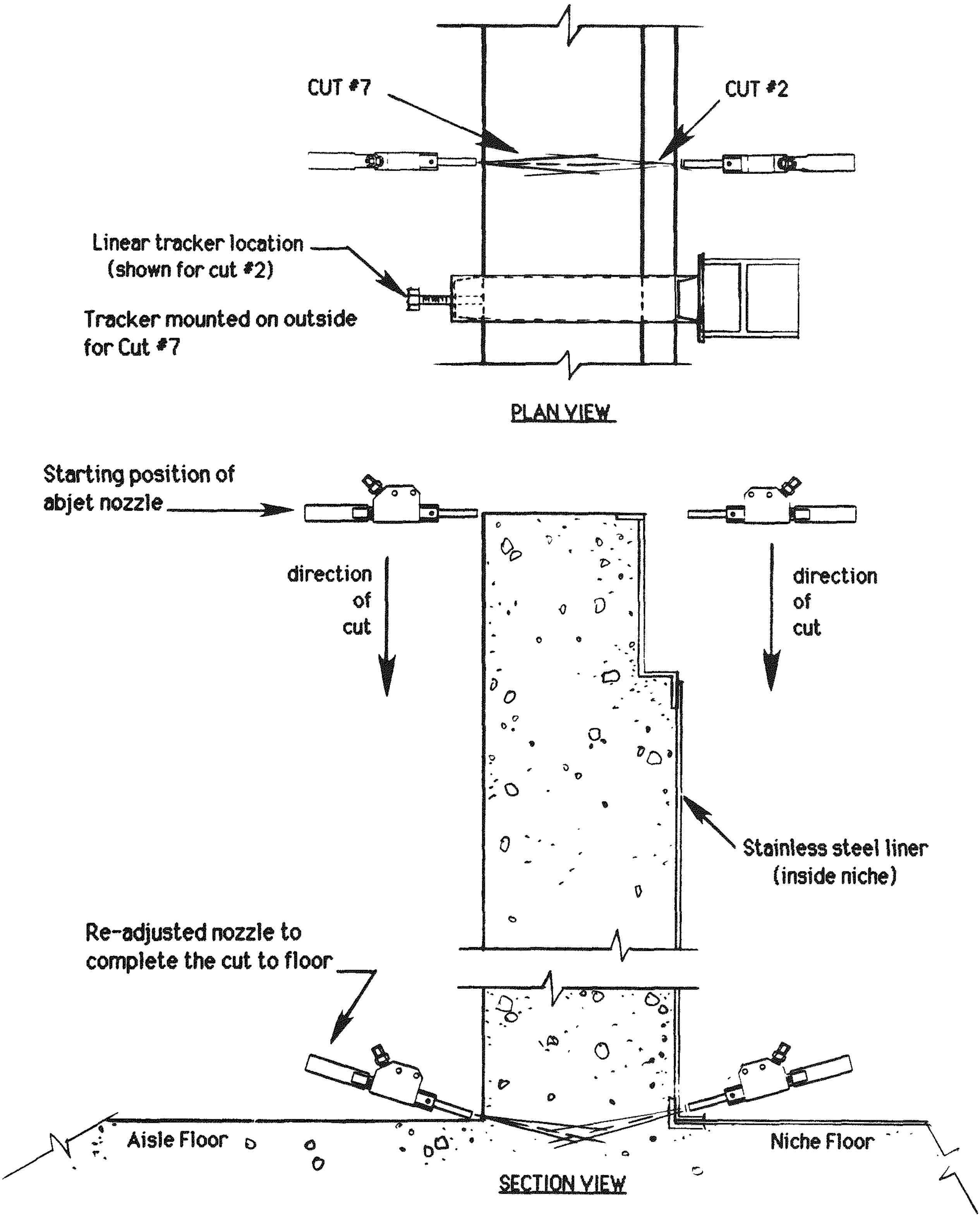


FIGURE 23
UWA Valve Niche Nozzle and Tracker Locations

Table 3

Upper Warm Aisle Valve Niche
Abjet Set-Up and Operation

A. WALL SIZE AND INFORMATION

1) 2.06 m (81") wide x 1.22 m (48") high x 30.5 cm (12") thick [0.8 m^3 (27 ft^3) volume].

2) Calculated weight [high density concrete - 4486 kg/m^3 (280 lbs/ft^3)].

Total wall weight: 3429 kg (7560 lb).
Each block weight: 1715 kg (3780 lb).

3) Wall reinforced with 12.7 mm (1/2") diameter rebar.

4) Niche side of wall lined with 14 gauge stainless steel sheet metal. Inside corners on wall framed with 5.1 cm x 5.1 cm x 6.3 mm (2" x 2" x 1/4") angle iron (embedded in concrete).

B. ABJET NOZZLE SET UP

- 0.81 mm (0.032") diameter orifice [15 ℓ/min (4.0 GPM) water flow].
- 2.29 mm (0.090") inside diameter focusing tube - 7.6 cm (3") length.
- Number 36 garnet grit - 1.4 kg/min (3 lb/min) flow.
- Cutting Rate: 10.2 cm/min (4 in/min) [inside cuts].
  5.1 cm/min (2 in/min) [outside cuts].

C. CUTTING TIME, GRIT AND WATER CONSUMPTION

1) 1.22 m (48") cut inside [10.2 cm/min (4 in/min)].

Cutting time: approximately 12 minutes.
Grit consumption: 16.3 kg (36 lb).
Water consumption: 182 ℓ (48 gal).

2) 1.22 m (48") cut outside [5.1 cm/min (2 in/min)].

Cutting time: approximately 24 minutes.
Grit consumption: 32.6 kg (72 lb).
Water consumption: 363 ℓ (96 gal).

3) 2.06 m (81") cut inside [10.2 cm/min (4 in/min)].

