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TEST OF FIXED-PIPE DISTRIBUTION SYSTEM
FOR MET-L-X DRY-POWDER FIRE EXTINGUISHERS

AT

EBR-II

by

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I. INTRODUCTION

A question has existed about the capability of a fixed-pipe distribution system to deliver a dry-powder fire extinguishing agent to a fire. There are really two parts to the question:

1. Can a dry powder be satisfactorily be moved through a complex fixed-pipe system to provide multi-point application?
2. Will the fixed-pipe system provide satisfactory distribution of the fire extinguishing agent?

Two tests were conducted that provide some answers to this question.

II. LOCATION

The tests were performed in the Suspect Waste Packaging Building (790) at the EBR-II reactor site located on the National Reactor Testing Station in Idaho.

III. TEST DESCRIPTION AND RESULTS

The system tested was a mockup of the fixed-pipe distribution system installed in the northeast quadrant of the basement of the EBR-II Sodium Boiler Building. The piping connecting the Met-L-X storage tank to the 16-nozzle distribution array shown in Fig. 1 closely approximates the longest piping run from storage-tank-to-nozzle array proposed in PM 400, Improved Sodium Boiler Building Met-L-X Systems. The layout was altered to fit the test facility, but the pipe size, pipe run lengths, and number of elbows were duplicated.

Hanger locations on the installed distribution system were duplicated, but wire was used for support instead of rod hangers.

The fire extinguisher unit used in the tests was a Met-L-X PS-2000 manufactured by the Ansul Chemical Company of Marinette, Wisconsin. This unit is shown in Fig. 2. The storage tank holds approximately 2000 lb of Met-L-X powder. Four 400-scf bottles of nitrogen pressurized at ~2500 psi provided the force to move the powder through the piping system. Met-L-X "Z" nozzles were used in the distribution system.

Ten 0-200 psi pressure transducers with a frequency response capability of 10 Hz were installed on the distribution system as shown in Fig. 1. Another identical transducer was installed at the outlet of the Met-L-X storage tank. The output signals of these transducers were fed into an 8-channel Beckman recorder and a 6-channel Brush recorder. The recorders were both pen type and recorded continuously at a 5 mm/sec chart speed during the tests.

Each test was recorded on motion picture film.

A. Test I

The purpose of Test I was to determine the capability of the distribution system to deliver an approximately equal amount of Met-L-X powder to each of the 16 nozzles in the array.

For this test, a plastic bag and a 20-gal can were supported under each nozzle to catch the powder discharged from the nozzle. See Fig. 3. The bags were tied around the nozzle and vented to prevent pressure buildup inside the bags. The storage tank was loaded with 1958 lb of Met-L-X powder.

Test I was conducted at 1500 hours, March 21, 1972. The ambient temperature was 52°F. Powder flowed through the system for ~2.5 min. When the powder in the storage tank had been discharged, ~1000 psi remained in the nitrogen storage bottles. The change from powder and gas flow in the distribution

system to gas flow was quite obvious. The "chugging" and piping vibration that accompanied the powder flow stopped and there was a marked increase in powder being blown out of the plastic bags. The change was also quite evident on the pressure recordings.

The powder and pressure distribution throughout the nozzle array is shown in Fig. 1. The total of the Met-L-X powder collected in the bags was 1779 lb. Some powder, of course, was lost in the form of dust, but this loss is estimated to be less than 50 lb. As shown in Fig. 1 the powder and pressure distribution throughout the fixed-pipe system is quite satisfactory.

The pressure tap at the outlet of the Met-L-X storage tank plugged very quickly so that no useful information was obtained from that transducer. Another instrument channel, identified in Fig. 1, gave a questionable value for pressure. This was later found to be a failure of a preamplifier in the recorder.

B. Test II

The purpose of Test II was to determine the ability of the distribution system to cover a surface with a coating of Met-L-X powder.

For this test the nozzle array was raised, as shown in Fig. 4, to simulate nozzle-to-floor distance existing in the Sodium Boiler Building; however, the restricted vertical space in the test facility necessitated the nozzles being about 15 in. lower than the installed distribution system. The floor beneath the nozzle array was marked by wire and string into a 3x3-ft grid and "ground zero" beneath each nozzle was marked as shown in Figs. 4 and 5. The height of the nozzles from the floor and approximate nozzle locations relative to the grid are shown in Fig. 6.

