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FOAM TEST FOR STORAGE TANK FIRES

WATER MISCIBLE FUELS

TEST PROTOCOL

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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.

1. PROTOCOL

1.1 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 1.2 describes the test fire requirements and methodology.

1.2 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 of not less than 99% purity. (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.

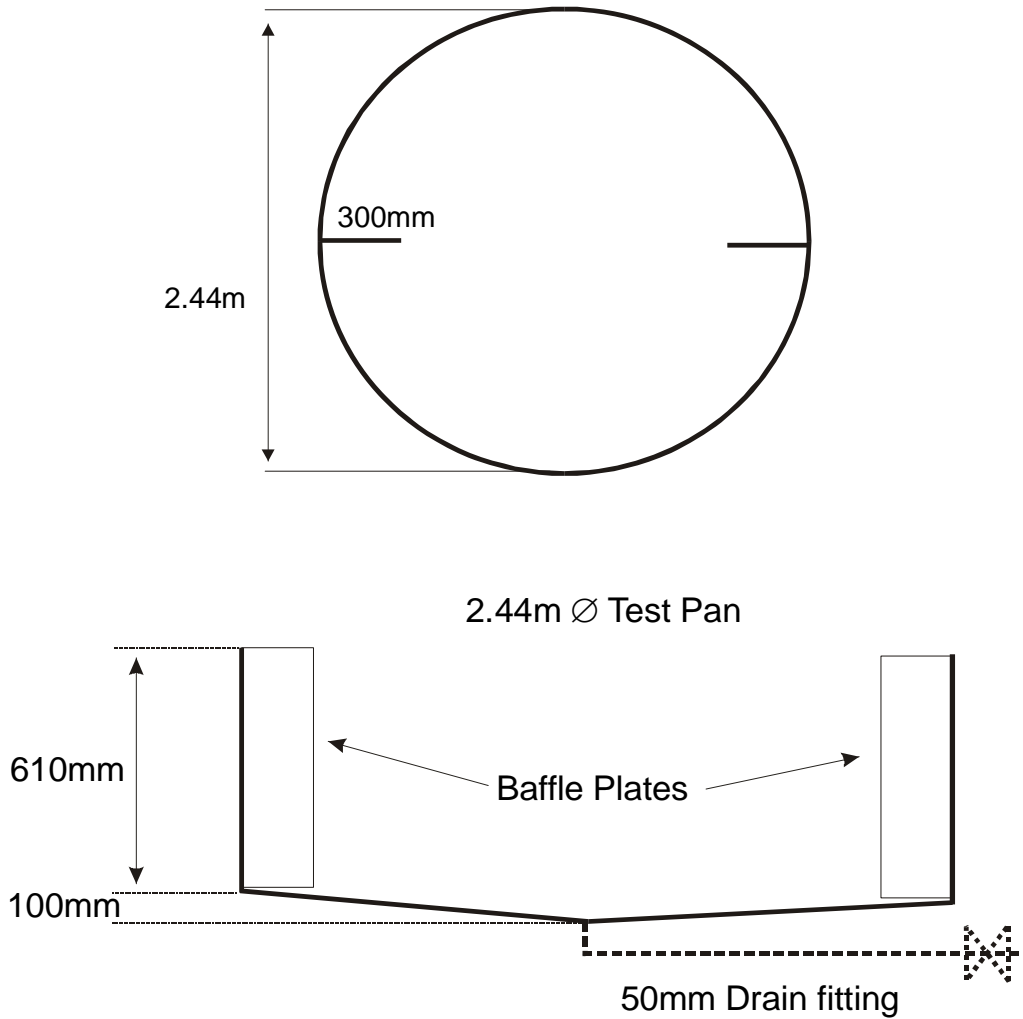
9. Time to 90% fire control shall be recorded by an experienced observer. At this point the radiative output from the fire will drop dramatically. Flames will still be visible although a large proportion of the fuel surface will be covered in foam.
10. Time to full extinguishment shall be recorded by 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 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.

