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A REMOTELY REPLACEABLE AND TESTABLE OFF-GAS FILTER SYSTEM FOR THE NWCF

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ABSTRACT

The process off-gas filter system designed for use in the New Waste Calcining Facility (NWCF) requires remote filter removal, replacement and in-place DOP testing. A series of full-scale mockup tests, modifications and retesting at the Remote Maintenance Development Facility (RMDF) resulted in a system in which a commercial High Efficiency Particulate Air (HEPA) filter can be installed, tested for leaks, operated and removed from a sealed filter housing using remote handling methods. This paper describes the development, testing and results of this effort.

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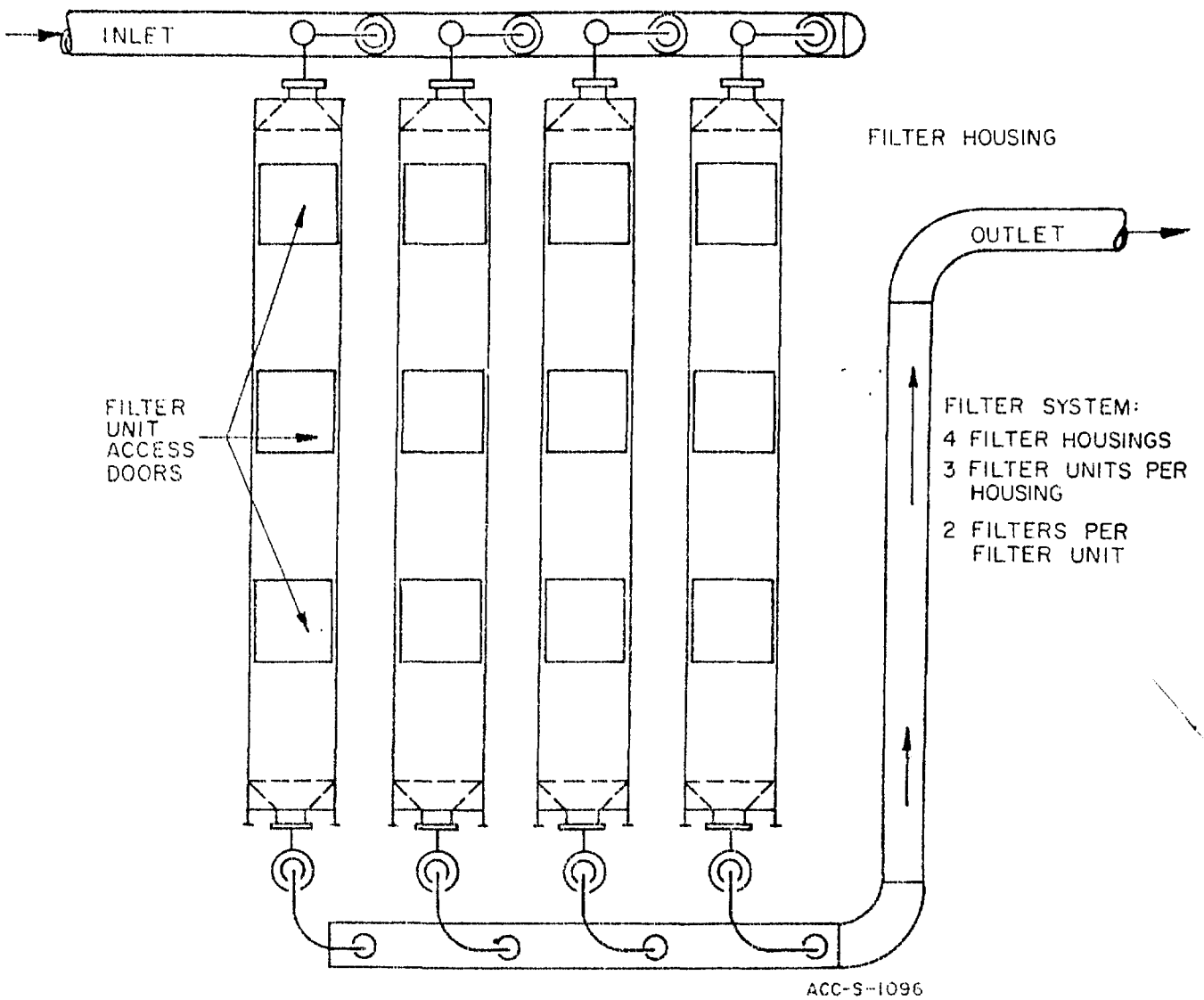
INTRODUCTION

The NWCF process off-gas filter system is designed to include remote handling capability. The RMDF was used to proof test full-scale mockups of the NWCF off-gas filter housings.

