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TRIALS OF METHODS OF FOAM DISPOSAL FOLLOWING USE OF HIGH-EXPANSION FOAM

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SUMMARY

Trials of methods of disposal of high-expansion foam have been performed. A jet/spray branch, a hosereel branch, a compact high-expansion foam generator, a dry-powder extinguisher and a stirrup pump with both water and antifoaming agent were all tested to demonstrate their ability to remove foam. A high pressure hosereel branch, a dry-powder extinguisher and the Compact Generator with semi-rigid ducting were all found to work effectively and efficiently.

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1. INTRODUCTION

A compact high-expansion foam generator has been designed under contract to the Home Office by the Design Unit of Newcastle University (Reference 1). The Compact Generator[1] was designed to have foam performance comparable with existing generators in use in the Fire Service, in particular with the Angus Turbex[2], but also to be small enough to be stowed in the locker of a first-line appliance. It can be used as a smoke extractor.

Brigade trials have been mounted using five Compact Generators (Mark 2) carried on first-line appliances in Tyne and Wear Metropolitan Fire Brigade. The primary object of the trials was to explore the extension of the application of high-expansion foam which may result when it is available with the first attendance. Reference 2 reviews the two years of trials of the Generators.

In response to the trials, some reservations about the use of high-expansion foam were expressed by brigade personnel. Comments confirmed the existence of problems related to the disposal of foam and these were :

1. Once foam had been used, difficulty in verifying that the fire has been extinguished may be encountered.

2. After a foam attack there was the problem of removing foam to determine the extent and cause of the fire and to ensure that the premises were safe so that members of the public would not be endangered by entering the foam.

3. If the use of foam was unsucessful, access to the fire with other extinguishing media was difficult through the foam.

As part of the Home Office Fire Research Programme, the Fire Experimental Unit (FEU), of the Scientific Research and Development Branch (SRDB), has undertaken a study of methods of removing or breaking down high-expansion fire-fighting foam.

Leaving foam to break down naturally may take several hours and a residue of foam solution will drain out which may cause limited damage. However, most methods intended to accelerate foam breakdown, will add either water or some other agent to the foam residue in the compartment and this will cause further damage.

This project was designed to assess methods of foam disposal in terms of limiting time taken and damage caused, whilst finding a method which was convenient to use on the fireground. A comparative method of assessing disposal techniques was chosen. A consistent volume and quality of high-expansion foam was made and the time taken to dispose of it by different methods measured. The input of additional water and/or other agents was also recorded.

The methods assessed were:

Application of water spray from a 'Home Office Diffuser' spray branch and from a hosereel branch at various pressures.

Use of a compact high-expansion foam generator in smoke extraction mode.

Use of a dry-powder fire extinguisher.

Application of water spray with and without an anti-foaming agent using a stirrup pump.

2. BACKGROUND

A literature search was performed to establish which methods of foam disposal had been previously identified and tested.

The use of a water spray to break down high-expansion foam is effective (Reference 3). However, one of the uses of high-expansion foam as an extinguishing agent is in situations where potential water damage may be a problem. In such situations the use of a water spray to dispose of the foam would nullify the advantage of using it.

The Manual of Firemanship (Reference 3) outlines two methods of foam breakdown apart from the use of a water spray. The first of these methods involves the application of an anti-foaming agent whereas the second technique uses a fan to break down the foam.

The Fire Research Station (FRS) studied the effect of commercially available anti-foaming agents (for use in paint and paper manufacturing industries) on high-expansion fire-fighting foam (Reference 4). Results of this work showed that a 5% solution of an agent in water gave a more convincing breakdown of the foam than water applied in the same manner. The application method was by use of a knapsack garden spray delivering 0.6 litres per minute at 2.5 bar. At this rate 2 litres of solution broke down $30m^3$ of foam in approximately 3 minutes. Despite enquiries the FEU has not found any reference to the operational use of this technique of foam disposal.

The Manual of Firemanship suggests that the use of a fan to remove foam may be slow and not always effective. However, Fire Magazine (Reference 5) reported the sucessful deployment of a fan to remove foam from the hold of a ship. The incident occured in London and the Salvage Corps was called upon to remove the foam to enable fire-fighters to reach hot-spots in the hold. An electrically powered fan and semi-rigid flexible ducting were used. The ducting could be moved around the hold to clear remaining pockets of foam. The report of the incident shows that this method was satisfactory but suggests the time taken may have been up to 3.5 hours.

At the Fire Service College a dry powder extinguisher is regularly demonstrated to student courses as a means of breaking down high-expansion foam rapidly.

No reference has been found to other methods of high-expansion foam removal, although the use of a compressed air blast has been suggested[3].

3. EXPERIMENTAL METHOD

To compare the different methods of foam disposal it was necessary to produce a consistent volume and quality of foam for each test. A general method was adopted for the tests and this is described in the sections which follow. The detailed procedures adopted for each method of foam disposal are described in Section 4.

All the tests were performed on foam enclosed in a $56m^3$ volume of dimensions 6m x 3m x 3m high (Figure 1). The enclosure was constructed of aluminium slotted angle and clear polythene sheet. Access to the enclosure was through a two-part door of dimensions 0.6m x 1.7m high. The door parts were inserted into runners from the top and this made it possible to raise the upper part slightly to create a small gap. The upper part could also be removed independently of the bottom part.

The high-expansion foam generator used to produce the foam for the tests was mounted on scaffolding above the enclosure so that the foam produced filled the volume from the top.

To monitor uniformity of foam production, fill-time of the enclosure and foam quality were measured, and found satisfactory (Appendix A).

3.1 Method of foam production

High-expansion foam was made using a Compact Generator[1].

The hydraulic arrangement is shown in Figure 2. Potable water was pumped from the tank of a water tender through a variable in-line inductor[4] and an electromagnetic flowmeter[5] before passing through a hose line to the foam generator. A second flowmeter[6] was connected in the pick-up tube from the foam concentrate container to the inductor in order to measure the flow of the concentrate[7].

Pressure gauges[8] were connected to piezometer tubes positioned as shown in Figure 2. These were mounted by the pump to enable the pump operator to monitor pump and generator pressures throughout the tests. The generator pressure was maintained at 7 bar during foam production.

The system was run up to operating pressure whilst inducting water[9]. The variable inductor was adjusted to give the correct flow of concentrate for a 2.0% solution strength before the pick-up tube was taken out of the water and placed into the foam concentrate. Minor adjustments were then made in the inductor setting to maintain the solution strength at 2.0%.

Timing was performed with stopwatches. The enclosure fill time was recorded from the point when foam first hit the floor to the time when the foam produced in the enclosure was level with the top. When this point was reached the pump operator immediately reduced the throttle and closed the valve to the generator. Despite such action excess foam was produced which stood above the level of the enclosure top (Figure 3). The height of the excess foam ('overfill') was recorded for each test (Appendix A, Table A1).

