NEW ZEALAND FIRE SERVICE
Whakaratonga Iwi

Fire suppression guide

September 2016

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Record of amendments

Date	Brief description of amendment
20 Jan 2014	Cover images updated following staff feedback
17 Mar 2014	Minor change to Class A foam page 12
3 April 2014	Minor typographical corrections. p6 Dynamic risk assessment - 'fire attack plan' changed to 'tactics'. p8 Use visual signs 'as well as' temperature changes. Specific fleet information for Class A foam and hose reels removed. p15 Matching nozzle to tubing capacity - 1400 kPa pump pressure changed to 'between 1500 and 1700 kPa.' p16 Decreased throw - air 'entrapment' changed to 'entrainment' p17 Type 3 and 4 'flowing up to 250L/min' changed to '230L/min', 'automatic' added to Type 1 500 kPa nozzle and Note added to refer to appliance manual. p23 Non-aspirated foam - rubbish, structure and vehicle fires added as uses p25 Flammable liquid fires – added 'Class A and Class B foams should never be mixed.'
27 Sept 2016	Broken link to TFT Ultimatic Information Note has been fixed.

About this Guide

Introduction

Firefighters work in dangerous environments where their safety and the success of their actions is determined by training, PPE and the most appropriate selection of fire suppression tools and medium application.

With the increasing frequency of structure fires that result in flashover or other forms of rapid fire progression, the importance of carrying out an efficient risk assessment and applying sufficient water appropriately is paramount. It is vital to get ahead of the fire growth curve and achieve a rapid knockdown before such conditions can occur.

The flow rate of the deliveries deployed must be sufficient to cool the high-temperature gases and smoke at the ceiling level, while at the same time absorbing enough heat to cool the surrounding walls, ceilings, floors, and other combustible contents, thereby avoiding uncontrolled gas ignition or flashover.

Purpose

The purpose of this guide is to provide the minimum information required by a firefighter to safely undertake an internal fire attack. It also describes basic NZFS fire appliance capabilities and the range of tools and media available to firefighters for use at different types and sizes of incidents, including Class A and B foam application.

It is important that tools and media form part of the fire attack plan and tactical decisions so that the correct selection is made before committing crews at an incident.

Status

This document has been produced by the operational advisory team at National Headquarters. Its content has been summarised from the fire suppression sections of the Training and Progression System (TAPS) and fleet documentation. It will be updated as new techniques and equipment are adopted.

Peer review

The content of this document has been peer reviewed by:

- National Advisor – Operations
- TAPS subject matter experts.

Fire Suppression

First-alarm response

Importance of preventing flashover

New Zealand and international experience shows that first-response crews often arrive at structural fires as they are approaching the flashover stage. This means that the fire is approaching its maximum heat flux and, unless it is cooled very rapidly, it can be expected to progress to flashover. It is essential that firefighters making entry into a structure under these conditions are equipped with a delivery that can flow sufficient water to prevent flashover occurring.

Under-equipped firefighters are less likely to prevent a flashover and are at serious risk of harm should a flashover occur.

Flashover: time and temperature

How a flashover forms

As a fire develops, heat and smoke from burning contents reach the ceiling, then accumulate, mushroom out and radiate extreme heat downward to floor level, which causes all the combustible materials in the fire compartment to reach their ignition temperature and ignite. Structure fires often develop to flashover in significantly less than 10 minutes from ignition, as gases at ceiling height reach a temperature of around 600°C. This development can be expected from any typical compartment fire.

Fire loading

Fire loading can vary - for example, a typical polyurethane upholstered lounge chair burning at its peak could produce a one megawatt (MW) fire, while a large sofa of similar construction at its burning peak could produce approximately a two MW fire.

Peak heat release rate (HRR)

As the proportion of hydrocarbon-based plastics and modern materials in furniture increases in typical homes, firefighters should anticipate the peak heat release rate (HRR) in a room fire to be higher than seven MW. They must also expect adjacent fully-involved compartments to generate radiant heat levels of at least 20 kW/m^2, which may affect the contents of the room from which they are operating or into which they are directing a water stream.

Size-up

Dynamic risk assessment

All officers are required to apply the principles of dynamic risk assessment as described in the NZFS Incident Management Command and Control Technical Manual (M1 TM).

The 360 degree assessment must include an analysis of:

- fire loading, including construction types
- compartment size and integrity (has the compartment vented?)

- fire intensity and pre-burn time
- visual signs, which include pyrolysis, materials changing physical state, the level of the neutral plane and, significantly, the effect that water application has on those conditions.

The picture formed from this process should determine the tactics to be used.

Inadequate resources

Initial tasking is often limited by the availability of resources. Where the risk to internal firefighters is determined to be too high, or where adequate resources are not immediately available, defensive tactics are the default position until the OIC determines otherwise.