As designed by the architect engineer, the NWCF off-gas filter system consists of four parallel flow filter housings (Figure 1), each approximately 6.1 M x 1.2 M x 0.6 M (20 ft x 4 ft x 2 ft). Each housing contains three filter units in series. Each unit contains two parallel flow filters and a DOP leak testing system for each filter. A door at the front of each filter unit permits access for replacement of the filters and the associated equipment. Each housing can be isolated from the off-gas system for filter change out and maintenance by closing valves mounted in the upstream and downstream plenums. Off-gas flow through the filter housing is from top to bottom.

Maintaining the off-gas filter system requires the following remote operations:

1. Opening, closing and sealing the door
2. Making and breaking the filter-to-housing seal



NWCF FILTER SYSTEM

Figure 1

3. Removing, replacing and transporting the filters
4. Removing and replacing the housing door for door seal replacement or for housing access
5. Removing and replacing the filter elevator assembly
6. In-place DOP leak testing.

DEVELOPMENT AND TESTING

Developing and testing the NWCF process off-gas filter system began with a slightly modified commercially available filter housing (Flanders Filters Inc. model E-2) which simulated one filter unit (Figure 2). The remote testing was done using a wall-mounted electromechanical manipulator (PaR 2000) and a 2-ton crane. An electric impact wrench was used for bolts and to operate the filter sealing mechanism. Initial test results with the commercial housing were poor, making major rework of the filter housing necessary. However, the tests were very valuable in detecting and identifying problem areas, information which was useful in and necessary for design modifications. As design and testing progressed, a series of modifications was necessary to develop equipment and demonstrate techniques for remotely replacing and transferring the filters. These modifications included changes to the door assembly, the elevator assembly and the combination filter cover and transport fixture. Door modifications included replacing the swing-away bolts with captive bolts and nuts, adding a flexible door handle to prevent binding during handling, and modifying the door support arms for easier door removal.

The elevator assembly was strengthened, and the elevator actuator bar was modified to accept a socket wrench that could be used with the impact wrench. The filter cover and transport fixture was changed from

