



LASTFIRE
FIRE TEST SPECIFICATION
WATER MISCIBLE FUELS
REVISION A
MAY 2015

REPORT No.	PREPARED BY	CHECKED BY	APPROVED BY
LFTEST WM	B. Chisholm	P. Watkins	N. Ramsden
	DATE: May 2015	DATE: May 2015	DATE: May 2015

CONTENTS

1.0 INTRODUCTION

2.0 TEST PROTOCOL

2.1 Objectives

2.2 Test Requirements

APPENDIX A	-	Test Set-Up
APPENDIX B	-	Test Nozzles
APPENDIX C	-	Test Criteria
APPENDIX D	-	Example Results Sheet

1.0 Introduction

The original LASTFIRE Study identified the need for a small-scale fire test to evaluate the performance of fire fighting foam for storage tank application. Other tests were considered to be aimed at different types of incident such as rapid rescue situations.

A test procedure was finalised in 2003 – the LASTFIRE Foam test for Storage Tank Fires. It is designed to simulate the special considerations for tank incidents such as forceful foam impact, hot tank walls and distorted tank shells. Since the development of the protocol the test has been used to evaluate the performance of foam concentrate samples taken from numerous facilities, as well as freshly manufactured concentrates for end user batch acceptance purposes. Foam manufacturers also employ the LASTFIRE test to develop their foams for storage tank applications.

The test is primarily used to evaluate foam performance on non-water miscible fuels. The current test standard uses heptane – a readily available and consistent fuel specification; other tests have been performed on fuels such as gasoline.

In recent times – partly due to the evolution of ethanol, biogasoline etc. storage and handling operations and due to the need to understand foam performance on tanks storing fuels such as MTBE – the LASTFIRE Steering Panel has identified a need to expand the LASTFIRE Specification so that foam performance on water miscible (WM) fuels can be tested. Thus a WM (or “polar solvent”) LASTFIRE Foam Test for Storage Tank Fires needs to be developed.

This Protocol outlines the requirements for such a test. It is based on the most recent test work by the LASTFIRE Group to establish the test methodology.

This protocol has been revised to address perceived variations in fuel, sea water and third-party test administration. Changes outlined in this document mean that it is the most current as of May 2015.

The main changes from the earlier version are as follows:-

- a) Clarification of fuel (ethanol) specification (Section 2.2.2);
- b) Clarification of simulated sea (salt) water recommended composition (Section 2.2.4);
- c) Clarification of system nozzle positioning for system nozzle part of test (Section 2.2.3).

2.0 Protocol

2.1 Objectives

The primary objective of the WM LASTFIRE Foam Test is to: -

1. Evaluate the fire performance of a foam when applied to a Water Miscible (WM) fuel or "polar solvent" under test conditions, so that the potential fire performance for large scale storage tank applications may be determined.
2. Critically evaluate a foam by standardising on various test parameters and conditions, and by evaluating certain aspects – such as:
 - a. Ambient temperature, wind;
 - b. Fuel type / grade;
 - c. Fuel quantity;
 - d. Tank "freeboard" height;
 - e. Fire characteristics, preburn period etc.;
 - f. Application Rate;
 - g. Foam application duration;
 - h. Foam nozzle positioning / application technique;
 - i. Vapour seal and burnback capability;
 - j. Fire performance criteria (control, extinguishment, post fire security).

Once the critical test parameters mentioned above have been defined, a protocol can be established that is suitable for WM fuels.

Section 2.2 describes the test fire requirements and methodology.