3.2 Foam quality measurement

Whilst the enclosure was filling with foam a 130 litre light aluminium alloy bin was suspended 1m clear of the floor in a corner of the enclosure and allowed to fill with foam. The bin was weighed on a digital underhang balance and the expansion ratio calculated. The 50% drainage time was determined and recorded (Reference 6).

Mercury-in-glass thermometers were used to measure the foam, water and air temperatures.

Results from the foam quality measurements and discussion of the foam used in the trials is given in Appendix A.

3.3 Foam disposal

Foam disposal was generally commenced 15 minutes after the start of foam production. This interval was thought to represent the minimum time before which a brigade would wish to remove foam. The period between the filling of the enclosure and the start of disposal was used to measure the foam quality and to prepare equipment for the disposal trial.

Disposal to half the height of the enclosure was defined as the 50% disposal point and was timed by stopwatch. In many trials, it was found increasingly difficult to reduce the residue below a depth of about 10cm. This was generally taken as the end point of the trial, denoted the 97% disposal point, and also timed.

4. METHODS FOR FOAM DISPOSAL

A summary of the test conditions and results is given in Table 2.

4.1 Use of a jet/spray branch: Tests 1 & 2

4.1.1 Method

The hydraulic arrangement for these tests is given in Figure 4. Details of the equipment are given in Footnotes 5,8 and 10. The branch used was a Home Office Diffuser[10].

The spray pattern was adjusted to give a cone angle of approximately 45 degrees, and this was left unaltered throughout the tests. Throughout the tests the pump operator maintained the branch pressure at 2.0 bar. The water flowrate was noted.

On commencing foam disposal the branch was inserted between the upper and lower door parts. When the foam was cleared from around the door the upper part was removed and the spray directed around the enclosure. The branch was knocked off when 10cm of foam residue remained.

4.1.2 Results

The results are tabulated below and shown graphically in Figure 5.

TEST	BRANCH	SPRAY ANGLE	PRESSURE bar	FLOW litres/min	DISPOSAL TIME 50% minutes	DISPOSAL TIME 97% minutes	WATER USED FOR 97% DISPOSAL litres
1*	HO Diffuser	45°	2.0	208	0.33	1.58	328
2	HO Diffuser	45°	2.0	212	0.33	2.00	423

* 30 minutes elapsed before disposal was commenced

Initial breakdown of the foam was rapid. After 50% of the foam had been broken down it was more difficult to breakdown the remaining foam. The foam residue at the end of each test was a foam and water mixture to a depth of approximately 10cm. Since breakdown had become very difficult the test was ended at this point.

4.1.3 Discussion

Water spray from a jet/spray branch at a relatively low pressure (2.0 bar) gave a rapid initial foam breakdown but would contribute to water damage considerably. The amount of water used for 97% disposal is equivalent to approximately 4 times the amount of water and foam concentrate used to make the foam.

An increase from 15 minutes (Test 2) to 30 minutes (Test 1) in the time before commencing breakdown did not affect the 50% disposal time but resulted in a slight improvement in the 97% disposal time. Hence the amount of water used in disposing of the 30 minute foam was less than that required for the 15 minute foam. This indicates that the longer the foam is left, the easier it is to break it down with a low pressure water spray.

The reason for this phenomenon is that as the foam ages the solution begins to drain out of the bubble walls, so weakening them. Foam at the top of the enclosure therefore contains less solution than that at the bottom after a period of time. The longer the foam is left the higher the percentage of 'weakened' bubbles and consequently the less water is required to dispose of the foam.

4.2 Use of a hosereel branch: Tests 5, 10, 11, 12, 14 & 15

The hydraulic arrangements for these tests is described in Figure 6 and Footnotes 6, 8 and 11. The branch used was an Angus 'Superfog'[11] set at its widest spray, which produced a cone angle of approximately 45°.

4.2.1 Method

Water flow and pressure were noted for each test.

With the exception of Test 12, all tests were performed with the branchman at the enclosure door. On commencing foam breakdown the branch was inserted between the upper and lower parts of the door. When the foam was cleared from around the door the upper part was removed and the spray directed around the enclosure.

In Test 12 the branchman stood above the enclosure and directed spray onto the foam from the top.

With all tests the branch was knocked off when a depth of 10cm of foam residue remained.

4.2.2 Results

The results are tabulated below and shown graphically in Figure 5.

TEST	BRANCH	SPRAY ANGLE	PRESSURE bar	FLOW litres/min	DISPOSAL TIME 50% minutes	DISPOSAL TIME 97% minutes	WATER USED FOR 97% DISPOSAL litres
5	'Superfog'	45°	12	110	0.37	2.00	221
11	'Superfog'	45°	2	42	2.00	6.00	252
12x	'Superfog'	45°	7	78	0.57	3.50	273
14*	'Superfog'	45°	16	121	0.28	1.50	182
15	'Superfog'	45°	16	120	0.28	1.75	210

x Spray directed from the top.
* The foam was left for approximately 25 minutes before disposal was started.

Initial breakdown of the foam was rapid except at the lowest branch pressure of 2 bar. Again, after 50% of the foam had been broken down it was more difficult to break down the remaining 'wetter' foam. The foam behaved similarly when attacked from the doorway and when attacked from the top (Test 12).

The residue at the end of each test was a foam and water mixture to a depth of approximately 10cm. Further breakdown of this proved to be very difficult.

4.2.3 Discussion

The results show that as a general rule 50% and 97% disposal times decreased with increasing pressure and flow.

The amount of water used for the 97% disposal was approximately 1.5 - 2.0 times the amount of water and foam concentrate used un foam production. Increased branch pressure gave only a small reduction in the amount of water used for disposal.

The results of Tests 14 and 15 confirm the results shown in Tests 1 and 2. In Test 14 the foam was left for 25 minutes before disposal commenced and, as in Section 4.1, the disposal time was lessened.

4.3 Use of a Compact Generator[1] with ducting: Test 3

4.3.1 Method

The hydraulic arrangement for this test is shown in Figure 7.

A Compact Generator[1] was positioned outside the enclosure doorway with 3m of semi-rigid ducting[12] leading from the inlet of the fan to the enclosure door (Figure 8). The generator was energised by water without foam concentrate, the water leaving the fan motor being allowed leave the spray nozzle freely.

At the end of the 15 minute waiting period, the pump operator applied water pressure to the generator to 7 bar and maintained this pressure throughout the test. The water flow was noted.

As the water pressure to the generator was applied, the inlet of the semi-rigid ducting came into contact with the door panel. Suction in the ducting then caused it to collapse upon itself causing an almost complete blockage (Figure 8). When the collapsed ducting was fed into the enclosure it had a very limited effectiveness. All attempts to restore the ducting failed. The test was therefore concluded at this point.

4.4 Use of a Compact Generator[1] with ducting: Test 13

4.4.1 Method

In this test, a procedure was adopted to avoid collapse of the ducting.

Before filling the enclosure with foam, a Compact Generator was positioned outside the enclosure with 3m of semi-rigid ducting leading from the inlet of the fan through the bottom part of the door (Figure 9). The door shutters rested on bolts just above the ducting and the area between the door frame and ducting was sealed with polythene sheet. The outlet of the water motor was coupled to a length of hose to lead the waste water away.