The pressure tap at the outlet of the Met-L-X storage tank was relocated to prevent plugging.

The 1779 lb of powder collected in Test I plus another 50 lb filled the Met-L-X storage tank. A mechanical vibrator was used to get the last ~125 lb in the tank.

An additional, identical transducer was added as a check against the recorder channel malfunction during Test I.

Test II was conducted at 1300 hours, March 29, 1972. The ambient temperature was 55°F. As in Test I, powder flowed through the system for ~2.5 min. The test facility was quickly filled with the airborne powder to the extent that visibility was reduced to zero.

The distribution of the Met-L-X powder on the floor of the facility is shown in Figs. 7 and 8. Coverage was very uneven and, in general, decreased in depth quickly as the distance from the center line of the nozzle increased. In general, there were ridges from the center of the nozzle in the direction of the nozzle ports. The space between nozzles had only a light coverage of powder. There were numerous random exceptions to the general pattern of coverage; however, where an area of maximum coverage was within only inches of an area of light coverage.

The powder in 15 of the 3x3 sections was collected and weighed. The weights are shown in Fig. 8. The sections for weighing were selected to be representative of the covered area. Those sections weighed that included nozzles had applications of up to ~4 lb/ft² of powder. Other sections within the nozzle pattern were covered with as little as ~0.5 lb/ft².

IV. GENERAL DISCUSSION

The Met-L-X storage unit and fixed-pipe distribution system performed satisfactorily. The storage tank contained 119 lb of powder after Test II. This indicates that the storage unit is capable of discharging 90-95% of the powder stored in it.

As shown in Figs. 1 and 9, the pressure distribution within the piping system was acceptable and there was good correlation between the two tests.

The piping moved noticeably during Test I. Motion at the extremities of the array was of the order of 2 in. Rod hangers, such as those used in the installed system, would adequately restrain the motion. Some motion could be seen at the start of Test II, but visibility was soon obscured.

In the process of preparation for Test II, some small diameter and some larger diameter piping was disassembled. There was essentially no residual powder in the piping. The inside wall of the piping was merely covered with a thin coat of dust. All transducer pressure taps were also checked to insure that they had not become plugged with powder during Test I.

The floor area to be covered by the installed system is $\sim 800 \text{ ft}^2$. The tests show that the storage unit will discharge $\sim 1800 \text{ lbs}$ of powder. This, if evenly distributed would provide 2.25 lb/ft^2 . Ansul Chemical Company has indicated the installed system was designed to provide an application of 3 lb/ft^2 . There is a discrepancy in capability of 0.75 lb/ft^2 . It should also be noted that Ansul now recommends the application of a minimum of 6 lb/ft^2 .

The data from Test II showed an application of $\sim 4 \text{ lb/ft}$ in the areas of concentration beneath the nozzles, but the application between nozzles is significantly deficient.

Fig. 10, an enlargement made from 16-mm motion picture film, shows that the discharge pattern from the nozzles tends to concentrate the powder under the nozzles.

Pressure loss calculations for the piping system were limited to an analysis of loss in the main supply line. This line consisted of 147 ft of 2-in. pipe including six 90° elbows. A L/D ratio of 30 was used for the elbows. Using a form of the Darcy equation, the percentage of the total

pressure loss was calculated for each pipe size. From this, the pressure loss in the 2-in. pipe was found to be 0.45 psi/ft, and in the 1½-in. pipe, 0.67 psi/ft.

V. CONCLUSIONS

The Met-L-X storage unit and fixed-pipe system performed adequately, but the distribution provided by the nozzles as located is not satisfactory. Relocation of the nozzles does not appear to offer much promise for improvement because the number of nozzles required would necessitate a piping array nearly impossible to design or install around existing equipment. It would leave little room for equipment to be protected in a new installation.

The tests reported herein did not address the question of whether Met-L-X powder will extinguish a sodium fire even if properly applied.

