HIGH PRESSURE
WATER MIST SYSTEM

Design, Installation, Operation and Maintenance Manual

2015 REV. 1

Catalogue

FOREWORD

This manual has been produced to provide the correct design, installation, operation and maintenance requirements for a High Pressure Water Mist Fire Fighting System for the 260m³ machinery and turbine in enclosure application.

Type Approval Documentation based upon: Approval Standard for Water mist Systems, Class Number 5560, November 2012 and according to: FM Approvals LLC

1 INTRODUCTION

Water Mist Principle

Water Mist is defined in NFPA 750 as a water spray for which the $Dv_{0.99}$, for the flow-weighted cumulative volumetric distribution of water droplets, is less than 1000 microns at the minimum design operating pressure of the water mist nozzle. The water mist system works at a high-pressure to deliver water as a fine atomised mist. This mist is quickly converted into steam that smothers the fire and prevents further oxygen from reaching it. At the same time, the evaporation creates a significant cooling effect.

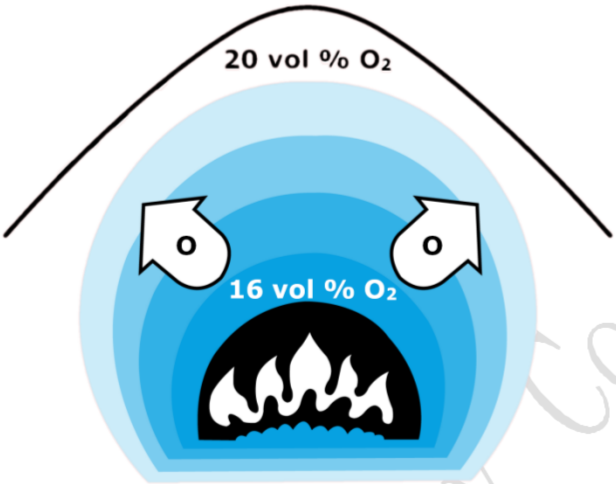
Water has excellent heat absorption properties absorbing 378 KJ/Kg. and 2257 KJ/Kg. to convert to steam, plus approximately 1700:1 expansion in doing so. In order to exploit these properties, the surface area of the water droplets must be optimised and their transit time (before hitting surfaces) maximised. In doing so, fire suppression of surface flaming fires can be achieved by a combination of

- Heat extraction from the fire and fuel
- Oxygen reduction by steam smothering at the flame front
- Blocking of radiant heat transfer
- Cooling of combustion gases

For a fire to survive, it relies on the presence of the three elements of the 'fire triangle': oxygen, heat and combustible material. The removal of any one of these elements will extinguish a fire. A high-pressure water mist system goes further. It attacks two elements of the fire triangle: oxygen and heat.

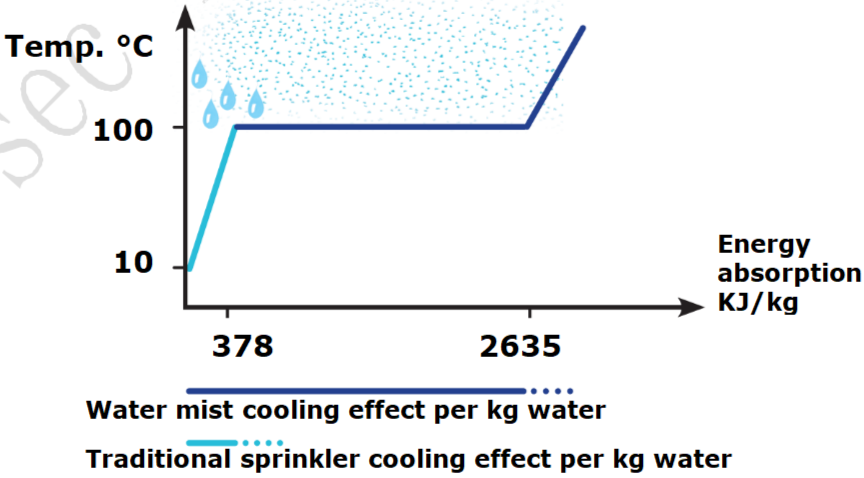
The very small droplets in a high-pressure water mist system quickly absorb so much energy that the droplets evaporate and transform from water to steam, because of the high surface area relative to the small mass of water. This means that each droplet will expand approximately 1700 times, when getting close to the combustible material, whereby oxygen and combustible gasses will be displaced from the fire, meaning that the combusting process will increasingly lack oxygen.

To fight a fire, a traditional sprinkler system spreads water droplets over a given area, which absorbs heat to cool the room. Due to their large size and relatively small surface, the main part of the droplets will not absorb enough energy to evaporate, and they quickly fall to the floor as water. The result is a limited cooling effect.



By contrast, high-pressure water mist consists of very small droplets, which fall more slowly. Water mist droplets have a large surface area relative to their mass and, during their slow descent towards the floor, they absorb much more energy. A great amount of the water will follow the saturation line and evaporate, meaning that water mist absorbs much more energy from the surroundings and thus the fire.

That's why high-pressure water mist cools more efficiently per litre of water: up to seven times better than can be obtained with one litre of water used in a traditional sprinkler system.



1.3 High Pressure Water Mist System Introduction

The high pressure water mist system is a unique firefighting system. Water is forced through micro nozzles at very high pressure to create a water mist with the most effective firefighting drop size distribution. The extinguishing effects provide optimum protection by cooling, due to heat absorption, and inerting due to the expansion of water by approximately 1,700 times when it evaporates.

1.3.1 The key component

Specially-designed water mist nozzles

The high pressure water mist nozzles are based on the technique of the unique Micro nozzles. Due to their special form, the water gains strong rotary motion in the swirl chamber and is extremely quickly transformed into a water mist that is jetted into the fire at great speed. The large spray angle and the spray pattern of micro nozzles enable a high spacing.

The droplets formed in the nozzle heads are created using between 100-120 bars of pressure.

After a series of intensive fire tests as well as mechanical and material tests, the nozzles are specially made for high-pressure water mist. All tests are carried out by independent laboratories so that even the very strict demands for offshore are fulfilled.

Pump design

Intensive research has led to the creation of the world’s lightest and most compact high-pressure pump. Pumps are multi-axial piston pumps made in corrosion resistant stainless steel. The unique design uses water as a lubricant, meaning that routine servicing and replacing lubricants are not needed. The pump is protected by international patents and is widely used in many different segments. The pumps offer up to 95% energy efficiency and very low pulsation, thus reducing noise.

Highly corrosion-proof valves

High-pressure valves are made from stainless steel and are highly corrosion-proof and dirt resistant. The manifold block design makes the valves very compact, which makes them very easy to install and operate.

1.3.2 Benefits of high pressure water mist system

The benefits of the high pressure water mist system are immense. Controlling/ Putting out the fire in seconds, without using any chemical additives and with minimal consumption of water and close to no water damage, it is one of the most environmentally-friendly and efficient firefighting systems available, and is totally safe for human beings.

Minimum use of water

• Limited water damage
• Minimal damage in the unlikely event of accidental activation
• Less need for a pre-action system
• An advantage where there is an obligation to catch water
• A reservoir is rarely needed
• Local protection giving you faster fire fighting
• Less downtime due to low fire and water damage
• Reduced risk of losing market shares, as production is quickly up and running again
• Efficient – also for fighting oil fires
• Lower water supply bills or taxes

Nozzles

• Cooling ability enables installation of a glass window in the fire door
• High spacing
• Few nozzles – architecturally attractive
• Efficient cooling
• Window cooling – enables purchase of cheaper glass
• Short installation time
• Aesthetic design

Small stainless steel pipes

• Easy to install
• Easy to handle
• Maintenance free
• Attractive design for easier incorporation
• High quality
• High durability
• Cost-effective at piece-work
• Press fitting for quick installation
• Easy to find room for pipes
• Easy to retrofit
• Easy to bend
• Few fittings needed

1.3.3 Codes, Standards and Drafts

Whilst performance of all Water Mist Systems is dependent upon the individual nozzle characteristics, as well as its positioning and the hazard itself, The National Fire Protection Association (NFPA) has prepared a standard for Water Mist Systems reference NFPA 750. This Standard is publicly available as a reference document.
Codes
National Codes
Standards

- FM Class 5560 – Factory Mutual Approval for Water Mist Systems
- NFPA 750 – edition 2010

1.4 High-pressure Water Mist System Design

1.4.1 Liability

Design and Installation of a igh pressure water mist system should only be carried out by persons/companies that have received the necessary training and have been authorized by Manufacturer.

Designs and all other technical information in this manual are based upon certain standard fire tests. The standard criteria derived from such standard tests and all technical recommendations resulting from those tests reflected in the design manual may not be transferable to every individual application. Therefore, it is the authorised design person's obligation to verify in every individual case whether the standard criteria provided by this manual may be used in connection with the relevant customer's needs.

Users of this manual should ensure themselves of familiarity with the requirements of the most recent edition of NFPA 750 and with any other relevant national codes applicable to the installation.

The high-pressure water mist system is intended solely for use in accordance with the instructions in the 'systems design manual'. Any use beyond this is regarded as incorrect. The risk of any resultant damage will be borne exclusively by the user of this manual.

Correct use also means observing the procedures described in this manual.

1.4.2 Limitation

Whilst the prospect of using small amounts of water to suppress and extinguish fire is very attractive, it must be recognised that there are limitations to how and where it can be used safely and effectively.

High-pressure water mist system should not be used for direct application to materials which react with water to produce violent reactions or hazardous products.
As examples of materials can be mentioned:

- Reactive metal, such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium.
- Metal amides, such as sodium amide.
- Metal alkoxides, such as sodium methoxide.
- Carbides, such as calcium carbide.
- Halides, such as benzoyl chloride and aluminium chloride.
- Oxyhalides, such as phosphorus oxybrumide.
- Silanes, such as trichloromethylsilane.
- Sulfides, such as phosphorus pentasulfide.
- Cyanates, such as methylisocyanate.

High pressure water mist systems shall not be used for direct application to liquefied gases at cryogenic temperatures (such as liquefied natural gas) which boil violently when heated with water.

High pressure water mist system should only be used where a fire test validated design basis exists.

Whilst the water droplets are small, they have a finite mass and do not disperse and permeate like gaseous suppression agents.

1.4.3 Competence

As one of the China's leading high pressure fire protection company with a comprehensive fire protection portfolio, company uses its good-trained and rich-experienced teams to maintain its premier position in the technology of the industry.

Sales Teams should have a competent knowledge of the following through education, training and experience.

- Relevant Health & Safety legislation
- Relevant Environmental legislation
- System installation requirements
- Basic Design Parameters
- Time and Material costs

Design Teams should have a competent knowledge of the following through education, training and experience.

- Analyse the risk
- Consider the alternatives
- Understand all the options
- Match the solution to the risk
- Water mist Design through In House training
- Relevant Health & Safety legislation
- Relevant Environmental legislation
- System installation requirements
- Design Manual

Installation Teams should have a competent knowledge of the following through education, training and experience

- Manual Handling
- Pipe work installation
- Working at heights regulations (if applicable)
- Confined spaces regulations (if applicable)
- Installation procedures

Commissioning Teams should have a competent knowledge of the following through education, training and experience

- Commissioning procedures & Forms
- Pipe work installation

2 PLANING

2.1 Hazard analysis

When planning there must be taken care of circumstances regarding the building constructions, plant in the building and working procedures that can have effect on the water mist systems efficiency.

Even though the water mist system normally comprise the whole building or industrial plant it must not be presupposed that all other fire proofing arrangement are completely superfluous. It is important to eye the whole buildings fire conditions security measures as a total part.

Remember to consider any interplay between the water mist system and other fire conditions security measures.

When planning a water mist system or extend / change an existing system it would always be relevant to involve relevant approving authorities on an early plan.