As in Test 3, on commencing foam disposal the pump operator applied 7 bar water pressure to the generator. This pressure was maintained throughout the test and the water flow through the generator was noted.

When the foam around the ducting inlet had been cleared, an operator entered the enclosure and moved the ducting into the remaining foam. The test was stopped when there was approximately 10 cm depth of foam remaining on the enclosure floor.

4.4.2 Results.

The results are tabulated below and presented graphically at Figure 5.

TEST	PRESSURE bar	FLOW litres/min	DISPOSAL TIME 50% minutes	97%
13	7.0	319.7	0.80	6.00

The first 50% of foam was removed fairly rapidly and uniformly. When the foam around the ducting inlet had been cleared it was necessary to move both the ducting and the Compact Generator to reach the remaining foam. This added to the 97% time recorded. The ducting could be used like a vacuum cleaner to remove the foam residue but the liquid tended to lie inside the ducting rather than be extracted through the fan.

4.4.3 Discussion.

The inlet of the ducting did not come into contact with the door shutter or floor in this test. Consequently, the ducting did not collapse as in Test 3 and the equipment performed satisfactorily.

When there was sufficient foam to flow towards the fan under the force of gravity it was removed rapidly. However, after this stage it was necessary to move the ducting mouth into the remaining foam. The limited length of the ducting meant that to reach the corners of the enclosure the generator itself had to be moved towards the enclosure.

The main advantage of this method is the reduction of water damage, since the foam is expelled from the compartment, and no water is added.

4.5 Use of a Compact Generator[1] unducted: Test 4

4.5.1 Method

The hydraulic arrangement for this test was again as shown in Figure 7. A Compact Generator was positioned in the centre of the enclosure before it was filled with foam (Figure 10). Hose was run to the generator inlet and from the outlet, under the lower part of the door. When the enclosure was filled with foam the generator was engulfed.

On commencement of foam disposal the pump operator applied the water pressure to the generator at 7 bar. This pressure was maintained throughout the test and the water flow noted.

4.5.2 Results.

The results are tabulated below and shown graphically at Figure 5.

TEST	PRESSURE	FLOW	DISPOSAL TIME 50%	97%
	bar	litres/min	minutes	
4	7.0	317.2	0.88	---

The first 50% of the foam was broken down fairly rapidly, the foam surface remaining horizontal. Ultimately, within about 1 metre from the generator, the foam surface was reduced to the bottom of the fan casing. Around this area a greater height of foam remained. A 97% disposal time was therefore not recorded.

Foam was drawn through the fan and physically broken down by the action of the fan blades and by being forced through the protective grill as in Figure 9. Broken down foam remained within the enclosure.

4.5.3. Discussion.

The use of a Compact Generator in high expansion foam to break it down has limited effectiveness. The method has the advantage of not creating any extra water damage provided the water from the outlet is lead away through a length of hose. However, the foam residue is not removed from the compartment.

It may not always be practicable to place the generator into the foam in operations.

Where a local area in the compartment needs to be cleared, this method of using the Compact Generator may prove effective. Generally, the overall effectiveness in a large area would be poor.

4.6 Use of a dry powder extinguisher.: Test 6

4.6.1 Method

A 9kg dry powder extinguisher[13] fully charged with Chubb G.P. powder was used for the test. The initial weight was noted.

As foam disposal was commenced the hose of the extinguisher was passed between the upper and lower parts of the door and the extinguisher trigger squeezed gently to introduce the powder to the enclosure. When the foam height had reduced to approximately 10cm the test was stopped.

The extinguisher was reweighed and the weight of powder used was calculated.

4.6.2 Results

The results are tabulated below and shown graphically at Figure 5.

TEST	WEIGHT OF POWDER USED kg	DISPOSAL TIME 50% minutes	97%
6	6.04	0.30	1.70

The rate of foam breakdown with a dry powder extinguisher was very rapid. 6.04 kg of powder was used in the test. Observation was difficult due to the powder cloud obscuring the enclosure. This cloud also caused breathing difficulties for the operator and observer without masks or BA.

The residue from the foam and the powder from the extinguisher settled to a depth of approximately 10 cm on the floor of the enclosure.

4.6.3 Discussion

The dry powder knocked down the foam very rapidly without introducing water. However, the powder filled the compartment with a dust cloud which later settled. Whether this form of damage is preferable to the introduction of water would depend on the operational situation. Although in this test it took 6kg of powder to knockdown $56m^3$ of foam, it is probable that a larger volume of foam could be knocked down with the same amount of powder since control of the extinguisher was difficult and much of the extinguisher discharged rapidly. The approximate cost of recharging a 9 kg dry powder extinguisher is £8 (1984 prices).

4.7 Use of a stirrup pump with water spray.: Test 7

4.7.1 Method

A stirrup pump[14] modified to use the adjustable spray nozzle of a knapsack-type garden spray[15] was used for the test. Water was pumped by a 'pump operator' from a trough through 10m of delivery hose to the nozzle held by a 'branchman'. The spray nozzle was adjusted to give a cone angle of approximately 45°. This was not altered during the test.

The trough was filled with water and the weight of this plus the weight of the pump and hose was noted.

At the commencement of foam disposal the 'branchman' opened a gap between the upper and lower parts of the door and started clearing the foam from this area (Figure 11). Throughout disposal, the 'pump operator' maintained pumping at approximately 60 double strokes per minute . This pumping rate was maintained throughout the test. When foam had been cleared from the doorway the 'branchman' entered the enclosure to complete the breakdown (Figure 12). When 10 cm of foam residue remained on the floor of the enclosure the test was stopped.

The trough, pump and remaining water were reweighed to calculate the amount of water used for the test.

4.7.2 Results

The results are tabulated below and presented graphically at Figure 5.

TEST	FLOW	DISPOSAL TIME		WATER USED FOR
		50%	97%	97% DISPOSAL
	litres/min	minutes		litres
7	2.05	8.00	15.60	31.6

Foam clearance took considerable time by this method. Apart from the speed, the method was effective, leaving a foam and water residue similar to that left after the hosereel tests.

4.7.3 Discussion

This test served as a control for Test 8. In the FRS tests on antifoaming agents (Reference 4) a knapsack garden spray was used. In order to simulate the solution flow and pressure used in those tests but to use Fire Service equipment, a stirrup pump was used for the present trials.

In this test the amount of water used to achieve 97% disposal was very low (equivalent to approximately 28% of foam solution used in foam production). However, the time taken was extremely long, even for the comparatively small area of the enclosure. It therefore seems unlikely that this method would be practicable in an operational situation, unless there were special circumstances.