2.2 Test Requirements & Methodology

Test requirements shall generally be in accordance with those of the non-WM LASTFIRE test; however, there are differences for the WM test. The requirements and general methodology for the WM test are as follows:

1. The LASTFIRE test pan (2.44 m diameter / 50 sq. ft) shall be used and the foam shall be made using the nozzles and equipment used in the (hydrocarbon) LASTFIRE Foam Test for Storage Tank Fires. See Appendix A for test set-up.
2. The test fuel shall be ethanol. (No water layer shall be provided as in the non-WM LASTFIRE test since this would mix with the ethanol).
3. 300 litres of ethanol shall be added to the LASTFIRE test pan*.
*(Following burning and foam application it will be necessary to remove any residual fuel from the tank because water from the foam solution will be absorbed. This is unlike a test using heptane or gasoline after which the foam can simply be skimmed off the top of the fuel).
4. The nozzles used to make foam shall be the aspirating "monitor" nozzle and "system" nozzle** as specified in the non-WM LASTFIRE test.
**The "monitor" nozzle is capable of producing aspirated foam designed to simulate an-aspirating large throughput monitor. The system nozzle runs at a low application rate and is capable of producing aspirated foam with slightly higher expansion characteristics than the equivalent "monitor" nozzle. Application using the monitor nozzle will be indirect from a backboard, whilst application via the system nozzle will be relatively gentle over the tank "shell".
5. Each nozzle shall be evaluated in turn (i.e. monitor test and system test). The aspirated nozzle stream shall be directed from a backboard onto the fuel surface. The system nozzle stream shall be directed over the side of the pan. See Appendix A for test/backboard set-up.
6. The application rates for the nozzles shall be as given in Table 1.

NOZZLE	SOLUTION FLOW (lpm)	NETT SOLUTION FLOW (lpm)	APPLICATION RATE (lpm/m ²)
Aspirated*	17.0	17.0	3.63
System	11.7	11.7	2.50

Table 1 – Application Rates

7. The Fuel shall be ignited and be allowed to burn for 3 minutes.
8. Foam application shall be started 3 minutes after full involvement. Foam solution shall be applied for 7 minutes.
9. Time to 90% fire control shall be recorded by an experienced observer. At this point the radiative output from the fire will drop dramatically. Flames will still be visible although a large proportion of the fuel surface will be covered in foam. It is recognized that, to some extent, this is a subjective parameter.
10. Time to full extinguishment shall be recorded by an experienced observer⁺.

+The time for total extinguishment shall be the point at which no visible flames are apparent, including any signs of 'ghosting' across the foam surface. The foam blanket shall seal against the tank walls and particularly the baffle plate area where the foam's sealing ability is tested to the full. Any failure to control and extinguish the fire during and following the period of foam application shall be noted.

11. A vapour seal test⁺⁺ shall be conducted at 12 minutes.
⁺⁺2 minutes following end of foam application (12 min into test)

Torch Test - A lighted torch shall be passed over the whole of the foam blanket (without contact). The extent of re-involvement (if any) shall be recorded at this stage and assessed against the performance criteria given in Appendix C. The test shall ensure that the edges of the blanket and particularly the baffle areas are given attention. The torch shall be passed around the complete circumference of the pan inner edge within 75mm (3") of the foam blanket and across the centre of the tray. The torch test shall take at least 1 minute to conduct.

12. A Burnback resistance test shall be conducted. In the case of the WM test, the burnback pot shall be introduced at 14 minutes. The burnback pot shall contain 2 litres of test fuel. At 15 minutes the fuel shall be ignited. The time at which 25% area re-involvement/burning is observed shall be recorded. The pot shall be placed in the area of the oldest foam.

13. Test Results shall be recorded using the proforma given in Appendix D.

2.2.1 Ambient Conditions

In many respects, there is an advantage to be gained from conducting the test in 'real' weather conditions since the objective of the test is to reproduce the expected incident conditions.

Ideally, the fire test shall be conducted outdoors in conditions of no precipitation. Where the test is unavoidably undertaken in conditions of precipitation (i.e. rain, sleet, snow etc.) an experienced person shall decide whether or not the weather conditions are likely to affect the test. Rain and/or high wind speeds or low ambient temperatures will tend to cause the test pan to cool slightly more quickly and therefore allow the foam to seal against the pan walls more effectively. Conversely, in hot environments with still wind conditions, a foam will take longer to seal since the pan walls will retain heat for longer periods. Clearly, if a test series is to be undertaken, then the conditions from test to test should not differ significantly. Any interpretation of test results shall therefore consider these factors.

