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ON-SITE SURVEY AND ANALYSIS OF PYROTECHNIC MIXER BAYS

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MMT-Safety engineering
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Pyrotechnic accidents, some fatal, have occurred at several pyrotechnic manufacturing facilities indicating that operator exposure to these operations must be improved. To cover the various aspects, the project was divided into the following four areas: mixer safety, transport and conveying safety, fire suppression system, and bay design safety. This report covers the bay design safety which is concerned with the on-site survey of the five pyrotechnic facilities: Longhorn Army Ammunition Plant (AAP), Lone Star AAP, Pine Bluff Arsenal, Crane Army Ammunition Activity, and Lake City AAP.

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INTRODUCTION

Background

Pyrotechnic accidents, some fatal, have occurred at several pyrotechnic manufacturing facilities indicating that operator exposure to these operations (particularly during mixing and transport) must be reduced to acceptable safety levels. This includes improving the design of these facilities with regard to propagation as well as operator survival. The behavior of most pyrotechnic mixtures is different from conventional propellants and explosives in that they are more sensitive to friction, impact, and static discharge, and are more prone to exhibit deflagration phenomena. Special techniques are required to reduce manufacturing hazards and risks. These techniques are complicated by the large number of differing pyrotechnic compositions, as well as the different operation procedures utilized in the current five pyrotechnic facilities.

The Energetic Systems Process Technology Division of the Large Caliber Weapon Systems Laboratory, ARDC, was tasked by the Project Manager for Production Base Modernization and Expansion to resolve the pyrotechnic problem, under MMT Project 58X4548, titled "Pyrotechnic Safety Enhancement." This project has been given a high priority rating by the Project Manager's Office. Ammann & Whitney, Consulting Engineers, is assisting ARDC in this project.

To cover the various aspects of this effort, the project has been divided into four tasks as follows:

1. Mixer Safety
2. Transport and Conveying Safety
3. Fire Suppression System
4. Bay Design Safety

The initial effort of Task 4 above, which is covered by this report, is concerned with the on-site surveys of the five pyrotechnic manufacturing facilities; Longhorn AAP, Lonestar AAP, Pine Bluff Arsenal, Crane AAA, and Lake City AAP. Subsequent to this effort, a test plan for analyzing and abating the hazards posed by pyrotechnics will be developed, and after tests are conducted, design recommendations will be made based on the results. Ultimately, an improved mixer bay design will be developed.

Purpose and Objectives

The purpose of ths program is to develop protective design techniques whereby propagation of an incident from a mixer bay to another will be negated and protection for operating personnel will be achieved. The purpose of this report is to present the results of the on-site surveys.

The objective of this report is to identify possible avenues of propagation between adjoining mixer bays whereby a test program can be established which will form a basis of an improved mixer bay design.

Scope of Report

The following pages describe the observations made during on-site visits. Discussions of possible avenues of propagation are presented. The report is subdivided by facility.

ON-SITE SURVEYS

GENERAL

On-site surveys were conducted at the pyrotechnic facilities at Longhorn AAP, Lonestar AAP, Pine Bluff Arsenal, Crane AAA and Lake City AAP. During and subsequent to these surveys, drawings (structural, layouts, etc.) and lists of compositions were collected for evaluation. Typical photographs of the pyrotechnic operations were taken at each facility.

These facility designs consist of differing bay layouts, venting and heating systems and pyrotechnic compositions. This report is concerned with avenues of direct propagation through fireball, vapor ignition or pressure for each facility. Since blast pressures may arise from the ignition of the pyrotechnic source, a scenario has been presented for each facility, covering the susceptibility of the doors, viewing windows, etc., to these pressures.

As a result of the on-site surveys, a test program is being devised to determine the hazard of propagation and how to abate it.

LONGHORN AAP

Description of Bays

Buildings 7 through 16 (Figure 1) and Building 212-33 (Figure 2) were visited.

Building 7 through 16 are similar in construction. Each consists of four bays (A through D), in a line, with a 12-inch thick reinforced concrete wall between B and C. This wall extends past a frangible wall in the corridor and through the roof. The other interior walls are 12-inch thick reinforced concrete. The common backwall and outside sidewalls consist of two such walls with sand fill in-between. The control area is located at the other side of the frontwall. Each bay has a frangible metal deck roof. Each bay is 10 ft. 6 in. wide, 11 ft. 6 in. long with a ceiling height of 10 ft. 6 in. at the frontwall and sloping down to 8 ft. 10 in. at the backwall. Viewing of the mix is in the control area by remote camera (Figure 3). A sliding steel door remains closed during the mixing operation (Figure 4). In some cases, each bay has an individual exhaust system (See Figure 5 showing individual exhaust systems at Building B12). In others, the exhaust systems is interconnected, as in Building B-11 (Figure 6).

Building 212-33 (Figure 2) consists of two bays, with a common sidewall extending past the walls with the doors and through the roof. Each bay in this building has an individual exhaust system (Figure 7). The interior dimensions of each bay are 10 ft. 6 in. wide by 11 ft. 6 in. long with the ceiling height varying from 10 ft., 6 in. to 7 ft., 8 in.

Avenues of Direct Propagation

In the bay configuration for Buildings 7 through 16, an avenue of direct propagation through fireball or vapor ignition exists in the corridor connecting Bays A and B or C and D. In the case of Building B-11, propagation may occur through the interconnected exhaust system via vapor ignition (Figure 6)

In the bay configuration shown in the sketch of Building 212-33 (Figure 7), each bay is partitioned and direct propagation is negated. Each bay has an individual acetone exhaust system.

Blast Pressures Scenario

If significant blast pressures occur, certain features of the bay design may be susceptible to these pressures and, as a consequence, enhance propagation.

In the bays of Building 7 through 16, the sliding steel door may not adequately resist blast pressures. However, if these doors are of adequate strength to resist blast pressures, they may not be sufficiently sealed to prevent fireball leakage. If leakage occurs through these steel doors, the fireball may travel up the side corridors into the main corridor or control area.

LONESTAR AAP

Description of Bays

Buildings G-33 and G-11 were surveyed.

Building G-33 (Figure 8) consists of 18 bays in a symmetrical arrangement. Walls are 12 inch reinforced concrete. The walls extend through the roof and the exhaust for the mixing bays are individual systems. Each bay is 15 ft. 6 in. long and 7 ft. 6 in. wide. The ceiling height is 14 ft. 9 in. sloping to 9 ft. 6 in. The backwall and roof are frangible for each bay. The side corridors leading into the main corridor or control area are not enclosed at the bay entrance (Figure 9). A 9 in. by 15 in. (approximate dimensions) viewport (Figure 10) at the frontwall (control area) is used to view the mixing operation.

Building G-11 mixing bays 9 and 11 are at one end of the building. The remaining bays are support bays (Figure 11). The walls are 12 inch reinforced concrete and extend through the roof. The backwall and roof are frangible elements. The rooms are open at the backwall leading to the side corridors. Each room is 8 ft. 6 in. long by 10 ft. wide.

Avenues of Direct Propagation

It can be seen, from the bay configuration of Building G-33, propagation may occur from one bay to the side corridor and/or to the adjacent bay. In building G-11, propagation can occur down the side corridor into the area of the support bays.

The exhaust systems at each bay are not interconnected and pose no threat to propagation.

Blast Pressures Scenario

If the viewports, which are located at the frontwall of each bay of Building G-33, are not of sufficient strength to resist the blast pressures, then these pressures will flow into the control area.

PINE BLUFF ARSENAL

Description of Bays

The following buildings were surveyed, at Pine Bluff Arsenal, for pyrotechnic safety enhancement: 33-620, 33-520, 31-520, and 31-620. Building 33-620 (Figure 12) contains twenty-one bays. At present, bays 5,6,20, and 21 are mixing bays. Bays 1,5,6,18,20 and 21 have a common acetone removal system (Figure 13). The heating system (hot air), which runs through the corridor separating the building is common to all bays (Figure 14). Walls are twelve inch reinforced concrete extending through the roof. The roof and backwalls are frangible (Figure 15). The remaining three buildings are structurally similar. At the time of the survey, Building 33-620 was used to process starter mix, 31-520 for colored smoke and C.S. riot mix, 31-620 for Thermate mix and 33-520 for H.C. mix. A periscope, which is used to view the mixing process, is mounted on the bay control area wall (Figure 16).

The interior dimensions of each bay vary. The width varies from 10 ft. to 19 ft. The length of each bay is approximately 13 ft. 10 in. while the height of each bay slopes from 14 ft. 6 in. to 10 ft.

Avenues of Direct Propagation

Avenues of direct propagation exist through the common acetone removal system and/or through the common heating system. Each bay is enclosed and provides no area of direct propagation either through an adjoining corridor or bay.