In order to determine whether HPWM is appropriate, and the type of protection to be provided, the hazard should be analysed. Identify the main fuel inventories, potential sources of fuel release and areas of fuel accumulation. Consider the possible duration of release and the effects of early ignition and delayed ignition, as well as the potential sources of ignition.

- Extinguishment, Suppression or Control
- Check Water Supply
- Pump unit type
- Detection Required
- Check Geometry of Room
- Cabinets/Equipment
- Check Obstructions
- Location of Pump unit/Central
- Power Supplies

2.2 Fire suppression, control or extinguishment and types of fire

It is important to define the performance expectation for the system to be designed from the outset. In order to assess this you need to clearly understand the meaning of fire suppression, fire control, fire extinguishment and the type of fire expected.

Fire Extinguishment – "The complete suppression of a fire until there are no burning combustibles".

Fire Suppression – "The sharp reduction of the rate of heat release of a fire and the prevention of re growth".

Fire Control – "The limitation of the growth of a fire by pre wetting adjacent combustibles and controlling ceiling gas temperatures to prevent structural damage".

2.2.1 Ventilation

Both natural and forced ventilation can disperse the fine droplets in HPWM systems, so ventilation systems and dampers should close upon system activation. Any unclosable openings should receive special consideration. **FM Approvals requires that all enclosure penetrations are sealed, all openings are closed, and all ventilation is shut down in the event of system actuation.**

2.2.2 Shutdowns

As powered plant and equipment are the primary source of ignitions, they should be shut down upon system activation.

2.2.3 Valve location

The valves controlling the HPWM system should be located in a safe, secure and accessible position, protected from freezing.

2.2.4 Water supplies

HPWM systems require clean filtered potable water. This may be supplied from a pump or a pump and tank unit. The choice is pre-determined by the application, site conditions or customer preferences.

Water can be normal potable water which complies with GB5749 or Directive 80/778/EEC (1980) and filtered before entering the system. The GB5749 or Directive 80/778/EEC (1980) limit for chloride ions or free chloride is 25 mg/l, but a contain chloride ions or free chloride not above a level of 200 mg/l are accepted.

The inlet filter should be of sufficient size and capacity with an absolute filtration of 10 micron.

Water Mist systems are susceptible to freezing, the allowable system temperature range is 40-130 F (4-54°C). Therefore, pump units and wet piping shall be located in an area with a guaranteed temperature above 4°C maintained at all times. Piping beyond group/section valves which is dry can be in areas below this temperature, nozzle performance is not adversely affected by temperature.

Note: The use of antifreeze solution will void FM Approval of the system.

3 SYSTEM DESCRIPTION AND COMPONENTS

3.1 Introduction

The HPWM system will consist of a number of nozzles connected by stainless steel piping to a high-pressure water source (pump units).

3.2 Nozzles

HPWM nozzles are precision engineered devices, designed depending on the system application to deliver a water mist discharge in a form that ensures fire suppression, control or extinguishment.

3.3 Section valves – Open nozzle system

Section valves are supplied to the water mist firefighting system in order to separate the individual fire sections.

Section valves manufactured of stainless steel for each of the sections to be protected are supplied for installation into the pipe system. The section valve is normally closed and opened when fire extinguishing system operates.

A section valve arrangement may be grouped together on a common manifold, and then the individual piping to the respective nozzles is installed. The section valves may also be supplied loose for installation into the pipe system at suitable locations.

The section valves should be located outside the protected rooms if not other has been dictated by standards, national rules or authorities.

The section valves sizing is based on each of the individual sections design capacity.

The system section valves are supplied as an electrically operated motorized valve. Motorised operated section valves normally require a 230 VAC signal for operation.

The valve is pre-assembled along with a pressure switch and isolation valves. The option to monitor the isolation valves is also available along with other variants.

3.4 Pump unit

Pump unit will typical operate between 100 bar and 140 bar with single pump flow rates rang 100l/min. Pump systems can utilise one or more pump units connected through a manifold to the water mist system to meet the system design requirements.

3.4.1 Electrical pumps

When the system is activated, only one pump will be started. For systems incorporating more than one pump, the pumps will be started sequentially. Should the flow increase due to the opening of more nozzles; the additional pump(s) will automatically start. Only as many pumps as are necessary to keep the flow and operating pressure constant with the system design will operate. The high pressure water mist system remains activated until qualified staff or the fire brigade manually shut off the system.

Standard pump unit

The pump unit is a single combined skid mounted package made up of the following assemblies:

- Filter unit
- Buffer tank (Depend on the inlet pressure and pump type)
- Tank overflow and level measurement
- Tank inlet
- Return pipe (can with advantage be leaded to outlet)
- Inlet manifold
- Suction line manifold
- HP pump unit(s)
- Electric motor (s)
- Pressure manifold
- Pilot pump
- Control panel

3.4.2 Pump unit panel

The motor starter control panel is as standard mounted at the pump unit. The pump controller is required to be FM Approved.

Common power supply as standard: 3x400V, 50 Hz.

The pump(s) are direct on line started as standard. Start-delta starting, soft starting and frequency converter starting can be provided as options if reduced starting current is needed.

If the pump unit consists of more than one pump, a time control for gradually coupling of the pumps has been introduced to obtain a minimum of starting load.

The control panel has a RAL 7032 standard finish with an ingress protection rating of IP54.

Starting of the pumps is achieved as follows:

Dry systems– From a volt-free signal contact provided at the fire detection system control panel.

Wet systems – From a drop in pressure in the system, monitored by the pump unit motor control panel.
Pre-action system – Need indications from both a drop in air pressure in the system and a volt-free signal contact provided at the fire detection system control panel.

3.5 Information, tables and drawings

3.5.1 Nozzle

XSWT 1.25/ 10- **

- Water mist nozzle → XSWT
- K-factor → 1.25
- Working-pressure → 10
- Release temperature → **
  For Open nozzle: blank

Special care must be taken to avoid obstructions when designing water mist systems, especially when using low flow, small droplet size nozzles as their performance will be adversely affected by obstructions. This is largely because the flux density is achieved (with these nozzles) by the turbulent air within the room allowing the mist to spread evenly within the space - if an obstruction is present the mist will not be able to achieve its flux density within the room as it will turn into larger drops when it condenses on the obstruction and drip rather than spreading evenly within the space.

The size and distance to obstructions depend of the nozzle type. The information can be found on the data sheets for the specific nozzle.

Fig 3.1 Nozzle

3.5.2 Pump unit

XSWB 100 / 12

- Pump Unit → XSWB
- Flow rate → 100
- Working-pressure → 12

Type	Output l/min	Power KW	Standard pump unit with control panel L x W x H mm	Oulet mm	Pump unit weight kg approx
XSWB 100/12	100	30	1960×430×1600	Ø42	1200
XSWB 200/12	200	60	2360×830×1600	Ø42	1380
XSWB 300/12	300	90	2360×830×1800	Ø42	1560
XSWB 400/12	400	120	2760×1120×1950	Ø60	1800
XSWB 500/12	500	150	2760×1120×1950	Ø60	1980
XSWB 600/12	600	180	3160×1230×1950	Ø60	2160
XSWB 700/12	700	210	3160×1230×1950	Ø60	2340

Power: 3 x 400VAC 50Hz 1480 rpm.

Fig 3.2 Pump Unit

3.5.3 Standard valve assemblies

Standard valve assemblies are indicated below Fig 3.3.

This valve assembly is recommended for multi-section systems fed from the same water supply. This configuration will allow other sections to remain operable whilst maintenance is carried out on one section.

Fig 3.3 – Standard section valve assembly – Dry Pipe System with Open Nozzles

4 SYSTEM DESIGN

4.1 General

The design criteria adopted should be as indicated in this design manual.

All deviations from those shown in the design manual shall be documented and approved by the authorities.

All risks outside those featured in the design manual shall be fully detailed on a fire risk analysis document in the normal way and a copy sent to the water mist product manager.

4.2 Pre -Design

To design a high-pressure water mist (HPWM) system for any application, the designer should from the outset ascertain all parameters of each risk to be protected and establish limiting factors such as potential nozzle obstructions.

When designing the system it could be in all interest to consult all interested parties, including fire authorities, building control authorities and insurers to ensure no conflict of interest.

4.3 Documentation and Drawings

The designer shall submit to the client and if necessary the authority having jurisdiction for comment/approval for the system a set of system design documents and drawings. Refer to section 4.6.6.

4.4 Pressure Equipment Directive (PED)

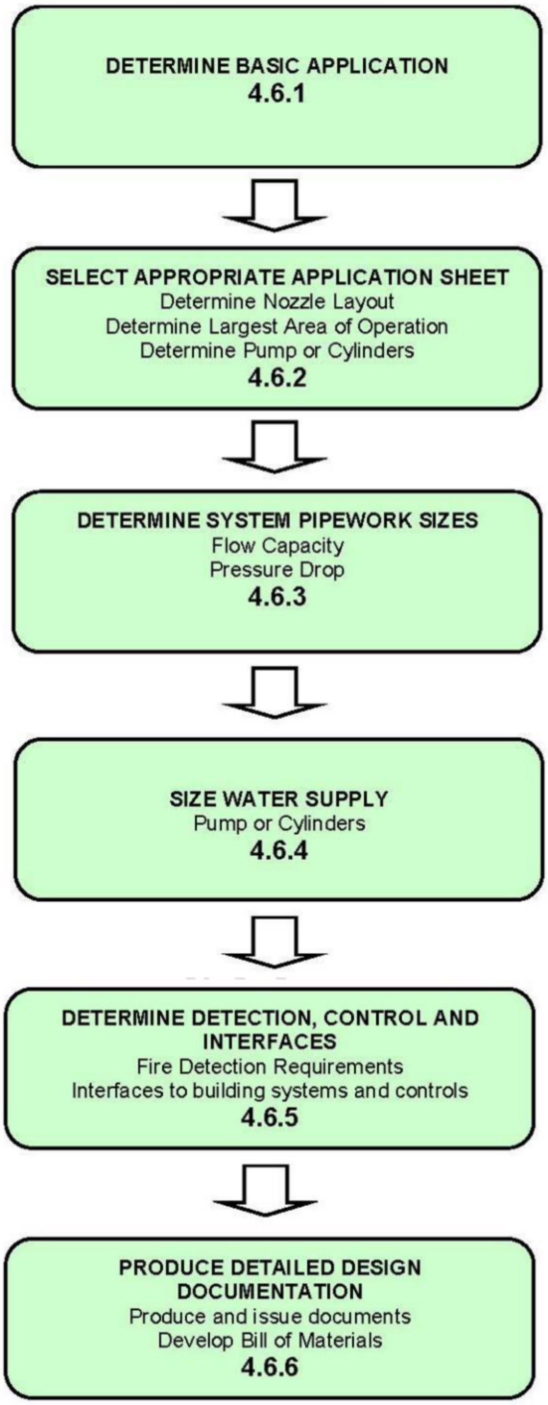
Users of this manual should ensure themselves of familiarity with the requirements of the Pressure Equipment Directive.

4.5 Application Sheets

The application sheets (section 5) provide the necessary parameters to plan a HPWM system layout. Nozzle type, minimum discharge periods, recommended type of water supply and other relevant criteria details are provided.

4.6 Design Process

Users of this manual should ensure that the application addressed falls within the scope of this manual and, if any doubt should exist, it is the user's responsibility to verify the application with the water mist product manager.


DETERMINE BASIC APPLICATION
4.6.1
SELECT APPROPRIATE APPLICATION SHEET
Determine Nozzle Layout
Determine Largest Area of Operation
Determine Pump or Cylinders
4.6.2
DETERMINE SYSTEM PIPEWORK SIZES
Flow Capacity
Pressure Drop
4.6.3
SIZE WATER SUPPLY
Pump or Cylinders
4.6.4
DETERMINE DETECTION, CONTROL AND INTERFACES
Fire Detection Requirements
Interfaces to building systems and controls
4.6.5
PRODUCE DETAILED DESIGN DOCUMENTATION
Produce and issue documents
Develop Bill of Materials
4.6.6

4.6.1 Determine the basic application

The HPWM system can be applied to protect risk that fall within the following base applications.

