The Archimedes Club of IWMA

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International Water Mist Association (IWMA) has its own internal club named the Archimedes Club. Members of this club are persons who have utilized the buoyancy to improve the performance of a water-based firefighting system.

Traditionally, sprinkler systems have nozzles located at ceiling level. The reasons for locating the sprinkler nozzle at the ceiling level is a combination of the obvious and the practical: Since the sprinkler nozzle is activated by a thermally sensitive device (a glass bulb which breaks at a certain temperature), it is important to locate it where the hot smoke from a fire collects, which is underneath the ceiling. The practical reason is that the ceiling will often be a place free of obstacles, and it is possible to integrate the pipework either inside the ceiling construction or at the surface of the ceiling.

However, the mounting of the nozzles at the ceiling level implies that the water droplets have to flow (with gravity and momentum from the exit) against the fire and smoke plume to reach the objects or the floor, since fires have a buoyancy driven direction of flow, which is vertically upwards.

> ***Archimedes' principle*** *states that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and acts in the upward direction at the centre of mass of the displaced fluid.*

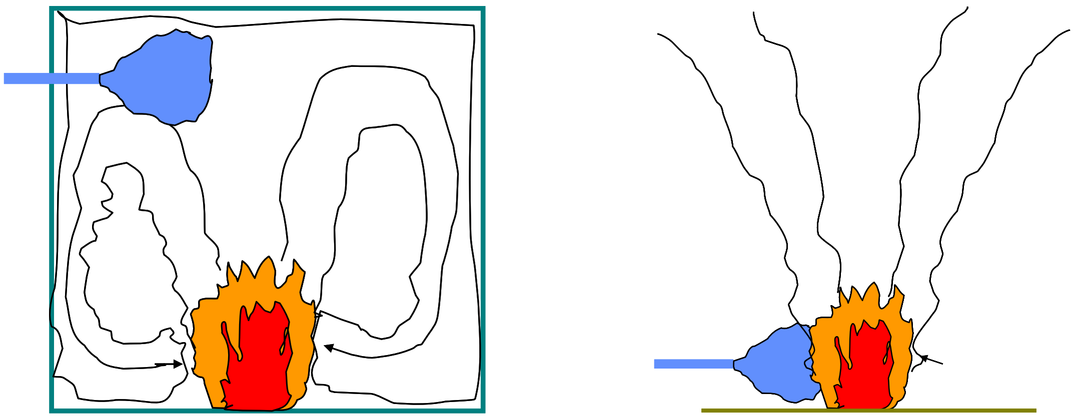

Figure 1. Principle of water mist application, in an enclosure to the left, local application to the right.

Figure 1 shows two scenarios for firefighting, with a water mist spray into an enclosure to the left, and with local application in the open to the right. The application within an enclosure shows the typical flow patterns of the combustion products, which is a recirculating movement. Upwards flow due to buoyancy occurs from the fire source, and downwards flow happen at the walls. If water mist is introduced as indicated, the water mist may follow the downwards flow at the walls and be entrained into the fire plume, and will eventually lead to extinguishing of the fire. The drawing to the right shows a situation in an open environment, and one can see that the most obvious way to apply water mist is directly attacking the base of the flames.

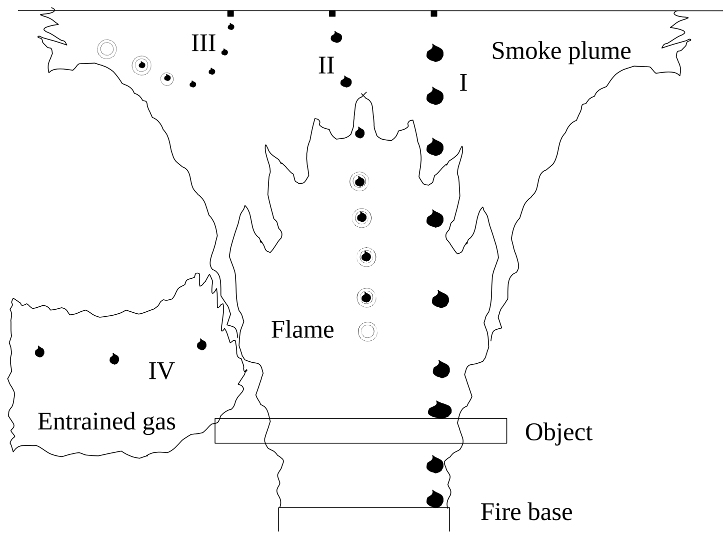

Figure 2. Illustration of the fate of droplets introduced at ceiling level into a fire. Relatively large droplets are denoted I, medium sized droplets are denoted II, very small droplets are denoted III. The situation denoted IV is when medium sized droplets are following entrained air and combustion products into the fire plume.