Blast Pressures Scenario

Propagation into the inside corridor due to blast pressures may occur through rupture of the heating system pipes or through the openings provided for the periscopes.

CRANE AAP

Description of Bays

Building 126 houses the Army's pyrotechnic manufacturing operation. A layout of this facility is shown in Figure 17. Mixing and blending bays are performed on the "A" side of the building. Walls are twelve inch reinforced concrete and extend above the roof. The backwall and roof are frangible elements (Figure 18). Each mixing bay has its own acetone exhaust system (Figure 19). The heating and ventilation system has an air inlet and outlet and runs under the corridor floor (Figure 20). Each bay has a sliding steel (Figure 21) or aluminum plate (Figure 22) door on the inside corridor (front) wall. The aluminum plate doors have a built-in window. The bays with the sliding steel door have viewing windows on the frontwall (Figure 23).

Avenues of Direct Propagation

Propagation may occur through the heating and ventilating system which is interconnected under the corridor floor. Direct propagation is unlikely to occur from one bay to an adjacent bay since each bay is completely enclosed.

Blast Pressures Scenario

Direct propagation into the inside corridor can occur if blast pressures cause the interior corridor doors to fail. The aluminum plate doors offer minimal blast resistance. However, the sliding steel doors may offer some resistance. Failure of the viewing window either on the door or the frontwall can also lead to propagation due to blast pressures. If the doors or viewing areas are sufficiently strong to resist blast pressures, leakage may occur through the doors (which are not sealed) or through the viewports. Leakage will not usually cause propagation but a safety hazard may exist in the corridor at the door.

LAKE CITY AAP

Description of Bays

This facility contains three buildings 38A, 38B, and 38C which manufacture pyro compositions. Each building contains six bays on the back side (Figure 24). The bay plan dimensions are 7 ft. 6 in. wide by 14 ft. 3 in. long with a 10 ft. (approx) ceiling height.All blending is performed in a dry state except for the IM136 igniter mix in 38B. This latter mix (14 lb) is made in its own shield which has been tested. The sidewalls are 10 inch reinforced concrete extending through the roof, and the frontwall is 12 inch reinforced concrete. The roof and backwalls are frangible (Figure 25).

A steel plate door is located in each bay at the frontwall in the control area corridor (Figure 26). Each door has a 6 in. by 8 in. (approx) viewing area. The bays are heated by radiators.

Avenues of Direct Propagation

Propagation may occur in the form of a flame through improperly sealed doors. An approximate one-half inch gap exists below the steel plate door. Otherwise, each bay is entirely closed.

Blast Pressures Scenario

Extensive propagation may occur into the control area if the steel plate doors or their supporting hinges are not of adequate strength. In addition, the viewports on each door may fail under elevated pressures even if the doors are strong enough to survive the blast pressures.

TEST PROGRAM

The avenues of propagation identified in the surveys are possible avenues; some are more probable than others and some are unlikely. The test program will be designed to determine the hazard of possible propagation and how to abate them. Modifications to the bay design may be made as a result of this testing.

The test program will consist of scaled barricades, modeled on the various pyrotechnic facilities. These tests will determine the thermal effects and pressure loads associated with an incident in the bay and its environment. The most hazardous compositions will be used in fireball tests to determine the scaling of the test charge. One-inch thick welded steel plates are proposed for the scaled tests.

Design modifications to the scaled barricades may follow as a result of the initial tests or they may be performed simultaneously. They may consist of an enclosed scaled bay and providing a roof vent opening.

CONCLUSION

The survey of pyrotechnic facilities herein has shown that in many of these facilities a pyrotechnic incident can possibly propagate from one bay to an adjacent bay. At this time, several solutions can be conceptually envisioned for most of the facilities involved.

RECOMMENDATION

It is recommended that this program continue to the testing phase of Task 4, as originally planned.

