Low Pressure Water Mist Fire Protection System

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Summary
The article describes the problem of seeking new and low cost extinguishing agents that are still current problem. Author shows that the most common, cheapest and neutral to the environment, and at the same time an effective extinguishing agent is water. Using the water as a mist strongly reduces the formation of post-fire losses. The paper was discussed Polish low-pressure spray solution and areas of its possible application.

Keywords: fire protection, water, water mist, low pressure water mist system

1. Introduction

Searching for new, and at the same time cheap extinguishing agents is still an issue for the fire protection companies. Effectiveness very often does not go along with low costs of production; additionally, strong emphasis on environmental protection eliminates many effective chemical agents, for example halons.

There is no doubt that the cheapest, the most common, environmentally neutral and efficient extinguishing agent is **water**. An unwanted side effect of extinguishing with water is high property damage caused by flooding, which results from excessive and disproportionate usage of water in comparison to the amount actually needed to extinguish the fire. When extinguishing with water, the following phenomena occur [1].

1.1. Cooling – as a result of heat transfer to water mist

What is important during cooling with water is its very high heat capacity – to raise the temperature of 1 kg of water by 1°C you need to use more energy than to heat 1 kg of steel. Moreover, water has high boiling temperature (100°C) and the process of transition from liquid to gas requires additional energy, which is absorbed from the surroundings. During fire, that means that water applied to the burning area heats up and takes over some of the energy, which otherwise would

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be used up to further heat the objects in the surroundings of fire. Portion of the water evaporates, taking even more energy from the fire.

Water temperature rise from 20ºC to 100ºC requires (approximately 335kJ kg^{-1}) which is 10% of heat flux, water phase transition from fluid to gas absorbs (approximately 2257 $kJ \cdot kg^{-1}$) – 68% of heat flux – and further steam temperature rise from 100ºC to 500ºC requires just (approximately 736 $kJ \cdot kg^{-1}$), which is 22% of heat flux. Water phase transition absorbs about **7 times more energy** than heating same amount of water to boiling point. The conclusion is that in order to obtain high effectiveness of extinguishing, water should be applied in a way, that its largest portion undergo phase change. To achieve that, water should be converted to smallest possible droplets and sprayed equally and uniformly [1].

1.2. Oxygen displacement – dilution of oxygen in the vicinity of fire

Another extinguishing function of water emerges during evaporation (transformation to gas) – the air around fire gets pushed out by expanding steam, this way decreasing concentration of oxygen 1 dm^3 (1 litre) of water can turn into about (1700 dm^3 (1700 litres) of steam in the presence of fire. Steam is an inert gas. This way another element vital for the fire to continue burning is eliminated. If oxygen concentration drops below certain level, critical for given material, then the combustion reaction stops and flames disappear.

The most common organic materials cease to burn if oxygen concentration is lower than 13–16%. In terms of inhalation, 13% of oxygen is relatively safe for humans, provided the exposure to this conditions is short (couple of minutes, which is enough for evacuation from danger zone) [1].

2. Water mist as an extinguishing agent

Despite water's excellent extinguishing characteristics, it has low effectiveness when used in the form of a jet – only about 5% of water actually takes part in extinguishing, the rest spills around and causes very high property damage due to flooding, often couple of times higher than caused by fire itself. However, this does not mean water should not be used as an extinguishing agent at all; quite the contrary, it just requires proper equipment to maximise water's advantages and minimise drawbacks [6].

The best way to utilise water's extinguishing properties is to change it to the smallest particles possible. The more dispersed the stream is, the more of the water takes part in effective extinguishing. Dispersed stream of water also has increased contact area with the burning surface, leading to faster heat exchange of water with surroundings, and thus taking energy away from the flames.

In order to achieve water stream dispersion, special nozzles have to be used. A good nozzle spreads water stream evenly and to small droplets in diameter. With conventional equipment, working under a few bar pressure, we can obtain water stream with droplets of diameter of 1–3 mm. With pumps providing water under pressure or dual fluid systems, we can obtain mist currents with droplets of diameter 10–200 microns.