4.8 Use of a stirrup pump with antifoaming agent: Test 8

The FRS report on the breakdown of high expansion foam using antifoaming agents (Reference 4) assessed three commercially available agents. Of these agents, two were considered unsuitable for Fire Service use by FEU. The first (Nalfloc 71-D5) is flammable and should be kept away from heat, it is a skin irritant and may attack rubber. The second agent (Foamaster NXZ) does not have such serious shortcomings but its shelf life of 4 months renders it impractical for Fire Service use. The agent tested by FEU (Foamaster DNH-1)[16] is not flammable (flashpoint 180°C) but it will burn. It has a shelf life of 12 months.

4.8.1 Method.

The equipment and method used in this test was the same as that in section 4.6.1. Instead of water in the trough, a 5% solution (as recommended by FRS) of DNH-1 was made up five minutes before foam disposal commenced. The trough of solution was then weighed as the water had been in Test 7. After 15 minutes foam disposal was started as in Test 7. Timing and solution application ceased when the foam level was at 10 cm.

4.8.2 Results

The results are tabulated below and shown graphically at Figure 5.

TEST	FLOW	DISPOSAL TIME		SOLUTION USED FOR
		50%	97%	97% DISPOSAL
	litres/min	minutes		litres
8	2.03	3.25	6.25	12.7

Foamaster DNH-1 is a viscous oily suspension. It settles out of solution fairly rapidly and so it was necessary to agitate the solution during the test. An oily film was left on the measuring vessels, trough and pump which proved extremely difficult to remove even with concentrated detergent solution as recommended by the agent manufacturers.

During the test the agent worked effectively. Foam breakdown continued even after spraying on a particular area had ceased. Because of this continuing action, less residue was left at the end of the test than with tests using water, even though spraying was stopped with foam at a level of 10cm.

After the test an oily film was observed on the walls and floor of the enclosure. The solution that had been applied to the foam and was left to stand overnight on the floor developed a 'scum' (Figure 13). This 'scum' had an unpleasant smell and had a tendency to adhere to surfaces exposed to it.

4.8.3 Discussion

The addition of a 5% solution of DNH-1 significantly improved disposal time for the foam using a stirrup pump. Very little solution was required to effect the breakdown, about 12% of the amount of foam solution used in foam production.

However, the small amount of solution used did cause a great deal of contamination to the enclosure and pumping equipment. The oily film which was deposited was extremely difficult to remove. Cleaning this off in salvage operations would appear to be almost impossible as would the cleaning of fire brigade equipment used in the incident.

Antifoaming agent is normally supplied in 200 litre drums at a cost of approximately £35. The cost of antifoaming agent used in Test 8 would be less than 15p. However, if the solution had been applied at a faster rate (for example through a hosereel branch) the cost would rise considerably. Use of a stirrup pump is an economical method of applying antifoaming agent since the slow rate of application gives time for the agent to have maximum effect. A faster rate of application would not allow this to happen.

5. DISCUSSION

The method of foam disposal employed should depend on the demands of the operational situation. In many instances it will be necessary to gain fast entry through the foam without disposing of all of it rapidly. In such cases the 50% disposal time would give the best guide as to which method to use.

In general, the faster the method of disposal, the more damage was caused.

With the use of a hosereel branch, pressures above 7 bar gave an efficient breakdown but with the introduction of additional water. The effectiveness of a stirrup pump with water would indicate that the volume of water used is not as critical as the method of application. It appears, however, that with water spray there is an inverse relationship between the time taken for foam breakdown and the volume of water applied. Economy in water supplied should be obtained by use of a small spray branch operated from a hosereel, but with a flow comparable to the stirrup pump.

The use of the stirrup pump with antifoaming agent demonstrated that the agent does increase the efficiency of the water by breaking down the foam by a chemical reaction. However, there are two main problems, firstly the method of application, with or without agent, is very slow and draining on manpower although cost effective in the use of the agent. Secondly, there is a serious problem with the contamination caused by the agent. Whereas salvage after water damage is fairly straightforward, salvage from antifoaming agent would be very difficult and maybe impossible. To overcome the first problem it would be possible to 'induct' the antifoaming agent into a hosereel or main jet, this would increase application rate but also increase contamination within the appliance pump, hose and branches. It is doubtful whether the efficiency of water spray from a hosereel would be significantly increased by the addition of agent.

When used with care a ducted compact generator will clear flowing foam effectively. By manoevering the ducting the foam could be removed totally from the compartment. Problems with the ducting are mainly due to its bulk and therefore limited manoeverability. If a means of attaching ducting of a smaller bore to the generator was developed, then longer lengths of ducting could be carried and these would be easier to handle. However, such ducting may lead to a drop in efficiency.

Even if the generator is within the compartment foam will be broken down without the addition of water. The effectiveness of a generator in a large compartment may be limited by the position of shelving, partitions etc. therefore caution must be excercised when using this disposal method. It must also be noted that all foam generators may not perform as well as the Compact Generator in suction.

The most rapid method of foam breakdown is by the use of a dry powder extinguisher. The injection of powder into the compartment may prove to be undesirable in some circumstances and this will limit the use of the method. There is also a cost factor in using an extinguisher which is not a problem with the use of water or a Compact Generator.

6. CONCLUSION

The use of a high pressure hosereel branch, a dry powder extinguisher or a Compact Generator[1] in suction with semi-rigid ducting can all be recommended as methods for breaking down or removing high-expansion foam. The choice of method will depend on the operational situation. Use of a hosereel branch will increase water damage and a dry powder extinguisher will leave a powder and foam residue. Where damage cannot be tolerated and time may be taken to remove the foam, a Compact Generator with ducting is the most suitable piece of equipment to use.

ACKNOWLEDGEMENTS

Acknowledgement is made to the assistance received from J.A. Foster and B.P. Johnson in the trials.

FOOTNOTES

1. Symtol Engineering Ltd, Blyth, Northumberland. - Compact HEF Generator.
2. Angus Fire Armour, Thame, Oxon. - Angus Turbex Mark II, high expansion foam generator.
3. Strathclyde Fire Brigade - Private communication.
4. John Kerr, Kirkby, Liverpool. - Total Z2 inductor.
5. Kent Flow Products, Stonehouse, Glos. - 80mm electromagnetic flowmeter.
6. Kent Flow Products, Stonehouse, Glos. - 15mm electromagnetic flowmeter.
7. Angus Fire Armour, Thame, Oxon. - Expandol foam concentrate.
8. Budenberg Gauge Co Ltd, Altrincham, Cheshire. - 6 inch gauge, 1-20 bar.
9. Water was initially inducted in order to set the variable inductor to give the correct concentration without making foam. By this method all the foam entering the enclosure is made with the correct solution strength.
10. Perry Barr Metal Co, Birmingham. - Home Office Diffuser.
11. Angus Fire Armour, Thame, Oxon. - 'Superfog' hosereel branch.
12. Angus Fire Armour, Thame, Oxon. - Turbex semi-rigid ducting.
13. Chubb Fire, Sunbury-on-Thames. - 9kg dry powder extinguisher.
14. Crown Suppliers, Bootle, Merseyside. - Stirrup pump.
15. Hills Industries Ltd, Caerphilly, Mid Glamorgan. - Spray from Model 375 knapsack sprayer.
16. Diamond Shamrock Process Chemicals Ltd, Eccles, Manchester. - Foamaster DNH-1.