Defensive attack

Tasking of crews for an internal attack must include delivery and nozzle selection that will safely control the expected heat release rate and manage flashover potential. Where resources or inadequate water supplies do not allow this, a defensive attack should be initiated to limit fire spread. Other factors that should be considered in the fire attack plan are aggressive ventilation - including the use of PPV fans - and the use of ground, deck and aerial monitors.

Fire types and techniques

Buildings over 20 years old

The type of construction typically used 20 or more years ago in New Zealand for domestic and light industrial buildings means that the great majority of structure fires are vented and free-burning by the time the first NZFS appliance arrives at the incident.

Modern construction

Modern construction methods and materials (such as fire-resistant linings and double-glazing) are more likely to result in unvented or partially-vented fires.

Vented fires (fuel controlled)

Volume of the fire compartment

In this case, the first attack delivery must be selected based on the estimated volume of the fire compartment involved, including any possible escalation in size that may occur before water can be applied. This will ensure that the attack team is equipped with a delivery that has the capacity to cool the entire contents of the compartment including ceiling, walls and floor as rapidly as possible.

Full capacity stream

This stream should initially be used at its full capacity with the intention of knocking down the fire and minimising the production of superheated steam, which can cause injuries to firefighters operating inside or just outside the compartment.

Nozzle setting	The nozzle should have a minimum flow capability of 440 L/min and a stream pattern setting of between 30˚-60˚. The stream pattern setting will depend on the penetration required to reach the seat of the fire and the need to absorb heat.
Direct fire attack	Initially the stream should be directed overhead to cool the hottest part of the fire as quickly as possible. It should then sweep the walls and contents to cool rapidly the primary fuel. Unvaporised water will fall to the floor cooling the fuel there. Where necessary, the delivery should be aggressively advanced with the flow from the nozzle constant until the fire has been knocked down. This fire attack technique is referred to as 'direct fire attack'.

Unvented fires (ventilation controlled)

Potential backdraught conditions	In an unvented fire, most of the products of combustion stay within the compartment and the air supply for the fire comes from the compartment alone. There may be sufficient air in the compartment for complete combustion if the fuel source is small. If the fuel source is larger, there will be insufficient oxygen available and incomplete combustion will occur. This can lead to backdraught conditions. If a fire in a compartment is unvented and impending backdraught conditions are identified, the appropriate door entry procedure and risk assessment must be used.
Indirect fire attack	When the first attack delivery is deployed, the use of gas cooling (as taught in compartment fire behaviour training), is the preferred technique. This is referred to as 'indirect fire attack' This technique provides an internal nozzle team with a method to successfully control a developing fire when impending flashover conditions are observed in an unvented compartment.
Pulses of water spray	It applies "pulses" of water spray of less than one second duration into the ceiling area to reduce the gas temperature. This cools the overhead gases and prevents their ignition and consequent flashover. When used together with application of similar "pulses", to the compartment linings this will reduce the temperature within the compartment and allow crews to gain control of the fire.
Careful control	The intent is to control the heat and maintain conditions of visibility by preventing flashover and gradually extinguishing the fire by cooling and producing steam, without creating untenable conditions for fire crews. The careful control of these conditions may be necessary to carry out search and rescue operations.

Monitor the environment	Care must be taken when using the pulsing technique to apply sufficient water to cool the fire but not disturb the neutral plane or gas layer. The environment must be constantly monitored to ensure that correct flow settings are used so that enough water is applied to exceed the rate of fire growth. Once the over-pressure region is controlled, a direct fire attack on the fire seat can be made, in conjunction with structure ventilation.
Nozzle settings	The nozzle should have a minimum flow capability of 440 L/min and a stream pattern setting of between 30° and 60°.
If the fire vents	If an unvented fire vents while this technique is being employed then the fire should be treated as a vented fire. The use of pulsing should cease and a direct fire attack should commence.

Partially-vented fires

Fire gas explosion	In a partially-vented fire, some of the products of combustion can exit the fire compartment and an air supply can enter. The fire compartment has vented, but other compartments within the structure have not. Fire gases can accumulate in the other unvented compartments. This situation may create conditions that can lead to a fire gas explosion.

Impact of PPE

Use visual signs	Modern PPE better protects firefighters from the high temperatures generated in compartment fires. This high level of protection decreases sensory awareness and, in cases of very low visibility, it is often difficult to observe flames in the overhead, or other visual clues. When assessing the risk of a compartment while wearing modern PPE, it is important that crews use visual signs of fire development as well as feeling temperature changes.
Importance of risk assessment	Poor risk assessment may cause firefighters to over-commit to an internal position. This could result in them being in a position where their delivery flow rate does not have the heat-absorbing capability to prevent or stop the fire's progression. In this situation, crews could be exposed to flashover.
Survival time in flashover	NZFS PPE allows approximately 20 seconds survival time in flashover conditions.