Cutting time: approximately 20 minutes.
Grit consumption: 27.2 kg (60 lb).
Water consumption: 303 ℓ (80 gal).

Table 3 (continued)

Upper Warm Aisle Valve Niche
Abjet Set-Up and Operation

4) 2.06 m (81") cut outside [5.1 cm/min (2 in/min)].

Cutting time: approximately 40 minutes.
Grit consumption: 54.4 kg (120 lb).
Water consumption: 606 ℓ (160 gal).

5) Total Time and Consumption:

Time: approximately 2.8 hours.
Grit consumption: 227 kg (500 lb).
Water consumption: 2536 ℓ (670 gal).

The set up time for this work took about three (3) weeks. The long set up time was influenced by the work conditions at the valve niche location: contaminated area and limited work time due to high temperatures. After the set ups for the cuts were completed, it took approximately three (3) hours of cutting time to remove the wall. In comparison, this project would take 6 to 8 weeks by conventional methods (i.e., jackhammer) to complete.

6.3 Underwater Cutting of Aluminum Canisters

Approximately 700 canisters, presently stored underwater in the Fuel Receiving and Storage (FRS) Pool, were previously used for storage of spent nuclear fuel assemblies. These canisters, fabricated from 6061-T6 aluminum, are cylinders 4.9 m (16') long and 32.4 cm (12.75") in diameter (Figure 24). Handling and support rings [50.8 cm (20") dia. x 15.2 cm (6") high] are attached to the upper end of the canister. The main body of the canister is 3.2 mm (1/8") thick, support rings are fabricated from 6.3 mm (1/4") thick material and the bottom of the canister is 12.7 mm (1/2") thick plate.

With the return of the spent fuel to the owner utility, the canisters are no longer useful and need to be removed and disposed of as LLW. Volume reduction of full sized canisters by compaction is impractical due to the length of the canister. The canisters were therefore cut into six pieces to facilitate compaction with available compaction equipment (Figure 24).

Radiation and contamination surveys were taken on several of the canisters prior to cutting. Radiation levels were found to be 10 mrem/hr gamma at 45.7 cm (18") from the canisters and 250-300 mrem/hr beta at 5.1 cm (2") from the canisters. Contamination levels were found to be in excess of 10^6 dpm/100 cm^2 beta/gamma. The canister cuts are being made underwater to shield personnel from radiation.