MET-L-X STORAGE TANK OUTLET
PRESSURE TAP PLUGGED

Figure 1

TEST OF FIXED-PIPE MET-L-X DISTRIBUTION SYSTEM
TEST 1 PRESSURE (psi) AND POWDER (lb) DISTRIBUTION

Figure 2

ANSUL MET-L-X PS-2000 DRY POWDER
FIRE EXTINGUISHER UNIT

Figure 3
TEST SETUP FOR TEST 1 OF FIXED-PIPE MET-L-X
DISTRIBUTION SYSTEM

Figure 4

SETUP AND POWDER DISTRIBUTION FOR TEST 2
OF FIXED-PIPE MET-L-X DIST. SYSTEM

Figure 5

GRID, NOZZLE LOCATIONS AND POWDER
COVERAGE FOR TEST 2 OF FIXED-PIPE
MET-L-X DISTRIBUTION SYSTEM

▲ Nozzle location
Squares are 3x3 ft

Figure 6

TEST OF FIXED-PIPE MET-L-X DISTRIBUTION SYSTEM
TEST 2 NOZZLE HEIGHT

		$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$< \frac{1}{4}$ $\frac{1}{4}$	$\frac{1}{4}$ $\frac{3}{4}$ ▲ $\frac{1}{4}$	$\frac{1}{4}$ $< \frac{1}{4}$	$< \frac{1}{4}$ $\frac{3}{4}$	$\frac{1}{4}$ $\frac{1}{4}$	$< \frac{1}{4}$ $\frac{1}{4}$	$\frac{1}{4}$ $\frac{3}{4}$	$\frac{1}{2}$ $\frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{2}$ $\frac{1}{2}$	$\frac{1}{2}$ $\frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$< \frac{1}{4}$ $\frac{1}{4}$	$\frac{1}{2}$ $\frac{3}{4}$	$\frac{1}{4}$ $< \frac{1}{4}$	$\frac{1}{4}$ $\frac{3}{4}$	$\frac{1}{2}$ $\frac{1}{4}$	$\frac{1}{4}$	$< \frac{1}{4}$ $\frac{1}{2}$	$\frac{1}{2}$ $\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{2}$ $\frac{1}{2}$	$\frac{1}{4}$ $< \frac{1}{4}$	$< \frac{1}{4}$	
		$\frac{1}{4}$ $\frac{1}{2}$	▲ $\frac{3}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{4}$ $\frac{3}{4}$	$\frac{3}{4}$ $\frac{3}{4}$	$\frac{3}{4}$ $\frac{1}{4}$	$\frac{1}{2}$ $\frac{1}{4}$	$\frac{1}{4}$ $\frac{1}{2}$	$\frac{1}{4}$	▲ $\frac{1}{2}$	$\frac{1}{4}$ $< \frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$< \frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$ $\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{2}$ ▲	$\frac{1}{4}$ $< \frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$\frac{1}{4}$ $\frac{1}{2}$	▲ $\frac{3}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$\frac{3}{4}$ ▲ $\frac{1}{4}$	$\frac{3}{4}$ $\frac{1}{2}$	$\frac{1}{2}$ ▲ $\frac{3}{4}$	$\frac{1}{2}$ $\frac{1}{4}$	$< \frac{1}{4}$	$\frac{3}{4}$ ▲ $\frac{1}{2}$	$\frac{1}{2}$ $< \frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$\frac{1}{4}$ $< \frac{1}{4}$	$\frac{1}{2}$ $< \frac{1}{4}$	$\frac{1}{4}$ $< \frac{1}{4}$	$\frac{1}{2}$ $< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	
		$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	$< \frac{1}{4}$	

▲ Nozzle location
Squares are 3 x 3 ft

Figure 7

TEST OF FIXED-PIPE MET-L-X DISTRIBUTION SYSTEM
TEST 2 POWDER DEPTH, in.

▲ Nozzle location
Squares are 3x3 ft

Figure 8

TEST OF FIXED-PIPE MET-L-X DISTRIBUTION SYSTEM
TEST 2 POWDER DISTRIBUTION, Lb/Sq

[illegible]

TEST OF FIXED-PIPE MET-L-X DISTRIBUTION SYSTEM
TEST 2 PRESSURE DISTRIBUTION, psi

Figure 10

Nozzle Distribution During Test 2 of
Fixed-Pipe Met-L-X Distribution System