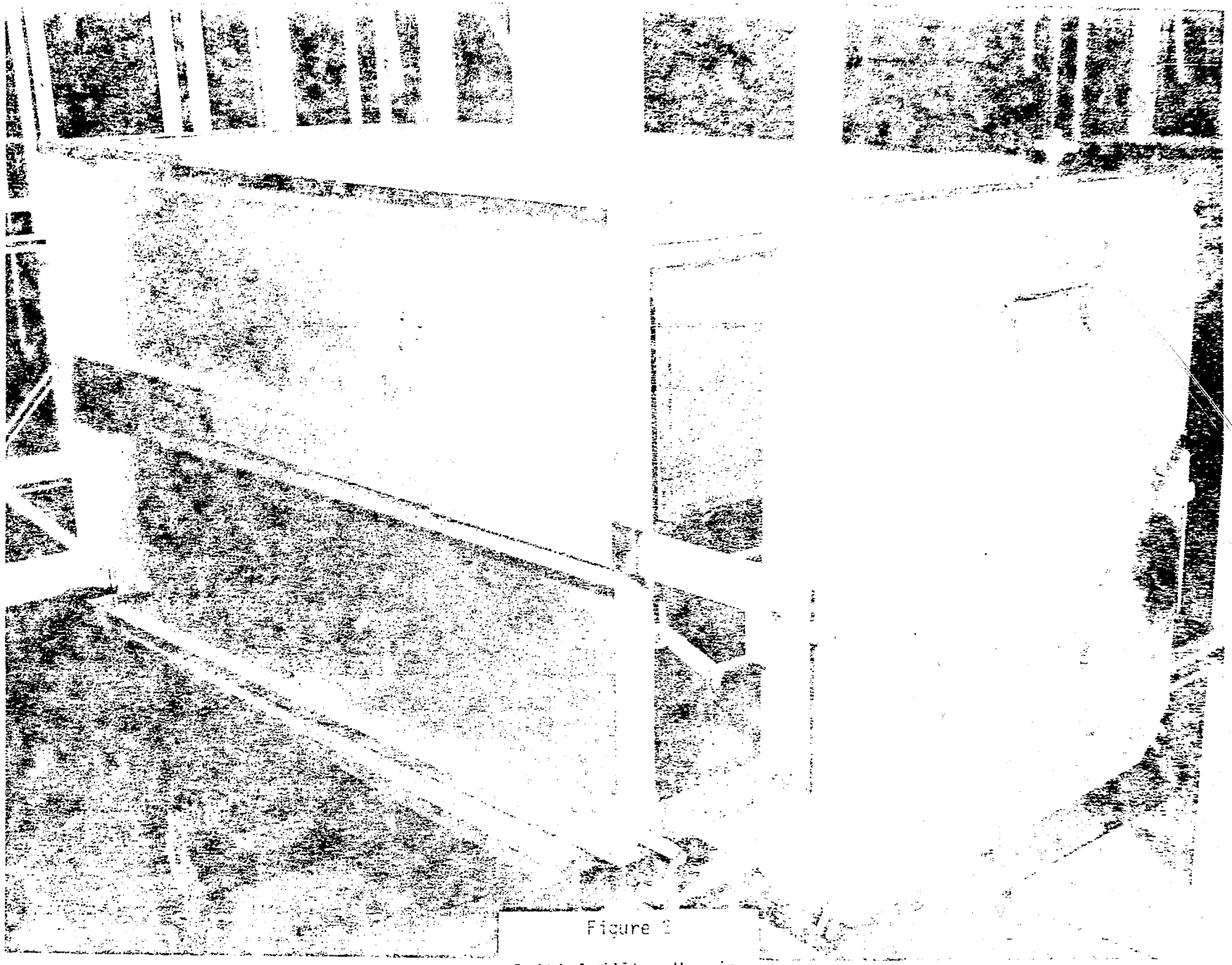


Figure 2

Initial Filter Housing

[illegible] slip-on unit to one that could be placed on top of the filter and clamped to the filter frame. Flexible bails were also installed on the elevator assembly and on the filters. The flexible bails on the filters eliminated the need for a special tool that had been used to pull the filters forward into position for [illegible] 1. The bails also provide a positive (Figure 3) link between the manipulator and the filter and in addition give visual indication of the direction of force being applied. Being able to see the direction of force essentially eliminates any binding problem while pulling the filters forward.

Once completed, the modifications made the work easier and simpler, and also matched the remote tasks to the capabilities of the remote equipment. After testing the commercial filter housing, which was constructed of 14 gauge stainless steel, a housing capable of withstanding the NACF operating pressure ([illegible] kPa) was designed, fabricated and installed in the [illegible], and remote handling tests on these modifications were continued.

In addition, ductwork and a blower were added to permit in-place DOP leak testing (Figure 4). Because of the housing configuration and the lack of sufficient space, conventional DOP test methods could not be used with the housing and special air sampling methods had to be developed which would fit and operate in the limited space between the NACF filters.