Heat release rates

Estimating HRR at flashover

Average residential fuel loads now have a maximum heat release rate (HRR) under flashover conditions of about 0.77MW/m^2. This figure can be used to estimate maximum potential heat flux of any compartment based upon its area. For example, a fire that has flashed over in a room 3m x 3m - similar to that of a small bedroom fire - can be estimated to produce a peak HRR at flashover of seven MW. In an open plan lounge living area that measures 6m x 6m, a peak HRR of 28 MW can be estimated (see table below).

Typical Heat Release Rates

Room dimensions	m^2	Estimated peak HRR
3m x 3m	9	7 MW
4.5m x 4.5m	20	15.5 MW
6m x 6m	36	28 MW
9m x 9m	81	63 MW

Heat-absorbing capacity of water

The theoretical capacity of water to absorb heat (latent heat of vaporization) defines the maximum potential HRR that a given amount of water can absorb. For practical purposes, a fog stream operating on a 600°C fire has a heat-absorbing efficiency of 75%, and a smooth bore stream has a heat-absorbing efficiency of 50%.

Critical flow rate

If the heat-absorbing capability, or knockdown power, of the flow rate is greater than the heat produced by the fire, the fire will go out. This is referred to as the “critical” flow rate.

Tactical flow rate

When the 25% efficiency loss of a fog stream (or the 50% loss of a straight stream) is taken into account, this is referred to as the "tactical flow rate".

Note: Additional flows may be required for exposure protection.

Nozzle and delivery selection

Small and medium fires	Deliveries with nozzles capable of flowing 440-550 L/min can safely control flashover in small and medium fire compartments with normal fire loading. They will also prevent the rapid build-up of steam that often occurs when lower flow rates are used, for example a hose reel.
Large fire compartments/high fire loading	A 70mm delivery fitted with 880-970 L/min nozzles should be used for larger fire compartments with high fire loading. These deliveries are often supported with high-flow ground, deck, and aerial monitors.

Typical NZFS hose and nozzle capabilities

Hose	Flows	Typical nozzles	Heat absorbing capability
25 mm hose reel	180-220 L/min nozzle (hose reel)	• TFT Utimatic 125 • Akron 1702 • Elkhart Phantom	14-17 MW
45 mm delivery	440-550 L/min nozzle (light delivery)	• Elkhart 125 • TFT Qudracup	34-42.3 MW
70 mm delivery	880-970 L/min nozzle (heavy delivery)	• Elkhart 250	67-74 MW

Approximate tactical flows required to obtain a rapid knock down related to compartment size

Compartment type (fully involved)	Floor area (2.4m stud)	Peak heat release rate (megawatts)	Gross flow (litres per minute)	Typical delivery required
Bedroom	9m^2	7 MW	90 L/min	1 x hose reel
Lounge/dining	20m^2	16 MW	200 L/min	1 x hose reel or 1 x 45 mm delivery
Large garage	36m^2	28 MW	360 L/min	2 x hose reels or 1 x 45 delivery
Small house	100m^2	77 MW	1,000 L/min	2 x 45 mm deliveries or 1 x 70 mm delivery

Average house	150m^2	115 MW	1,500L/min	3 x 45 mm deliveries
Large house	200m^2	154 MW	2,000 L/min	4 x 45mm deliveries or 2 x 70 mm deliveries

Size up and calculate tactical flow

From the tactical flow table it can be calculated that, for every square metre of area involved, a flow of about 10 litres per minute is required to achieve rapid knockdown. This allows officers doing their 360-degree survey to very easily size up a fire and calculate the required flow rate.

For example: A 360-degree survey of a house fire indicates that the area involved in fire is approximately 5m x 8m. 5 x 8 equals 40 m^2 x 10 L/min = 400 L/min. In this case, deploy two hose reels or one 45 mm delivery with the nozzle set at 400 L/min or higher.

Class A foam

Use for fully vented fires or defensive external attack

Class A foam (non-aspirated, nozzle-aspirated and Compressed Air Foam Systems or CAFS) will knock down normal combustibles faster than fog streams. Class A foam is most suitable for fully-vented fires where flashover has already occurred or is no longer possible, and for defensive external fire attack.

For offensive internal attack on unvented or partially-vented compartments, the minimum nozzle flows of 440 L/min must not be reduced. This is the recommended flow that is required for the control of flashover.

Don't use CAFS for large compartments

CAFS deliveries will not provide adequate flows or the narrow and wide pattern capability required for firefighter protection against flashover in large compartment fires. The Quadracup aspiration nozzle will.

CAFS is suitable for defensive attacks.