3. Mist Systems

The idea behind Systems is to improve the mist generating technology in a way to make it possible to extinguish fires of all classes with more efficient and more accessible means. Mist Systems allow obtaining mist of very small droplets (25–75 μm diameter) with use of low pressures (4 bar for two media systems – 25 μm) or medium pressures (up to 16 bar 75 μm).

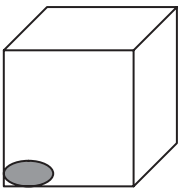
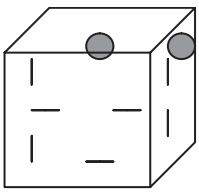
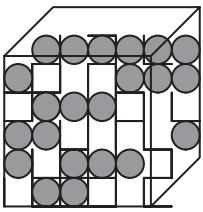
Water mist has perfect extinguishing properties, provided that the droplets are small enough, and that the mist is supplied under high enough pressure. If droplets are too large, mist loses its properties and the water falls to the ground. If the mist has too low kinetic energy, the droplets will be caught by convection flows of fire and taken away from it. Systems provide water mist of very beneficial droplet diameter (about 25 microns), at very high velocity of about 2 Mach (two media FEN nozzles). In other cases, when such high energy is not needed, uses one media collision nozzles of CSFH and GWP type.

The basic nozzles in Mist Systems are the **FEN-T, N-CSFH and NGWP.** They disperse water at low pressure (from 4 bar at the nozzle); produced droplets create a stream of mist. Mist degree of dispersion and kinetic energy depend on nozzle type and parameters of provided media. Mist Systems provide:

1) maximum mist effectiveness thanks to large evaporation surface of tiny droplets,
2) feeding a continuous stream of mist,
3) quick mist distribution thanks to optimal kinetic energy,
4) exclusion of cracks in construction, housings, steel and ceramic elements – mist does not cause thermal shock,
5) no damage caused by flooding – minimal water use,
6) installation efficiency and safety thanks to low pressures,
7) possibility to extinguish energised equipment – mist stream from FEN nozzles practically does not conduct electricity, which was confirmed by High Voltage Laboratory in Institute of Power Engineering (Table 1) [2, 6].

Table 1

Ratio between droplet size and droplet cross-section and total droplet surface

Droplet Diameter [cm]	Number of Droplets [l/m^3]	Droplet cross-section [m^2/m^3]	Droplet surface [m^2/m^3]	
12	1	0,01	0,05	
0,0600	8 846	0,25	1,00	
0,0100	1 910 828 025	15,00	60,00	
0,0050	15 286 624 204	30,00	120,00	
0,0025	122 292 993 631	60,00	240,00	
0,0010	1 910 828 025 478	150,00	600,00	

The fourth column shows total surface (in m^2) of all droplets generated from 1 liter of water in 1 m^3 that is generated by mist and sprinkler systems. Sprinkler systems obtain about 1 m^2 surface of droplets (which corresponds for heat exchange) whilst mist systems give between 100 m^2 and 240 m^2 (!) of droplet surface.

Principles of extinguishing with mist are well known and applied on a large scale. In the newly designed buildings the typical flooding systems are no longer used.

Mist systems extinguish most of all by volume, in 3D, and individual calculations are based on tests; calculations for traditional sprinkler systems base on a 2D „river" of water in mm per m^2.

4. Basic water mist products

Based on experience and market research, products have been designed in a way to provide solutions best and adequate for the clients.

4.1. SUGM Systems

These are low pressure, two media systems, which produce very fine mist using pressurized air or nitrogen and water. The main part of SUGM Systems are FEN-T nozzles (Fig. 1). In fire protection version they are made of stainless steel. They use de Laval nozzles, which accelerate gas to supersonic speed, and the shock wave breaks water stream into tiny particles. Mist degree of dispersion and kinetic energy depend on nozzle type and parameters of provided media (gas, water) [6].