APPENDIX A
TEST SET-UP

Specification of Test Apparatus



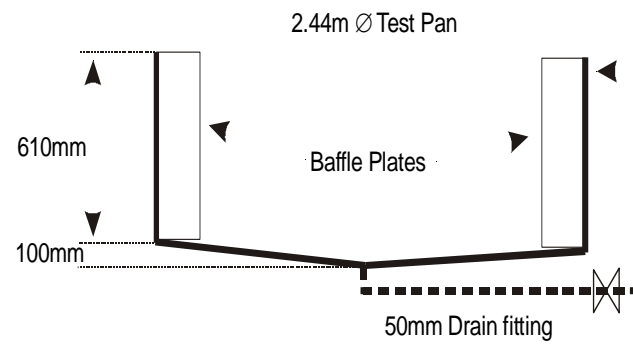
Material : Carbon steel or 304 SS lined carbon steel

Shell thickness : 6.35 - 9.52mm

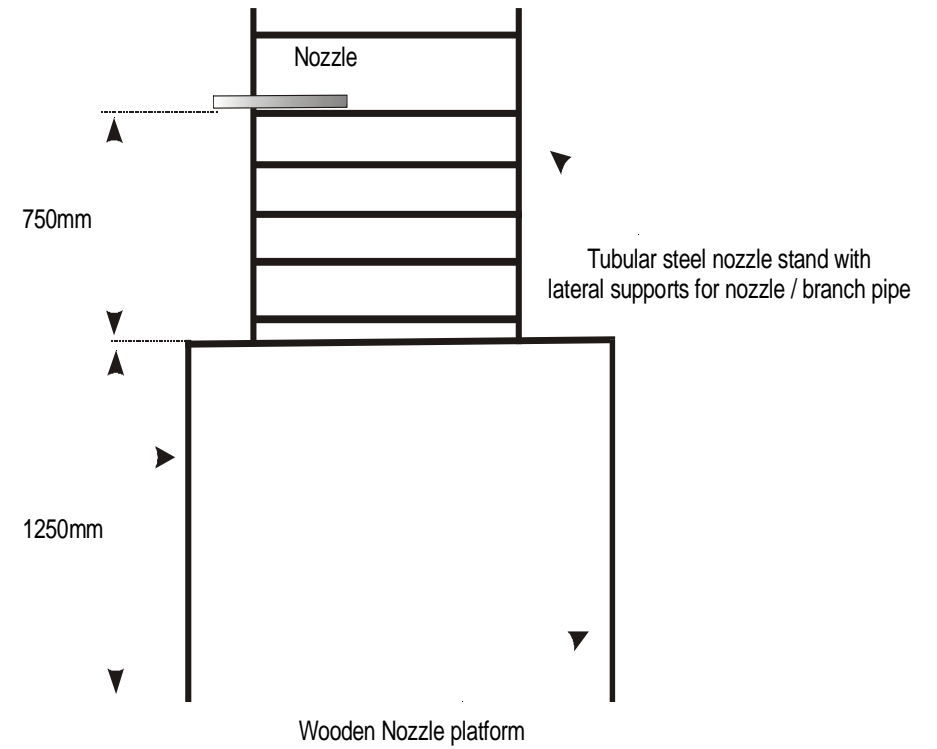
Baffle plates (x2) : 300mm width, 600mm height (approx)
clamped and / or bolted to pan sides