Features of delivery methods	Water delivery	Class A solution delivery	Class A aspirated delivery
Foam setting (%)	na	0.3	0.5
Water flow (L/min)	360	360	360
Knockdown time (seconds)	50	25	14
Knockdown water (litres)	280	160	80
Temperature drop from 315°C to 93°C (Minutes: seconds)	6:03	1:45	1:30

These figures are taken from a Los Angeles County Fire Department burn trial using three identical furnished 100 m2 structures with the same pump, crew and contents.

Fire suppression conclusions

All firefighters are required to have knowledge of the delivery and nozzle capabilities used in compartments found in residential fires. They should understand tactical and critical flow rates and be able to apply the direct and indirect fire attack firefighting techniques on vented, unvented and partially-vented fires. They should understand the different media and be able to select the correct equipment to apply them.

Pumping appliances water tanks

Water tank requirements	Water tanks should contain enough water for: • the protection of crew undertaking a snap rescue at a structure or vehicle fire, HazMat incident or an accident • the initial knockdown at structure and vegetation fires to limit fire growth until a secondary water supply is established • extinguishing a small structure or vehicle fire (some heavy vehicles will require secondary water supplies) • extinguishing typical small outdoor rubbish and miscellaneous fires • supplying water for emergency decontamination.
Tank size	Larger water tanks will extend the time for secondary water supplies to be provided. Typically, appliances with a rural risk have larger water tanks.
Flow rates	A minimum of 440 L/min is required for initial fire attack in a structure fire with one room fully involved. A minimum of three minutes continuous flow is a guide for rapid knockdown.
Water conservation	Non-aspirated Class A foam is 100% more effective than water, and aspirated Class A foam is 300-500% more effective than water. When water conservation is necessary, using foam will proportionally decrease suppression times or allow lower flows of water to be used, without reducing extinguishment effectiveness.

Pumping appliance tank supply discharge times.

Tank discharge times	Type 1	Type 2	Type 3	Type 4
Tank size in litres	2000	1800 Note: FFR T2 have 2000 litre tanks	1350	1350
Hose reels	• 1 x 180 L/min lasts 11 minutes	• 1 x reel at 220 L/min lasts 8 minutes • 2 reels lasts 4 minutes	• 1 x reel at 220 L/min lasts 6 minutes • 2 reels lasts 3 minutes	• 1 x reel at 220 L/min lasts 6 minutes • 2 reels lasts 3 minutes
Light delivery 440 L/min	4.5 minutes	4 minutes	3 minutes	3 minutes

Class A foam for operational use

Class A induction rate and applications	Compound used for:		
	Hose reel or delivery rated at 220 L/min	Light delivery rated at 440 L/min	Two light deliveries rated at 880 L/min
Wetting agent 0.2% (range 0.1%-0.2%) Induction rate used for vegetation fires and overhaul. Use normal nozzles.	• Uses 0.4 L/min. • A 20-litre foam container will last 45 minutes.	• Uses 0.8 L/min. • A 20-litre foam container will last 22.5 minutes.	• Uses 1.7 L/min. • A 20-litre foam container will last 11 minutes.
Wet foam 0.5% (range 0.3%-0.5%) Induction rate used for fires in trees, structures and transport. Normal nozzles OK - aspiration nozzles produce superior foam.	• Uses 1.1 L/min. • A 20-litre foam container will last 18 minutes.	• Uses 2.2 L/min. • A 20-litre foam container will last 9 minutes.	• Uses 4.4 L/min. • A 20-litre foam container will last 4.5 minutes.
Dry foam 1% (range 0.6%-1%) Induction rate used for exposure protection. Use aspiration nozzles.	• Uses 2.2 L/min. • A 20-litre foam container will last 9 minutes.	• Uses 4.4 L/min. • A 20-litre foam container will last 4.5 minutes.	• Uses 8.8 L/min. • A 20-litre foam container will last 2.2 minutes.

<u>Notes:</u>

1. The 60-litre inbuilt foam tank will last three times longer than the 20-litre container figures.
2. A slight variation of the induction rate has little effect on the quality of the foam.

Fire suppression tools

Hose reels

Background

In the early 1970s, high-pressure pumps and hose reels made their appearance on New Zealand Fire Service pumping appliances. Hose reels were generally fitted with three 30m lengths of 25mm smooth-bore tubing combined with an Elkhart SFS 700 kPa constant-pressure control nozzle. These nozzles have selectable flows rated at 10, 20 and 30 US gallons per minute, which equate to 38, 76 and 114 L/min.

Over time, successive generations of firefighters were trained in this standard configuration.

Friction loss

The friction loss in 25mm hose reel tubing is considerable. As flow increases friction loss increases.