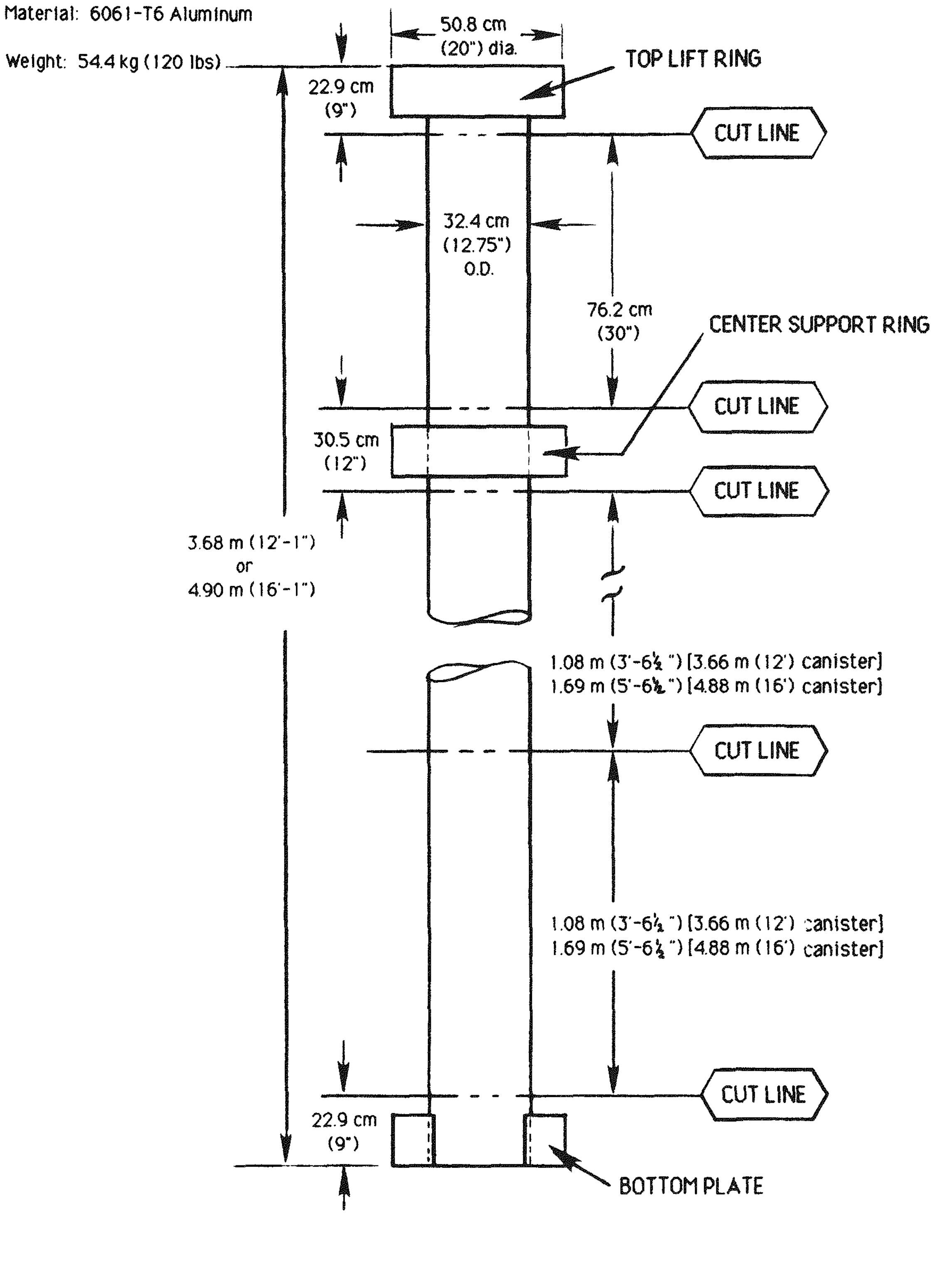


FIGURE 24
Fuel Storage Canister Sectioning Location

A system was designed by WVNS which utilized the UHP system to make the five required underwater cuts on each canister simultaneously. The system is comprised of a tank, a lid, canister rotating wheels, Abjet nozzle support arms and a water flow control system (Figures 25, 26 and 27). The tank is hung from the pool wall and is completely submerged in the pool except for its top 15.2 cm (6"). A door is located on the bottom end of the tank for canister loading (Figure 28). The lid, which is located on top of the tank is connected to the plant ventilation system to provide the operators protection from potential airborne contamination. The lid also prevents splashing of contaminated pool water into the tank. The canister rotating wheels on the bottom of the tank and are driven by a variable speed motor located on the pool wall above the water (Figure 29). Canisters are placed on these wheels and rotated at a rate of 1/2 revolution per minute. The Abjet nozzles are independently mounted on arms that allow the nozzles to be positioned against the canister at the required locations for cutting (Figure 30). Pivot points on the nozzle support arms allow them to be pulled out of the water for maintenance (Figure 31). The water control flow system, which consists of a bag filter and a 378 ℓ/min (100 gpm) pump, removes the cloudy water from the cutup tank during the cutting operation and discharges it into the pool filtration system. As the water is removed from the tank, it is replaced with clear water drawn in from the pool through the canister loading door.

Each Abjet nozzle in this cutting system is setup with a 0.36 mm (0.014") diameter orifice and a 1.52 mm (0.060") inside diameter focusing tube. A number 60 garnet grit [0.41 cm (0.016") average particle grit size] is used for cutting at a rate of 0.45 kg/min (1 lb/min) to each nozzle. The UHP power unit is located outside the building in a heated weather shelter and is connected to the cutup tank with a single high pressure hose. With its location outside, the power unit can be easily moved to other job sites as required. Also, with the power unit outside, there is no chance that it can become contaminated from work being done inside the building.

The cycle time to load a canister into the cutup tank, make the cuts and return the sections back to the pool for storage before compaction is 1 1/2 to 2 hours. The actual cutting time was two minutes. As the personnel become more experienced, the cycle time is expected to be reduced to 1 hour.