The fire test shall be undertaken in the following ambient temperatures and wind conditions wherever possible. Measurements of these shall be taken and recorded.

Ambient Temperature: $5\text{ }^{\circ}\text{C} < T_a < 20\text{ }^{\circ}\text{C}$
Wind speed: *less than 3 m/s , gusts less than 5 m/s*

2.2.2 Test Fuel

The test fuel shall be ethanol of not less than 95% ethanol and no more than 5%isopropanol mixture.

Fuel temperature shall be within the following limits: -

Fuel Temperature - $10\text{ }^{\circ}\text{C} < T < 30\text{ }^{\circ}\text{C}$

Tank wall temperatures shall be maintained at a level below the maximum temperature above, in between tests.

Note: - If required by an end user, alternative fuels may be used. However, it must be recognised that test assessment criteria may need modification for interpretation.

2.2.3 Nozzle Positioning

'Non-system nozzle' shall be arranged according to the configuration shown in Appendix A. A suitable nozzle platform shall be constructed to allow such positioning.

The 'System nozzle' shall be held in place by means of a suitable support that will allow the nozzle to be positioned over the test pan rim and the produced foam to flow down the inner wall of the pan.

The system nozzle shall be positioned (ideally) so that the rear edge of the discharge nozzle is against the test pan, so that foam flows partially down the tank inner wall, and the remainder drops directly into the tank. The intention is to simulate a Type II discharge outlet that is designed to lessen submergence of the foam, but for the purposes of a meaningful test, not avoid it completely.

It is recognised that sometimes, test pan/tank distortion makes this positioning difficult but it should be possible to allow a proportion of the foam solution discharge to flow down the "tank" inner wall.

2.2.4 Salt Water Premix

Where the test is to be conducted using salt water premix, sufficient premix shall be made in a single batch for at least 3 nozzle tests (i.e. semi-aspirating, aspirating and system nozzle tests).

The quantity of salt water premix shall be made with the following simulated sea water (i.e. salt water) composition: -

Component	% by Weight
<i>Sodium Chloride (NaCl)</i>	2.5
<i>Magnesium Chloride (MgCl₂ x 6H₂O)</i>	1.1
<i>Calcium Chloride (CaCl₂ x 2H₂O)</i>	0.16
<i>Sodium Sulphate (Na₂SO₄)</i>	0.40
<i>Potable water</i>	95.84

If other simulated sea water compositions are to be used then these shall be subject to approval by the LASTFIRE Co-ordinator.

2.2.5 Foam Properties

The accurate reproduction of the foam properties achieved on site from real foam-making equipment is a crucial part of the test, and to achieve this, special nozzles have been developed.

Foam quality tests (Expansion and 25% Drainage Time) shall be undertaken to quantify foam properties.

It is recommended that the end user determines the foam properties for the foam solution produced from foam-making equipment on-site, so that these properties can be compared with those achieved during the test.