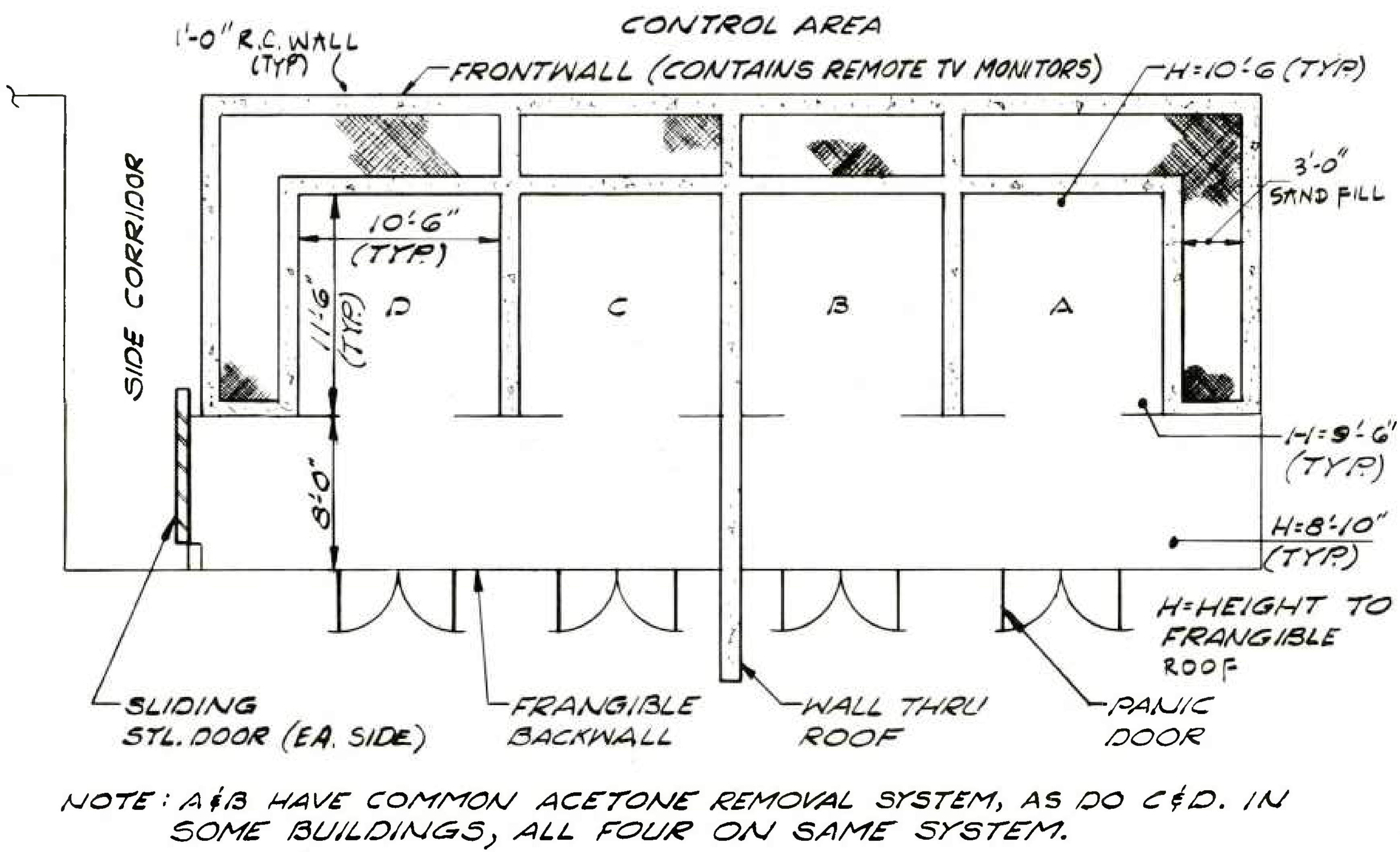


Figure 1 Plan of bays, Buildings 7 through 16, Longhorn AAP

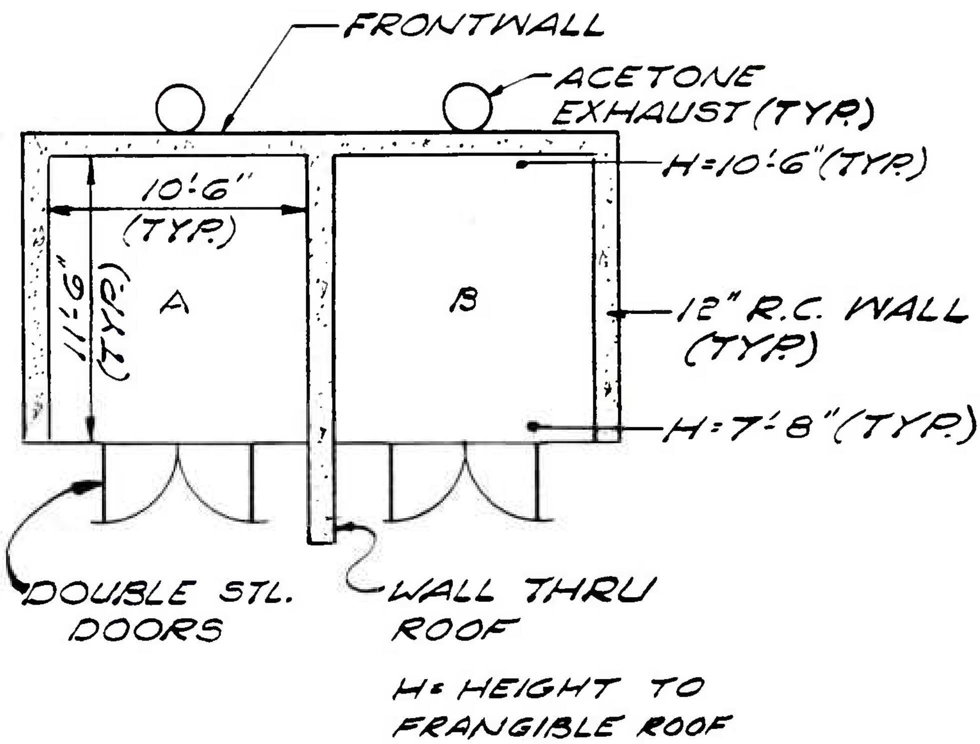


Figure 2 Plan of Building 212-33, Longhorn AAP

Figure 3 Remote camera, Longhorn AAP

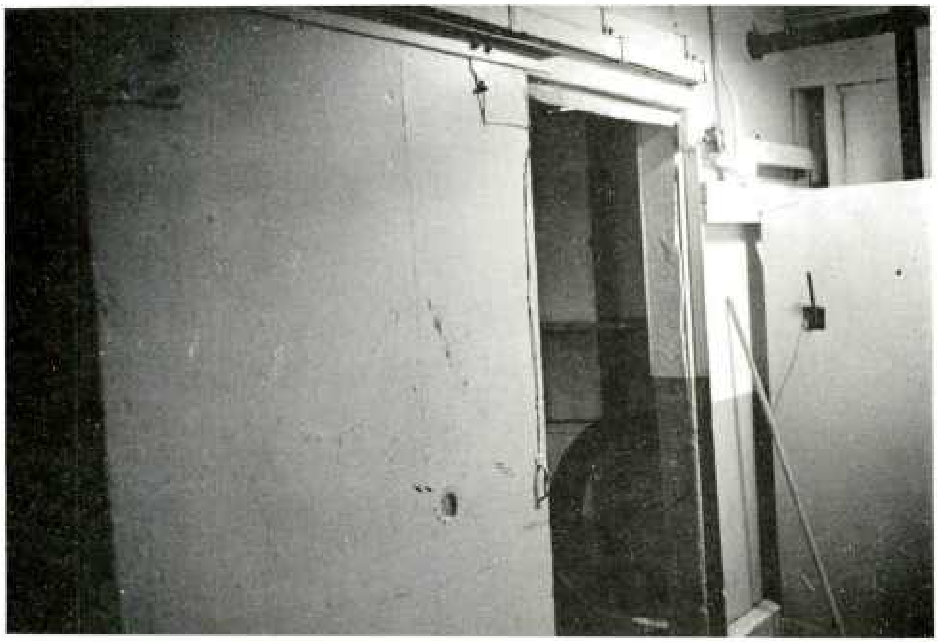


Figure 4 Sliding steel door, shown open, Longhorn AAP

Figure 5 Exhaust systems of each bay roof, Longhorn AAP

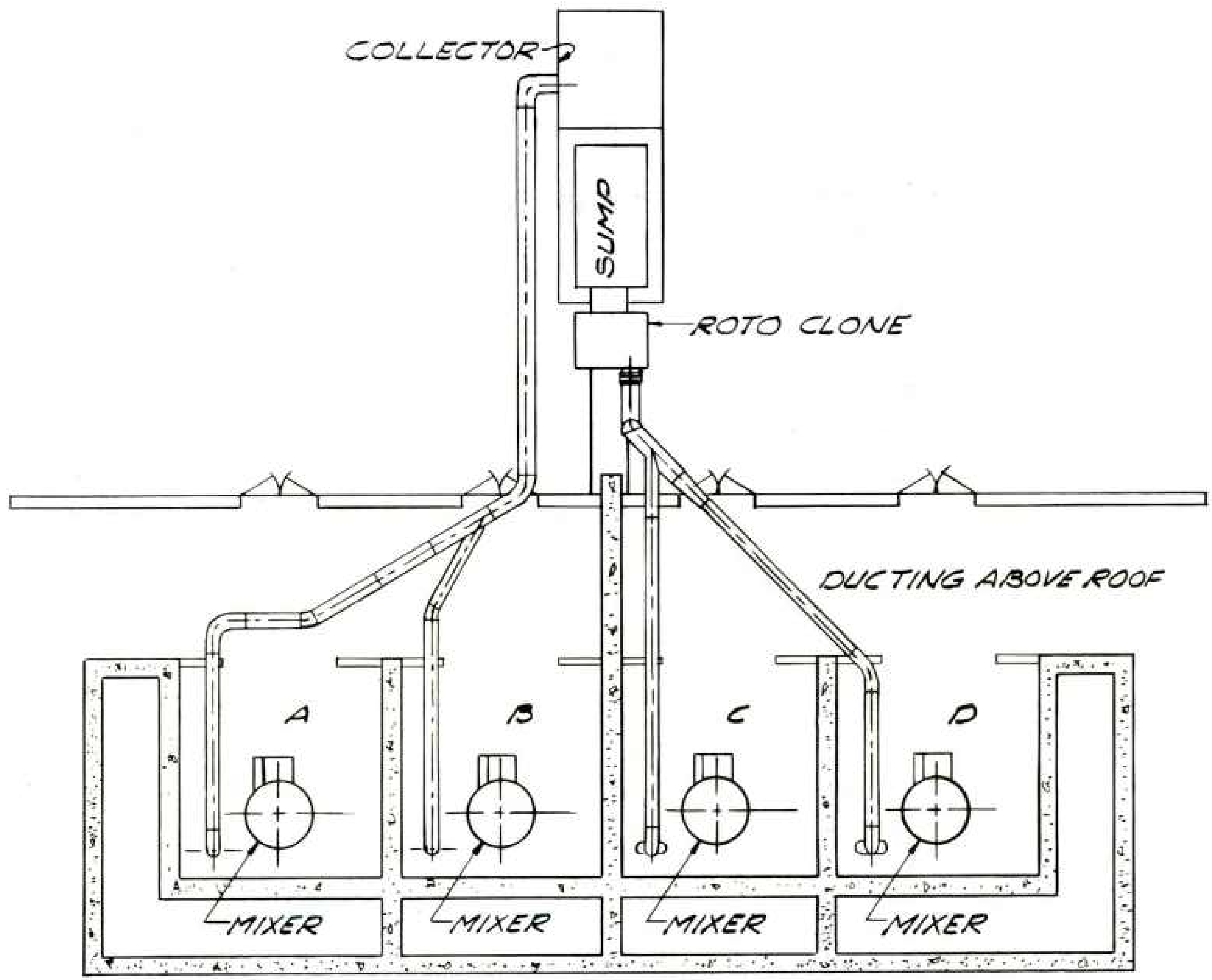


Figure 6 Partial Plan of Building B-II showing interconnecting ductwork, Longhorn AAP