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3. Manual of Firemanship: Book 3 - Fire Extinguishing Equipment, London, HMSO (1976).

4. Tonkin P.S., Berlemont C.F.J., - 'Breakdown of high-expansion foam using antifoaming agents.', Fire Research Note No 764 (1969), Fire Research Station, Borehamwood.

5. Milner J., - 'Two new techniques successful at ship fire in London Docks.', Fire 788, 422 (1971).

6. J.C.D.D. Specification 28 (1972) - High-expansion foam liquid.

TABLE 1 - SUMMARY OF TESTS

TEST No	EQUIPMENT USED	METHOD OF USE	PRESSURE AT EQUIPMENT bar	WATER FLOW litres/min	DISPOSAL TIME 50% minutes	DISPOSAL TIME 97% minutes	AMOUNT OF WATER OR AGENT USED FOR 97%
--	----	----					---
1#	H.O. Diffuser	45° Spray	2.0	208	0.33	1.58	328 litres
2	H.O. Diffuser	45° Spray	2.0	212	0.33	2.00	423 litres
3	Compact Generator	Ducted	7.0	309	*	*	------
4	Compact Generator	In foam	7.0	317	0.88	*	------
5	Hosereel gun		12.2	110	0.37	2.00	221 litres
6	Dry powder extinguisher		---	---	0.30	1.70	6.04 kg powder
7	Stirrup pump	With water	---	2	8.00	15.60	32 litres
8	Stirrup pump	With DNH-1	---	2	3.25	6.25	13 litres solution
11	Hosereel gun		2.0	42	2.00	16.00	291 litres
12	Hosereel gun	from top	7.0	79	0.57	3.30	279 litres
13	Compact Generator	Ducted	7.0	320	0.80	6.00	------
14$	Hosereel gun		16.0	121	0.28	1.50	182 litres
15	Hosereel gun		16.0	120	0.27	1.75	210 litres

* No result obtained
\# 30 minutes elapsed before disposal commenced
$ 21 minutes elapsed before disposal commenced

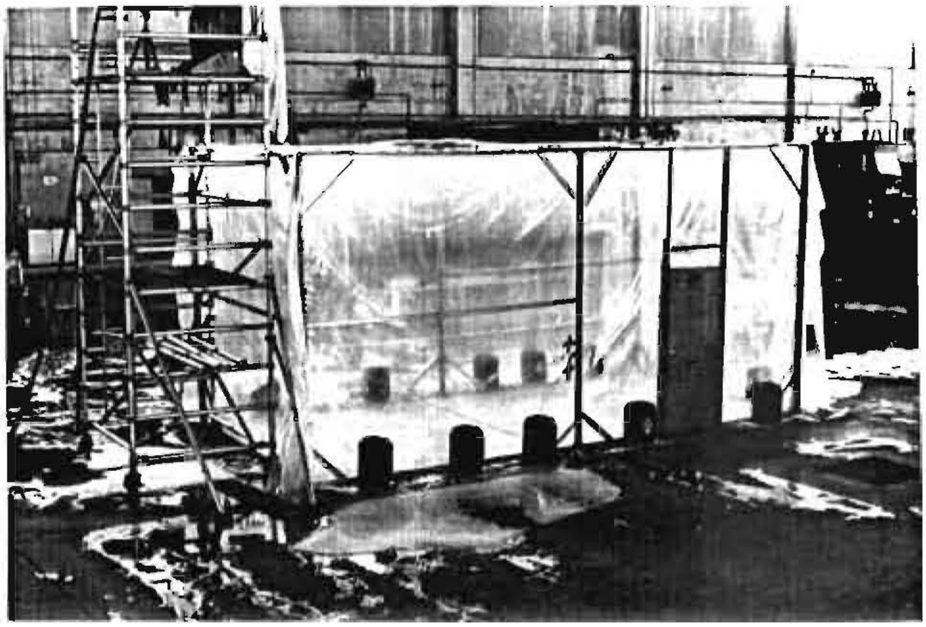

Figure 1 - The test enclosure before foam production
B/168/84

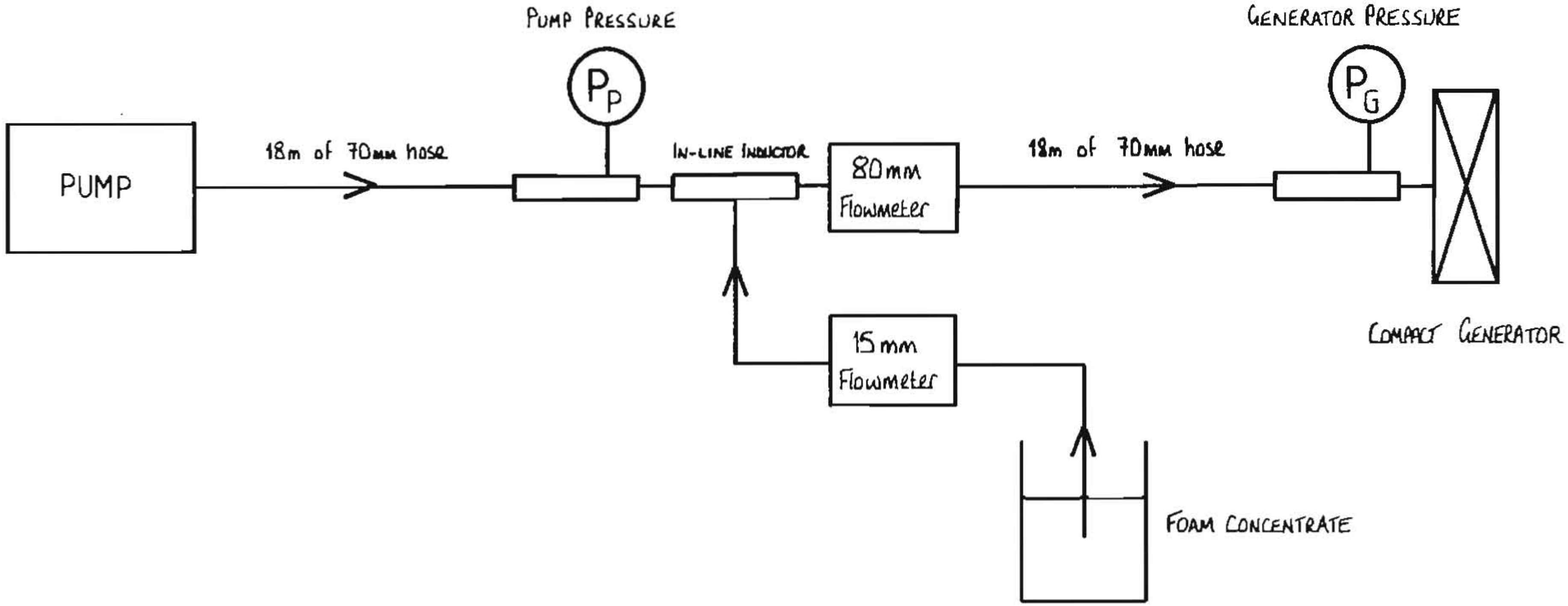

Figure 2 - Hydraulic arrangement for high-expansion foam production.