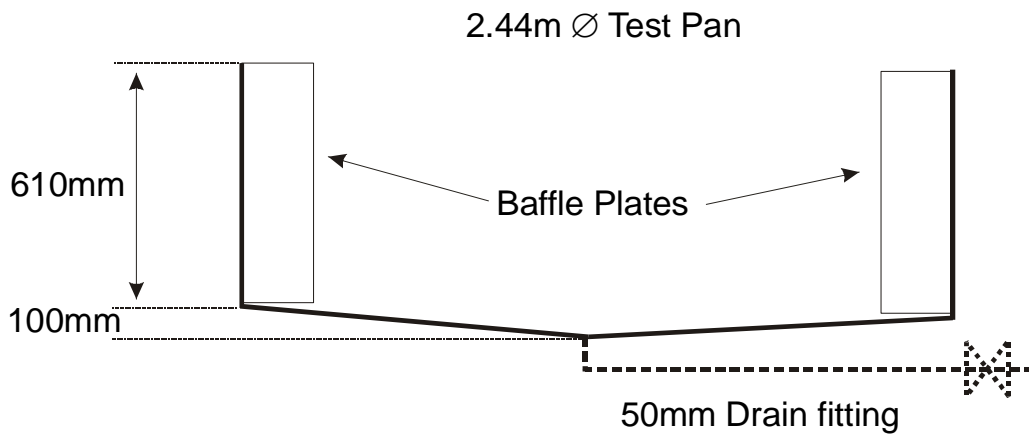
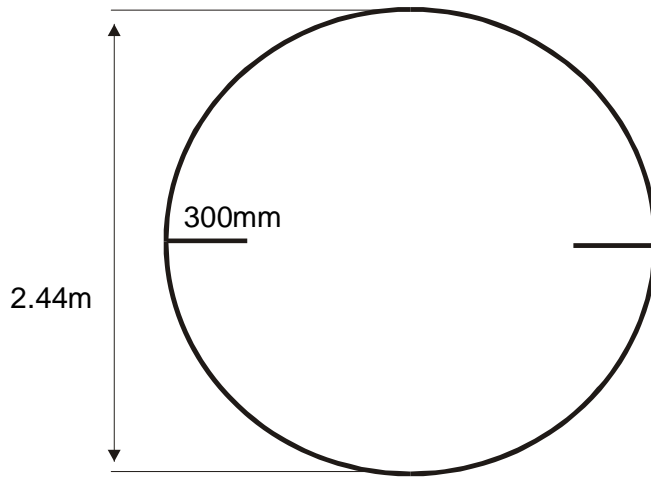
The collection of foam samples from foam-making equipment shall be undertaken in line with the methods described in NFPA 11, Appendix C.

Where a sample from the two non-system nozzle is required, the person undertaking the test shall direct the foam from an appropriate distance from the collection board (typically 2-3 metres) such that a representative sample is obtained.

Where a sample from the 'system' nozzle is required, the person undertaking the test shall discharge the foam sample by running foam down the collection board in a gentle manner in order to simulate such application.

APPENDIX A
TEST SET-UP

Specification of Test Apparatus



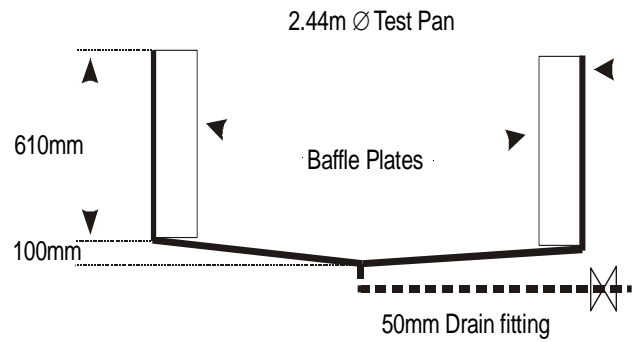
Material : Carbon steel or 304 SS lined carbon steel