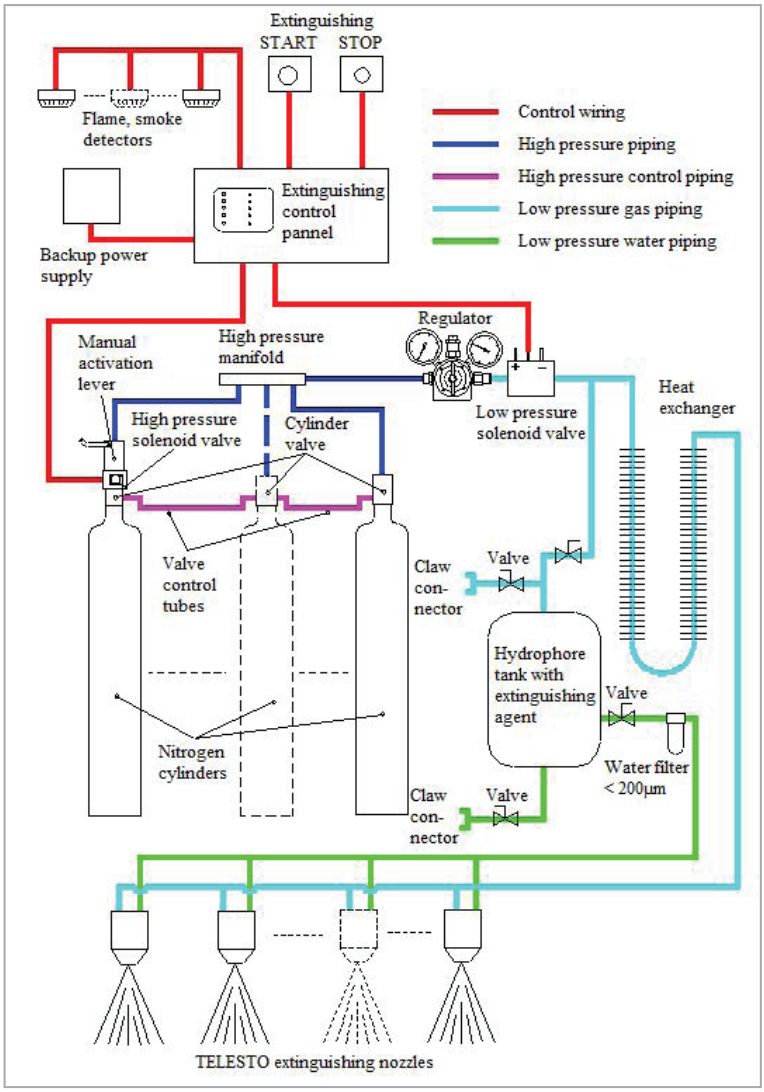


Fig. 1. Installation scheme of SUGM System feeding from gas cylinders and water tank

Mist systems are designed for protection of:

1. Any industrial buildings, utility or production building, including engine rooms with turbines, oil pumps, containers with oil or other flammable liquids, fuel filters, gear boxes, transformers, transmission shafts, sliding surfaces, diesel engines, generators, and other similar equipment using fuel and greases. The systems are especially recommended in closed areas up to 80 m^3.
2. Canals and containers with flammable liquids.
3. Freestanding industrial machines and equipment exposed to fire, such as injection moulding machine, electrical switchboards, transformers, turbines, boilers.
4. The system can also be used to create mist curtains shielding from heating and protecting emergency escape routes.

The unique properties of water mist allow to extinguish fuels, light and cooking oils, as well as energised equipment.

4.2. Hose reel-type extinguishing devices

TG-2M water mist extinguishing device is designed for the industry; it can work continuously with no limitations in operation time. It is an innovation in the field of fire protection. The use of water mist significantly increases fire fighting effectiveness, and greatly reduces property damage caused by flooding.