Figure 7 Building 212-33 showing individual exhaust systems, Longhorn AAP

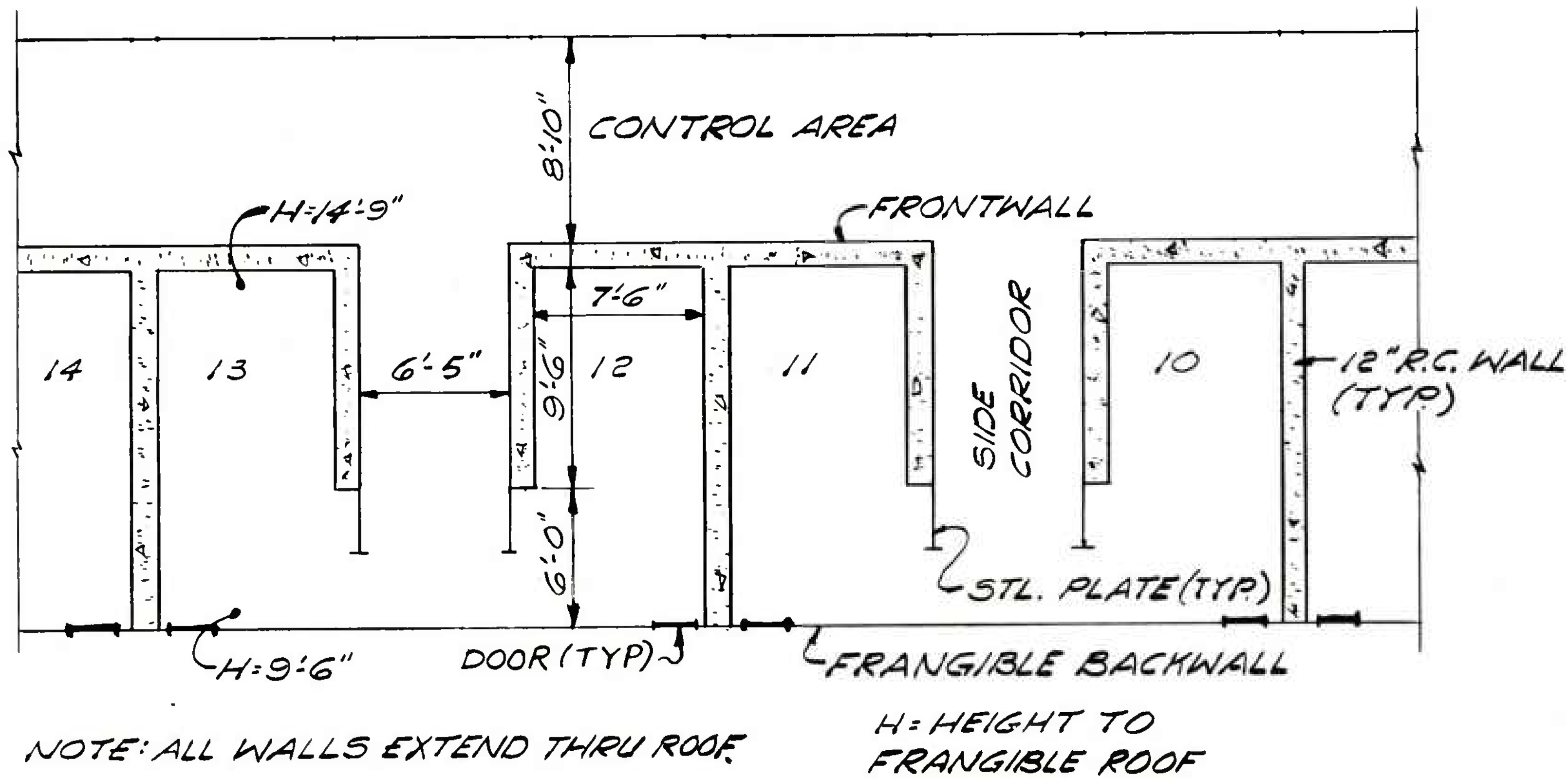


Figure 8 Partial Plan of Building G-33, Lonestar AAP