Flow in litres per minute	Friction loss in kPa per 30m length of 25mm hose reel tubing
60	100
120	155
180	505
240	925

Overcoming friction loss

To achieve the designed nozzle pressure, pump pressure must be high enough to overcome friction loss The practical flow rate of 25mm hose reel tubing is approximately 250 L/min.

Matching nozzle to tubing capacity

The Elkhart SFS (design nozzle pressure 700 kPa) has a flow at 700 kPa of 114 L/min. Testing has shown that the Elkhart SFS will typically flow 114 L/min at pump pressures between 1500 and 1700 kPa. It can be seen that this nozzle is not matched to the capacity of the hose reel tubing supplying it.

Increased nozzle pressure

If, for example the pump is run at 3500 kPa, the nozzle will have a nozzle pressure of around 2200 kPa where it is designed to run at 700kPa. This increased pressurisation also occurs when lower flows are selected on the nozzle, without proportionally lowering the pump pressure.

Optimum nozzle pressure	The practice of regularly operating the hose reel, fitted with the SFS Elkhart nozzle, well above its optimum nozzle pressure has created an incorrect perception that the Fire Service operates high-pressure deliveries. The SFS Elkhart is in fact a low-pressure nozzle and should be operated accordingly.
Effects of over-pressurisation	Over-pressurisation has three key adverse effects: • **Water droplet size reduces to below the optimum 3–4 microns**. While smaller water droplets can be desirable for indirect cooling of hot gases in unvented compartments, they are not suitable for direct fire attack. Smaller droplets may also produce excessive steam, creating a harsher environment for firefighters and an untenable environment for trapped occupants. • **As the nozzle pressure increases, jet reaction increases.** This has the effect of making the hose reel difficult to manoeuvre and handle. The higher velocity of the water will also entrain larger volumes of air. This high velocity water can cause damage to property not involved in the combustion. • **Decreased throw** As the velocity and air entrainment increases, the throw lessens and considerable feathering of the jet will occur.
Optimum flow	When using selector flow nozzles, the pump pressure needs to be adjusted whenever the flow is reduced manually at the nozzle in order to maintain optimum flow. This is not practical when two hose reels are in use. To overcome this issue and to achieve the optimum flow available from hose reels, automatic pressure control nozzles which have a flow range of 40-500 L/min are fitted to all new fleet. An automatic pressure control nozzle will automatically manage the flow over its full flow range. See 'Automatic pressure control nozzles' on page 19 and the TFT Ultimatic Hose Reel Nozzle Information on FireNet under General operational equipment.

Current specifications

On new pumping appliances built since 2005, a pre-connected hose reel system is configured when the appliance is built. This system matches the capability and configuration of the pump with the overall hose reel length and the nozzle.

Current fleet specifications		
Types 3 and 4	**Type 2**	**Type 1**
Twin hose reels supplied from a high pressure pump with: • 3 x 30m lengths • an automatic 700 kPa nozzle • flowing up to 230L/min at 3500 kPa.	Twin hose reels supplied from the main pump with: • 2 x 30m lengths • an automatic 500 kPa nozzle • flowing up to 220 L/min at 1750 kPa.	Single hose reel supplied from the main pump with: • 2 x 30m lengths • an automatic 500 kPa nozzle • flowing up to 220 L/min at 1750 kPa.

Note: These figures will vary depending on the pump. Refer to the appliance manual.

Nozzles

Nozzle types

Three types

The Fire Service uses three types of nozzles:

- Smooth-bore straight
- Constant pressure-control
- Automatic pressure-control.

Light or heavy delivery

Nozzles with flow ranges up to 500 L/min should be connected to a 45 mm branch length delivery (light delivery). Nozzles with a flow range up to 1000 L/min should be connected to a 70 mm delivery (heavy delivery).

Smooth-bore straight nozzles

Size

Typical sizes range from 12mm to 32mm.

Features

These nozzles have a tapered bore and are screwed to a tapered branch. The branch has a formed instantaneous coupling at the other end.

Flow

The flow is determined by the diameter of the nozzle and the nozzle pressure.

Typical use

They are not now used on deliveries but are occasionally used on monitors and for water testing. There is no on/off or stream pattern capability. They produce a very good straight stream but modern master stream constant pressure control nozzles are comparable.