Figure 3 - The enclosure filled with high-expansion foam.
C/615/84

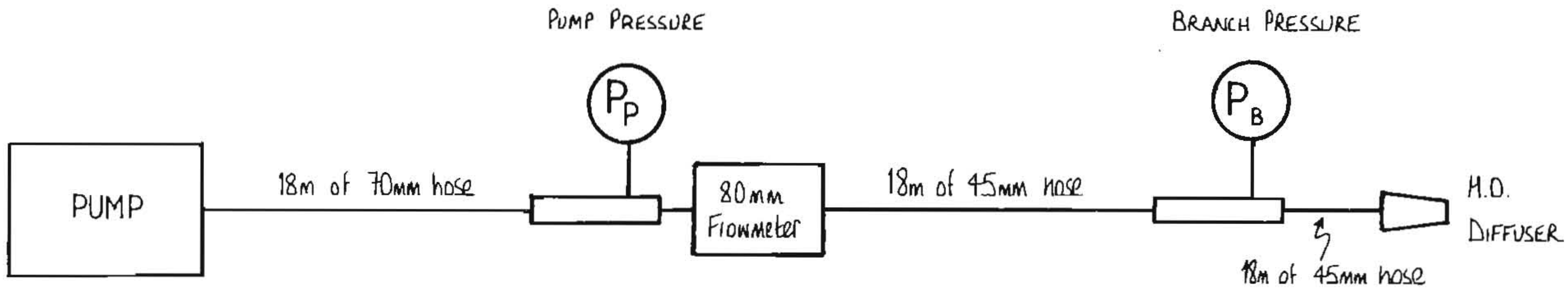

Figure 4 -Hydraulic arrangement for Home Office Diffuser branch tests (Tests 1 & 2).

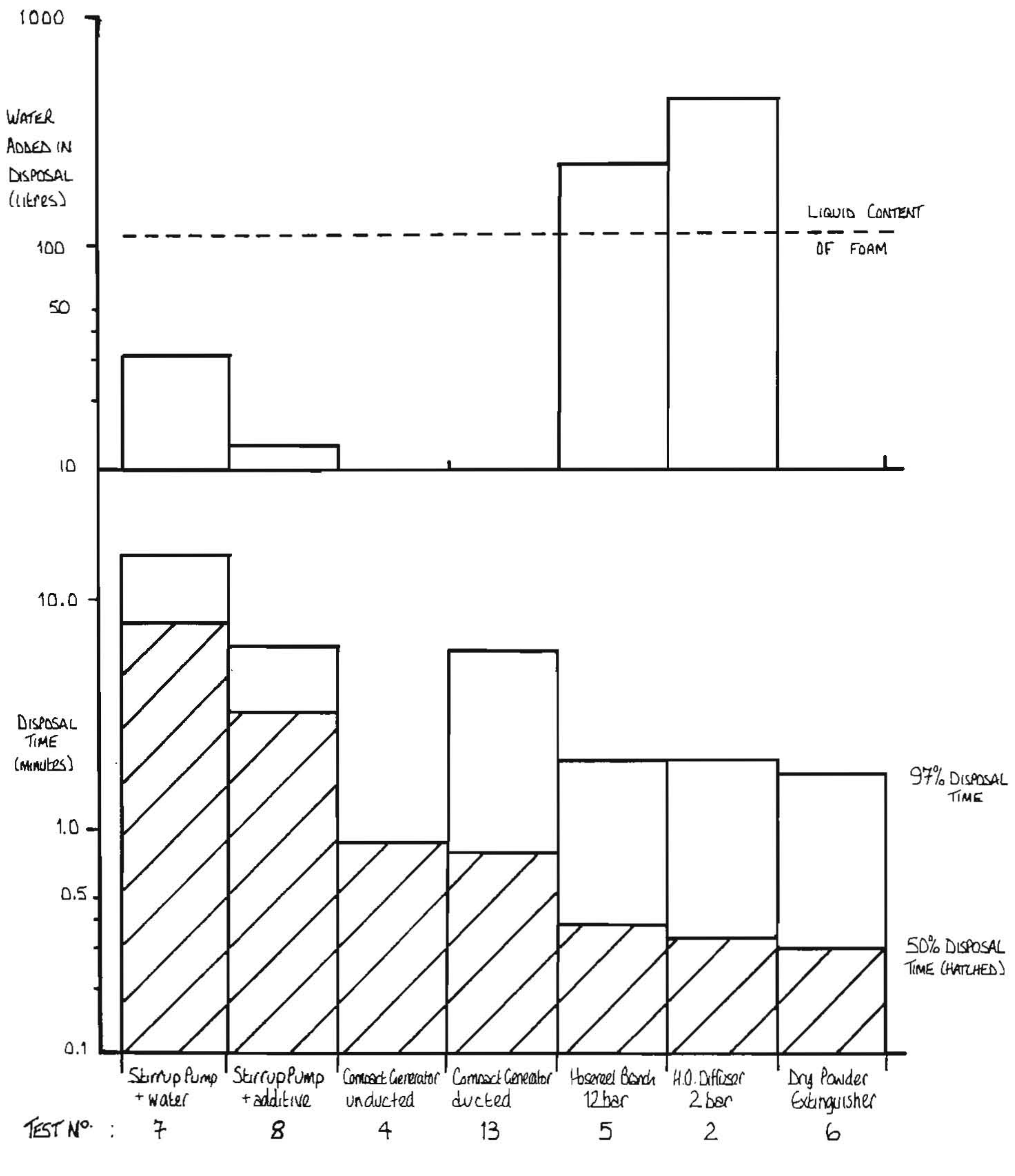

Figure 5 - Bar chart showing time for disposal and water used against method employed.