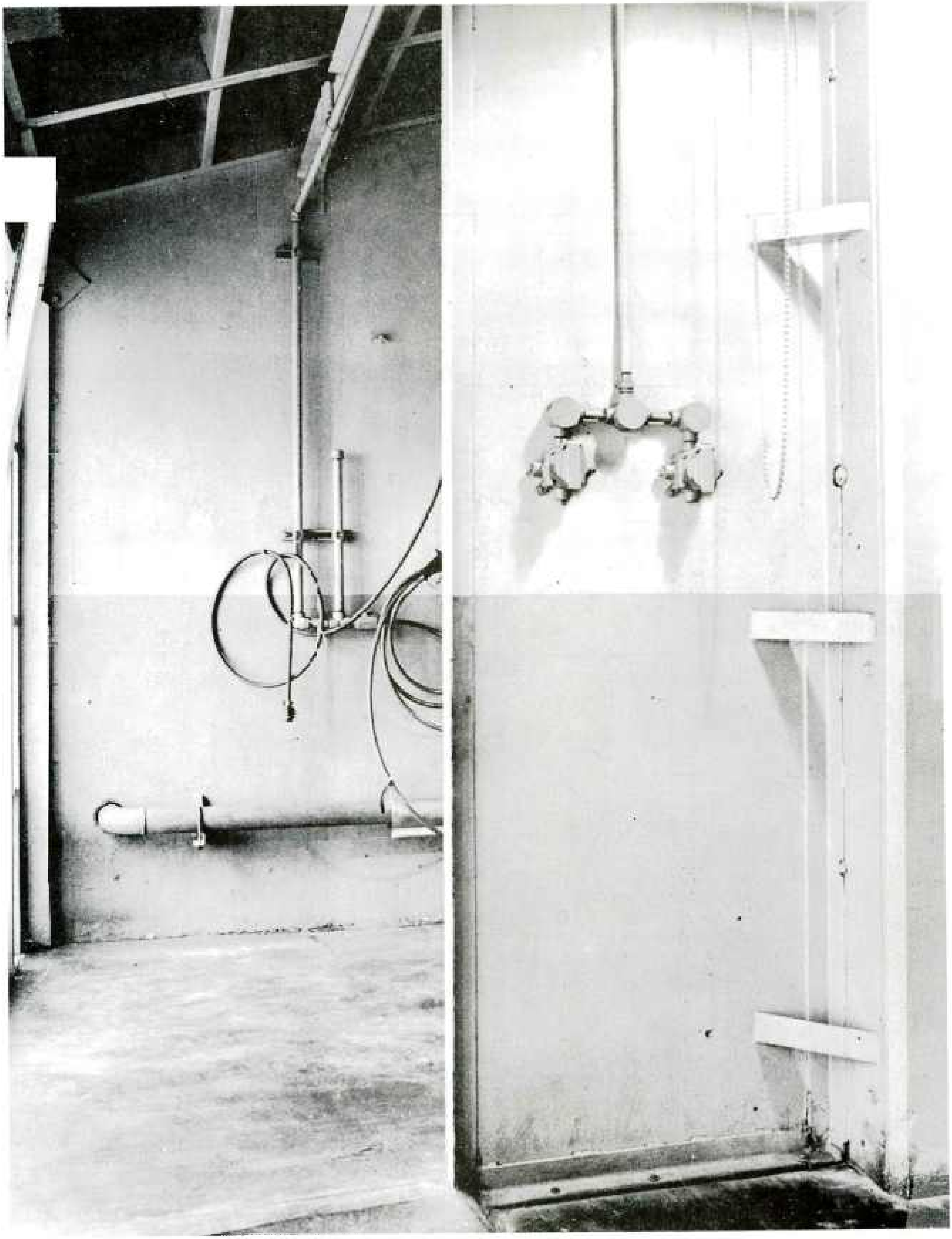


Figure 9 Open bay entrance viewed from side corridor, Lonestar AAP

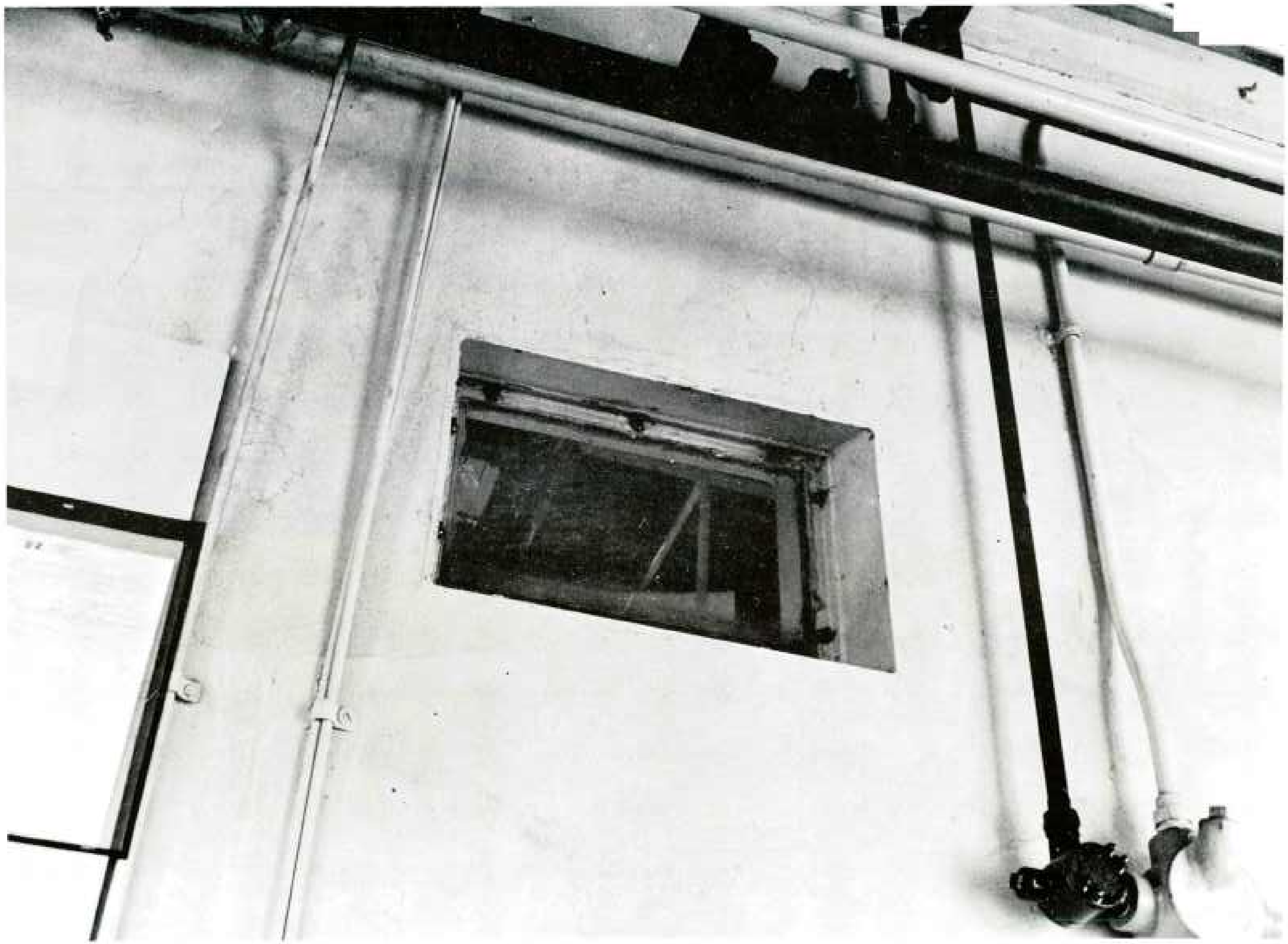
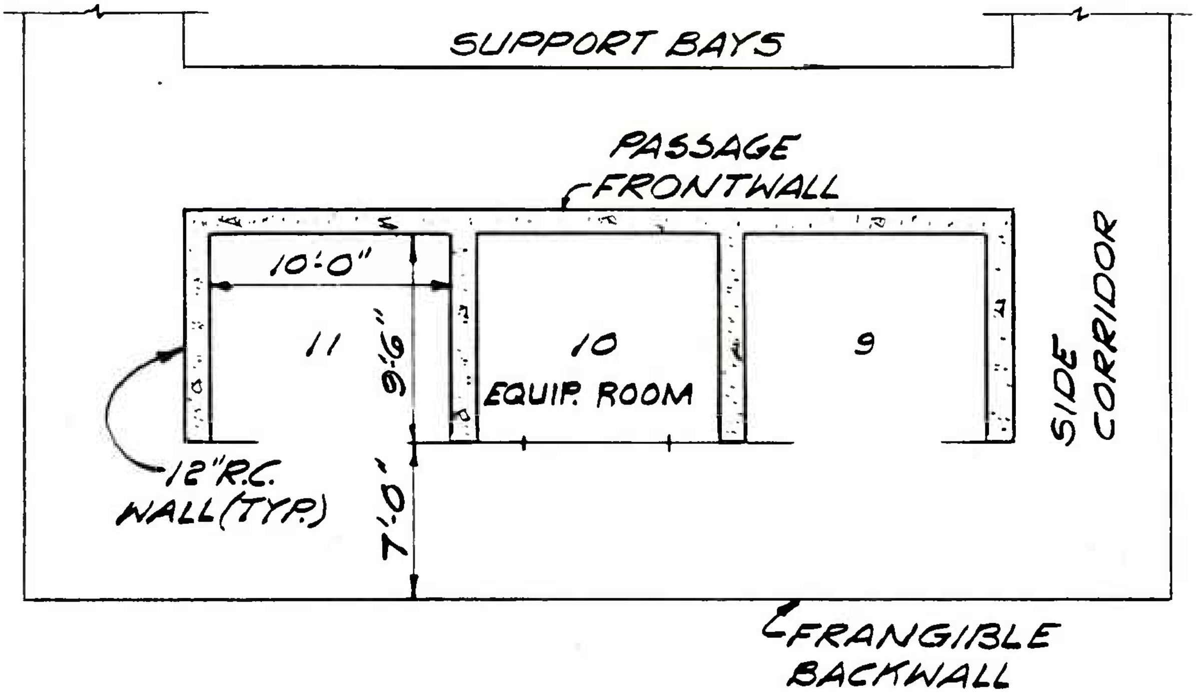