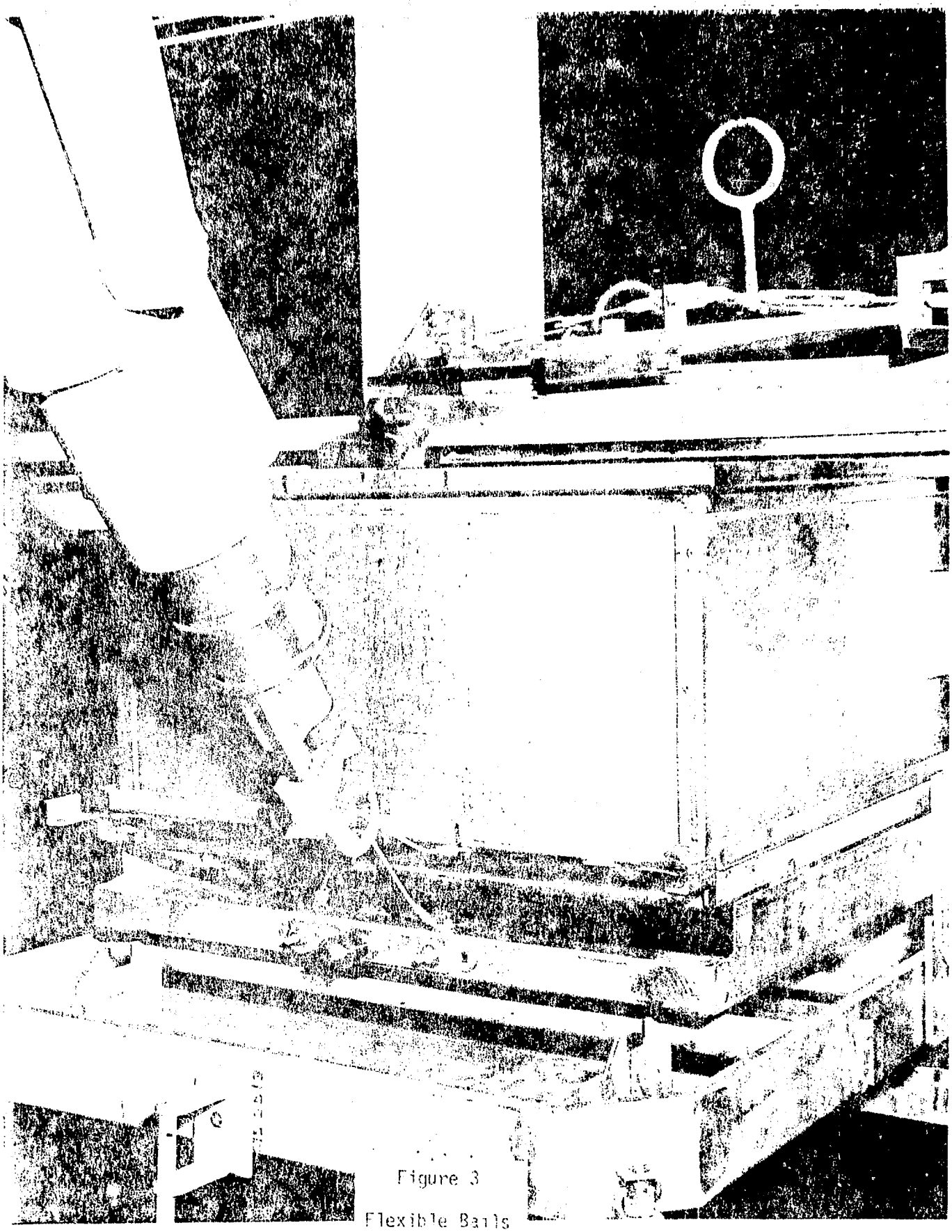


Figure 3

Flexible Rails

Some of the problems associated with the in-place testing of the HEPA filters that had to be solved included:

1. Even distribution of the challenge medium across the inlet side of the filter.
2. Collection of representative samples downstream of the filter.
3. Remote operation of the DOP test equipment.

A diagram of the DOP test equipment is shown in Figure 5. The test assembly consisted of the mockup housing, blower, DOP injection and dispersal apparatus, sample lines and a flow collector downstream of the filter (Flanders Filters Inc. "crab trap").

Conventional industry leak testing methods require DOP aerosol injection 7 to 10 duct diameters upstream of the filters to achieve an equal dispersion of the aerosol across the face of the filter. Sample probes near the face of the filter and 12 to 15 duct diameters downstream of the filter are used to check DOP concentration before and after filtration.

Federal regulations require each filter to be leak-tested in-place before being utilized in the system. Because the NWCF filter housing does not provide space to use conventional methods, tests were conducted at the RMDF to develop and demonstrate a method to do in-place remote testing of the filters. The DOP aerosol was mixed with air and released in the housing immediately above the filter (0.4 m) at 20% of design flow. To achieve even dispersion over the entire surface of the filter, it was necessary to baffle the flow. A cone installed over the end of the injection duct served as the baffle (Figure 6). Without the baffle the test particulate would stream into the filter directly below the duct outlet. The baffle method produced excellent distribution