Shell thickness : 6.35 - 9.52mm

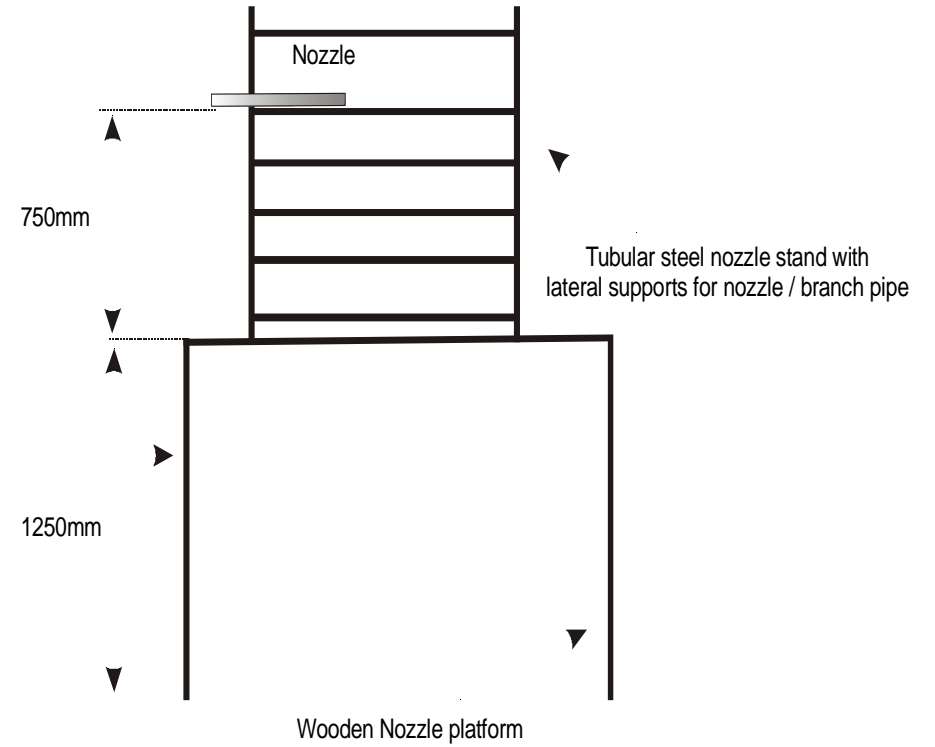
Baffle plates (x2) : 300mm width, 600mm height (approx)
clamped and / or bolted to pan sides

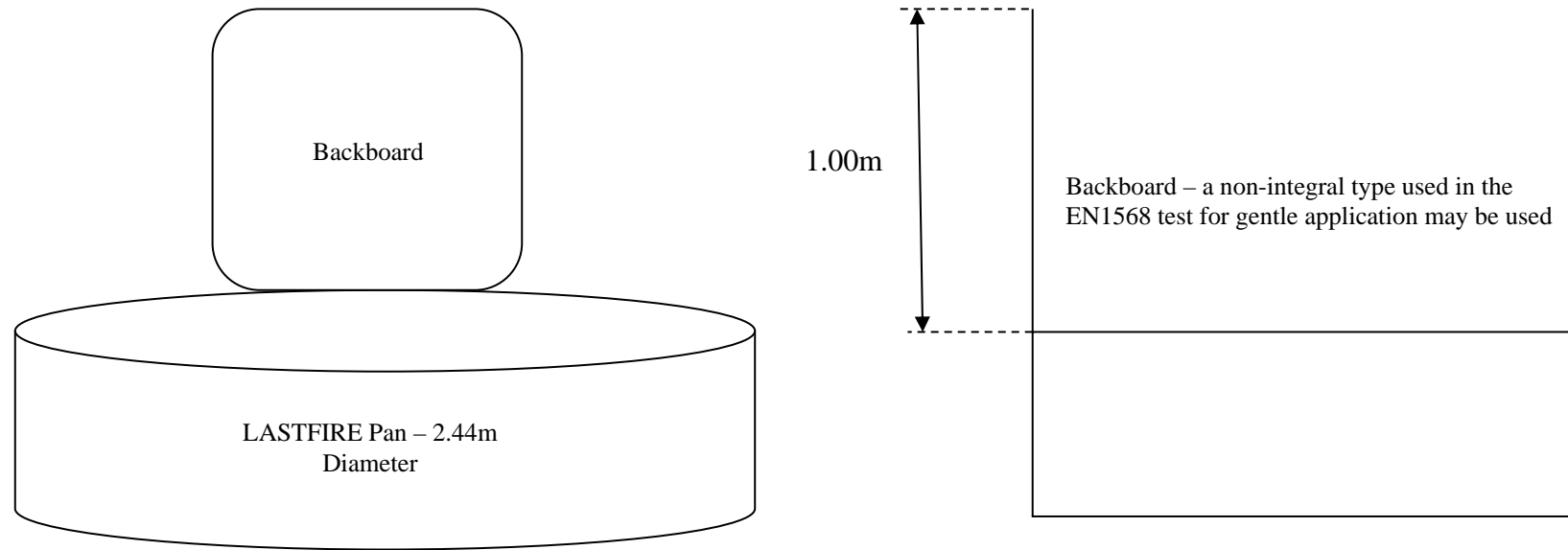
Pan should be supported approx 300mm above ground by means of suitable legs.