Figure 10   Viewport at frontwall of bay, Lonestar AAP



NOTE: ALL R.C. WALLS EXTEND THRU ROOF

Figure 11 Partial Plan of mixing bays, Building G-11, Lonestar AAP

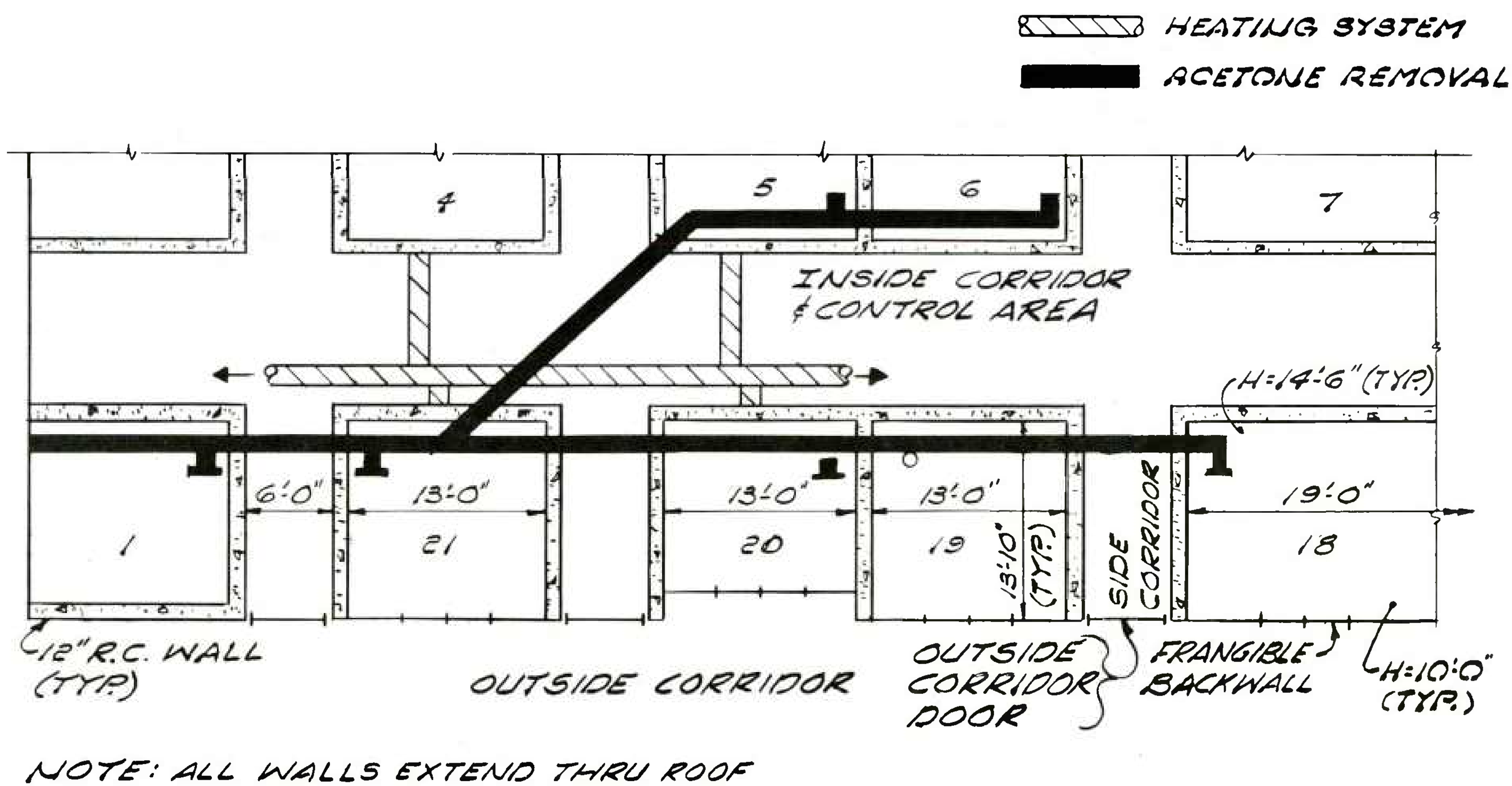


Figure 12 Partial Plan of Building 33-620 Pine Bluff Arsenal

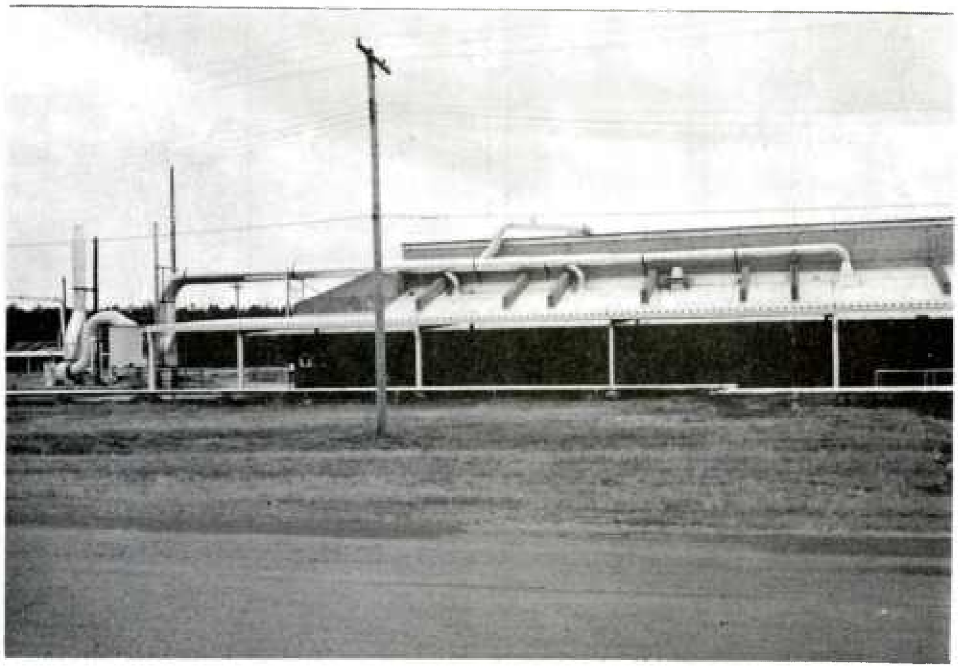


Figure 13 Common acetone removal system shown on bay roofs, Pine Bluff Arsenal

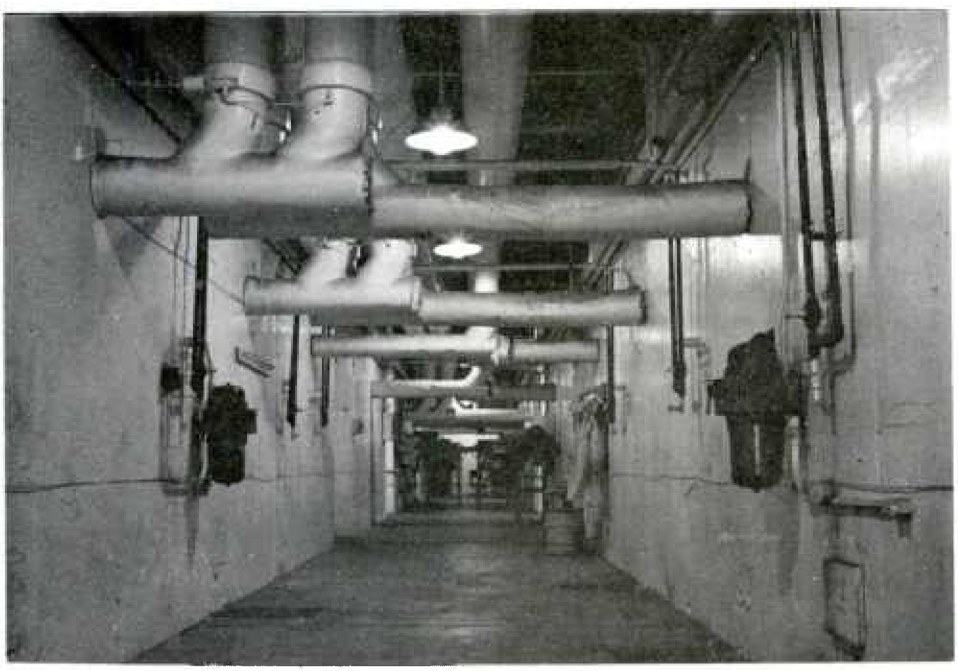


Figure 14 Common heating system joining each bay, Pine Bluff Arsenal

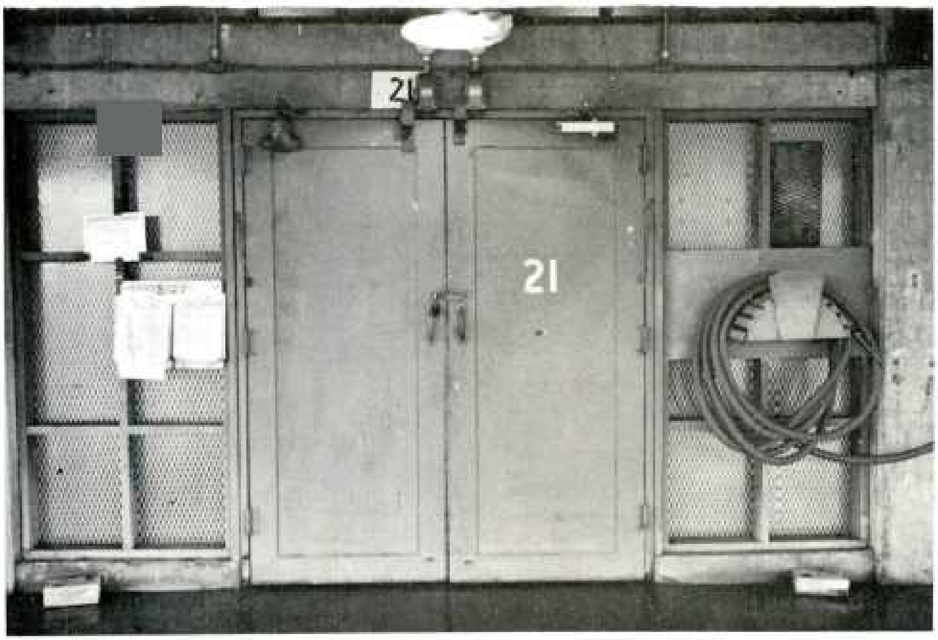