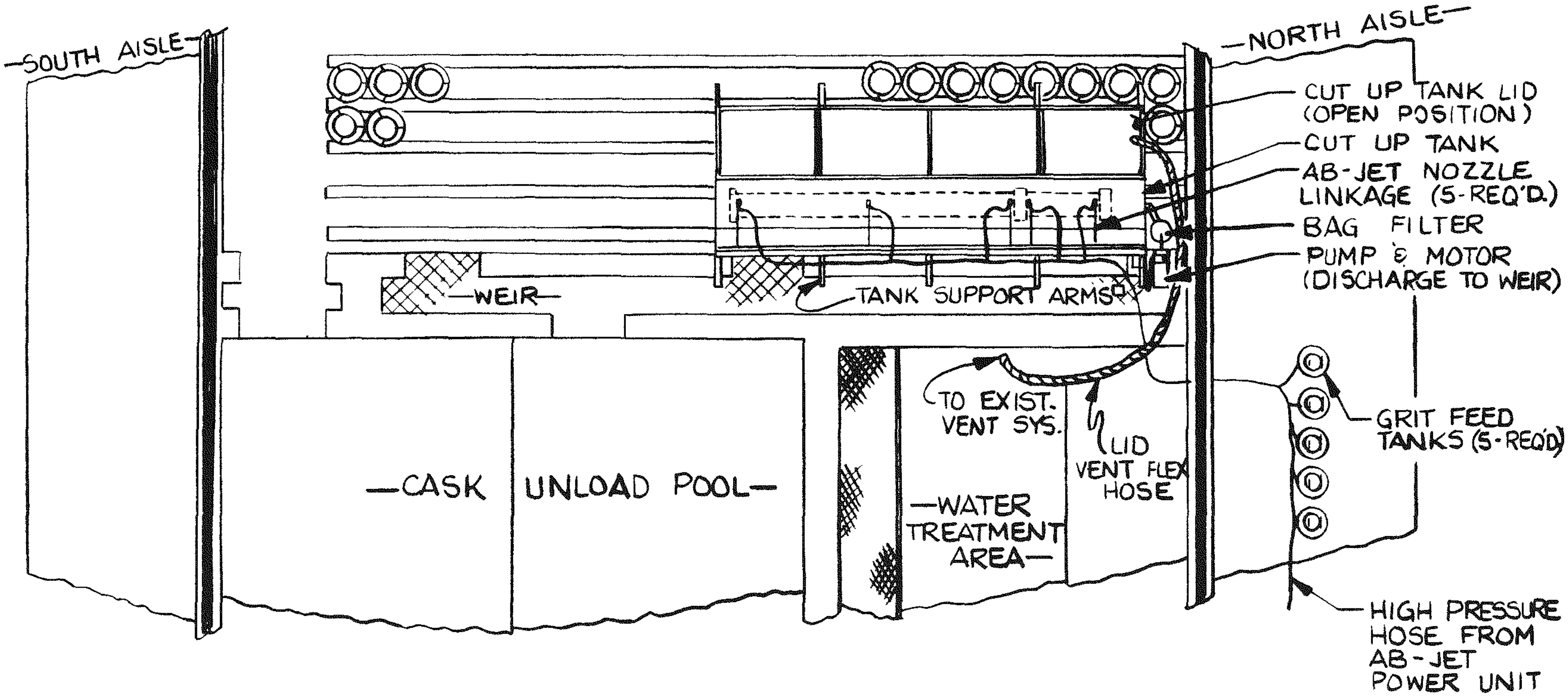


FIGURE 25
Canister Cut-Up Equipment Layout in FRS

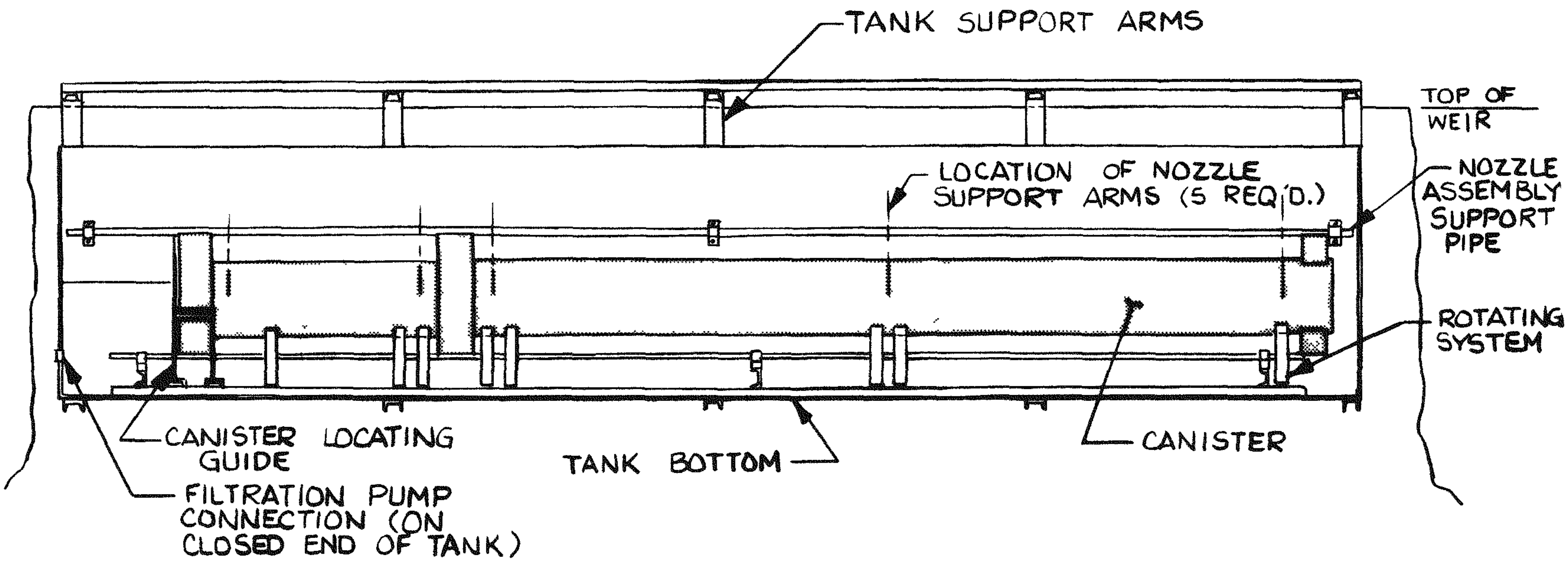


FIGURE 26
FRS Canister Cut-Up Tank Assembly Section View

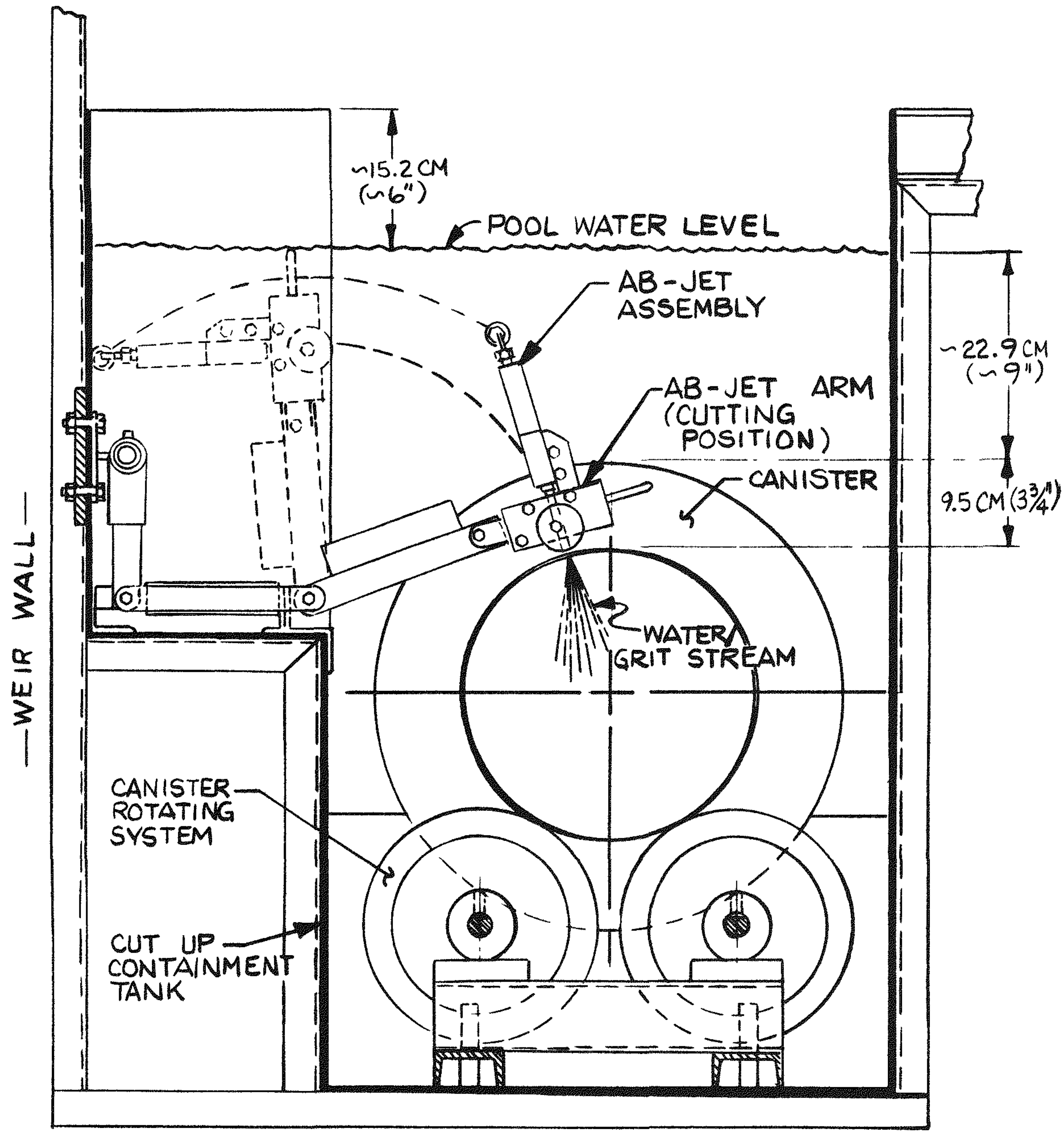


FIGURE 27
FRS Canister Removal Cut-Up Tank Assembly Section View

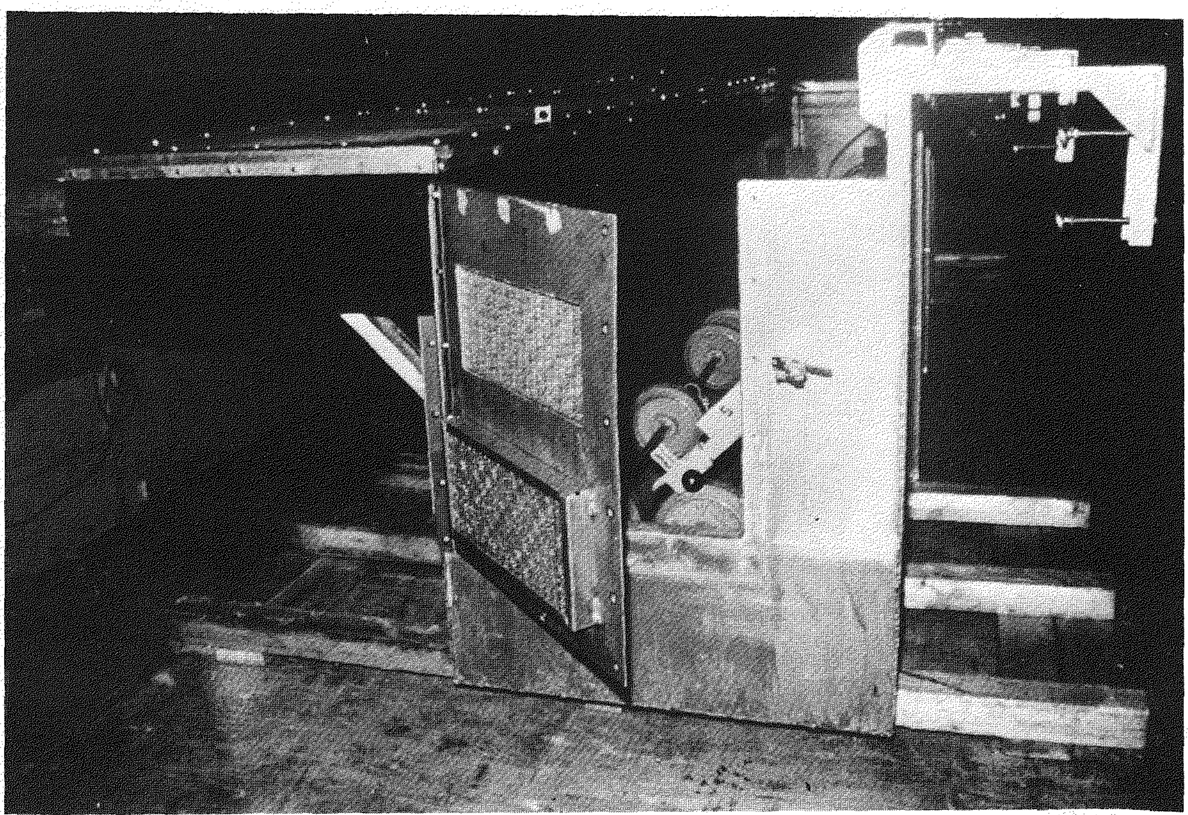


FIGURE 28
Cut-Up Tank - Canister Loading End Door

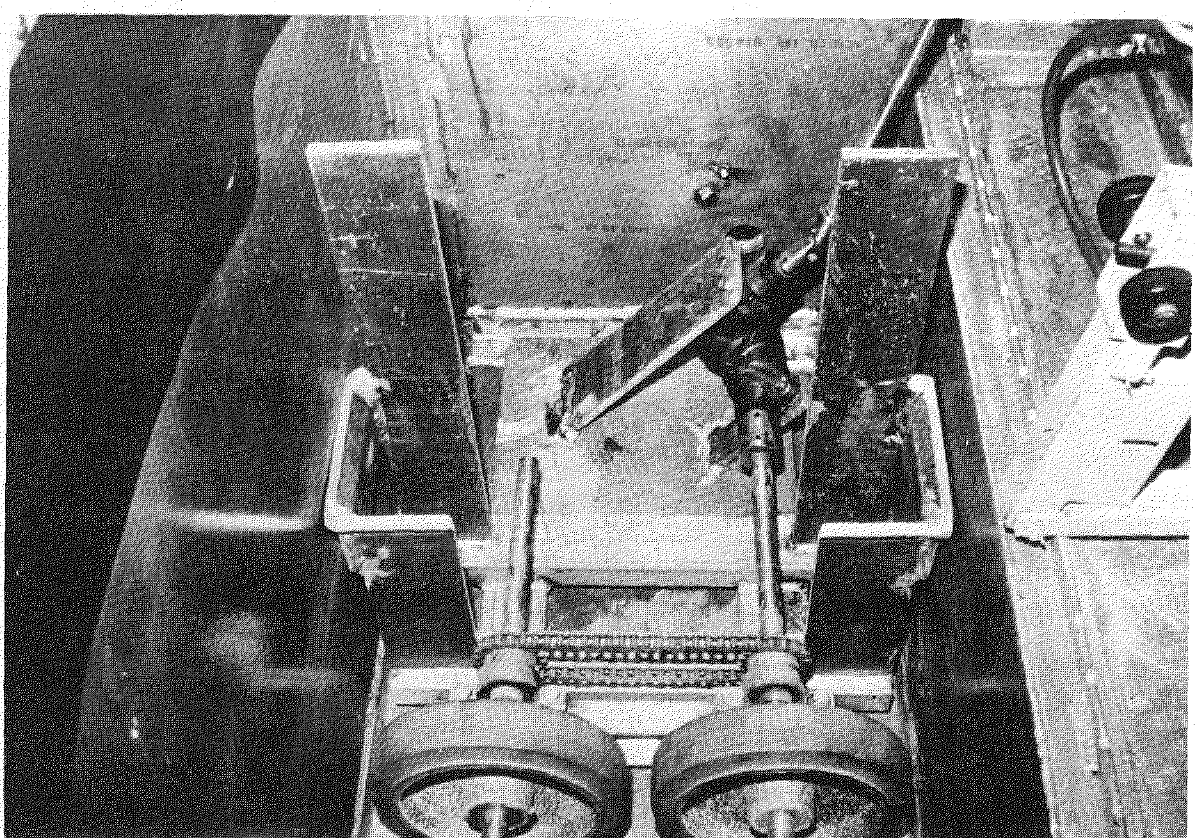


FIGURE 29
Canister Rotation Drive Wheels

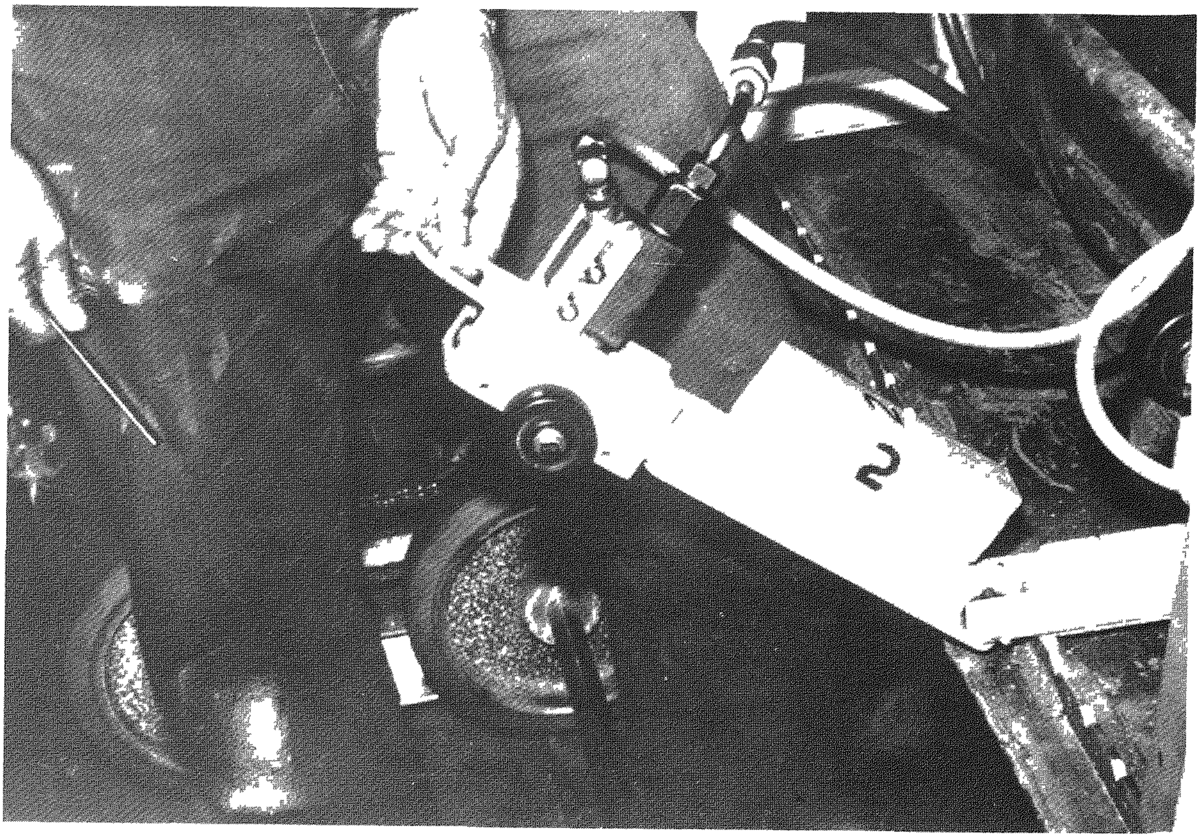


FIGURE 30
Abjet Nozzle Support Arm

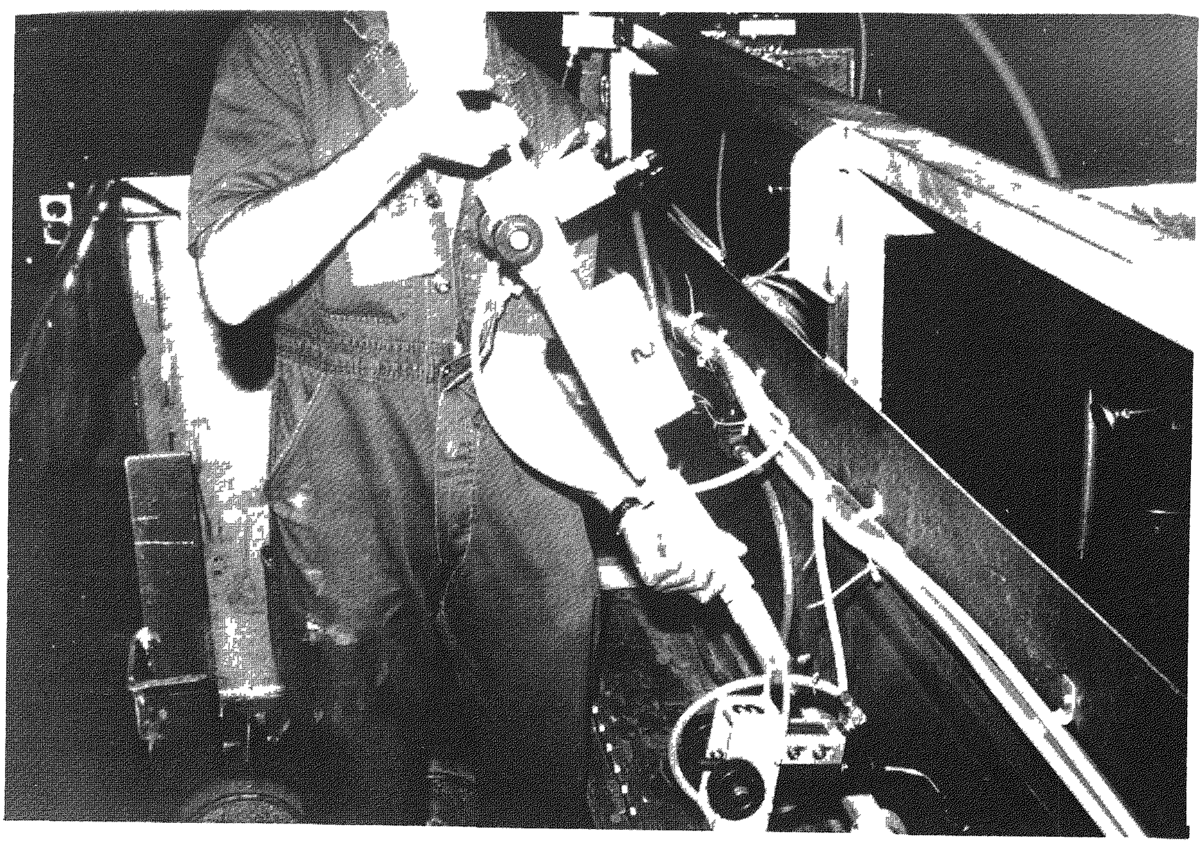


FIGURE 31
Extended Abjet Nozzle Support Arm

7.0 COST OF OPERATION

The cost of completing a project with the UHP system can be divided into three (3) areas: capital equipment, consumable materials and special tooling.

a) Capital Equipment

At the present time, WVNS has approximately $150,000 invested in the UHP power unit and tracker. It is possible to lease the equipment from the manufacturer, but due to the number of projects at WVNS it was cost effective to buy the equipment.

