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REMOTE OPERATION OF DEFENSE WASTE PROCESSING FACILITY SAMPLING STATIONS

by

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REMOTE OPERATION OF DEFENSE WASTE

PROCESSING FACILITY SAMPLING STATIONS

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ABSTRACT

A full-scale liquid sampling station mockup for the Defense Waste Processing Facility (DWPF) at the Savannah River Laboratory (SRL) demonstrated successful remote operation and replacement of all valves and instruments using master/slave manipulators in a clean atmosphere before similar stations are placed in a radioactive cell (Fig. 1). Testing of the sample stations demonstrated the limitations of the manipulators which resulted in minor design changes that were easily accomplished in a clean cell. These same changes would have been difficult and very costly to make in a radioactive environment.

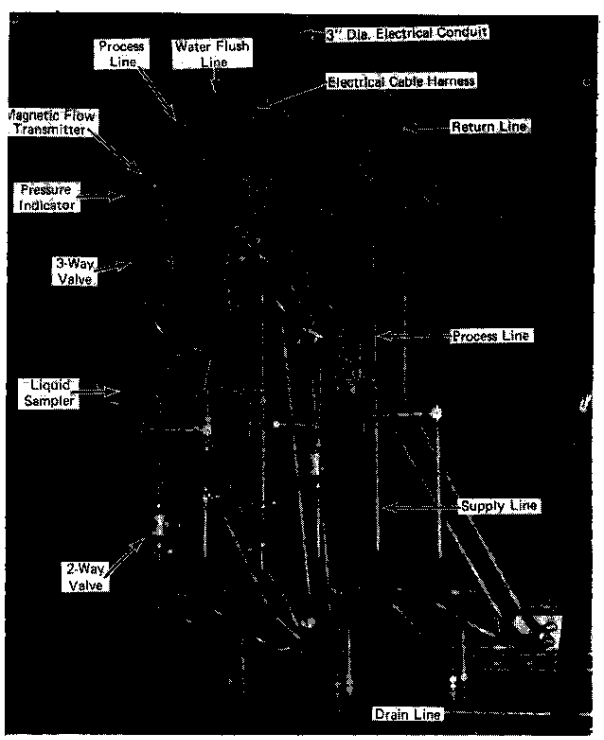

Fig. 1. Prototype sampling stations.

INTRODUCTION

The DWPF is being designed in conjunction with Bechtel National, Inc., and is currently under construction at the Savannah River Plant (SRP). In DWPF, an immobilization process solidifies radioactive waste sludge by vitrification into a leach resistant borosilicate glass. After the mixture of waste and glass solidifies, it will be placed in stainless steel containers for eventual transportation to an offsite federal repository.

Liquid sampling stations have been designed to sample the contents of all radioactive chemical process tanks in the DWPF. The liquid sampling cell contains twelve sampling stations that remotely obtain samples from twelve vessels. During sampling, a pump in each tank provides continuous circulation of waste to a corresponding sample station and back to the tank.

Each sample station contains a process, supply and return line. In addition, the stations that sample radioactive sludge are equipped with a water flush line (Fig. 1). After each sludge sample is obtained these stations are flushed with water to inhibit line pluggage. The water is introduced into the process line and flows through the supply and return lines back to the tank from which the sample was taken. After the lines are cleared the sampling valve is flushed to remove residual waste. If a line becomes plugged and the water flushing fails to dislodge the blockage two options are available: if the plug is in the supply or return line, the process line can be connected to the spare supply and return lines that are provided with each station; if the process line becomes permanently blocked, it can be removed and be replaced with a new line.

DEVELOPMENT OF DESIGN CRITERIA

Three design factors were considered when choosing valves, instruments, and materials of construction: environmental durability,

operational interference, and system maintenance. The design criteria that evolve from these factors include the following:

Electrical Design Criteria:

1. Withstand radiation doses of 10^8 ergs (10^6 rads), gamma exposure.

2. Withstand 50 weight percent nitric acid fumes from cleanup solution.

3. Withstand a maximum temperature of 49°C.

4. Maintain minimum interference with manipulator operations.

5. Provide optimum accessibility of electrical connectors and components for manipulator operation.

Items 1 through 3 contain the maximum environmental conditions that may exist during normal operation and therefore set the tolerable parameters for the equipment in the sampling stations. The operational interference constraint involved obtaining electrical equipment with physical properties (minimum size, configuration, operating method, mounting versitility, etc.) that minimize interference with the manipulators' ability to operate and dismantle the stations, while meeting the environmental constraints.