Typical flows at 700 and 1050 kPa

Nozzle size in mm	Flows in L/min at 700 kPa	Flows in L/min at 1050 kPa
12	250	300
15	400	490
20	700	860
25	1100	1350

Constant pressure-control nozzles

Adjustable flow selector	These nozzles have a bore that can be reduced in diameter manually by adjusting the flow selector. Typically the flow selector will have division at 110, 230, 360 and 470 L/min.
Connections	These nozzles may be directly connected to an instantaneous coupling or hose reel tubing or connected to a branch. They are the most common nozzle type used on 45 and 70 mm deliveries.
Designed pressure	The optimum flow and stream is achieved when the nozzle is run at its designed pressure. This has typically been 700 kPa but many newer nozzles operate at 500 kPa.
Selecting lower flows	When lower flows are required, the manual flow selector is rotated and the pump pressure should be adjusted accordingly to maintain the designed nozzle pressure.
Debris	Many nozzles have a flush facility on the flow selector. This enables small debris to pass through the nozzle. To prevent large debris from entering the nozzle, many later nozzles are fitted with a grabber screen at the coupling.
Stream pattern control	The stream pattern can be adjusted by rotating the front bumper, and a lever-operated ball valve controls the on/off function. This valve is not designed for flow control by gating, as severe nozzle turbulence is created.

Low-pressure nozzles

Used on aerials	Low-pressure 500 kPa nozzles have typically been used on aerial appliance monitors where head loss and waterway friction loss constrain flows, particularly where we limit inlet pressures to 1050 kPa. Flow is more important than throw as an aerial is generally already elevated. Ground and deck monitors typically have 700 kPa nozzles as throw is more important as they are projecting at ground level.
Other uses	In the case of hand-held deliveries and hose reels, low-pressure nozzles are now common. It is important that low-pressure nozzles are fitted to multi-storey deliveries.
Advantages	Advantages of low-pressure nozzles: • Required flow at lower pressures • Less jet reaction • Lower pump revolutions, hence less noise and less wear.
Disadvantage	The disadvantage is reduced throw, however the reduction is minimal and not considered important except on deck and ground monitors.

Aspiration nozzles

Ability to aspirate foam	A modern addition to the constant-pressure control nozzle is the ability to aspirate both Class A and B foams. Foam is inducted either through the Foam Pro system or from an inline inductor. These nozzles are a normal fire attack nozzle with the additional feature of a retractable foam aspiration sleeve.
TFT Quadracup aspiration nozzle	The TFT Quadracup aspiration nozzle is currently the Fire Service's selected nozzle for use on a 45 mm light delivery. It is a low-pressure 500 kPa nozzle.

Automatic pressure-control nozzles

Uses	The Fire Service uses automatic nozzles on aerial, deck and ground monitors and hose reels.
Mechanism	Automatic pressure-control nozzles will provide a relatively constant nozzle pressure throughout their flow range. In simple terms, an automatic nozzle achieves this by having a spring-controlled baffle fitted within the bore. As water pressure increases, the baffle is forced open against the predetermined spring pressure, allowing increased flow but retaining a relatively constant pressure.

Nozzle pressure	Typically, a 700 kPa hand-held nozzle with a flow range of 40–500 L/min will have a nozzle pressure of 400 kPa-850 kPa throughout the flow range.
Performance	As long as the nozzle is operating within its designed range, the droplet size, jet reaction and throw will be efficient and effective.