Total Flooding -A system designed to discharge water mist to protect all hazards in an enclosure. Typical areas are where hot surfaces combined with risk of combustible liquids. It will typical be areas where hoses or pipes with hydraulic oil, fuel oil etc. are placed close to hot surfaces; a typical application would be an engine test cell. Enclosures with net volumes up to and including 260 m³ can be protected using the HPWM system.

Open type nozzles are used operated by either automatic fire detection or manual operation.

Discharge period is twice the time to extinguish test fires or 10 minutes minimum.

The system is designed to extinguish the fire.

4.6.2 Nozzle Layout and Largest Area of Operation

1. From section 5 select the appropriate application sheet for the risk, ensuring that the following points are taken into account;

a. Dimensions are within the parameters specified.
b. Fire risk is as specified
c. Aware of purpose of the system i.e. extinguishment, suppression or control.

2. Select the appropriate nozzle from the application sheet and using the spacing parameters determine the number of nozzles required to cover the risk.

3. Calculate the flow from each nozzle, using the nozzle K-factor as indicated on the application sheet.

The nozzle K factor is a constant that gives the ratio between the flow rate and the pressure at the nozzle.

Systems pressure (P) at the nozzle will be identified on the relevant application sheet.
Typically 100 bar for pump. Most favourable condition shall be considered.

$$Q = K \cdot \sqrt{P}$$

Where:
Q = Flow from the nozzle (l/min)
K = Nozzle K factor (lpm/bar^½)
P = Pressure at the nozzle (bar)

4. Calculate the flow for calculating areas. (The most critical area.)

<u>**For open nozzle systems**</u>

For same nozzles within the same area

$$Q_{MAX} = Q \cdot N_Z$$

Where:
Q_{MAX} = Total flow for the area (l/min)
Q = Flow from the nozzle (l/min)
N_Z = Total number of nozzles

For different nozzles within the same area

$$Q_{MAX} = (Q_1 \cdot N_{Z1}) + (Q_2 \cdot N_{Z2}) + etc.$$

Where:
Q_{MAX} = Total flow for the area (l/min)
Q_1 = Flow from the nozzle type 1 (l/min)
N_{Z1} = Total number of nozzle type 1
Q_2 = Flow from the nozzle type 2 (l/min)
N_{Z2} = Total number of nozzle type 2

Calculate the flow for calculating areas.
The most critical area calculated using the formulas above.
The most favourable area can be calculated as the max.flow from the pump unit because of the pump design.

4.6.3 Pipework Calculations

4.6.3.1 Introduction

The pipe work must be sized to suit the application design in order to achieve the correct parameters for both water flow and pressure drop.
The sizing of the piping is determined from the following procedure and calculations. The guidelines are based upon Darcy Weisbach Calculation for High Pressure Single Fluid Systems - NFPA 750 Chapter 9.

The following procedure is a two-step process for manual calculation of pipe sizes and pressure losses. *Manual calculations shall be used for estimating purposes only.*

4.6.3.2 Calculating internal pipe sizes

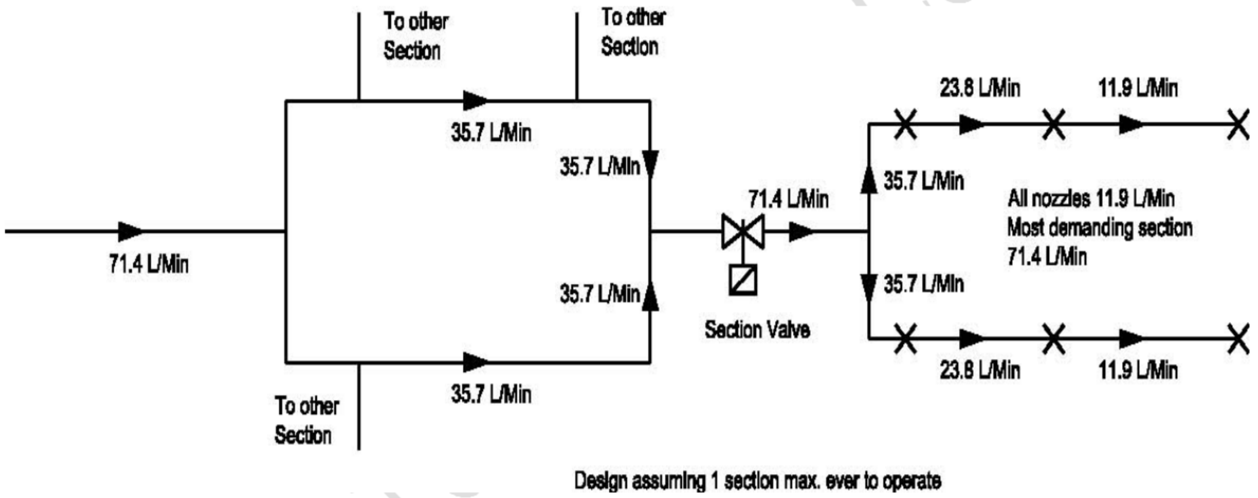
At this stage the designer must ensure that the flow velocity in the piping is approx. 7 m/s, in order to avoid excessive pressure drop. On the final pressure calculation a higher flow velocity and higher pressure drop can be accepted.

To calculate the allowable inner pipe diameter the following variables are used.

$$d_i = 4{,}607 \cdot \sqrt{\frac{Q}{v}}$$

Where:
d_i = Inner diameter of the pipe (mm)
Q = Flow from the nozzle (l/min)
v = Flow velocity through the pipe – normal use 7m/s

The main pipe size is defined for the design capacity of the most demanding section.
If a ring main pipe is utilised to feed a number of sections then the flow rate of the most demanding section is divided by 2. Refer to below.



4.6.3.3 Calculating pressure drop

The pipe work sizes must be adjusted to ensure that the pressure drop does not exceed 20 - 25 bar between the pump and the furthest nozzle. The pressure drop is calculated from the pump pressure manifold.

Sizing of the system pipe work can only be determined accurately on completion of the detailed design. The detailed design shall reflect the agreed/approved pipe routes and pump locations.

The manual pressure drop calculation is carried out according to the following pipe friction chart (moody diagram) for specific resistance for pipes.

Calculation based on the hydraulically most remote nozzle at the design capacity for each section, to ensure the minimum design pressure at the nozzle.

Pressure drop calculation formula:

$$\Delta P_{PIPE} = 2.252 \cdot \frac{f \cdot L \cdot \rho \cdot Q^2}{d^5}$$

Where:
ΔP_{PIPE} = Friction loss (bar gauge)
f = Friction factor (bar/m)
L = Length of pipe (m)
Q = Flow (L/min)
ρ = Weight density of fluid (kg/m³)
d = Internal diameter of pipe (mm)

Reynolds, Re:

$$\mathrm{Re} = 21.22 \cdot \frac{Q \cdot \rho}{d \cdot \mu}$$

Where:
Re = Reynolds number
Q = Flow velocity (L/min)
ρ = Weight density of fluid (kg/m³)
d = Inner diameter of pipe (mm)
μ = Absolute (dynamic) viscosity for water

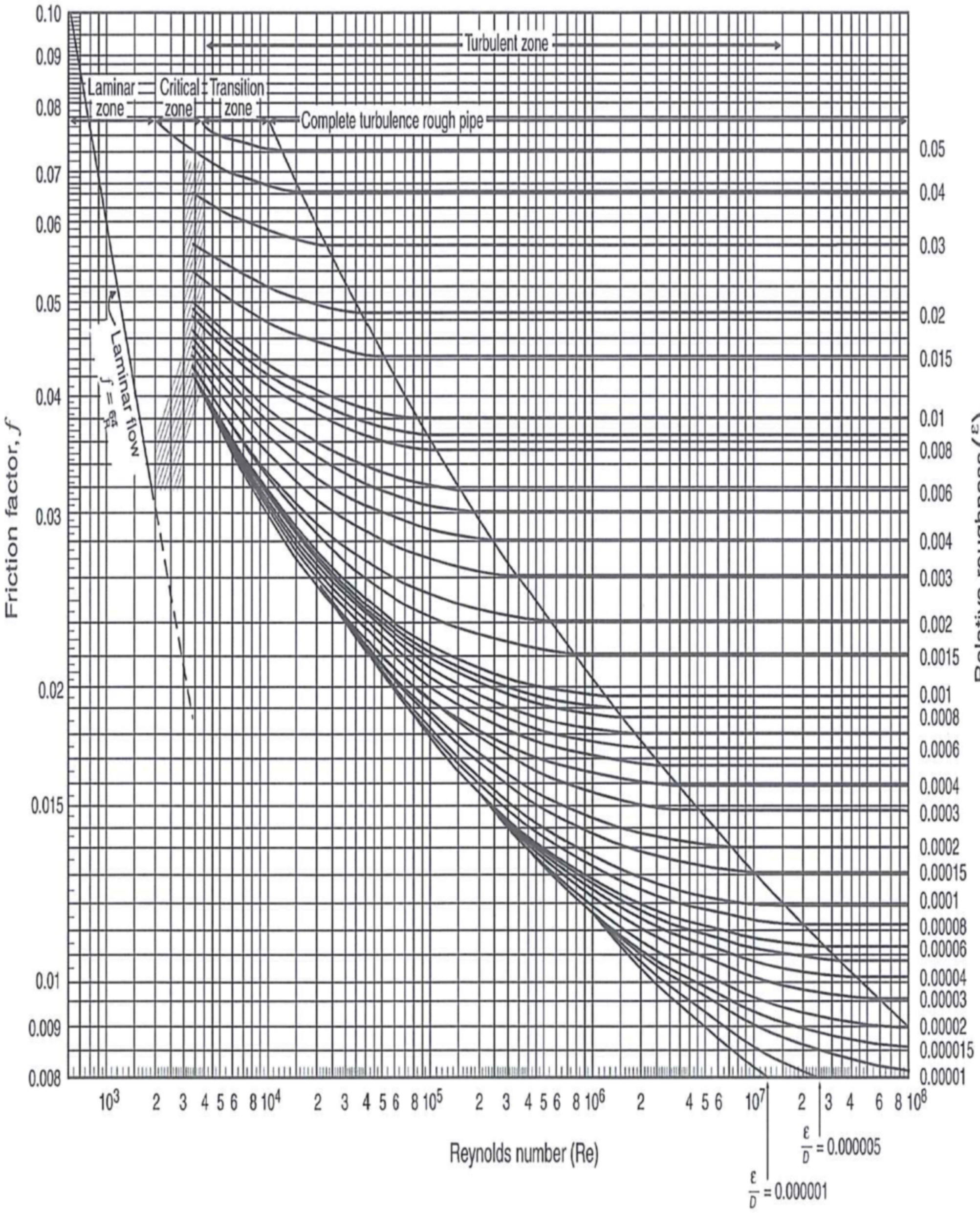
Temperature °C	Weight Density of water kg/m³	Absolute (Dynamic) Viscosity, μ (centipoises)
4.4	999.9	1.50
10.0	999.7	1.30
15.6	998.8	1.10
21.1	998.0	0.95
26.7	996.6	0.85
32.2	995.4	0.74
37.8	993.6	0.66

Relative roughness:

$$relativeroughness = \frac{\varepsilon}{d}$$

Where:
ε = Roughness (depend of pipetype (normally 0,002-0,0009 for stainless steel pipes))
d = Internal pipe diameter (mm)

Moody Diagram:



Pressure drop of height:

$$\Delta P_{HEIGHT} = \frac{h \cdot \rho \cdot g}{100000}$$

Where:

ΔP_{HEIGHT} = Pressure drop of height – static head (bar)

h = Height of water column (m)

ρ = Weight density of fluid (kg/m³) – Fig 26.