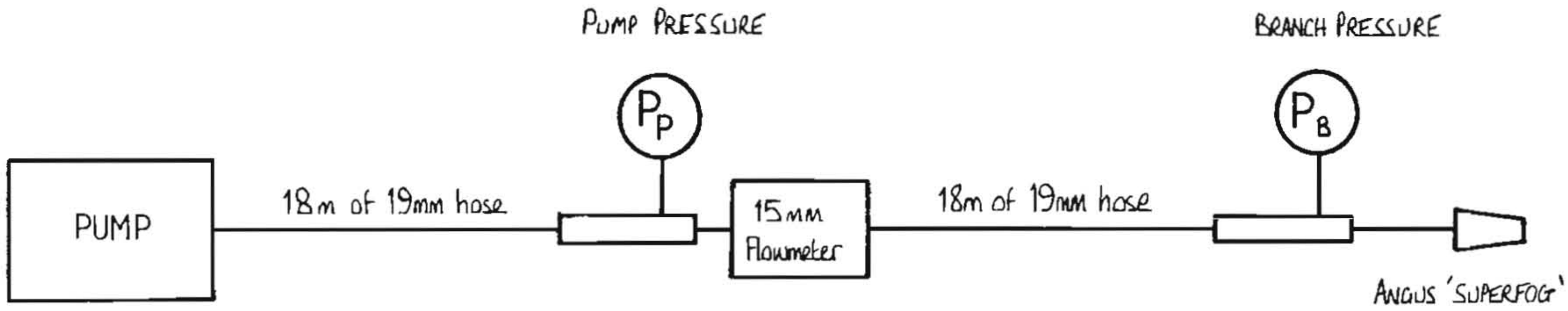

Figure 6 - Hydraulic arrangement for hosereel branch tests (Tests 5, 11, 12, 14 & 15)

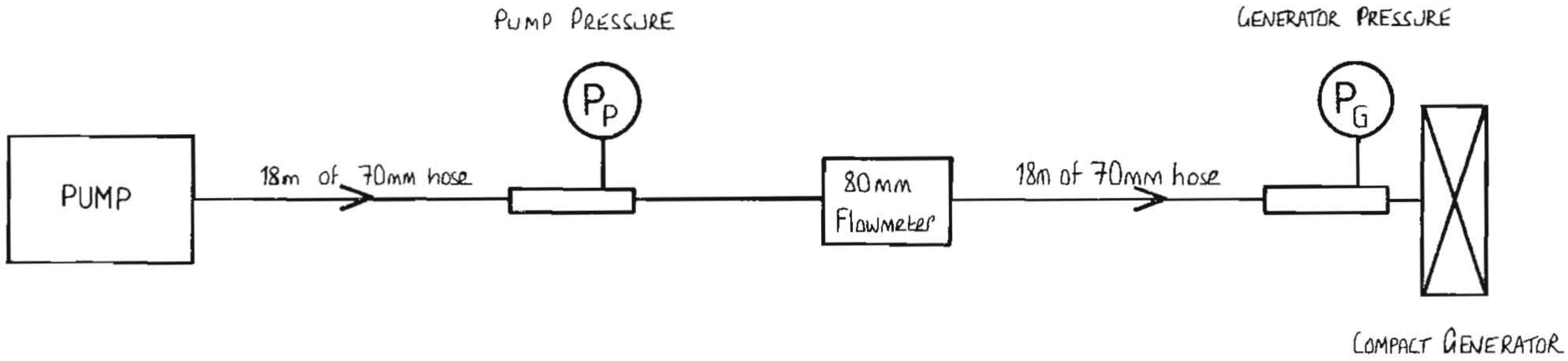

Figure 7 - Hydraulic arrangement for Compact Generator tests (Tests 3, 4 & 13).

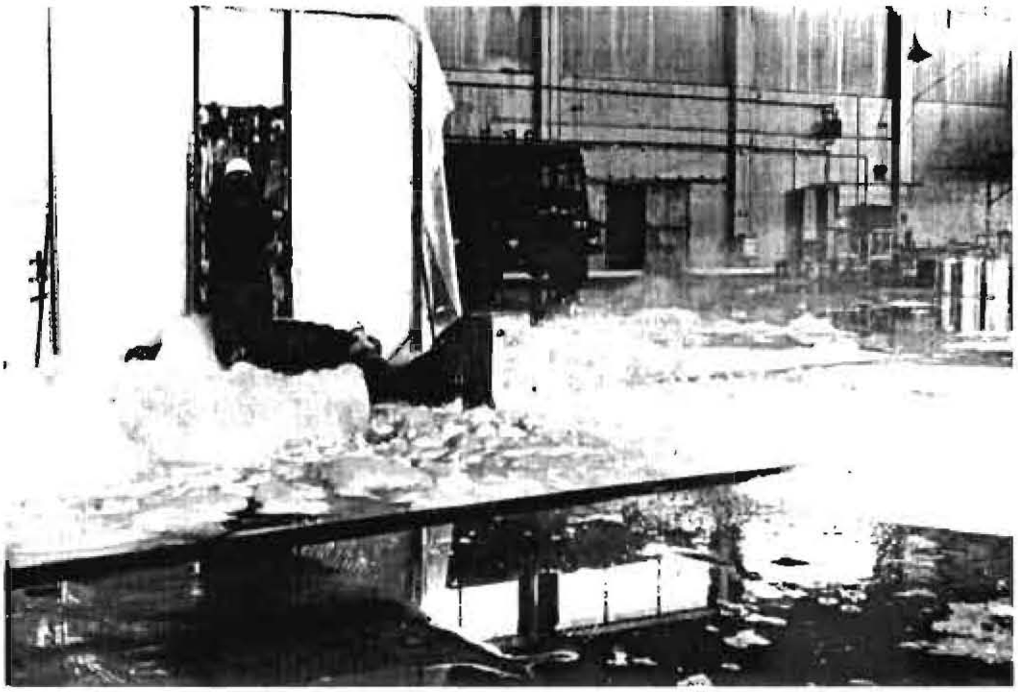

Figure 8 - Collapsed semi-rigid ducting on Compact Generator (Test 3).
C/619/84

Figure 9 - Foam removed from the enclosure and broken down by the Compact Generator.
C/643/84

Figure 10 - Unducted Compact Generator clearing foam (Test 4).
C/626/84

Areas of the enclosure where foam remains can be seen in the background.

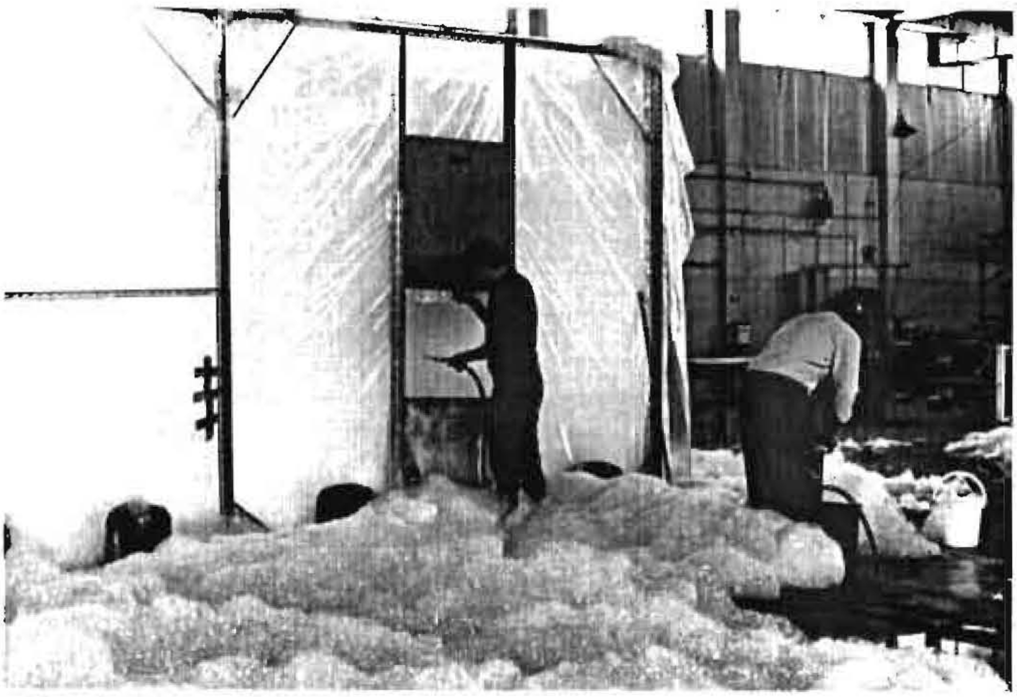

Figure 11 - Clearing foam from the doorway of the enclosure using a stirrup pump.
C/628/84

Figure 12 - Using the spray from the stirrup pump to complete
C/631/84 foam breakdown.