Figure 15 Frangible bay backwall, Pine Bluff Arsenal

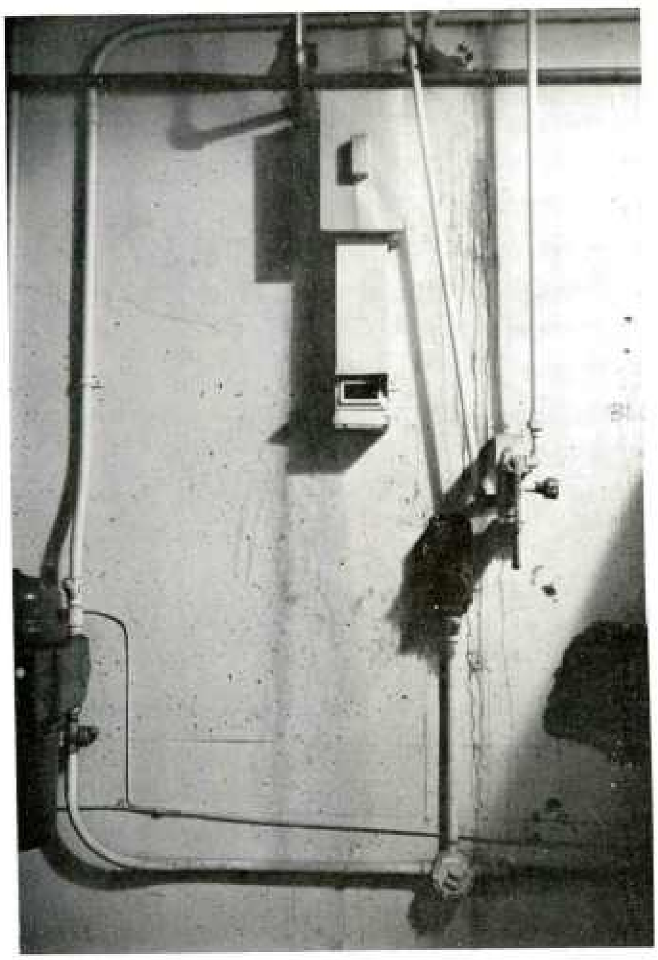


Figure 16 Bay frontwall periscope, Pine Bluff Arsenal

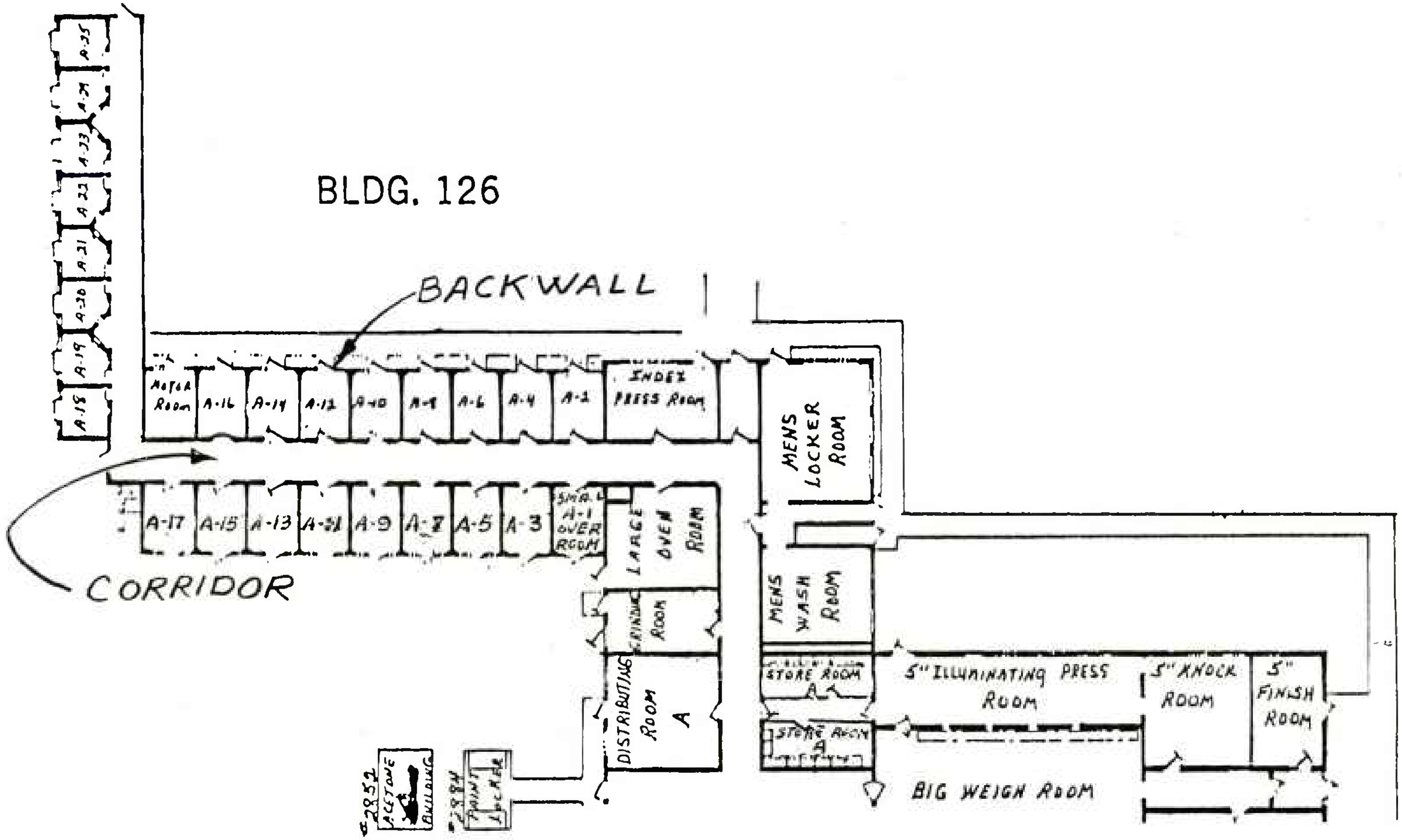


Figure 17 Plan of Bays of Building 126, Crane AAP

Figure 18 Frangible backwall (mixer shown on right), Crane AAP

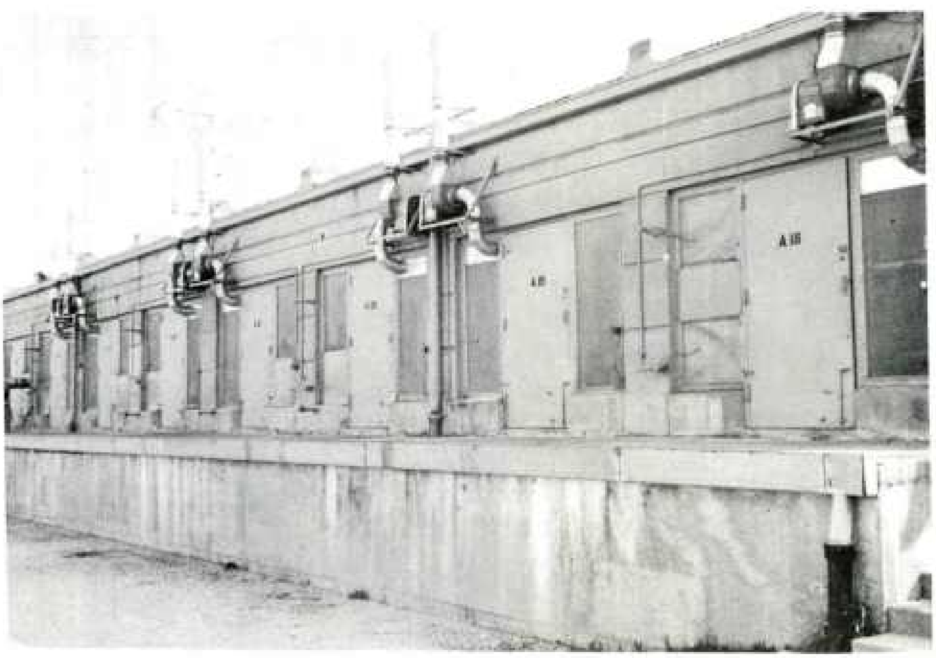


Figure 19 Individual acetone removal systems at each bay, Crane AAP

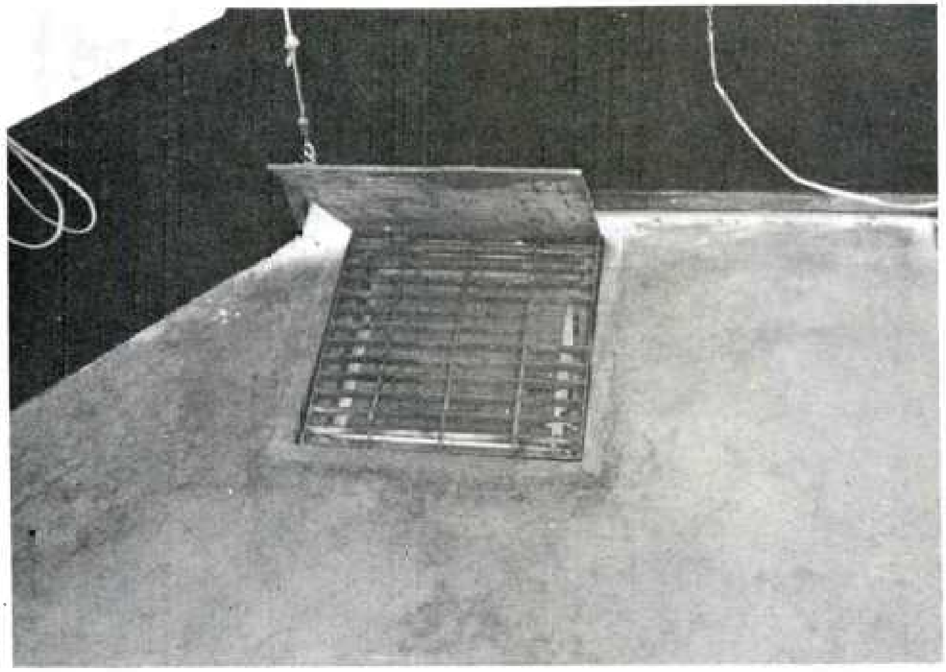


Figure 20 Floor mounted ventilating system, Crane AAP