g = Gravitation constant (9.81 m/sec²)

Pressure drop in fittings and valves:

$$\Delta P_{FITTING} = \frac{\varepsilon \cdot \rho \cdot v^2}{200000}$$

Where:

$\Delta P_{FITTING}$ = Pressure drop in fitting (bar)

ε = Specific resistance (refer to table 4 below)

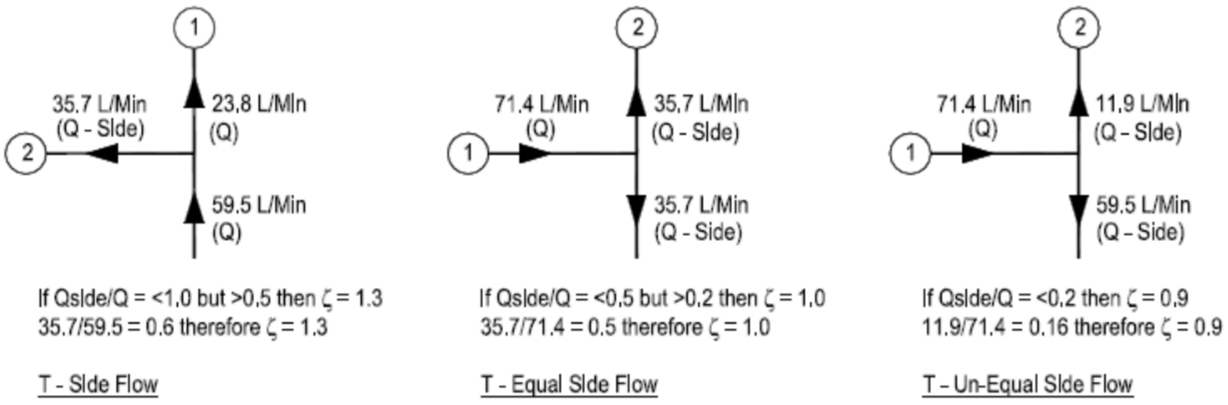
ρ = Weight density of fluid (kg/m³) – Fig 26.

v = Flow velocity (m/s)

The total specific resistance for pipe system ΔP is equal to the sum of the individual drop:

$$\Delta P = \Sigma\Delta P_{PIPE} + \Sigma\Delta P_{HEIGHT} + \Sigma\Delta P_{FITTING}$$

Example of T-Side flow



4.6.4 Sizing of Pump Unit and Tank

4.6.4.1 Pump Unit and Tank

Note: It is required to add a further 20% of flow as a safety factor i.e Q_{max} + 20% (FM approved)

To calculate the size and number of pump

$$N_{PUMPS} = \frac{Q_{MAX}}{q}$$

Where:

N_{PUMPS} = Number of pumps

Q_{MAX} = Total flow for area (l/min) + 2***0% safety factor***

q = Flow rate output of selected pump unit

To calculate pressure required from the pump

$$P_{REG} = P_{NOZZLE} + P_{SMAX}$$

Where:

P_{REG} = Pressure required (bar)

P_{NOZZLE} = Pressure required at the nozzle (bar)

P_{SMAX} = Total pressure drop in system pipework – calculated as ΔP

To calculate the external water supply capacity to a buffer tank.

Remember that the capacity of the pump unit buffer tank as provided standard is determined by the number of pumps on the unit.
Establish the required discharge period (t=min) from the relevant application sheet.

$$Q_{IN} = Q_{MAX} - \frac{V_{TANK}}{t}$$

Where:
Q_{IN} = Flow rate required of external water supply (l/min)
Q_{MAX} = Total flow for the area (l/min)
V_{TANK} = Volume of tank (litres)
t = Required discharge period (min)

To calculate the size of a full capacity water storage tank

$$V_{TANK} = Q_{MAX} \cdot t$$

Where:
V_{TANK} = Volume of tank (litres)
Q_{MAX} = Total flow for the area (l/min)
t = Required discharge period (min)

4.6.5 Detection, Control and Interfaces

4.6.5.1 Fire detection

The need for detection and control is dependent upon the type of risk and application. To determine if fire detection and control is required for the HPWM system, refer to the relevant application sheet.

In designing a fire detection system, particular consideration must be given to the type of risk being protected and the likely fuel load for the fire. The suitability of the detection chosen shall be determined by a competent fire detection engineer.

The fire detection system shall be designed and installed in accordance with recognised fire detection standards e.g. EN54, BS5839, and NFPA 750 etc. and comply with applicable legislation in the territory.

All detection and control used with the water mist system must be FM Approved.

4.6.5.2 Control and Interfaces

It is extremely important that the function of the control and interface system is understood by all relevant parties. To this end, it is recommended that a system cause and effects diagram be produced to identify the system operation.

4.6.6 Design Documentation

The documents issued shall at least include the following:

- Process and Instrumentation Diagram
- Nozzle and Tube/Pipe Layout
- System Cause and Effects
- Pump General Arrangements
- Pump Sizing Calculations
- System Hydraulic Calculations
- Component Data Sheets
- Material List
- Factory Test Certification
- Commissioning Procedures
- Operational and Maintenance Manual

5 APPLICATION SHEETS

Total flooding application - Machinery/Turbine enclosure volume not exceeding $260m^3$

5.1 DESCRIPTION

The scope of this application covers typical machinery spaces, gas turbines, small diesel engines, and emergency diesel power back units in enclosures.

5.2 SIZE LIMITATIONS

This application sheet covers enclosures of up to and including volumes $260m^3$

5.3 FIRE RISK

The main fire risk is the breakage or rupturing of pipe/hoses causing leakage of fuel or lubricating/cooling oil onto a hot surface or sparks. A further risk may be the possibility of a mechanical failure of a component such as bearings.

5.4 PURPOSE OF THE SYSTEM

The purpose of the system is to rapidly extinguish a fire and cool the surrounding machinery to prevent reignition.

5.5 DESIGN RECOMMENDATIONS

		Note
SYSTEM TYPE	Open nozzles – Pump	
NOZZLE DESIGN PRESSURE	100 bar	
DISCHARGE TIME	10 minutes	**Discharge time is a minimum of 10 minutes.**
FIRE DETECTION	Yes	Appropriate fast acting electronic fire detection as determined by type of risk.
SHUTDOWNS	Yes	Machine, fuel lines, vent control and other associated processes.
SPECIAL REQUIREMENT	Yes	Consideration shall be given shutdown of ventilation and closure of doors. Refer to criteria below for these scenarios.
RELEVANT TEST	According to FM5560 protocol fire test appendix C and D	

SKETCH REFERENCE	**1**
VOLUME	$260m^3$ Controlled vent / door
NOZZLE TYPE	XSWT 1.25/10
NOZZLE K FACTOR	1.25
CONTROLLED VENTILATION AND DOOR CLOSURE	Yes

Notes:

1. Ceiling nozzles shall be installed approx. 150 – 200mm below the ceiling.
2. Discharge time is a minimum of 10 minutes. FM Global Datasheets should be consulted for actual required discharge time.

6 INSTALLATION

6.1 Introduction

The purpose of this section is to provide a synopsis of the general requirements for installation of the HPWM System.
All installation work is to be carried out in accordance with –
Certificated Installation Company approved construction drawings
Certificated Installation Company standard process controls
Certificated Installation Company H&S Project file including method statements risk assessments and site specific requirements.
Clients Requirements
Agreed Programme

Installation should only be undertaken by personnel who are familiar with the installation of high pressure water mist fire extinguishing and suppression systems. Installation by untrained or inexperienced personnel may jeopardise the integrity of the system, the safety of personnel, and the warranty of the system.

All staff and sub contractors involved in the installation phase shall meet the requisite training and competency requirements, and carry the appropriate skill cards.

6.2 Safety at Site

The installation shall be carried out in line with the contract design, with particular attention being made to the health and safety requirements and site requirements.
Method statements and risk assessments shall be provided for all associated works.

Personnel must attend any site induction safety course prior to carrying out any work, and they must familiarise themselves with relevant safety and site instructions prior to carrying out the work.
Personnel protective equipment must be used at all times including, but not limited to:
Safety footwear
Protective goggles
Gloves
Overalls
Prior to commencing any pressure testing, all un-authorized personnel must leave the area. When pressure testing is being carried out, under no circumstances must the operative leave the water pump unattended when it is in operation.

In event of an accident on site, the site supervisor must be notified immediately. Where site staff have a concern regarding a risk to health, safety or the environment they carry an obligation to bring that to the attention of the project manager for action. The project manager has an obligation to resolve any concerns raised by site staff.

Any significant issues/concerns should be brought to the attention of the local EHS manager for corrective/preventive action and reporting purposes.
Due to possible erroneous activation of system (if fitted) caused by dust or smoke due to drilling of brickwork or masonry, the fire detection system in the area will be isolated prior to the period commencing works. Isolations to be carried out by authorized personnel as decided by the client/owner or the authorities having jurisdiction.
Any access equipment used is only operated by suitable qualified operators.

Any calibrated equipment shall be stored safely and protected from inadvertent damage. Copies of calibration certification shall be available at site for inspection.

Welding must be carried out in accordance with relevant standards by a suitably qualified welder. In the case of approved suppliers the firm shall provide evidence that welders are coded suitable for the work for which they are employed.

6.3 Documentation, Drawings and Forms

Drawings as listed in section 4.6.6 shall be provided as a minimum; all drawings must be available before installation is started. The drawings must be approved by the client/owner or the authority having jurisdiction before installation can be started, unless other agreements have been made with the customer. The drawings shall clearly indicate that they are approved for construction.

Drawings, Documents and Forms at site must be controlled in the same way as in an office with care being taken to ensure that only up to date information is being used.

All drawings shall be controlled and working drawings marked up as progress is made to ensure accurate records are kept. Marked up drawings are returned to the project engineer for recording purposes and to enable "AS INSTALLED" Drawings to be produced.

Factory testing documentation shall be available prior to installing the relevant equipment. For pressure carrying equipment this shall include evidence of testing to a minimum 1.5 times the design working pressure of the component assembly.

The client/owner or authority having jurisdiction shall approve any deviation from the approved drawing layout, with drawings updated at the as-built stage.

6.4 Equipment Received at Site

The Project Engineer or nominee should be notified immediately following receipt / inspection of a delivery in order to sign off the goods received note as soon as practicable.

All incoming goods shall be directed to the relevant area or agreed storage facility.

Before any goods are accepted the site supervision/lead operative shall check that the goods and delivery conform to the goods received note. Any goods failing to meet the goods received note description shall not be accepted. In the event of any error between the quantity being delivered and the quantity stated on the goods received note, it shall be agreed that both the deliverer and the receiver's goods received note be amended to show the correct quantity delivered. In the event of confirming the quantity of the goods being delivered proving to be impractical, it shall be left to the discretion of the goods receiver to sign the delivery note and add 'quantity not checked'. Any discrepancies must be advised to the project engineer and where necessary the materials segregated pending inspection by the project engineer.

6.5 Transport and Storage of Equipment and Materials

6.5.1 Transport

The shipping crate in which the pump unit, nozzles, section valves, tube and pipes etc are transported must only be moved by means of a lift truck or in a similar manual way. Lifting instructions will be provided with shipping crate.

Transport and handling of pipes should be carried out by using approved tabs and in such a way that the pipes will not be bended or damaged. Please also make sure that no impurities enter the pipes during transportation.

6.5.2 Storage – Stainless Steel (Tube, Pipes, Fittings etc)

All stainless steel materials must be handled and stored in a way that the corrosion quality of the stainless steel will not be reduced. As a minimum, the following precautions need to be followed to prevent unwanted corrosion.
Stainless steel must not get in touch with unalloyed steel during transport, handling and storage. This means that all handling tools, all storage racks etc. used for stainless steel need to be made of stainless steel or wood or to be covered with textile, nylon or similar materials.