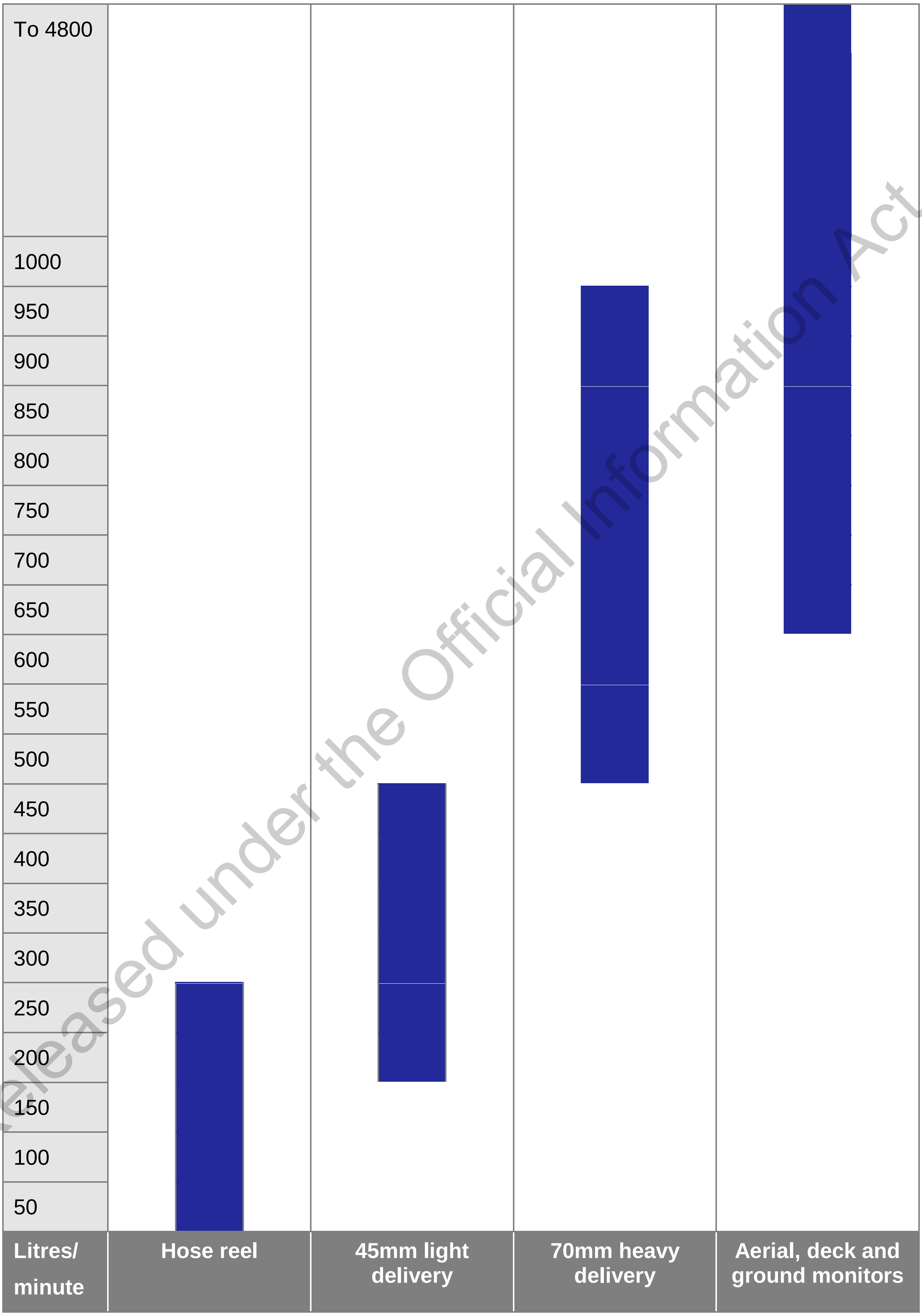
Older types of automatic nozzles

Reduce flow by reducing nozzle pressure	The older types of hand-held automatic nozzles are fitted with a lever-operated ball-type on/off valve. This valve is not designed for flow control by gating as severe nozzle turbulence is created. The correct way to reduce flow with these nozzles is to reduce nozzle pressure. This is difficult to control at the pump due to communication limitations with the pump operator, and when multiple deliveries are in use.

Sliding valve automatic nozzles

Mechanism	This automatic nozzle is able to regulate flow manually while retaining a relatively constant pressure. It achieves this by having a sliding valve that limits the incoming water, but allows flow to maintain a relatively constant pressure against the spring-controlled baffle.
How to operate	This flow is regulated by the firefighter moving the valve handle through six detent positions from fully-opened to closed. This is not a ball valve and does not disturb the quality of the water stream. This allows multiple deliveries or twin hose reels to operate independently when being supplied from the same source.
Caution at high pump pressures	When set on the lowest detent positions and operating at high pump pressures, generally over 2500 kPa, the valve handle will become very sensitive. Care is needed when shutting down in these circumstances. If the nozzles are to be used for long periods at low-flow settings, the pump pressure should be reduced.

Typical Flow Ranges



Friction loss of delivery hose

Flow in Litres/min	Loss per length of 45mm delivery hose in kPa	Loss per length of 70mm delivery hose in kPa
60	2.25	0.21
120	9	1
180	20	2
240	36	3
300	56	5
360	81	8
420	110	10
480	144	14
540	182	17
600	225	21
660	272	25
720	324	30
780	380	35
840	441	41
900	506	47
960	576	54

Foam

Foam application

Non-aspirated

Low induction rate	The predominant use of Class A foam in the Fire Service is at a low induction rate of between 0.1 and 0.2 %. This ratio reduces the surface tension and softens the water, which promotes greater penetration and absorption.
Uses	Generally it is used for organic type fires, typically scrub, grass and most ground growth, and is exceptionally good for deep-seated fires, including rubbish. It can also be used on structure and vehicle fires. This application method provides superior heat absorption to straight water. Time of knockdown and water usage is reduced.
'Foam Pro'	All post-2005 NZFS fire appliances are fitted with 'Foam Pro' Class A foam systems and are capable of producing foam from hose reels and dedicated delivery outlets or forestry outlets. Minimal aspiration takes place and all types of nozzles can be used.