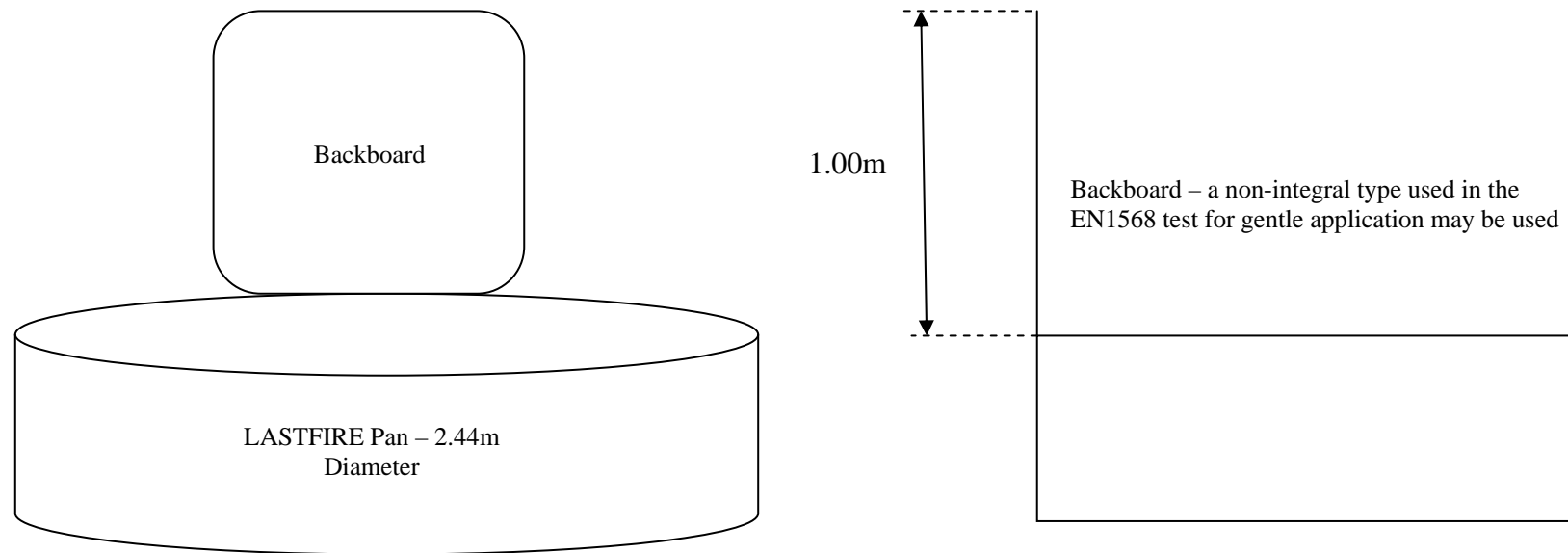
Pan should be supported approx 300mm above ground by means of suitable legs.

Test Pan / Nozzle Arrangement

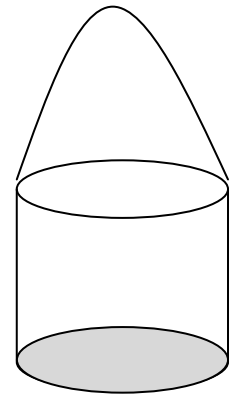
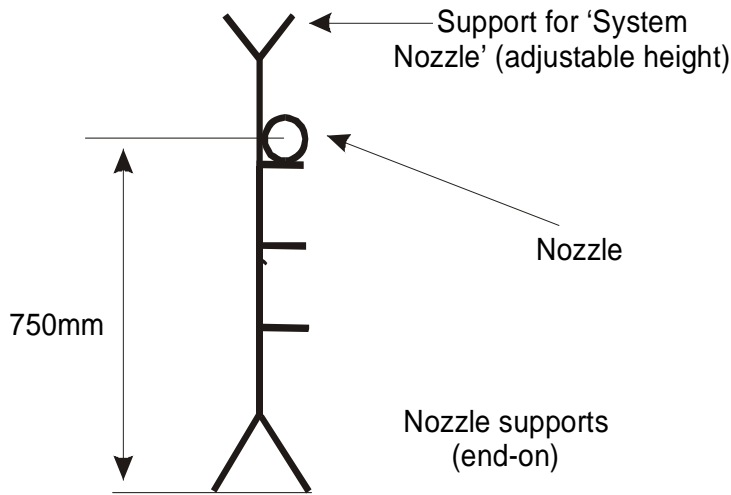


2200mm (Variable)