Stainless steel is to be stored at a dry and clean place, where it will not be exposed to iron particles, abrasive dust or welding smoke from unalloyed steel. Protection is also required from material particles from both unalloyed and other stainless steel.

The equipment must be stored in such a way that the equipment is not damaged in any way.

The tubes and pipes must be stored in the shipping crate in which it was transported. The shipping crate must be stored in such a way that it is protected from rain, snow and in following surroundings:

Storage temperature: 0-50 ºC (32-122 ºF), frost-free
Storage humidity: 0-90% R.H.
Pipes must also be protected from dust and dirt.
The pipes must be protected from falling objects and any mechanical action.
The shipping crate cannot be stacked.

6.5.3 Storage - Equipment (Pumps, Section Valves, Nozzles etc)

The equipment must be stored in the shipping crate in which it was transported. The shipping crate must be stored in such a way that it is protected from rain, snow and in following surroundings:

Storage temperature: 0-50 ºC (32-122 ºF), frost-free

Storage humidity: 0-90% R.H.

The unit must also be protected from dust and dirt.
The pump unit must be protected from falling objects and any mechanical action.
The shipping crate must not be stacked.

6.6 Installation sequence

6.6.1 Check Equipment against Bill of Materials and Drawings

Check the equipment and materials to bill of materials and drawings to ensure that all the correct equipment and materials have been delivered.

The equipment and materials shall also be checked for any signs of damage.
Missing or damaged equipment or materials shall be reported immediately to the project engineer.

6.6.2 Check drawings for location of Pumps, Nozzles and Pipe Routes
Check the drawings to ensure the positions indicated on the drawings for pump units, valves, nozzles and any other associated equipment are not obstructed.

Visually check the agreed tube/pipe route to the drawings to ensure both access and positioning can be achieved.
Any deviations from the agreed positions as indicated on the drawings as a result of obstructions or coordination clashes shall be reported to the project engineer. Changes to the design shall be finalised prior to the commencement of the installation, and agreed with the client/owner or the authority having jurisdiction.

6.6.3 Nozzles

Special care must be taken to avoid obstructions when designing and installing water mist systems, especially when using low flow, small droplet size nozzles as their performance will be adversely affected by obstructions. This is largely because the flux density is achieved (with these nozzles) by the turbulent air within the room allowing the mist to spread evenly within the space - if an obstruction is present the mist will not be able to achieve its flux density within the room as it will turn into larger drops when it condenses on the obstruction and drip rather than spreading evenly within the space.

It is recommended that a clear envelope of 0.75m be maintained around an open water mist nozzle and 1m around a closed nozzle. The absolute minimum being approx. 500mm (only open nozzles), with a reduced spacing of 50% in one direction.

6.6.4 Installation of Pump Unit and Section Valves

Pump Unit

The pump unit including control panel is supplied ready mounted in a skid frame, pre-piped and pre-wired.
Only connections for power supply, water inlet after a filter unit and high pressure outlet needs connecting.

A typical pump unit can be seen on next page Fig 6.1. Pump unit to be transported on site to final location by fork lift truck or other approved means using agreed access routes.

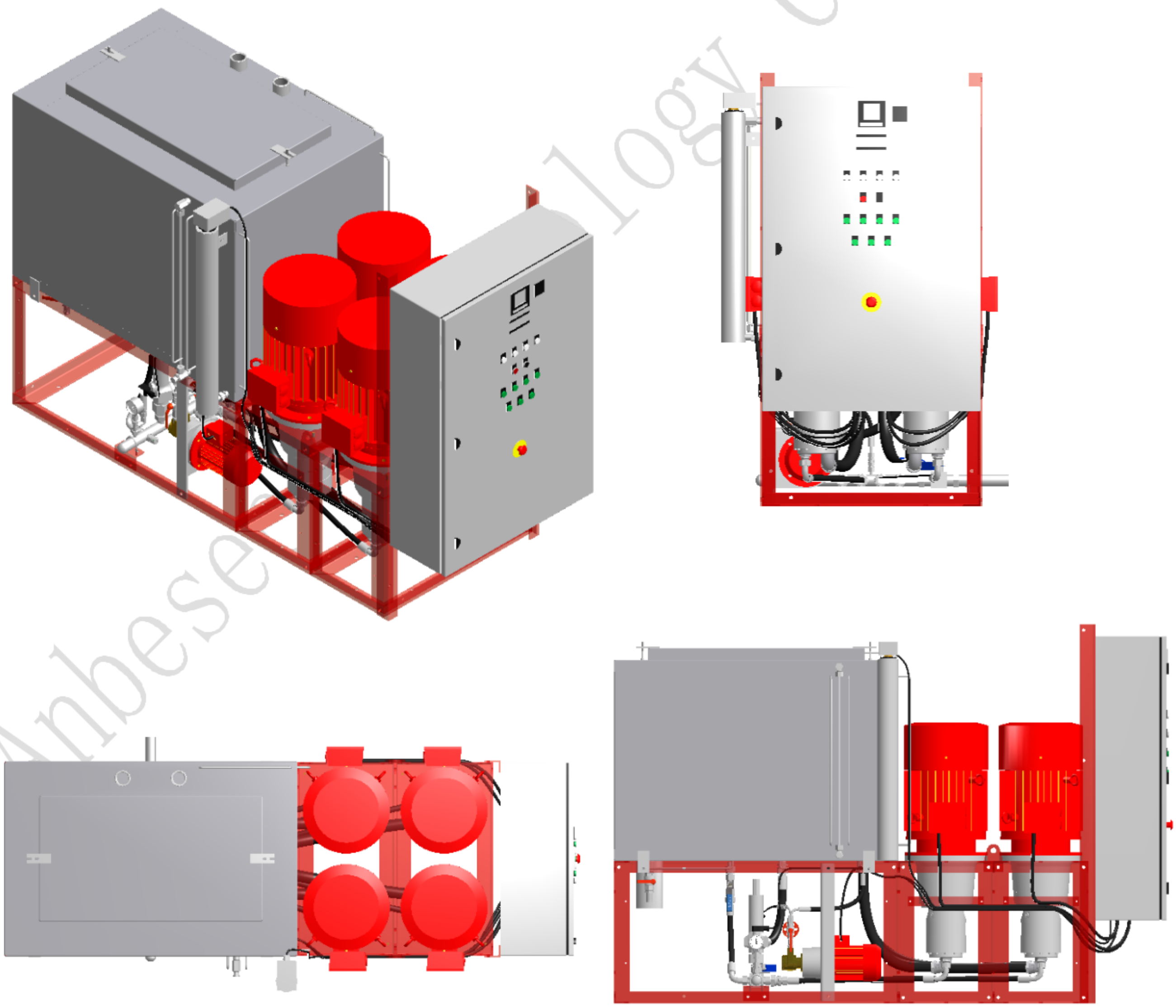
The pump unit should be unpacked and positioned according to the project drawings.

Secure fitting of the skid to the floor. The pump unit is provided with a number of 17mm diameter holes in the base of the unit.

Connect the high pressure water distribution pipe work to the pump unit delivery manifold using the appropriate connections in accordance with the system design.
Connect the low pressure domestic feed water supply to a filter unit and afterwards to the unit inlet using the appropriate connections in accordance with the system design.

Connect the power supply circuit cabling and alarm circuit interface cabling to the pump unit controller in accordance with the system design.

<u>Fig 6.1</u> – Pump Unit with tank (Typical XSWB300/12 shown)



Section Valve

A section valve arrangement may be grouped together on a common manifold, and then the individual piping to the respective nozzles is installed. This manifold may be pre-installed to the pump unit depending on project requirements.

The section valves may also be supplied loose for installation into the pipe system at suitable locations or as a pre-assembled unit (Valve Assembly) can be provided.

The section valves should be located outside the protected rooms.

The system section valves can be supplied as either an electrically operated solenoid valve or as an electrically operated motorized valve.

Motorised operated section valves require a 230VAC signal for operation depending on project requirements.

Section valves should be unpacked and positioned according to the project drawings.

Secure section valve to either the pipe work using the appropriate connections in accordance with the design or for pre-assembled units fix to the building structure as defined in the system design.

Connect the high pressure water distribution pipe work to the inlet and outlet ports using the appropriate connections in accordance with the system design.

Connect the valve activation circuit cabling and alarm circuit interface cabling from the system flow switch, monitored valve switches etc in accordance with the system design.

All section valves shall be provided with permanently marked weatherproof labels which indicate the associated hazard/risk covered by the section valve.

6.6.5 Installation of Tube/Pipe Route and Nozzles

6.6.5.1 General

The pipe system is made from stainless steel tubes, pipes and fittings in order to ensure a corrosion free pipe system.

Stainless steel tube shall be specified to ASTM A269 - AISI 316L with stainless steel pipe specified to ASTM A312 - AISI 304L.

The sizes of the tube/pipe range from 10.0 mm outer diameter x 1.0 mm wall thickness to a diameter of 60.3 x 5.54mm refer to tables 10 and 11.

Table 1 – Tube/Pipe Schedule ASTM A269 – AISI 316L

TUBE OD mm	WALL THICK mm	TUBE ID mm	TUBE AREA mm²	WORK PRESS bar	APROX FLOW* l/min	WEIGHT kg/m	WEIGHT kg 3m	6m
10	1	8	50	258	21	0,225	0,675	1,350
10	1,5	7	38	387	16	0,319	0,957	1,914
10	2	6	28	516	12	0,401	1,203	2,406
12	1	10	79	215	33	0,275	0,825	1,650
12	1,5	9	64	322	27	0,394	1,182	2,364
12	2	8	50	430	21	0,501	1,503	3,006
14	1,5	11	95	276	40			
14	2	10	79	368	33	0,601	1,803	3,606
15	1	13	133	172	56	0,351	1,053	2,106
15	1,5	12	113	258	47	0,507	1,521	3,042
15	2	11	95	344	40	0,651	1,953	3,906
16	1,5	13	133	242	56	0,545	1,635	3,270
16	2	12	113	322	47	0,701	2,103	4,206
18	1,5	15	177	215	74	0,620	1,860	3,720
18	2	14	154	287	65	0,801	2,403	4,806
20	1,5	17	227	193	95	0,695	2,085	4,170
20	2	16	201	258	84	0,901	2,703	5,406
22	1,5	19	284	176	119	0,770	2,310	4,620
22	2	18	255	234	107	1,002	3,006	6,012
25	1,5	22	380	155	160	0,883	2,649	5,298
25	2	21	346	206	145	1,152	3,456	6,912
25	2,5	20	314	258	132			
25	3	19	284	310	119			
28	1,5	25	491	138	206	0,995	2,985	5,970
28	2	24	452	184	190	1,302	3,906	7,812
30	1,5	27	573	129	240			
30	2	26	531	172	223			
30	3	24	452	258	190	2,028	6,084	12,168

** Based upon flow velocity of 7 m/s.*
Preferred sizes shown in red and highlighted.

Table 2– Tube/Pipe Schedule ASTM A312 – AISI 304L

TUBE OD mm	WALL THICK mm	TUBE ID mm	TUBE AREA mm²	WORK PRESS bar	APROX FLOW* l/min	WEIGHT kg/m	WEIGHT kg 3m	6m
33,4	1,65	30,10	712	127	299	1,300	3,90	7,80
33,4	2,77	27,86	610	214	256	2,090	6,27	12,54
33,4	3,38	26,64	557	261	234	2,500	7,50	15,00
33,4	4,55	24,30	464	351	195	3,240	9,72	19,44
35	2,00	31,00	755	147	317	1,653	4,96	9,92
38	3,00	32,00	804	204	338	2,629	7,89	15,77
38	4,00	30,00	707	272	297			
42,2	1,65	38,90	1189	101	499	1,650	4,95	9,90
42,2	2,77	36,66	1056	169	443	2,700	8,10	16,20
42,2	3,56	35,08	967	218	406	3,390	10,17	20,34
42,2	4,85	32,50	830	296	348	4,470	13,41	26,82

48,3	**1,65**	**45,00**	**1591**	**88**	**668**	**1,910**	**5,73**	**11,46**
48,3	**2,77**	**42,76**	**1436**	**148**	**603**	**3,110**	**9,33**	**18,66**
48,3	**3,68**	**40,94**	**1317**	**197**	**553**	**4,050**	**12,15**	**24,30**
48,3	**5,08**	**38,14**	**1143**	**271**	**480**	**5,410**	**16,23**	**32,46**
60,3	**1,65**	**57,00**	**2552**	**71**	**1072**	**2,400**	**7,20**	**14,40**
60,3	**2,77**	**54,76**	**2355**	**118**	**989**	**3,930**	**11,79**	**23,58**
60,3	**3,91**	**52,48**	**2163**	**167**	**908**	**5,440**	**16,32**	**32,64**
60,3	**5,54**	**49,22**	**1903**	**237**	**799**	**7,480**	**22,44**	**44,88**

**** Based upon flow velocity of 7 m/s.***
Preferred sizes shown in red and highlighted.

6.6.5.2 Pipe Cleanliness

During the system discharge any foreign matter in the pipe work will ultimately collect in the strainers to the micro nozzles and which when fouled up enough will crush and block the nozzles completely.