b) Consumable Materials

During the cutting operation materials are consumed and must be replaced. The garnet grit, which cannot be recycled, costs approximately 33-44 cents per kilogram (15-20 cents per pound). The carbide focusing tubes cost approximately $45.00 each and last for about 3 to 6 hours depending on the grit flow rate. The sapphire orifice jewels have a life of 20-40 hours and cost $5.00 each.

c) Special Tooling

The special tooling required for each project will vary. For example, the tracker support hardware and the fork lift supports for the knee brace removal cost less than $1,000; the deflector/collector system for the UWA pipe chase wall cost less than $1500.00. The canister sectioning tank was considerably more expensive (approximately $22,000) due to the size, material and complexity of the design.

8.0 WASTE GENERATED

The waste generated from this type of cutting operation is primarily grit, water and concrete cuttings. All the grit used for the cutting operation is disposed of as waste. The bulk density of the grit is 2243 kg/m^3 (140 lb/ft^3). Four hundred fifty four (454) kilograms (1000 lb) of used grit can be disposed of in a 208 ℓ (55 gal) drum. The concrete cuttings are a fine material and do not add any appreciable volume to the drums. The disposal method for the cutting or clean up water used with the system depends on the area where the work was done. For example, the uncontaminated waste water from the knee brace cutting was collected, sampled and pumped to the ground. The contaminated water from the UWA cuttings was collected, sampled and sent to the LWTS via the floor drains. The water used for canister cutting in the FRS pool is filtered and reused as make-up water for natural evaporation of water from the pool.

9.0 PERSONNEL EXPOSURE

Three (3) of the cutting projects were completed in Contamination and Radiation Control Areas of the plant. The two projects in the UWA involved little exposure since the general background radiation level was generally < 2 mrem/hr. Higher radiation areas existed in the area but the remote operability of the equipment allowed the operators to avoid these areas. The total exposure for the UWA projects was < 50 mrem.

The canister cutting project in the FRS is being performed in an area that has a radiation field of 5-8 mrem/hr, which is the general field over the storage pool. Since the cutting is done underwater with the Abjet nozzles, the operators are not exposed to any additional radiation field from the canisters. Also, since the cutting is done remotely and the actual cutting only takes two (2) minutes to complete, the majority of the operators exposure occurs when handling the canisters in the pool. Plans are presently being made to move this equipment to another location in the pool where a lower radiation field exists.