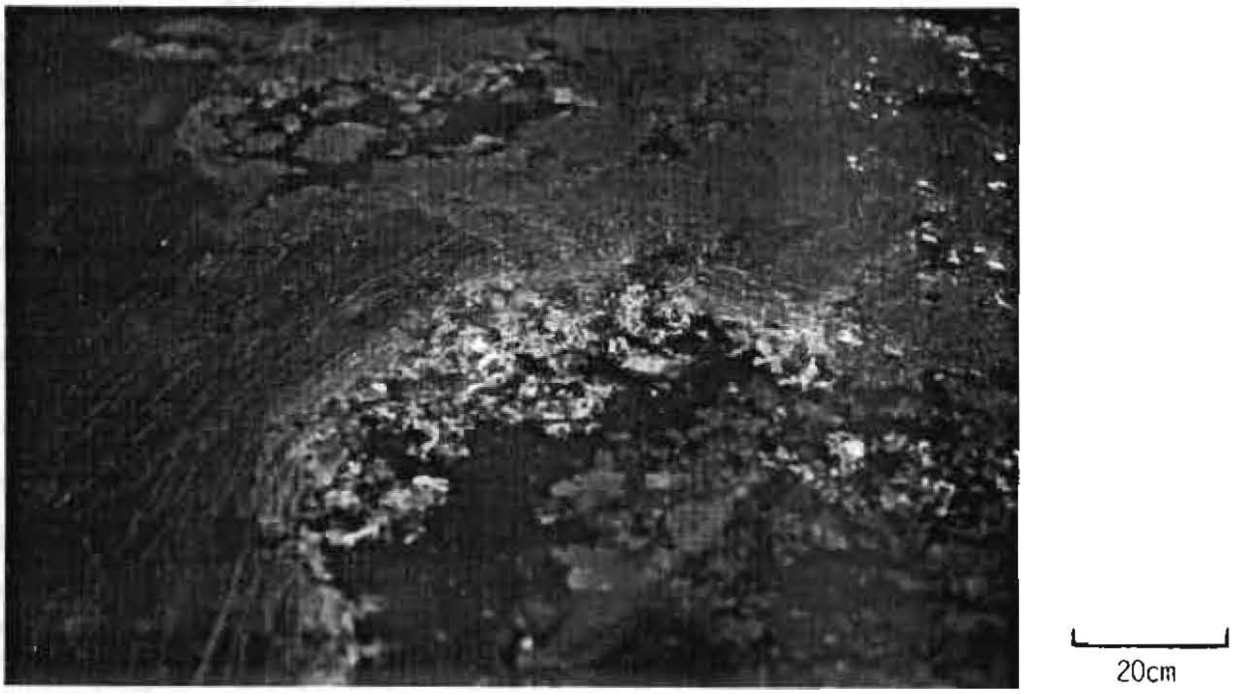

Figure 13 - Oily 'scum' on antifoaming agent residue
C/635/84 approximately 18 hours after application.

APPENDIX A - FOAM QUALITY MEASUREMENTS

The general method for the measurement of foam quality is given in Section 3.2.

Table A1 shows the values recorded for enclosure fill time, expansion ratio, drainage time and temperature for each of the tests. Conditions at the pump and generator are also given. 'Overfill' is a measure of the height of foam standing proud of the top of the enclosure (Section 3.1).

Discussion

To ensure that the foam for each test was of similar quality enclosure fill time, expansion ratio and drainage time were all monitored. The enclosure fill time is related to the volume output of the generator thus consistency in fill time indicates that the generator is performing similarly for each test.

Table A1 indicates that the quality of the foam throughout the trials was consistent.

The 'overfill' is also seen to be consistent throughout the tests. Since the tests are comparative this may be regarded as a systematic experimental error and therefore needs no further discussion.

TABLE A1 - FOAM QUALITY MEASUREMENTS FOR ALL TESTS

TEST	TEMPERATURE			FOAM GENERATOR		FOAM CONCENTRATE		ENCLOSURE	EXPANSION	50% DRAINAGE	OVERFILL	TOTAL WATER
No	AIR	WATER	FOAM	FLOW	PRESSURE	FLOW	%	FILL TIME	RATIO	TIME		+ FOAM USED
--	°C	°C	°C	litres/min	bar	litres/min		minutes	---	minutes	metres	litres
1	21.0	18.5	19.5	293	6.8	5.9	2.0	0.38	2650	8.28	0.3	111.5
2	19.0	18.5	19.5	302	7.0	6.0	2.0	0.36	1310	13.63	0.3	108.8
3	20.0	18.5	19.5	300	7.0	6.0	2.0	0.39	1130	11.15	0.3	117.2
4	20.5	18.5	20.5	303	7.0	6.1	2.0	0.37	1110	11.75	0.3	112.3
5	22.5	18.5	21.5	301	7.0	6.0	2.0	0.36	1000	10.60	0.3	108.4
6	23.0	18.5	22.5	301	7.0	6.0	2.0	0.36	880	11.67	0.3	108.4
7	20.5	18.0	20.5	300	7.0	6.0	2.0	0.36	1020	13.17	0.3	107.8
8	21.0	19.0	21.5	304	7.0	6.1	2.0	0.36	1010	12.35	0.3	109.3
9	22.0	19.0	22.0	302	7.0	6.0	2.0	0.40	880	10.58	0.3	120.6
10	22.0	21.0	22.0	304	7.0	6.1	2.0	0.38	1300	12.88	0.3	115.5
11	22.5	21.0	22.5	303	7.0	6.0	2.0	0.36	751	12.67	0.3	108.9
12	23.0	21.0	23.5	304	7.0	6.1	2.0	0.37	1410	6.71	0.3	112.6
13	23.5	21.0	22.5	305	7.0	6.1	2.0	0.37	1170	13.58	0.3	112.7
14	22.5	20.0	22.0	302	7.0	6.0	2.0	0.38	*	*	0.3	114.8
15	23.0	20.0	22.0	302	7.0	6.0	2.0	0.38	*	*	0.3	114.8

* No result obtained

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