This can be prevented by giving very careful attention as to how pipes and fittings are handled and cleaned before installation.
The need for this treatment is vital to effective system operation.

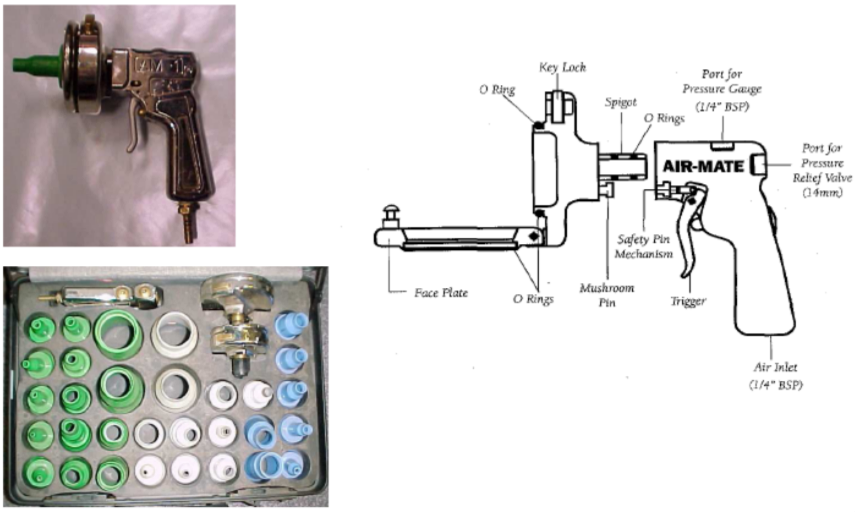
All tube and pipe must be stored with both ends properly capped to prevent ingress of dirt. Caps shall be kept on as long as possible.

Immediately following all "bench work" during which the pipe is cut and/or formed into shape, the pipe shall be thoroughly cleaned internally using a compressed air powered cleaner, ex. Compri-cleaner or similar, and when clear of all contaminants be fitted with caps or plugs on both ends.

Open outlets on fittings shall be kept absolutely clean and covered by plastic bags or similar until pipe is fitted.
Off-cuts of pipe awaiting re-use shall similarly be capped whilst in storage.
This regime cannot be over emphasised. It is vital that proper instruction is given to and supervision of the site teams is conducted on this matter to ensure that the above requirements are followed.
A cleaning gun with appropriate plugs ex. Compri-cleaner, Eurocomp Jetcleaner, or similar shall be used. The cleaner system is a mechanical cleaning system. A polymeric projectile is shot through the pipes by means of compressed air. The projectile is compressed and pressed against the internal pipe wall, thereby removing particles and other impurities.

The polymeric projectile is shot through the piping before installation of the next pipe length. Please note that if the pipe is provided with branches, they have to be provided with plastic plugs. When cleaning the main pipe, the projectile has to be shot through each branch with the plastic plug on and off in order to clean all branches and to remove the polymeric plug. After cleaning of the main pipe, the cleaned pipes are provided with plastic plug.

Fig 6.3 – **Compri-Cleaner Kit**



At least two shots (more if necessary) are to be blown through each pipe. It must be ensured that no plugs are left in the pipe, by blowing air through each pipe and fittings before installation.

The drawing shall be stamped or clearly marked "Pipe Hygiene conforms to the requirements for installed pipe work and signed and dated by the installer.

Factory manufactured pipe work shall also conform to these requirements to the same degree and the manufacturing drawing or sketches shall be similarly marked.

6.6.5.3 Tube/Pipe Cutting

Always cut pipe with a cutting machine, manual or automatic manufactured for the purpose of cutting stainless steel pipe with a cutting guide, for a right angle cut.
Burrs inside and out must be removed, using a purpose made de-burring tool.
Pipe cutting fluids shall not be used.

Fig 6.4 – **Cutting Machine**

6.6.5.4 Fittings

Compression fittings are to be manufactured to DIN2353.

6.6.5.5 Jointing

Only tube having an outer diameter up to and incl. 30 mm, are to be joined with cutting ring fittings. Piping having a larger diameter is to be joined by means of press fittings or butt welding.

6.6.5.6 Compression fittings

For tube up to 30mm single ferrule fittings single ferrule DIN2353 fittings are to be used as standard.

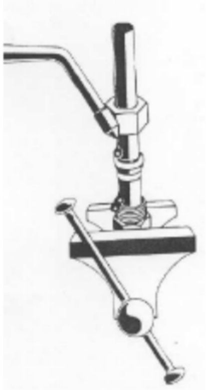
However, where high vibration is evident, then consideration shall be given to employing double ferrule fittings.

Hydraulic or manual hand pre-mounting tools shall be used for forming compression fittings, however, it is recommended that hydraulic forming tools are used for all sizes.

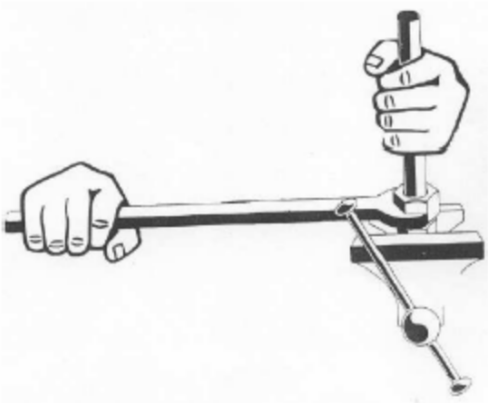
Manual hand forming of compression fittings would normally be carried for pipe sizes 10 to 25mm. Where manual hand forming is adopted a mandrel or vise shall be used in the pre-assembly.

For manual hand forming the following steps shall be followed;
· Cut tube at right angles and lightly debur the ends inside and outside.
· Place fitting in mandrel or vise (or similar tool). Positively press tube against the stop in the inner cone of the fitting.

Unscrew the fitting nut ensuring the inner ferrule is on tube. Fitting oil must be applied to the threads of the fitting and ferrule. Dry PTFE spray is recommended or grease with a graphite content.



Hand tighten the nut so that the tube cannot be turned. Further tighten ¾ to 1 turn of the nut. For final assembly turn the nut approx. ½ of a turn beyond this point.



Hydraulic tube/pipe wall forming tools are available as are hydraulic pipe end preparation tools, which swage the ferrules onto the pipe correctly with little physical effort and without undue stress having to be applied to nuts, body threads or body seal surfaces.

These tools are advisable for all pipe sizes over 25mm O.D. but can include 10 - 25mm sizes also.

Nuts shall be tightened in two steps (where ferrule has been pre-fitted by hydraulic machine):

Nuts shall first be hand tightened and a mark in the form of a line using indelible marker pen shall be made across the nut and onto the fitting to form an index point.

Nuts shall then be fully tightened using spanners by at least two "flats" of the nut, and/or as below:

As soon as the nuts are fully tightened, they shall be marked by an 'X' on the nut flats (using the indelible marker pen) to indicate that the joint has completed the final assembly process.

6.6.5.7 Welded Joints and Welding

Shaping

The materials are to be shaped so the construction after welding and mounting obtains form and dimensions according to the drawings. This means that deformations arisen during welding should be considered.
Just before welding, the edges are to be degreased with a suitable thinner. The degreasing is to be carried out on both sides of the material and cover at least 50 mm from the welding joint.
If cold working is used, i.e. bending, the protective oxide coat on the stainless steel may crack and hereby the rustproof qualities are damaged. Pickling is to be carried out on both sides of the material.

Fixing
The shaped and cleaned parts are to be fixed.
Fixing equipment must not be removed before all welding is completed. There are to be a sufficient numbers of tack weldings to carry the subject, when the fixing equipment is removed. After fixing the shearing of the rear edges must not exceed 0.5 mm. The fixing is to be carried out as careful as all other welding and to include use of backing gas.

Welding
Filler Materials
Filler materials for welding to be chosen, so that welding joints are at least as corrosion-proof as the parent material, they are to have at least as high a content of alloying elements as the parent material.
Welding Methods
Bottom runs to be welded with TIG-welding with or without pulsating electric arc. Filling has to be carried out with TIG, MIG or coated electrode.
Backing Gas
Backing gas is to be used, if possible, during all welding work and when impossible always to finish the back of the welding with some kind of additional treatment. This is also valid for fixing, filling and welding of edge joints. The backing gas to be argon or formiergas (90% nitrogen and 10% hydrogen). If subsequent treatment is to be avoided the content of impurities in the backing gas to observe the following:
Oxygen max. 25 ppm.
Water max. 25 ppm. (Dew-point temperature max. -53 ℃)
This purity percentage of the gas is necessary at the welding point.
The backing gas to displace the atmospheric air so the formed combination fulfils the requirement. This means that the backing gas is to be supplied with a bigger purity than mentioned here.

The purity of the backing gas is to be controlled with measuring equipment with a limit of detection for oxygen and water of approx. 10 ppm or less. If such measuring equipment is not available, the gas may be controlled by a survey of the root, when the welding has cooled down to room temperature. If there are blue, black or brown tempering colours, the backing gas has not been clean enough.
The backing gas is to be supplied through backing gas equipment cutting off a minor volume around the welding root. The efficiency of the backing gas equipment is to be tested before using it in the production.
Pipes with diameter below 100 mm can be flushed without the use of the backing gas equipment, flushing to be carried out as follows:

A: Pipes with diameter (d) up to 25 mm can be flushed without using restriction given the condition that the groove is below 1.5 mm and that a suitable gas flow is used.

B: Pipes with a diameter from 25 to 100 mm can be flushed without backing gas equipment given the condition that the gas inlet takes place through a tight membrane, that the gas after the welding point is passing through a restriction with a diameter of approx. 22 mm, and that the groove is below 2.0 mm.

Flushing flow, 0, during welding for pipe diameter d to be set at

0 = d/3 l/min (example d = 60 mm = > 0 = 60/3 = 20 l/min.)

The flushing with backing gas given the conditions to be sustained until the temperature is below 250°C.

Pickling after welding

If adequate backing gas covering cannot be achieved, the side of the root will be strongly oxidized and takes on blue, brown and black shades. This is not acceptable with regard to corrosion.

Therefore, welding with unacceptable tempering colours is to be pickled, grinded and pickled or brushed with stainless steel brush and pickled. This form of after-treatment is to be carried out at the front of the welding.

Pickling can be carried out with obtainable common pickling liquids or pastes. After pickling the surface is to be smooth and metallically clean without tempering colours.

Extent of inspection

All welding to be inspected 100% visually inside and outside the weld.
Accept criteria both sides of the welding to be metallic clean or have a white finish without traces of oxide scale/tempering colours.
Repair

Welds, which are not observing the accept criteria are to be repaired.
Welding defects in the shape of tempering colours and weak oxide scale formation to be repaired by pickling.