10.0 LESSON LEARNED

There were no personnel experienced in the use of the UHP equipment when it was received at WVDP. Through training classes, testing and on the job training, experience was gained such that the equipment was effectively used at WVNS for a variety of projects.

The following are specific lessons learned using the UHP equipment at the WVDP.

a) Classroom and hands-on training are important for all personnel involved with the equipment. The amount of power that the equipment possess initially leads to operator concern until it can be replaced by "respect" gained from understanding and use of the equipment.

b) Operating experience is necessary before the operators can effectively use the equipment.

   - Operators had to rebuild Abjet nozzles several times before they could tell if the nozzles were properly aligned.

   - Cutting with the Abjet nozzle involves both sight and sound, particularly when cutting dissimilar materials like steel reinforced concrete. When rebar is encountered while cutting through concrete at a maximum cutting rate, the water stream is deflected back out of the kerf. When this occurs, it is an indicator to the operators that the cutting rate must be reduced to allow cutting of the rebar. The operators can only be trained for this kind of operation through experience.

c) During Abjet cutting operations, a mist is generated and must be controlled in a Contamination Control Area. Simple demisting systems have been effective in controlling the mist such that the airborne contamination has not been a problem.

d) After the UHP jet stream cuts through the required material, it still possesses a considerable amount of energy which could potentially damage other surfaces it comes in contact with. Precautions must be taken to protect these surfaces. The following precautions were made for the UHP projects:

1. During the knee brace removal, the concrete walls on each side of the brace were protected with 14 gauge sheet metal.

2. The UWA pipe chase cut out used the 25.4 mm (1/2") thick steel collector/deflector frame located about 5.2 cm (6") from the wall to stop the jet stream.

3. During the valve niche wall removal, the back concrete wall was protected with 14 gauge sheet metal.

4. When cutting the aluminum canisters underwater, the water inside the canisters absorbed the energy of the jet stream and no other protection was required.

Before undertaking a cutting operation, tests should be conducted simulating cutting conditions to determine the amount of protection that is required.

e) The aluminum canister underwater cutting process produced a significant amount of cloudiness in the pool water. This was caused by "dust" in the grit, particles of pulverized grit from cutting and the aluminum oxide film on the canisters being cut. The 25 micron bag filter on the water flow system plugged after three (3) canisters were cut. A 100 micron bag would last longer but would not give satisfactory filtering results. Since the manual change out of the bag filter is time consuming and limits the canister cutting operation, a self backwashing 25 micron filter system has been installed.

f) The "dust" in the grit created another problem with the underwater cutting of aluminum canisters. The "dust" would collect in the abjet nozzle body and in the grit feed tube causing the grit feed tube to plug and the flow of grit to the nozzle to stop. Until washed grit becomes available from a supplier, the plugging problem has been minimized. A low pressure water flow is put through the nozzles before they are placed underwater for cutting and is left on after the cutting is completed until the nozzles are taken out of the water. This prevents the pool water from back flowing up the grit feed line and wetting the interior surfaces that collect the grit "dust".

g) Suppliers of the grit do not necessarily use the same grit size system; therefore, grit should not be purchased by "grit size" alone. The average required particle size should also be included. The grit sizes referenced in this report are shown in Table 4. The size of the grit being used on a cutting project is important since the size of the Abjet nozzle focusing tube and the grit flow orifice plate are both directly dependent on this size.

11.0 FUTURE PROJECTS

The successfully completed projects at the WVNS site have gained plant wide acceptance for the UHP system. As a result, it is being considered for use in numerous other projects. The following is a list of some of the projects planned:

a. Cut 13 holes in a 61 cm (24") thick concrete vault roof. These will be a variety of round and rectangular holes varying in size from 76 cm (30") in diameter to 162 cm (64") in diameter. The steel reinforcing rebar of this concrete roof is 19 mm (3/4"), 25.4 mm (1") and 34.9 mm (1 3/8') diameter.

b. Remove two 2.44 m (8') diameter x 2.44 m (8') high concrete pedestals from within the contaminated Chemical Processing Cell (CPC).

c. Section test borosilicate glass logs from the vitrification system. These are 56 cm (22") diameter x 3.05 m (10') high cylinders encased in steel.

d. Decontaminate surfaces in the CPC.

Table 4

GRIT SIZE TABLE

	AVERAGE PARTICLE SIZE	
GRIT NUMBER	INCHES (in)	MILLIMETERS (mm)
4	.2577	6.545
6	.2117	5.377
8	.1817	4.615
10	.1366	3.469
12	.1003	2.547
14	.0830	2.108
16	.0655	1.673
20	.0528	1.341
24	.0408	1.036
30	.0365	.917
36	.0280	.711
46	.0200	.508
54	.017	.432
60	.016	.406
70	.0131	.333
80	.0105	.267
90	.0085	.216
100	.0068	.173
120	.0056	.142
150	.0048	.122
180	.0034	. 86
220	.0026	. 66
240	.00248	. 63
280	.00175	. 44
320	.00128	. 33
400	.00090	. 23
500	.00065	. 17
600	.00033	. 8

12.0 ACKNOWLEDGEMENTS

The following group should be recognized for their assistance in the successful use of the UHP equipment at the WVDP.

a) Fuel Handling Operators: This group of talented operators has setup and operated the UHP equipment for all of the projects discussed in this report. Without their extra efforts, the UHP projects would have been more difficult to complete. They showed dedication to perfection, willingness to overcome obstacles, and understanding of equipment operation. All of these things contributed to the successful completion of each job.

b) Radiation Safety Technicians: The technicians that have assisted with these projects have contributed many meaningful and valuable suggestions. They have had a direct effect on keeping the exposures as low as reasonably achievable and the contamination contained.