The main element of the system is a mist gun with **FEN nozzle.** It creates high kinetic energy stream of mist by dispersing water stream with gas under low pressure. **The mist gun creates mist stream which is couple of meters long and diameter of about 1,3 m.** The system consists of mist gun, hose, hose reel, pressure regulator and filters. Its fitted in a freestanding cabinet fixable to the ground. The TG-2M (H-1000) device requires connecting to installation providing water and gas under adequate pressure and expenditure (Fig. 2).

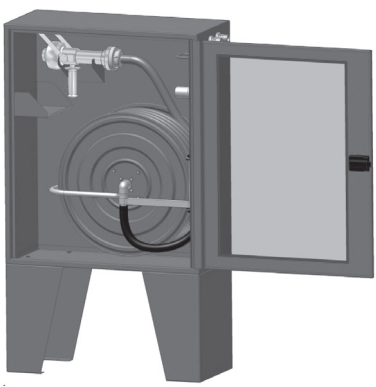


Fig. 2. H-1000 Hose reel-type device

Other variant of hydrant-type device is the H-3000, which has its own 60 l water tank and a gas cylinder, therefore it is completely independent and does not require any external sources of media. It works the same as the H-1000, but has limited operating duration of about 4,5–5 minutes.

4.3. RotorMist Systems

The **RotorMist Extinguishing System** have been designed as an alternative to two media systems. Its supply cylinders contain both water and gas under pressure. Each cylinder also has a rotor unit inside, which mixes water and gas in a pulse flow manner. The extinguishing medium then flows through piping to CSFH nozzles. The nozzles create mist with droplets of diameter of several dozen microns. The mist stream exiting the nozzles has shape similar to a cone. Properly set up nozzles cover the protected object with mist, or fill the entire room creating fire inert conditions (Fig. 3).

Fig. 3. The Rotor Mist System is designed for indoors and temperatures above 0°C

This system is designed to protect any freestanding machines and equipment exposed to fire, like injection moulding machines, transformers, turbines, boilers, professional kitchen / catering equipment, engines, power generators, dryers, electrical switchboards etc., which do not exceed 40 m^3 in size.

The unique properties of mist allow to extinguish fuels, light and cooking oils. According to confirmed research, water mist can be used to extinguish class A, B and F fires (Fig. 4) [4].

Note: for temperatures below 0°C it is possible to use antifreeze additives, and / or additional heating system, which allow the system to work in temperatures down to –40 C.