Repairs to be controlled with the same method as originally used.

Fig 6.5 – Welding Machine

6.6.5.8 Tube Bending

Manual or hydraulic bending machines can be utilised. It is recommended the for tube sizes above 20mm, hydraulic machines are used.
The bending radius is to be three times the diameter of the pipe.
Fig 6.5 – Bending Machine

6.6.5.9 Tube/Pipe Supports

All brackets shall be of a design that will firmly attach the pipe work to the building structure. The pipe work shall be attached to the supporting brackets or directly to the building/machinery using the correctly sized clamps for the diameter of pipe to be supported. In the case of machinery the use of pop rivets for attaching brackets is not precluded and particularly in the food industry, stainless steel welding of brackets to machinery may be preferred by the customer.

For Public Space applications

Where appropriate heat resistant synthetic block clamps.

For industrial applications

Aluminium black clamps

Stainless steel saddle clamps

For food industry

Stainless steel block clamps

Stainless steel saddle clamps

Pipe supports are to be fixed to solid structures only. Additional support may need to be provided to secondary structures, i.e. false ceilings.

Tube/pipe supports are fixed in regular intervals with a maximum distance as indicated in table 12 below.

Supports to be no more than 300 mm from any bend or fitting.

Ensure the length of an unsupported arm over to a nozzle does not exceed 2 ft (0.6 m) for pipe, or 1 ft (0.3 m) for tubing.

Table 3

Tube/Pipe Size (mm)	Horizontal Distance (mm)	Vertical Distance (mm)
10 to 15	1500	1800
16 to 28	1800	2400
30 to 60,3	2400	3000

If the installation is made after NFPA 750 rules, the hanger spacing will be different than these in table 12.

6.6.5.10 Earth Bonding

The pipe work must be earth bonded, long lengths being bonded at 100 metre intervals or according to project requirements. This except in very long length installations, such as in tunnel installations, where the customer may require discontinuity provisions.

6.7 Pressure Test - Hydrostatic

Advise the customer that tests are to commence. The customer should witness all testing.

Ensure no un-authorised personnel are inside the area where tests are being carried out.
Advise the customer when tests are completed.
Water (potable) using to charge the system shall always be passed through a filter (maximum 10 microns).
Hydrostatic testing is to be carried out to 1.5 times the maximum working pressure.
The system must be vented before pressure testing with water.
Test pressure shall be held for 120 minutes without any pressure decay and witnessed and signed off by the customer.

Testing will require open head outlets to be plugged before the test takes place.

Such plugs shall be individually identified and recorded in order to ensure that all plugs are removed and replaced by nozzles after testing.

Ensure that there is no pressure in the pipes before removing plugs or caps

6.7.1 Test Procedure

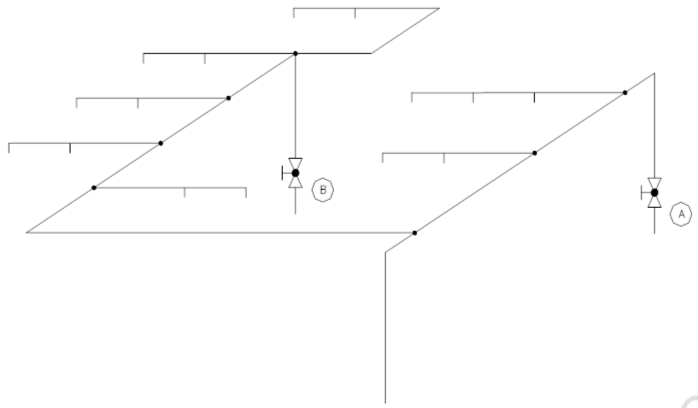
Ensure all nozzle connections are plugged using suitably rated plugs (open systems); tighten all plugs except for the most remote (in piping terms) nozzle connection.

Where manifolds are fitted, ensure that all inlets except one are fitted with suitably rated caps.

Connect a high pressure hand test pump to the pipe work via the manifold or pipe work inlet connector. Note the test pump shall be equipped with a suitably rated and calibrated pressure gauge. The pressure gauge and test pump shall be supplied with calibration certification.

Fill the pipe work with water until all air is expelled from the system through the last nozzle connection and water is seen to flow, tighten the last plug, and lock off the pump.
Note: Systems using multiple discharge heads, which are fed off a main feed pipe by tee or cross fittings each section of pipe is to be bled of air, refer to Fig 45.

Fig 6.6



1. Close drain valve A and B
2. Open drain valve A and bleed air until water runs with constant flow.
3. Repeat for other pipe sections using drain valve B.

Unlock the test pump and slowly pressurise the pipe to the required test pressure, lock off the test pump.
Ensure pressure is maintained for a minimum of 120 minutes. Failure to maintain the pressure indicates leakage. This should be located and appropriate rectification will be required. Repeat test procedure until pressure is maintained.

Slowly depressurise the pipe work through the pump and drain off all water.

Complete and sign the relevant pressure test certificate.

6.8 Flushing of Installation

When the installation of the pipe system is complete, the entire system is to be flushed.

Flushing should only be carried out with fresh water that have passed through a filter (maximum 10 microns).

Each section of the system shall be flushed; therefore, section valves shall be opened. For systems containing a number of sections, each section shall be flushed independently of the others.

Each drain valve placed strategic in the section shall be closed except for drain valve a in the first section. This drain valve shall remain open with a flexible hose connected to allow drainage to a previously agreed point. After flushing through this drain valve, close the drain valve and continue with the other valves.

It is recommended that only one pump is used for the flushing exercise. Full capacity of the pump unit is ***NOT*** used for flushing.

Flushing utilising this method shall be for duration of 5 minutes, to ensure that there are no impurities or air left in the main pipe system.

Where progressive flushing of the system is adopted, the system or section shall be connected to a domestic water supply via flexible hose. Flushing utilising this method shall be for duration of 10 minutes, to ensure that there are no impurities or air left in the main pipe system.

7 COMMISSIONING

7.1 Introduction

This section is intended to provide a synopsis of the actions required to complete the commissioning and hand-over to the client of the HPWM system.

Commissioning should only be undertaken by personnel who are familiar with the installation of HPWM fire extinguishing and suppression systems. Commissioning by untrained or inexperienced personnel may jeopardise the integrity of the system, the safety of personnel, and the warranty of the system.

All staff and sub-contractors involved in the commissioning phase shall meet the requisite training and competency requirements, and carry the appropriate skill cards.

All commissioning and testing activities shall be documented as per the project requirements and in line with company procedures.

Commissioning procedures, method statements and data recording schedules shall be issued to the client/owner or the authorities having jurisdiction prior to commencing the commissioning for approval.

All system design documentation shall be available prior to commencing the commissioning.

Commissioning test shall be witnessed by a representative of the client/owner or the authorities having jurisdiction.

7.2 Pre- Commissioning

In order that HPWM system can be commissioned, the following tasks shall be completed.
All system pipe work shall be installed; pressure tested and flushed in accordance with the test requirements.

All nozzles shall be in place.

Water supplies shall be available in sufficient quantity so as to allow commissioning to be completed.

Power supplies shall be available.
Note: Certification of safe and tested circuits shall be available for viewing.

Fire Detection and Controls shall be available.
Note: Certification of safe and tested circuits shall be available for viewing.

Pump Units shall be in place and adequately secured.

All equipment shall be earthed in compliance with current local standards and regulations.

All relevant "permit to" work actions shall be completed, and site personnel made aware of commissioning in progress.

Visual inspection required for –

Pressure test.

Electrical function test at the system.

Nozzle locations, check for obstructions or damage.

Location of system equipment to the project drawings, highlight any changes.

All equipment for physical damage.

Availability of water.

Logo Labels fitted to pump unit and cylinders

Availability of electrical supplies.

Electrical connections to all associated indicating and control unit.

7.3 Commissioning

Once it has been established that the system and all its components are complete, the system can be commissioned in line with the project requirements and in line with procedures.

The commissioning activities and tests are to verify the system operation in accordance with the project requirements.

The tests are to be carried out to the satisfaction of the commissioning engineer and a representative of the client/owner or the authorities having jurisdiction.

Where commissioning includes third party systems a representative of each, shall verify correct operation of their system.

Commissioning activities shall generally include the following; however, the project specific procedures shall be adhered to.

Synopsis for pump systems –

Test water storage tank filling control.

Test start-up of pump(s) - automatic and manual

Test pump unit fault monitoring, alarms and indications.

Test pump running alarm and indications.

Test over pressure actions and controls.

Test section valve(s) operation, alarms and indications.

Test pump unit control panel functions, alarms and indications.

Test associated fire detection and control alarm, indications and interfaces (if applicable).

7.4 Third Party Approval and Acceptance

On completion of all commissioning activities and tests the system shall be demonstrated to the representative of the client/owner or the authorities having jurisdiction.

The project hand-over documentation pack shall be completed and issued to the client/owner or the authorities having jurisdiction.

Familiarisation of the system is extremely important for the client/owner. Therefore, it is recommended that at least two representatives of the client/owners site fire and safety team be familiarised with the installed system layout and basic operational and maintenance requirements. A copy of the project operational and maintenance manual shall also be issued with a copy permanently available adjacent to the system pump unit.

8 OPERATION

8.1 Introduction

This section is intended to provide a synopsis of the actions required to operation of the HPWM system.

All persons who might be expected to operate water mist systems shall be trained thoroughly in the functions they are expected to perform by the manufacturer or by the authority having jurisdiction.

The system should be used in the power supply voltage, working pressure, working temperature range, and should not be used in super temperature or work pressure.

8.2 System Principle

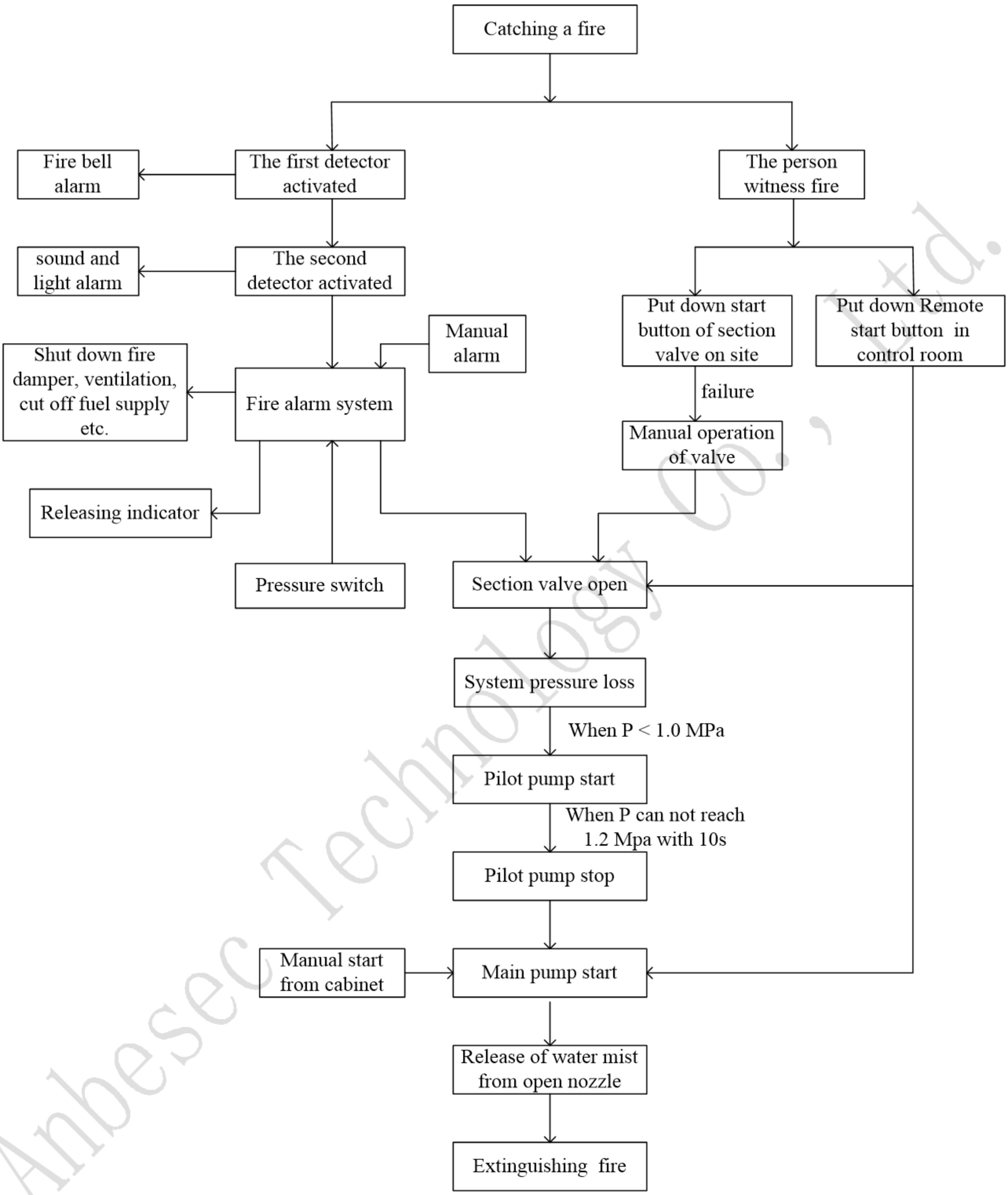
The system with open nozzles, in this case the system can be manual released or released automatically by means of a detection system. Often the release is only made after two different types of detectors are activated. The first detector that is activated gives alarm only, then release on the second.