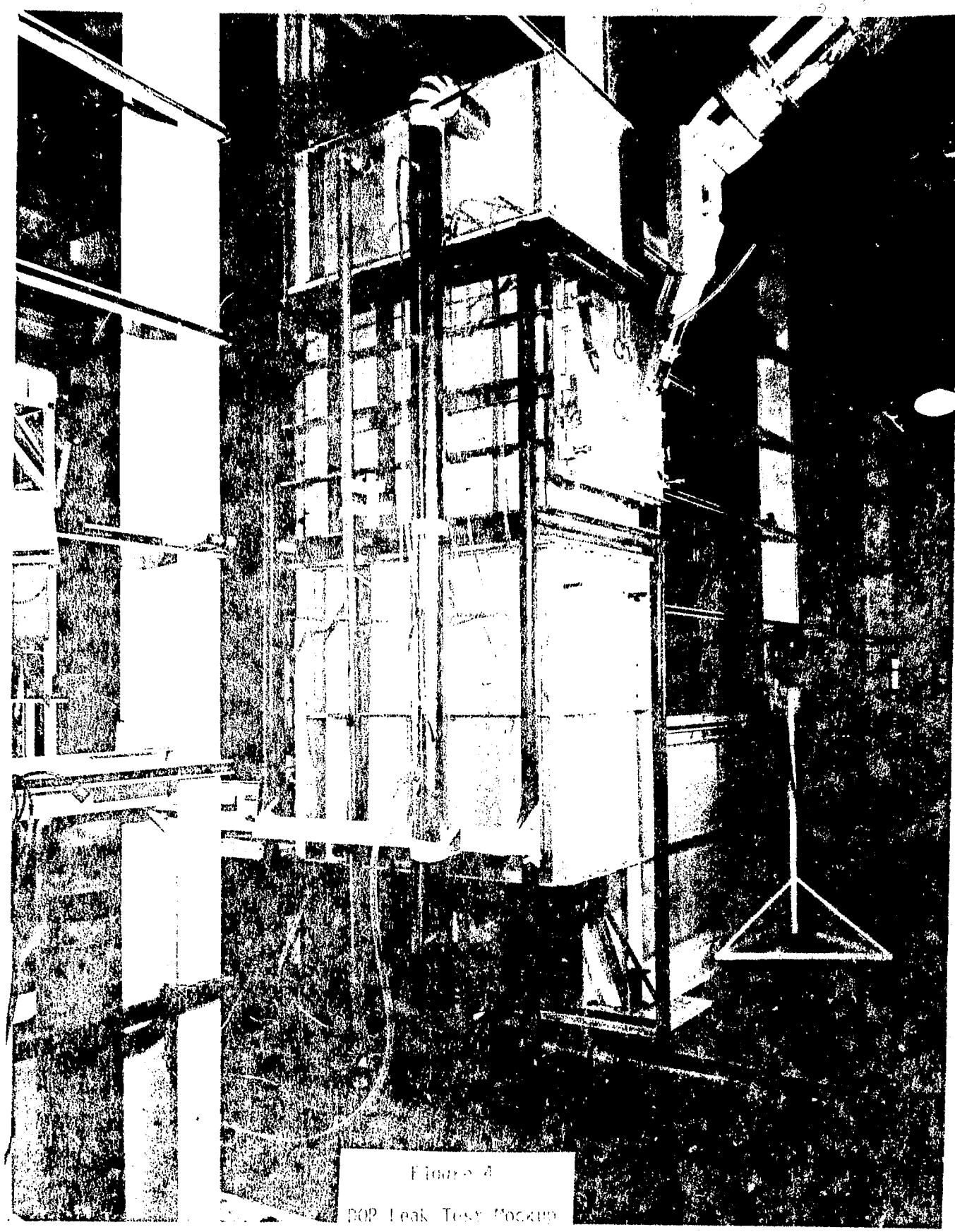


Figure 4

BOP Leak Test Package

NWCF FILTER HOUSING

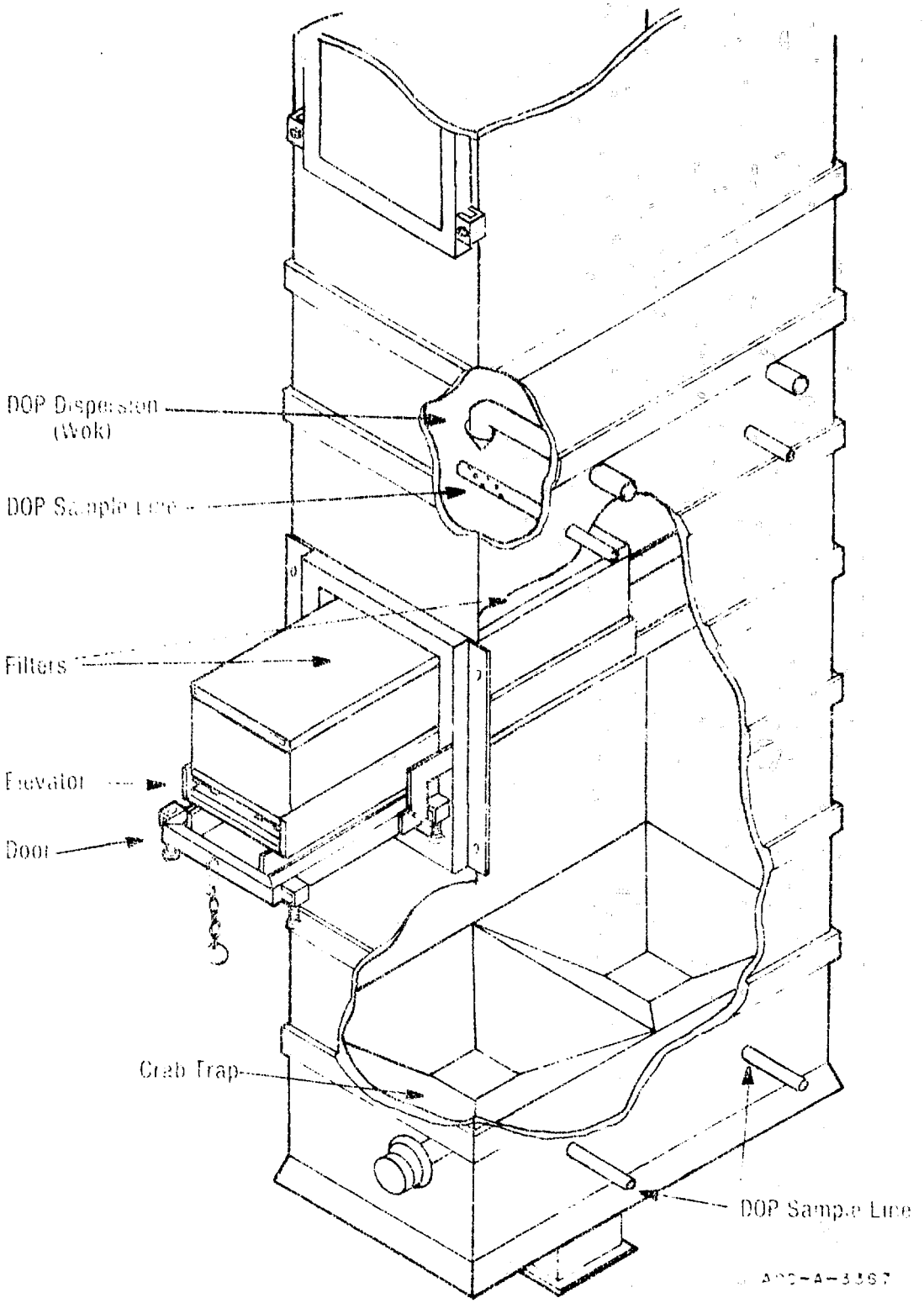


Figure 5
NWCF Filter Housing

SAMPLE PROBES

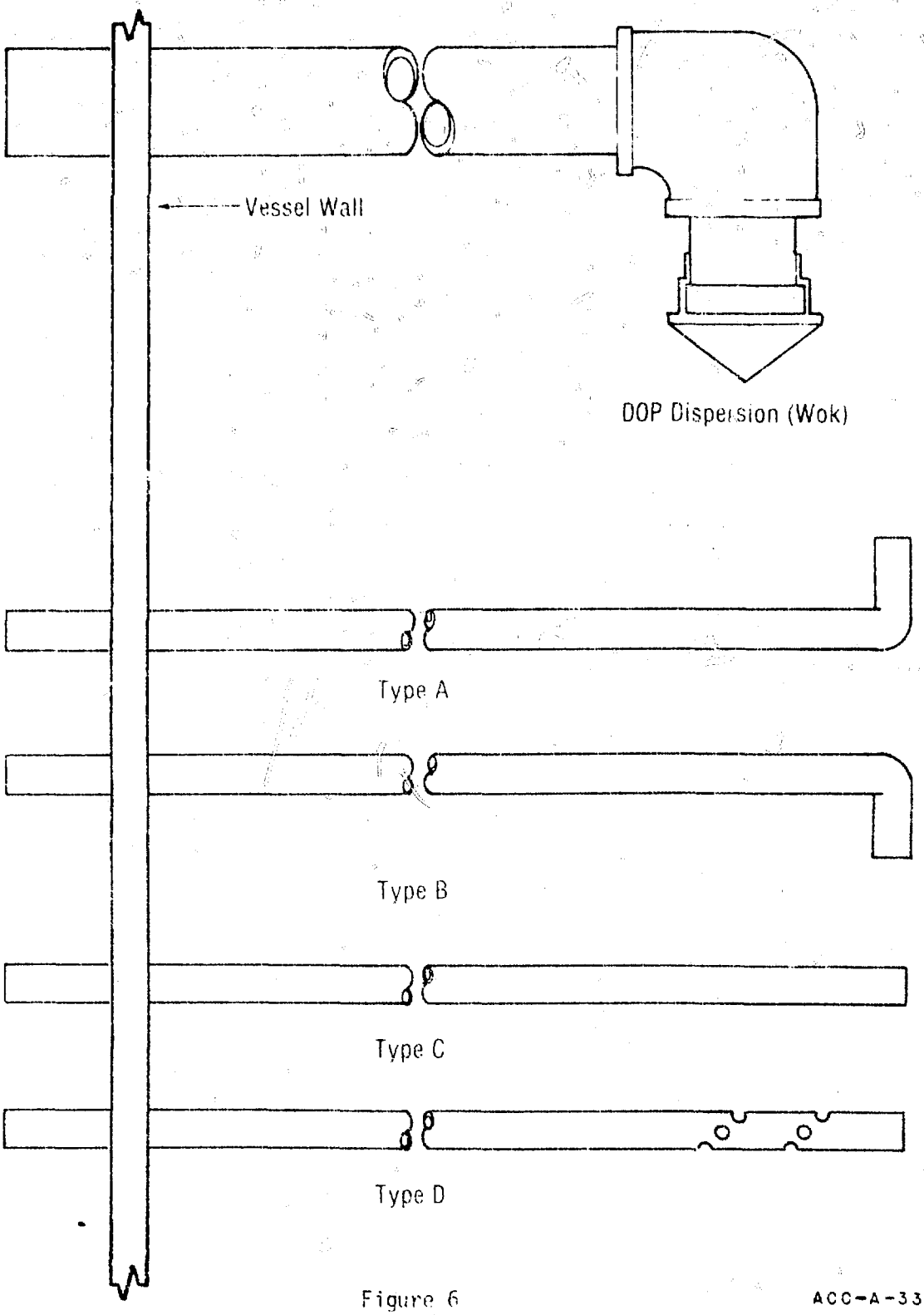


Figure 6 ACC-A-3368

Dispersion Baffle and Sample Probes

characteristics and typically, sample readings across the face of the filter varied no more than 1%.

Sampling was accomplished by piping a small stream of sample gas through an analyzer for detection of any DOP that might be passing through or around the filter.

The filter seal integrity and the efficiency of the filter media were tested by sampling the gas flow downstream of the filter. As the gas passed through the crab trap the cross section of the flow was reduced to a 6 in. square which was then sampled. When compared to samples taken 15 duct diameters downstream, these samples indicated representative gas samples were being collected. Figure 6 shows the different types of sample probes tested. The best results were obtained using a multiple port tube. This type will be installed in the NWCF. Sample line penetrations in the injection line and in the filter housing were used to check DOP concentrations before and after filtration.

DOP testing requires one remote manipulation, opening and closing the crab trap. The crab trap hinge pin passes through the wall of the filter housing and is coupled with the penetration cap . A handle fastened to the penetration cap operated by a wall-mounted manipulator is used to open and close the crab trap. The penetration cap is remotely removeable for gasket replacement.

NWCF filter cell viewing will be provided by windows at the second and third operating levels. To test visibility, window mockups were fabricated and installed at the RMDF.