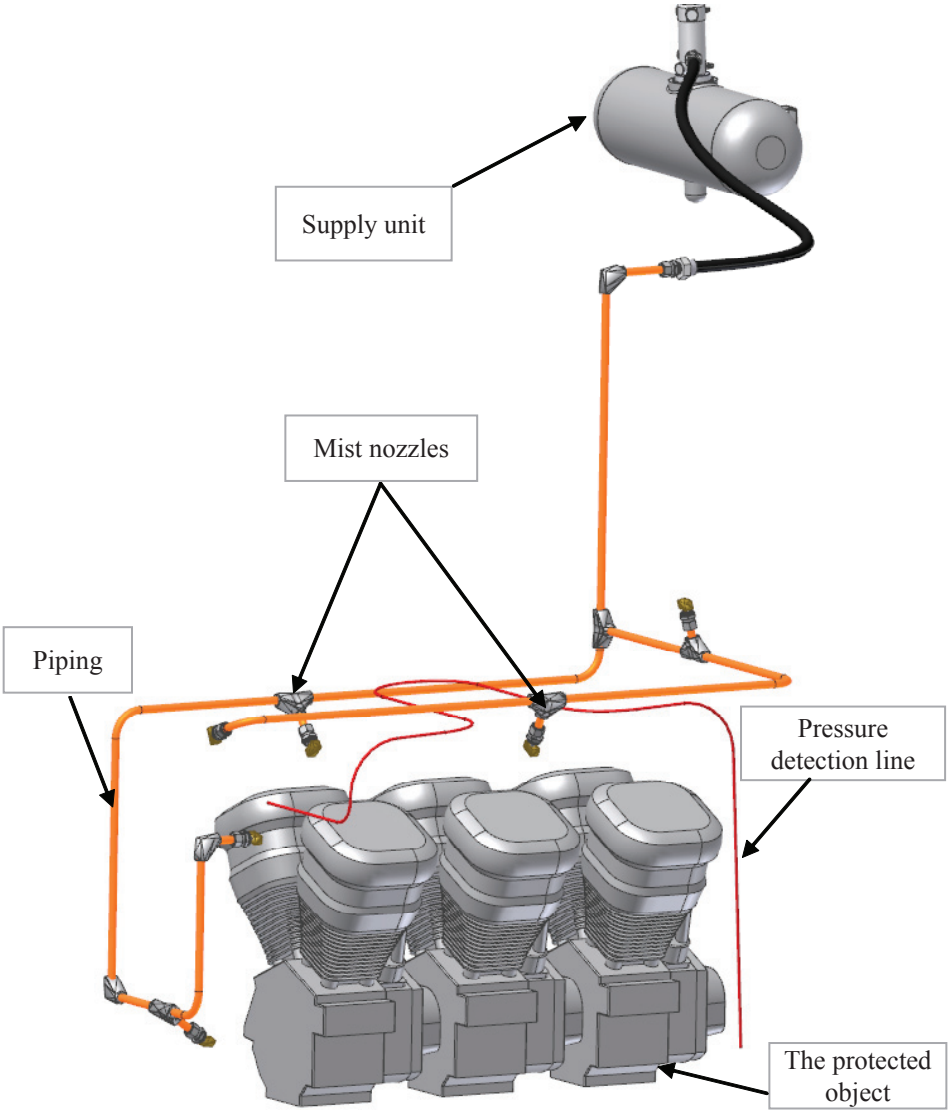


Fig. 4. Design of water mist fire protection system for engines

4.4. Deluge medium pressure systems

The Mist Medium pressure System is an alternative not only to gases but to other foam and mist systems as well, as it is environmentally safe, practical and relatively inexpensive to build and maintain. Its designed to work under pressure of 16 bar at the nozzles.

Water volume and required number of nozzles needed to obtain certain effect is defined during designing stage of specific room or machine. The effectiveness of systems designed by company has been tested many times and proved reliable and efficient.

The system can be activated both manually or automatically by a signal from detection line. It works with pumps or water-nitrogen pressure tanks, which use cylinders with dry nitrogen to pressurize the system. This system can be designed as mist sprinkler with bust bulbs built into the nozzles.

Literature

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Niskociśnieniowy system mgły wodnej do ochrony przeciwpożarowej

Streszczenie
W artykule opisano poszukiwania nowych i jednocześnie tanich środków gaśniczych. Autor udowadnia, że najpowszechniejszym, najtańszym i obojętnym dla środowiska naturalnego, a równocześnie skutecznym środkiem gaśniczym jest woda, której stosowanie w postaci mgły wodnej zdecydowanie ogranicza powstawanie strat popożarowych. W artykule omówiono polską technologię generowania mgły niskociśnieniowej oraz możliwe obszary zastosowania mgły wodnej w systemach ochrony pożarowej.

Słowa kluczowe: ochrona przeciwpożarowa, woda, mgła wodna, system niskociśnieniowej mgły wodnej

Система тушения пожара водяным туманом, распылённым под низким давлением

Резюме
В статье описан вопрос поиска новых и одновременно дешёвых средств, служащих для тушения пожара, которые всё время ставят проблемы. Автор доказывает, что самым распространённым, самым дешёвым и нейтральным для естественной среды, а одновременно эффективным средством для тушения является вода, которой применение в виде водяного тумана значительно ограничивает возникновение потерь, понесённых в результате пожара. В статье обсуждён польский подход к водяному туману, распыляемому под низким давлением, и возможные области его примененния.

Ключевые слова: противопожарная защита, вода, водяной туман, система водяного тумана, распылённого под низким давлением