The operational accessibility constraints consisted of designing size, shape, location and configuration of brackets that support limit switches, electrical connectors and cable harnesses. Cable routing and trouble shooting adjacent stations was also a factor considered in specifying cable lengths.

Special attention was given to the unique top cell entry of electrical cable. This not only had to meet the interference guidelines but also required testing to ensure that the manipulators could perform in-cell replacement of the cable. Each station in the cell is supplied by a 3" conduit which enters through the top of the cell and terminates 4" above the station on its vertical centerline (Fig. 2). The power and instrument cables are alternated between the conduits for isolation to prevent induced noise on the signal leads. Thus, due to the design of one conduit per station, each cable must be capable of supporting its immediate station and an adjacent station.

Mechanical Design Criteria:

1. Process lines must be 0.3 m (12 in.) apart.

2. Height of sample stations must not be more than 1.3 m (4 ft 2 in.).

3. Distance from back wall of cell to connection of process line with supply and return lines must be 0.2 m (8 1/4 in.).

4. Bend radius of the 1.9 cm (3/4 in.) stainless steel tubing is 4.4 cm (1 3/4 in.).

5. Valves and instruments had been specified.

6. E-Type manipulators must be used.

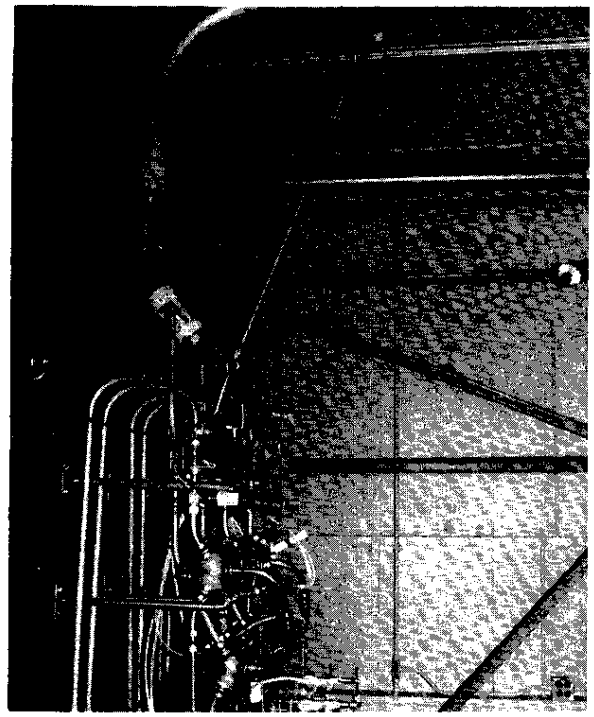

Fig. 2. Stations with conduit and hoist.

7. Process and water flush lines must break down into sections no longer than 0.6 m (2 ft).

8. Sampling valves should be independently replaceable.

Items 1 through 4 were determined primarily by the available space in the cell and the limited motion of the manipulators. A sample station located directly between two cell windows will be the most difficult for the manipulators to operate and disassemble (Fig. 3). The maximum reach of Sargent Ind. - Model (TM) E manipulators is 292 cm (115 in.) and the minimum reach is 126 cm (49.5 in.). Therefore, testing of the manipulators was important to determine if they could reach and operate each component in the center location despite the difficult angles and extensions involved. The sampling valves have a small diameter needle assembly through which the sample is extracted; thus the possibility exists that frequent blockage can occur in the valve

process lines. Therefore it is desirable to be able to replace the sampling valves with minimum down time if they become permanently plugged. A transfer case is used to move equipment into and out of the cell. Due to the size of the transfer case, the maximum length of any section is 0.6 m (2 ft). These sections can weigh as much as 22.7 Kg (50 lb) which introduces another consideration. The manipulators, having a weight lifting capacity of 11 Kg (25 lb), require additional assistance in lifting the sections during equipment change-out.