Test Pan / Nozzle Arrangement

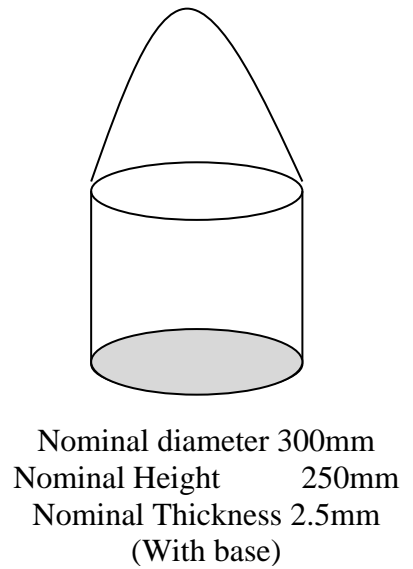
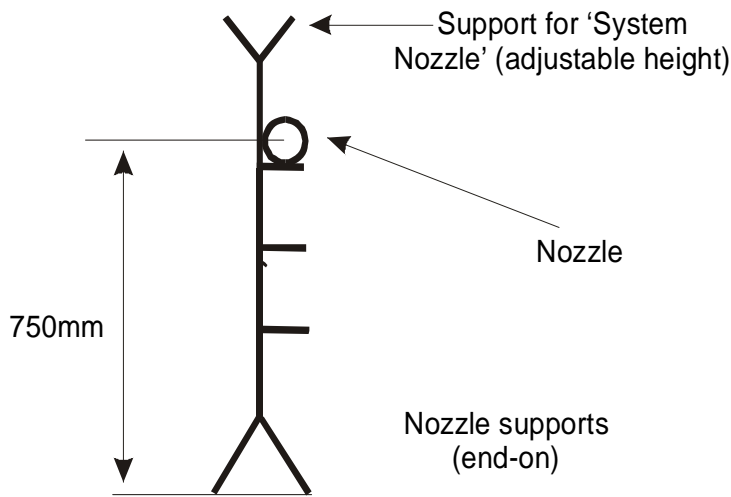


2200mm (Variable)