Aspirated

Aspirated foam	Class A foam can be aspirated at the induction point or at the nozzle. Foam is inducted from 0.3% to 0.5% and mixed with air. The resultant aspirated foam mixture has the ability to: • cling to surfaces, thereby creating a non-flammable barrier • exclude air from cavities, so preventing fire spread and radiated heat absorption. The higher the foam ratio the dryer the resultant foam produced.
Features	Typically at 0.3% to 0.4% the foam will penetrate foliage, flows easily and has moderate drain times. At 0.4% to 0.5 % the foam will have poor penetration but will cling to surfaces and has slow drain times.
Uses	This thick foam is extremely effective on standing trees, gorse and scrub, but can also be used for normal combustibles. Vehicle fires and structure fires can easily be attacked externally via windows and doors. This is most effective when water supplies are poor and conservation is necessary.
Crews in defensive mode	Aspirated foam will provide rapid control of a fire until further water is obtained. There is a noted benefit in areas with minimal crewing and or short crewing. Generally these crews would operate in defensive mode. Careful reapplication and damping down is required for final extinguishment.

Environmental impact	The environmental impact of Class A foam used at induction ratios of 0.1% to 1% is considered to be low.

Foam equipment

NZFS personnel aspirate foam at the pump by using compressed air foam systems (CAFS) or at the nozzle using aspiration nozzles.

Compressed Air Foam System (CAFS)

CAFS fleet	CAFS units must be fitted to the pump from new. The Fire Service has approximately 50 CAFS units fitted to appliances built between 1997 and 2001. They are predominantly on Type 1 appliances and are well liked and used often. The small number fitted on Type 3 appliances are used less often.
Advantages of CAFS	The advantage of CAFS application is that fully aspirated foam at 0.4 to 0.6% is very dry and will cling to vertical surfaces. This is particularly good for pre-treatment prior to a fire front arriving. Aspirated nozzles produce a wetter mixture at 0.4 to 0.6%, however, the Fire Service rarely pre-treats, as it is more likely to be involved in direct fire attack. The lightness of CAFS deliveries is also a considerable advantage when manoeuvring hose in rough terrain.
CAFS limitation	Typically CAFS deliveries use straight-bore nozzles which flow around 220 L/min. These nozzles should not be used for internal structure fire attacks where flashover is possible, as 440 L/min is the minimum water required for fire fighter safety.

Aspiration nozzles

Mechanism	Aspiration foam nozzles are designed to induct air at the nozzle. This is a simple one-handed operation. At other times, they operate as a normal firefighting nozzle.
TFT Quadracup	The TFT Quadracup is suitable for internal fire attack using water or Class A foam as it will flow up to 470 L/min, therefore providing flashover protection even when using foam.
Experiment with nozzles	All nozzles, including hose reel nozzles, will partially aspirate at 0.3 to 0.4%. Crews should experiment with all the nozzles carried on their appliances.

Flammable liquid fires	Dry-aspirated Class A foam is suitable for use on flammable liquid **spillages**, however Class B foam should be used for flammable liquid **fires** as they will rapidly burn back Class A foam. Class A and Class B foam should never be mixed.

Variable inline inductors

Types of inline inductors

The modern inline inductors are capable of inducting Class A foam from 0.25 to 1% and Class B foam from 1 to 6%. The Fire Service has nationally selected two inline inductors:

- TFT UEM 225 L/min
- TFT UEM 450 L/min.

When to use

These inductors should be used on appliances where Class A foam is required but Foam Pro systems are not fitted.

They should also be used on any appliance for Class B foam application. The TFT Quadracup nozzle can be used for Class B foam aspiration and it will produce excellent foam quality.

Setting up

Inline inductors use the Venturi principle to induct foam.

Consider the following when setting up:

- Connect inductor directly to the delivery outlet.
- Run at 1100kPa.
- The inductor will lose 30% of this pressure through the venturi leaving 770 kPa.
- Using a low-pressure 500 kPa nozzle this leaves 270 kPa available to be lost through friction loss.

Friction loss per length

Delivery hose size	Flowing 225 L/min through a UEM 225	Flowing 450L/min through a UEM 450
41 mm	65 kPa per length	Not practical
45 mm	35 kPa per length	127 kPa
70 mm	3 kPa per length	12 kPa

Considerations for a foam delivery from an inline inductor

- On flat ground you can extend a 41mm delivery over four lengths and a 45 mm delivery over seven lengths. Using 70 mm hose up to the nozzle length will significantly extend the delivery.
- Any head losses should be calculated at 10 kPa per metre.
- It is **very important** to match the flow of the nozzle to the inductor. For example, the TFT Quadracup aspiration nozzle matches the two inductors when the flow selector is set at 230 L/min for the UEM 225 and 470 L/min for the UEM 450.
- Inline inductors can be used for both Class A and Class B foams.
- Class B foam used by the NZFS is inducted at 3% for all normal flammable liquids and at 6% for polar solvents. The induction rates do not vary the 30% losses across the inductor. Delivery length calculations are the same as when used for Class A foam.
- Class B foam is best applied aspirated using a low or medium expansion attachment but the TFT Quadracup and Quadrafog nozzles are suitable for use.