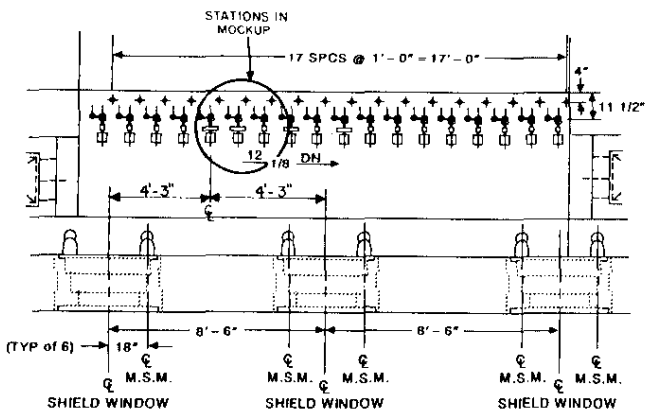

Fig. 3. Sample cell - general arrangement.

Sample station design was completed using these criteria. The stations were fabricated and the prototype was prepared for testing.

VERIFICATION OF DESIGN

Three of the twelve sampling stations were fabricated and mounted on a portable rack. The unit was aligned in the clean cell such that one station was located directly between two cell windows. An overhead crane was positioned directly in front of a sample station and 0.6 m (2 ft) from the back wall. The overhead crane was used to simulate the in-cell hoist available in the liquid sample cell (Fig. 2).

Testing was performed for physical interferences, operability of valves, assembly and disassembly of each station, and accessibility of electrical connectors. All valves and instruments were accessible and operable by the manipulators. While all electrical connectors on valves and instruments were accessible, some were relocated during testing to avoid interferences. Procedures were written for replacement of all station equipment as each station was disassembled and reassembled.

The electrical supply cable replacement required testing due to its unique design (Fig. 4). Replacement of damaged cable is accomplished using the manipulator to simultaneously pull the damaged cable and the new cable through the conduit. The attachment of the new cable to the damaged cable is made by hand on the cold side. As the damaged cable is pulled into the cell the new cable is pulled into place. Then the attachement is disconnected and fitted into the adapter on the end of the conduit. The cable harness from the valves and instruments is then connected to the new cable while the damaged cable is coiled up and placed in a box for disposal.

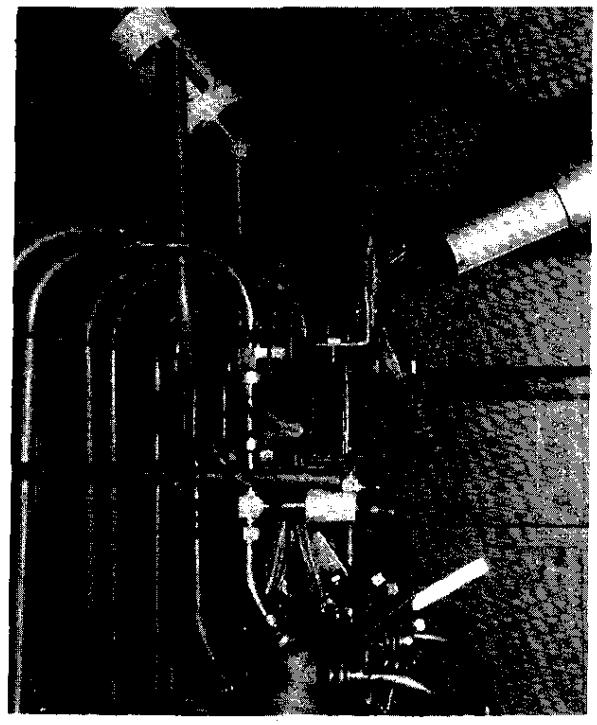

Fig. 4. Manipulator replacing cable.

TEST RESULTS

Clean cell testing of the liquid sampling station was very important in revealing many unforeseen problems. Changes were made to the design and location of the elctrical connector brackets which reduced interferences with manipulator operations. Testing of cable replacement showed that a change in the conduit routing was needed. The conduit directly above the stations was bent to a 45° angle to allow for manipulator access of the cable as shown in Fig. 4. These changes greatly enhance the ability of the manipulator to dismantle, reassemble and operate the sampling stations.

The 3-way valve handle was redesigned twice before a suitable arrangement was obtained. These changes produced handles that are easier for the manipulator to reach and operate.