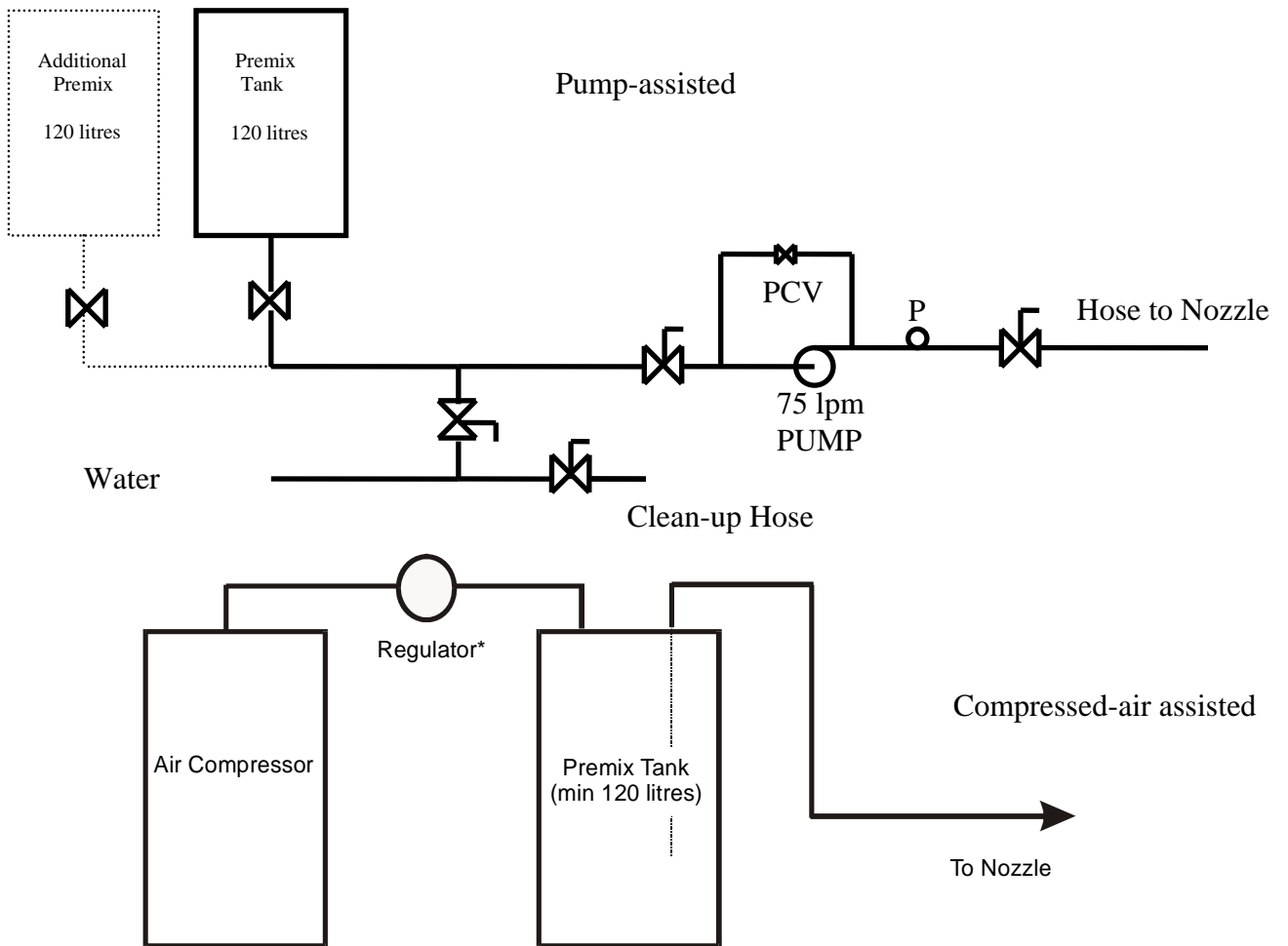


Backboard Detail



Nozzle Support Structure

Burn-back Pot



* e.g. Nullmatic Pressure Regulator 3-200psig range. Approx 110 psig for Aspirating (4USG) Nozzle / 85 psig for system nozzle

Typical Piping Arrangements

APPENDIX B
TEST NOZZLES

B.1.0 The following pages detail the nozzles, which should be used for this fire test. No other nozzles should be used.

B.1.1 The aspirating nozzle was developed in line with the requirements of fire test UL 162 to provide foam quality (expansion and drainage time) similar to that produced from the application equipment actually used at incidents. (essentially monitors in this case).

B.1.2 The simulation of topside foam pourers is achieved through the use of a foam 'system' nozzle, specified in drawing B-3. This nozzle produces fully aspirated foam, and is able to be hooked over the rim of the test pan, providing suitable supports are available. (Appendix A)

Drawing **B-2** Aspirating foam nozzle and detail

Drawing **B-3** Foam 'system' nozzle (aspirating)

B.1.3 The foam characteristics of these nozzles are summarised below based on best current data available.

Nozzle	Emulation	Foam Quality	Foam Properties
B-2	Titan / Colossus / Mega ‡	Good quality	Expansion 5-10; 25% Drainage 3 mins
B-3	Fixed system (Foam Pourer)	Variable quality	Range of expansion ratios and drainage times

‡ Typical aspirating monitors

B.1.4 'Aspirating' nozzles were developed to represent large throughput monitor nozzles designed to aspirate foam in the order of 6:1.