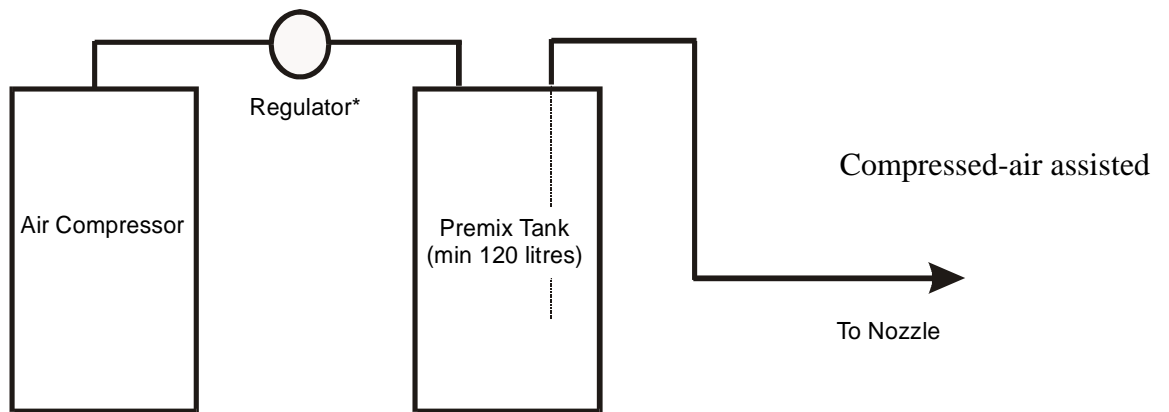
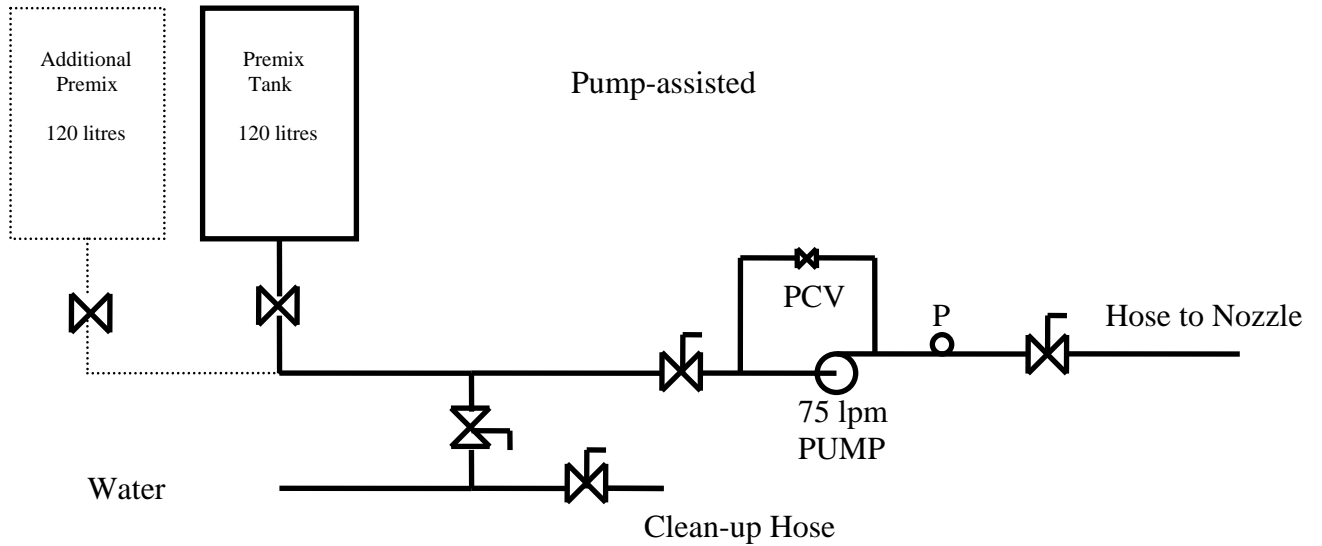
Backboard Detail



Nominal diameter 300mm
 Nominal Height 250mm
 Nominal Thickness 2.5mm
 (With base)