Testing demonstrated the need to use the in-cell hoist for replacement of all equipment except the sampling valve. The weight of the station sections exceeds the weight lifting capacity of the manipulators so changes were made to aid in disassembling and assembling the stations (Fig. 5). Lifting tabs were added to the flow meters, 3-way valves and 2-way valves. Using these tabs, the hoist can remove any section from a station and place it on the floor of the cell for repair. The hoist is located 30 cm (12 in.) in front of the sample stations making it difficult for the manipulators to push the repaired sections back into place, align the tubing and tighten the fittings. Therefore station supports were placed in the process lines under the 3-way valves and the flow meters. The manipulators can push the sections back so they rest on the supports and the hoist cable can be loosened to prevent it from pulling the section forward and off the supports. While the section rests on the supports the manipulators can align the tubing and tighten fittings without having to support any weight.

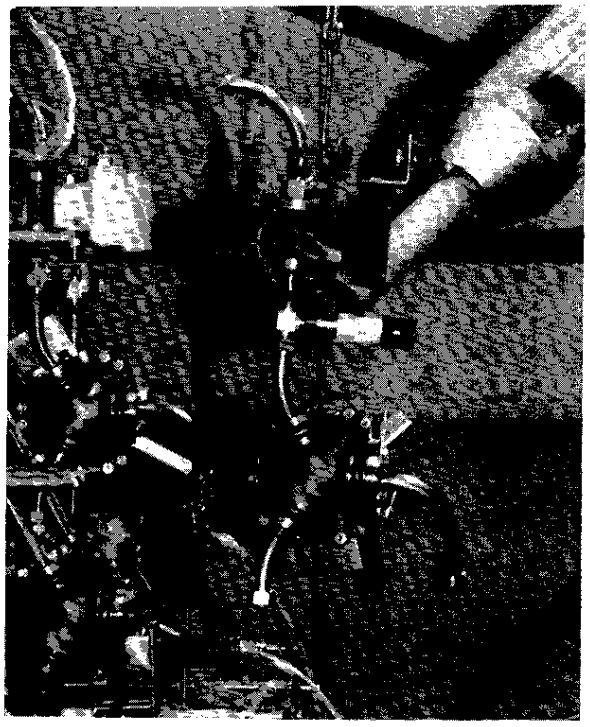

Fig. 5. Section replacement using manipulator and hoist.

Preliminary testing was performed without gauntlets on the manipulators. After preliminary testing, gauntlets were placed on the manipulators and several problems were disclosed. The lining of one gauntlet rolled up in the manipulator and would have caused severe problems had this occurred in a radioactive cell. Subsequently, plastic shields were added to the manipulators and the diameter of the gauntlets was increased to fit over the shields.

Another problem surfaced when the gauntlets prevented the manipulator fingers from completely closing (Fig. 6). The minimum obtainable gap between the fingers was 1/2" which made it very difficult for the manipulator to grasp and use the tools needed for dismantling. Five convolutions exist in the hand of the gauntlets and at least two convolutions will be removed to allow complete closure of the fingers.

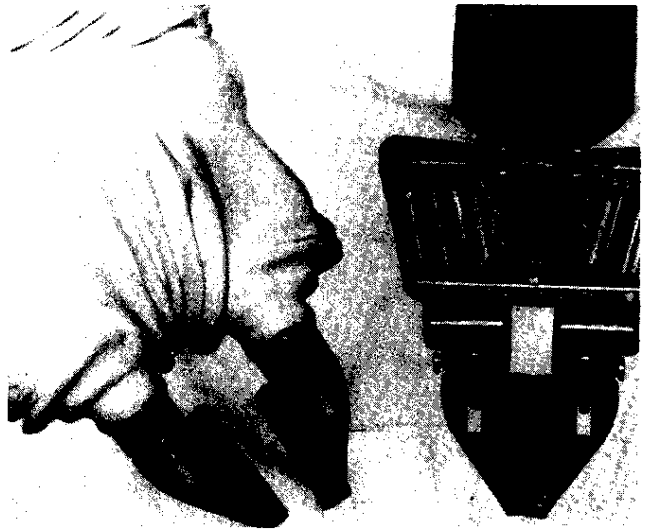

Fig. 6. Manipulator fingers.

CONCLUSION

Corrections for all design inadequacies were easily achieved in the clean cell mockup. Thus the clean cell mockup proved to be very important in revealing modifications that would be costly and time consuming if made in a radioactive environment.

ACKNOWLEDGMENTS

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