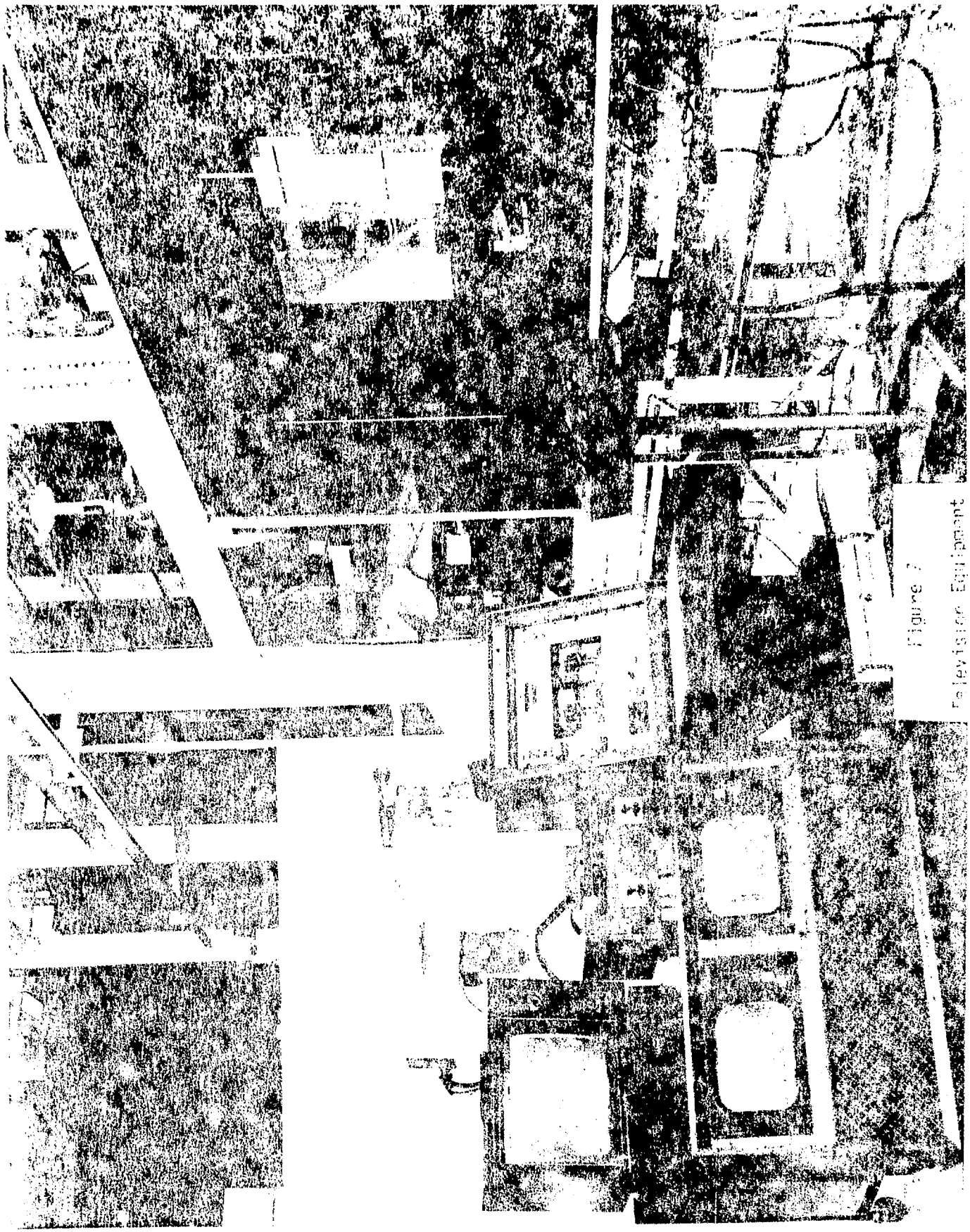
The view tests indicated that the valve cubicle and the filter cell should be wider, identifying a required design change and also, that extended view windows should be used for the filter cell. Although all filter remote manipulations can be performed by direct view, closed circuit TV capability is also incorporated in the NWCF to augment the window views. To further test the effect of visibility upon remote filter handling, each operation was tested three ways - direct viewing, combination direct and closed circuit TV and only closed circuit TV. Each method proved adequate for performing the necessary operations.

Additional TV viewing tests were performed with the filters by placing the TV camera at several locations including some cell locations, outside a viewing window, and mounted on the PaR manipulator.

Three cameras (Figure 7) equipped with zoom lenses and pan and tilt were used for these tests, and included both a two-dimensional (2-D) camera and a three-dimensional (3-D) camera. Separate monitors for each camera were provided which permitted simultaneous overall and close-up views thus eliminating the need for camera and monitor control adjustments each time the cameras were switched. The 3-D TV (at close range) gave reasonable depth perception but was restrictive to the operator. For general maintenance work the 2-D TV image was adequate to perform filter maintenance operations.

The off-gas HEPA filter development effort resulted in a system in which a commercial HEPA filter can be installed, tested, operated and removed from a sealed filter housing using remote handling

methods. In addition, all parts which may require maintenance can be remotely removed for inspection and maintenance. Mockup testing also resulted in needed changes to the calcining building and to shielding window designs that gave better views of the work area and provided easier access to the equipment.


Television Equipment

Figures