Drawing B-2

Aspirating Nozzle and Detail

Drawing B-3
'System' Nozzle

APPENDIX C
TEST CRITERIA

Criteria	Score - (all times from ignition) mins		Remarks
Fire Control	<i>0 – 5</i>	5	
	<i>>5 – 8</i>	2	
	<i>8 – 10</i>	0	
	<i>> 10</i>	FAIL	<i>OVERALL FAIL</i>
	Maximum score	5	5% of total
Extinguishment	<i>0 – 7</i>	65	
	<i>>7 – 10</i>	45	
	<i>>10 – 12</i>	25	
	<i>>12 – 20</i>	15	
	<i>20 – 30</i>	5	
	<i>>30</i>	FAIL	<i>OVERALL FAIL</i>
	Maximum score	65	65% of total
Vapour Suppression		10	<i>No reignition</i>
		7.5	<i>Minor edge ignition only</i>
		5	<i>Full circumference ignition or single ghosting over surface</i>
		0	<i>Full flash and prolonged ghosting over surface</i>
	Maximum score	10	10% of total
Burnback Resistance			Time not less than (mins)
		20	15
		15	10
		10	7.5
		0	5
		FAIL	<i>< 5 mins</i>
Maximum score	20	20% of total	
TOTAL		100	

Ratings:

Good Fire Performance -	80 – 100
Acceptable Fire Performance -	50 – 79.5 % inclusive
Reduced Fire Performance -	25 – 49.5 % inclusive
Poor Fire Performance -	0 – 24.5 % inclusive

Vapour Suppression Criteria

Vapour suppression performance shall be assessed in the LASTFIRE test by passing a lighted torch around the full circumference and centre of the foam blanket. The test is given a maximum possible 7.5% of the total test marks. The extent of re-ignition shall be evaluated and scores given based on the following observations: -

10 marks (10% of total) shall be given if: -

- No re-ignition occurs

7.5 marks (7.5% of total) shall be given if: -

- Only minor edge ignition is observed around part of the tank circumference (<65%), which then subsides and extinguishes. Flames must be less than or approximately equal the test pan height.

5 marks (5% of total) shall be given if: -

- Re-ignition around > 65% of the circumference is observed, or minor 'ghosting' across the foam blanket occurs.

And

- Ghosting or re-ignition is short lived, extinguishes rapidly, and results in only minor deterioration of the foam blanket (e.g. top layer removal only).

0 marks shall be awarded for vapour sealing capability if: -

- A full surface 'flashover' of the foam blanket is observed. If a full flash occurs, flames must subside rapidly.

Or

- Greater than 65% circumference re-ignites

And

- Flames are significantly greater than the test pan height.
- Flaming is prolonged

Or

- Flaming or ghosting occurs, and is prolonged with continued deterioration of the foam blanket. (e.g. multiple layer removal or 'exfoliation')

And

- Flames are less than or approximately equal to the test pan height.

APPENDIX D
EXAMPLE RESULTS SHEET



Lastfire Foam Test Results (WM)

Manufacturer/Site _____

Date: _____

Foam Concentrate Characteristics			
Type:	_____	pH at 20°C	_____
Concentration:	_____	S.G. at 20°C	_____
Water type	_____	R.I. at 20°C	_____
Batch No.	_____	S.T. at 1%	_____
		Viscosity at 20°C	_____

Foam Quality	Expansion	25 % Drainage Time
Aspirated System	_____	_____
	_____	_____

Test Conditions		Fuel Type / Tank Temps °C	
	Ambient Temp: °C	Wind Velocity: m/s	Type
Aspirated System	_____	_____	Ethanol
	_____	_____	_____
	_____	_____	_____

Nozzle Calibration			
	Source	Specified	Actual
Aspirated System	Lastfire	17.0 lpm	17.0 lpm
	Lastfire	11.7 lpm	11.7 lpm

Fire Performance Data			
	Aspirated	Marks	System
'Control' Time	_____	_____	_____
Extinguishment Time	_____	_____	_____
Torch Test @ 12min:	NO REIG	_____	NO REIG
Burnback (Time to 25% re-involvement)	1% REIG	_____	1% REIG
Overall Rating		0 GOOD	0 GOOD

Notes / Comments		Test Reference
Purpose of Test	_____	LFRRevB-15-000 (WM)
Test Location:	_____	
Initial of Tester	_____	Signed:
Ref	_____	
Note: This certificate is valid for these batches only		Lastfire Project Co-ordinator