Nozzle Support Structure

Burn-back Pot



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

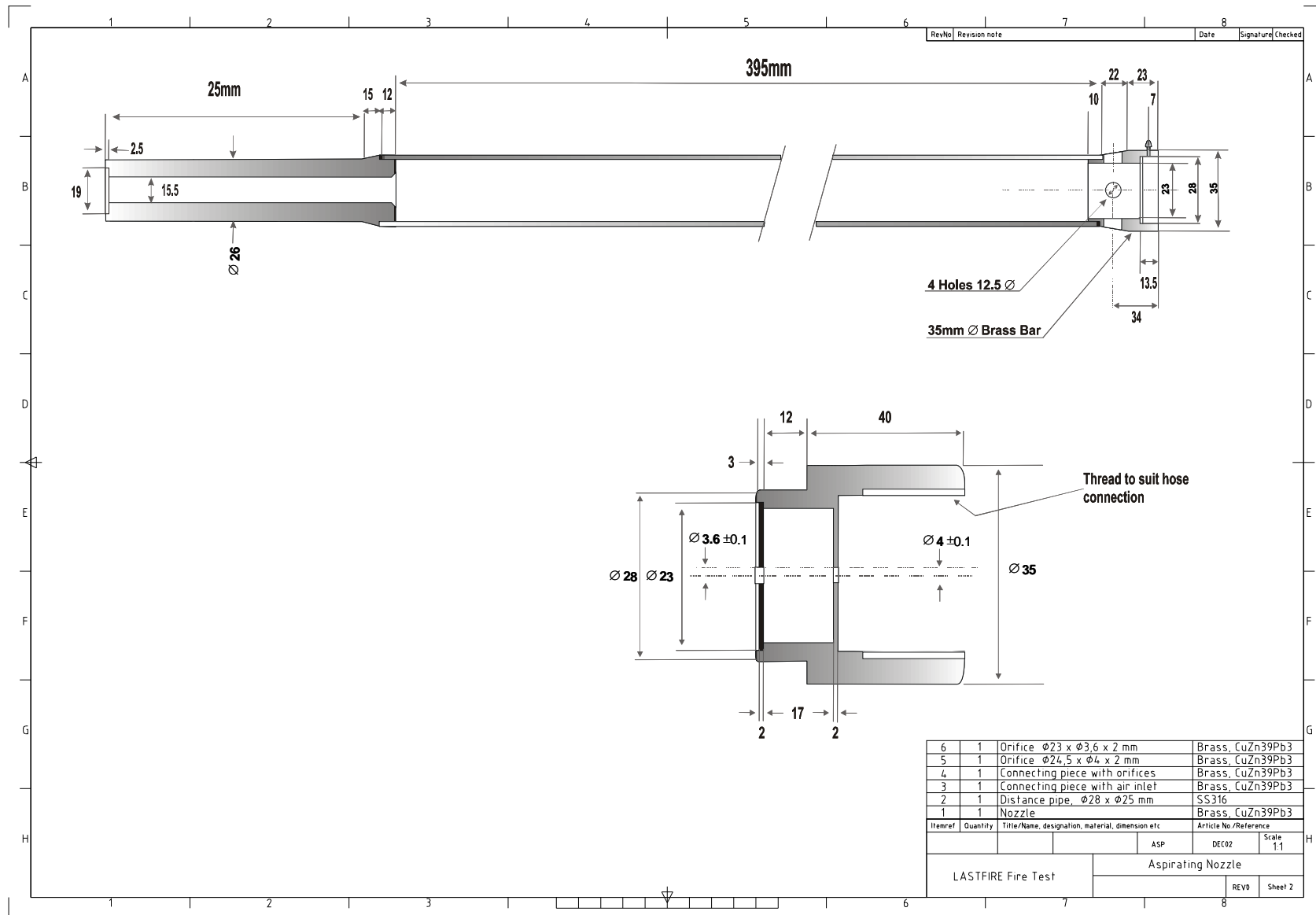
‡ Typical aspirating monitors

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

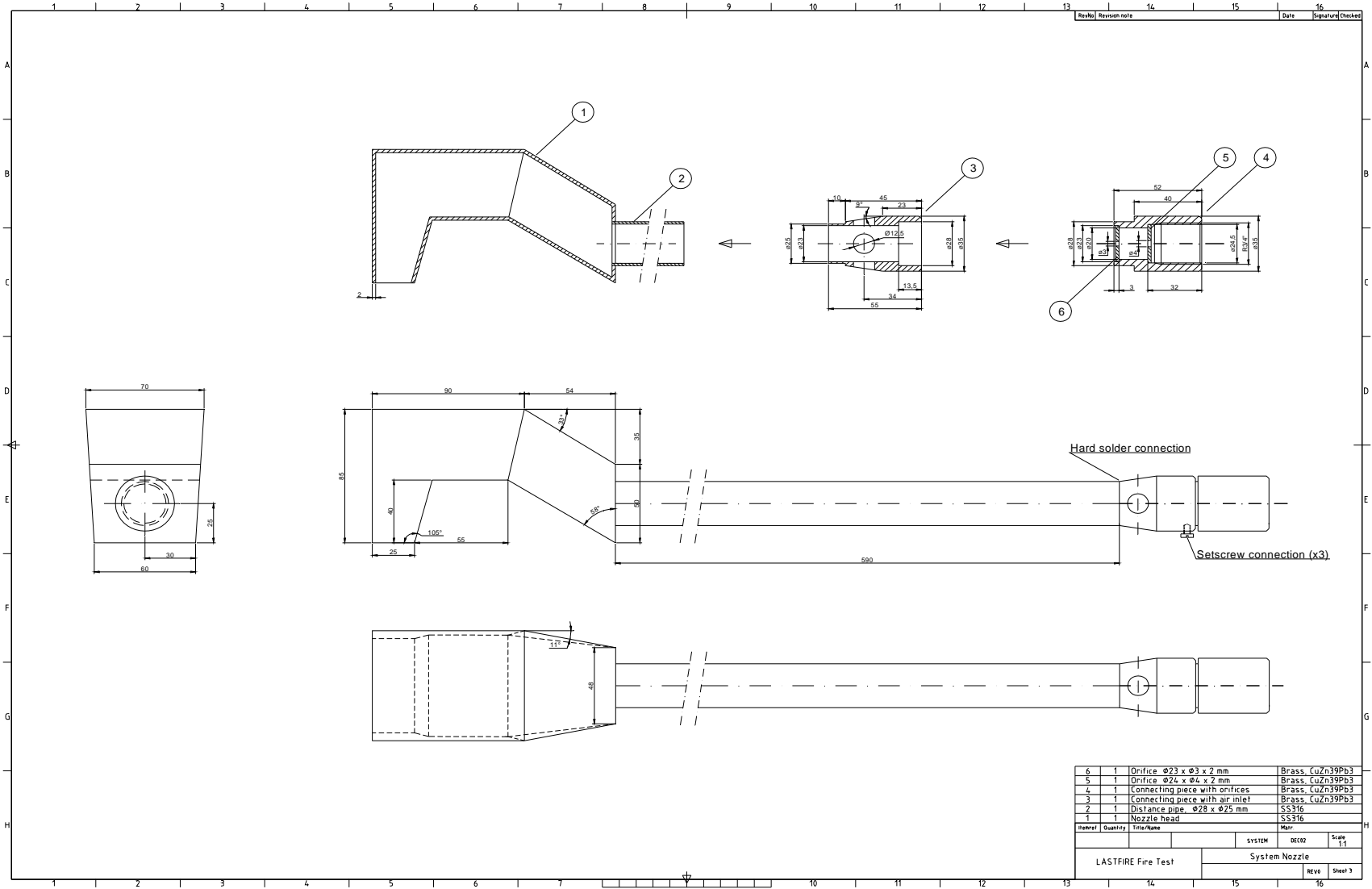
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Drawing B-3

'System' Nozzle

LASTFIRE FOAM TEST PROTOCOL FOR WM FUELS



APPENDIX C
TEST CRITERIA

Criteria	Score - (all times from ignition) mins		Remarks
Fire Control	0 – 5	5	
	>5 – 8	2	
	8 – 10	0	
	> 10	FAIL	<i>OVERALL FAIL</i>
	Maximum score	5	5% of total
Extinguishment	0 – 7	65	
	>7 – 10	45	
	>10 – 12	25	
	>12 – 20	15	
	20 – 30	5	
	>30	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			<i>Time not less than (mins)</i>
		20	15
		15	10
		10	7.5
		0	5
	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

Date:

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

Foam Quality	Expansion	25 % Drainage Time
Semi-Aspirated
Aspirated
System

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

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

Fire Performance Data	Aspirated	Marks	System	Marks
'Control' Time
Extinguishment Time
Torch Test @ 12min:
Burnback Resistance
Overall Rating

Notes / Comments	Test Reference WM-LFR-11-001 Signed: For Resource Protection International Lastfire Project Co-ordinator
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