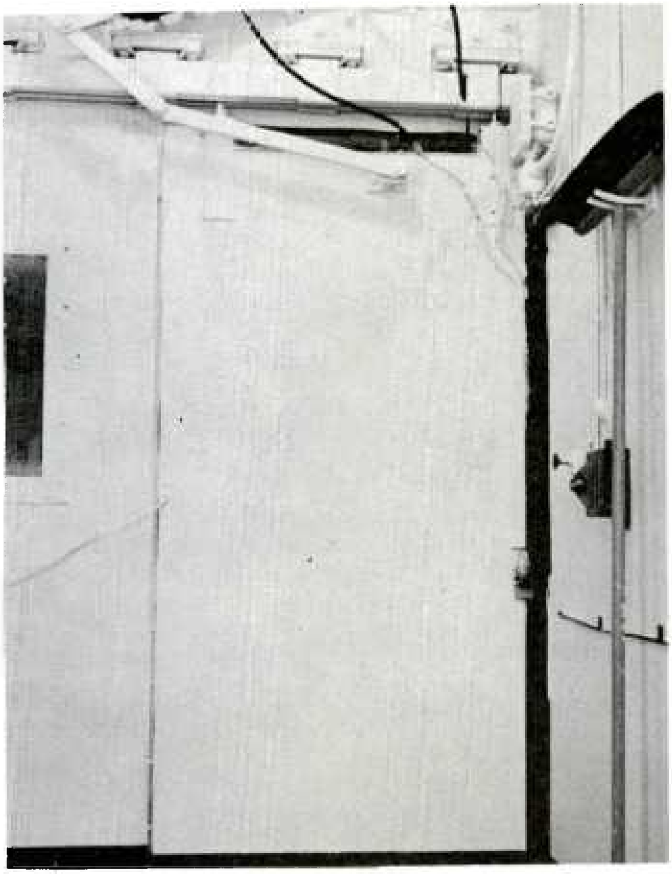


Figure 21 Sliding steel door on bay frontwall, Crane AAP

Figure 22 Aluminum plate bay door with view panel, Crane AAP

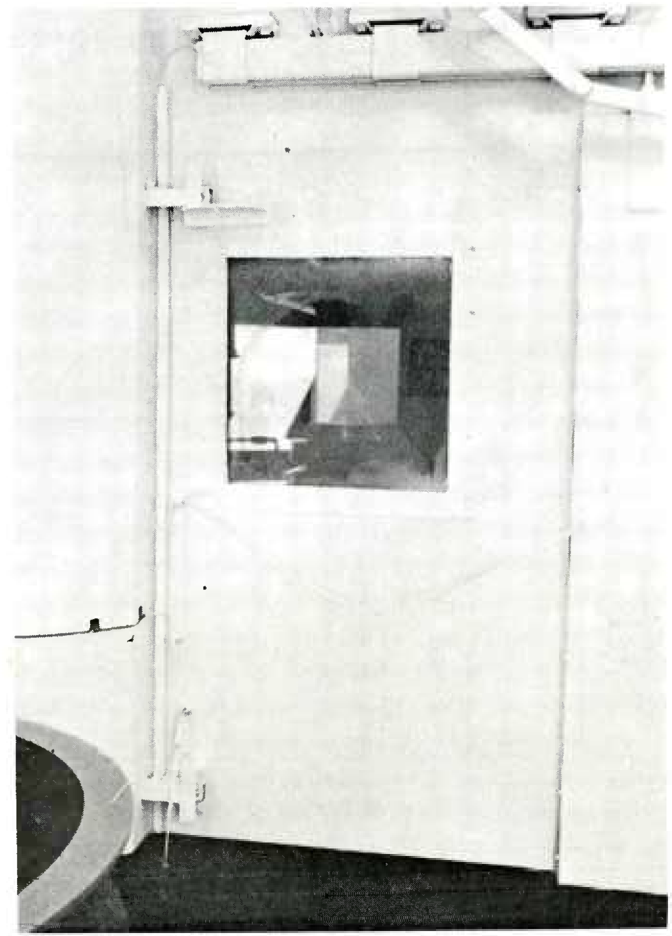


Figure 23 Window on frontwall of bay Crane AAP

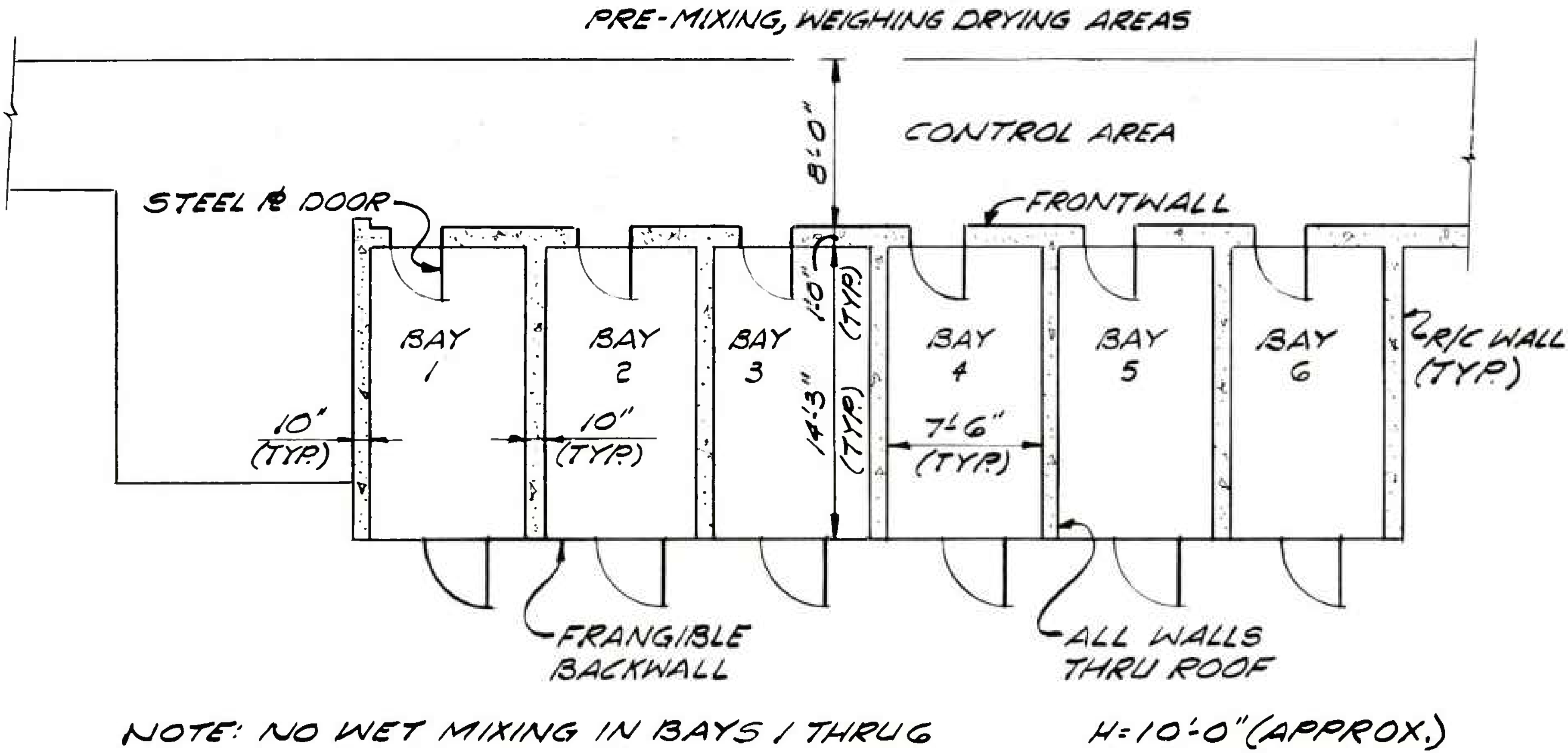


Figure 24 Partial Plan of Building 38A/B/C, Lake City AAP

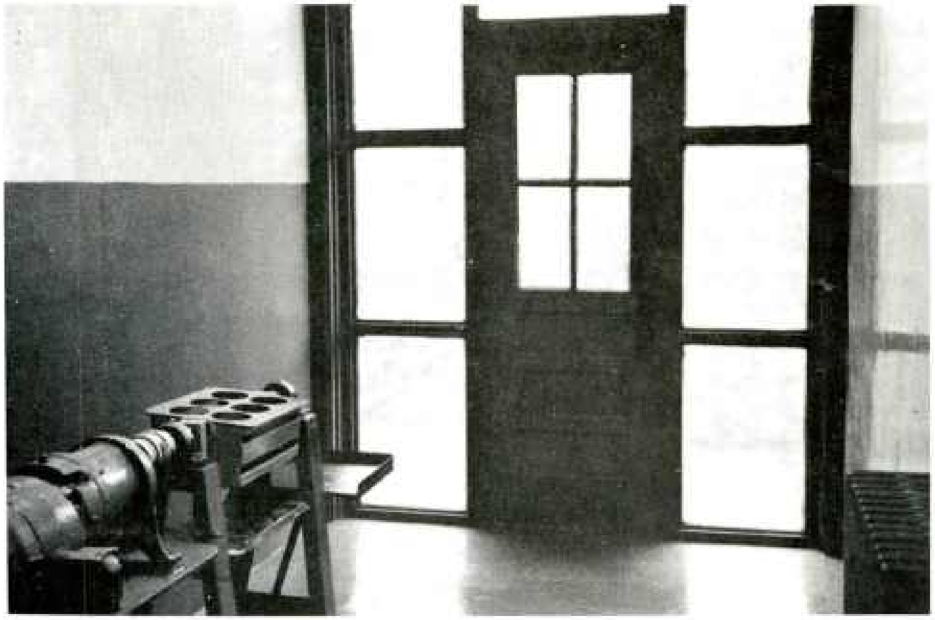


Figure 25 Frangible backwall, Lake City AAP

Figure 26 Steel plate door at bay frontwall, Lake City AAP

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