The detection system starts the pump unit and opens the section valves, see the below figure.

8.3 System actuation

The HPWM system has automatic start, remote start in the fire control room, and local emergency start.

Fig 8.2 - Open System Flow Chart

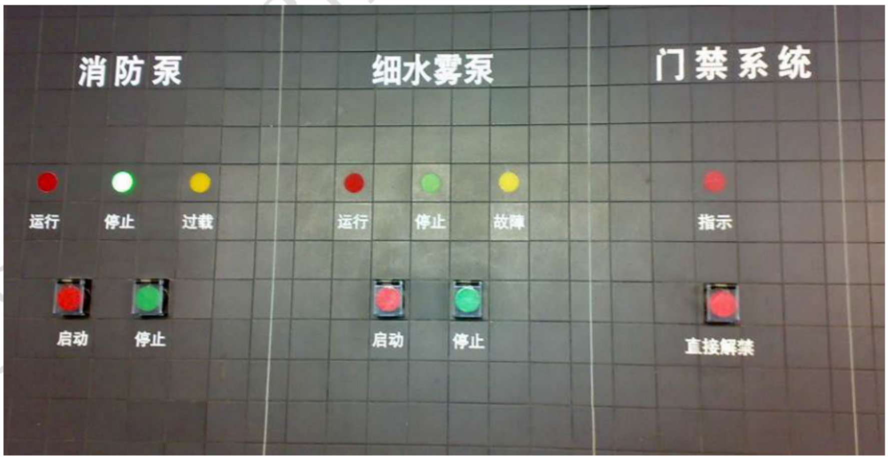


Automatic start: the open system was normally in the standby state with the main pipe pressure between 1.0Mpa and 1.2Mpa. When catching a fire, the section valve automatically opened through the linkage fire alarm system with two independent fire detectors, and then the main pipe pressure was decreasing which will start of pilot pump, however the pressure could not be sustained, and then start of main pump, finally water mist released from nozzle for firefighting.

Fig 8.3 – Automatic activated by fire alarm system

Remote start: the open system was normally in the standby state with the main pipe pressure between 1.0Mpa and 1.2Mpa. When catching a fire, the witness person in the control room put down the system remote start button to open both the section valve and pump unit, water mist released from open nozzle for firefighting.

Fig 8.4 – Remote activated in fire control room

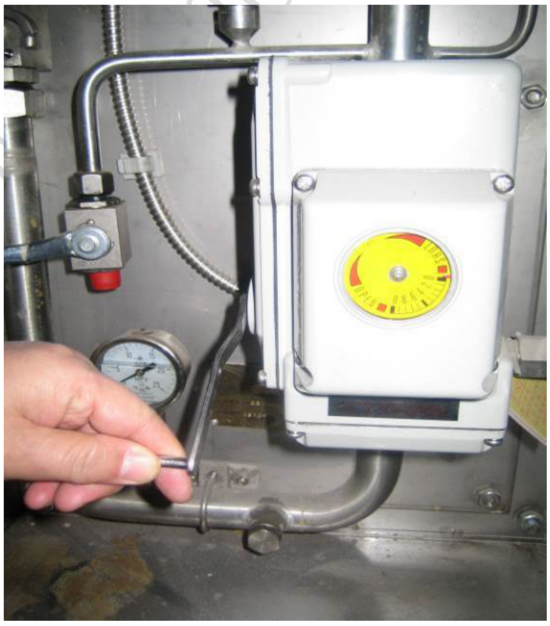


Local emergency start: the open system was normally in the standby state with the main pipe pressure between 1.0Mpa and 1.2Mpa. When catching a fire, the witness person on site put down the start button to open the section valve, and then the main pipe pressure was decreasing which will start of pilot pump, however the pressure could not be sustained, and then start of main pump, finally water mist released from nozzle for firefighting.

Fig 8.5 – Put down start button to open section valve

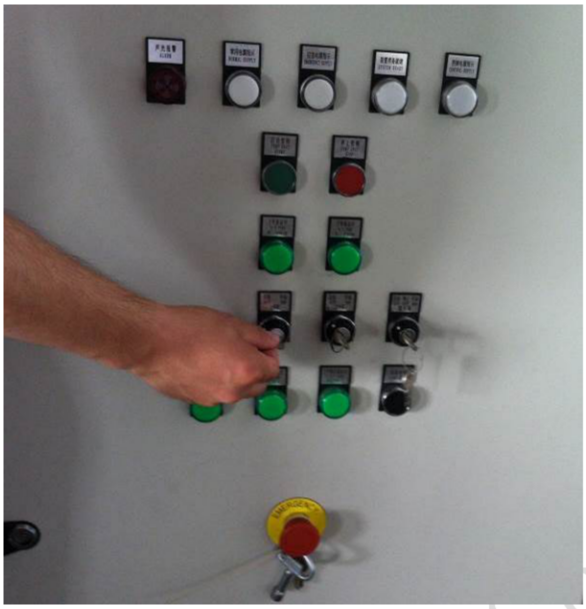
If the section valve start button failed for loss of electricity, you may use the handle to open the valve manually.

Fig 8.6 – Using handle to open section valve manually (loss of electricity)



If you want to start the pump unit without any delay, Put down the start button immediately from the control cabinet in the pump room to activate the main pump immediately.

Fig 8.7 – Put down start button from control cabinet to activate the main pump immediately



9 INSPECTION, TESTING AND MAINTENANCE

9.1 Introduction

This section is intended to provide a synopsis of the actions required to testing, inspection and maintenance of the HPWM system.

Testing and inspection and maintenance shall be in accordance with the requirements of the most recent edition of NFPA 750, NFPA25, and FM Global Property Loss Prevention Datasheet 4-2.

All persons who might be expected to inspect, test, and maintain water mist systems shall be trained thoroughly in the functions they are expected to perform.

Refresher training shall be provided as recommended by the manufacturer or by the authority having jurisdiction.

9.2 Inspection and Testing

All components and systems shall be inspected and tested to verify that they function as intended. The components of water mist systems to be inspected and tested are provided in Table 9.1. The frequency of inspections of components of water mist systems shall be in conformance with the manufacturer's listing requirement and NFPA 25 STANDARD FOR THE INSPECTION, TESTING, AND MAINTENANCE OF WATER-BASED FIRE PROTECTION SYSTEMS, NFPA 750 STANDARD ON WATER MIST FIRE PROTECTION SYSTEMS and FM GLOBAL PROPERTY LOSS PREVENTION DATASHEET 4-2 WATER MIST SYSTEMS.

Table 9.1 frequency of inspections

Item	Task	Weekly	Monthly	Quarterly	Semi-Annually	Annually	Other
Water supply (general)	Check source pressure.			X			
	Check source quality (* first year).				X*	X	
	Test source pressure, flow, quantity, duration.					X	
Water storage tanks	Check water level	X					

	(unsupervised).						
	Check water level (supervised).			X			
	Check sight glass valves are open.		X				
	Check tank gauges, pressure.			X			
	Check all valves, appurtenances.				X		
	Drain tank, inspect interior, and refill.					X	
	Inspect tank condition (corrosion).					X	
	Check water quality.					X	
	Check water temperature.						Extreme weather
Water recirculation tank	Check water level (unsupervised).		X				
	Check water level (supervised).			X			
	Inspect supports, attachments.					X	
	Test low water level alarm.					X	
	Check water quality, drain, flush and refill.					X	
	Test operation of float operated valve.					X	

	Test pressure at outlet during discharge.					X	
	Test backflow prevention device (if present).					X	
	Inspect and clean filters, strainers, cyclone separator.					X	
Pumps and drivers	Inspection, testing, and maintenance shall be in accordance with the requirements of NFPA 20 and NFPA 25.	X	X	X	X	X	
Standby pump	Check outlet water (standby) pressure.		X				
	Test start/stop pressure settings for standby pressure.			X			
Section valves	Inspection, testing, and maintenance shall be in accordance with the requirements of NFPA 25.	X	X	X	X	X	
Control equipment	Inspection, testing, and maintenance shall be in accordance with the requirements of NFPA 72.						
Water mist system piping	Inspection, testing, and	X	X	X	X	X	

and nozzles	maintenance shall be in accordance with NFPA 25.						
	Inspect sample of nozzle screens and strainers						After discharge
Enclosure features, interlocks, Ventilation and shutdown	Inspect enclosure integrity				X		
	Test interlocked systems (e.g., ventilation shutdown).					X	
	Test shutdown of fuel/lubrication systems.					X	

Following tests of components or portions of water mist systems that require valves to be opened or closed, the system shall be returned to service, with verification that all valves are restored to their normal operating position, that the water has been drained from all low points, that screens and filters have been checked and cleaned, and that plugs or caps for auxiliary drains or test valves have been replaced.

9.3 Maintenance

Maintenance shall be performed to keep the system equipment operable or to make repairs. As-built system installation drawings, original acceptance test records, and device manufacturer's maintenance bulletins shall be retained to assist in the proper care of the system and its components.

Preventive maintenance includes, but is not limited to, lubricating control valve stems, adjusting packing glands on valves and pumps, and cleaning strainers.

Scheduled maintenance shall be performed as outlined in Table 9.2.

Table 9.2 Maintenance Frequencies

Item	Activity	Frequency
Water tank	Drain and refill	Annually
System	Flushing	Annually

Strainers and filters	Clean or replace as required	After system operation

Corrective maintenance includes, but is not limited to, replacing loaded, corroded, or painted nozzles, replacing missing or loose pipe hangers, cleaning clogged fire pumps, replacing valve seats and gaskets, and restoring heat in areas subject to freezing temperatures where water-filled piping is installed.

Emergency maintenance includes, but is not limited to, repairs due to piping failures caused by freezing or impact damage, repairs to broken water mains, and replacing frozen or fused nozzles, defective electric power, or alarm and detection system wiring.

Specific maintenance activities, where applicable to the type of water mist system, shall be performed in accordance with the schedules in Table 9.2.

Replacement components shall be in accordance with the manufacturer's specifications and the original system design.

Spare components shall be accessible and shall be stored in a manner to prevent damage or contamination.

After each system operation, a representative sample of operated water mist nozzles in the activated zone shall be inspected.

After each system operation due to fire, the system filters and strainers shall be cleaned or replaced.