Figure 2 shows patterns and fate of droplets of different size introduced into a compartment with a fire, with ceiling mounted nozzles. The largest droplets (I) will penetrate the fire plume, will be heated but not evaporated in the flames, and may cool objects and reach the fire base due to the gravity of the droplets. The smallest droplets (III) will very soon follow the smoke and may evaporate in contact with the hot smoke, and may not be very efficient in cooling the base of the fire. The medium-sized droplets will be able to penetrate the fire plume, will enter the flames and may evaporate inside the flame zone. The traditional fixed firefighting systems (sprinkler and deluge systems) have utilized the cooling ability of water together with wetting of combustibles, to fight fires. In this case, it is obvious that the more water – the better effect. Water mist systems will utilize the inerting effect of water vapour in addition to the cooling effect.

The medium-sized droplets illustrate what is considered to be the most efficient water mist droplets. The combined effect of cooling and inerting, which is the key to success with the water mist technology, is obtained when water is evaporated and the water vapour can entrain the combustion zone. The principle of attacking the base of the fire with the firefighting medium is well known by hand-held extinguishers, and is the first choice of the fire brigade using fire hoses. An ideal way to utilize water for firefighting is to combine cooling of the fire zone and inert the zone with water vapour.

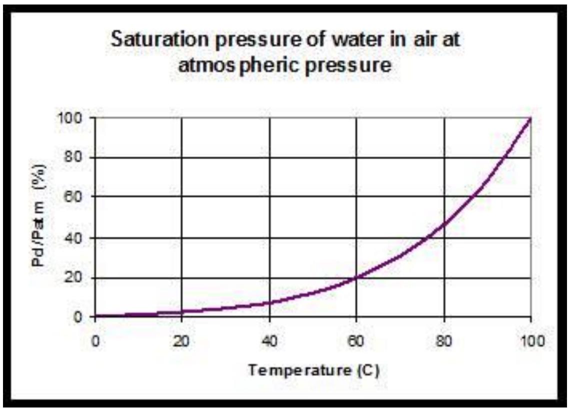

Figure 3. Saturation pressure of water in air at atmospheric pressure. The saturation pressure corresponds to the volume concentration.

Figure 3 shows the saturation pressure of water in air at atmospheric pressure. This is an important factor in how water can act as a gas system in firefighting. If water should act as an inert gas, it is necessary to have a water vapour concentration of approximately 30% in the atmosphere. The graphical presentation of the saturation pressure of water in air indicates that this can only occur if the temperature of the mixture of air and water vapour is approximately 70°C. At a temperature of 20 °C a vapour concentration can be maximum 2%. This is an important fact for humanity, since the normal atmosphere will never allow water vapour to occupy at concentrations that will make breathing problematic. Even at 70 °C, like in a sauna, humans can breathe and survive, even after water has been poured onto the oven, but it not a pleasant atmosphere to live in for a longer time. These vapour concentrations is not to be mistaken for what is often measured: Relative humidity of air. The relative humidity is a measure for how large portion of the saturation pressure is present in the air. At a normal indoor climate, one will find that a relative humidity of 50% will be pleasant, together with a temperature of 20-25 °C. In this case, only half of the saturation pressure of 2% is water vapour, around 1%.

To obtain inert atmosphere in a compartment, it is necessary to have about 70°C in the air, which is possible when a fire is started. Inside the flames, much higher temperatures will be experienced, and the only way to create an inert atmosphere with water in a fire, is to heat the water until it evaporates. To understand this, it is important to know that water is evaporating at all temperatures, even below the boiling point (100 °C). The limit of how much water that will be in the atmosphere is the saturation pressure graph, shown in Figure 3. An ideal way to evaporate water in a firefighting situation is to use small droplets, with a large surface area compared to the volume, so that evaporation can occur inside the flames or in the hot smoke zone.

The Archimedes Club of IWMA will draw attention to creative means of designing firefighting systems that utilize the buoyancy of the fire plume. The Club is a quite informal institution inside IWMA. A presenter at one of the events arranged by IWMA, for instance the International Water Mist Conference (IWMC), may be awarded to be a member of the Archimedes club, having demonstrated that water is introduced into a fire zone in a way utilizing the principle if Archimedes.

As a last statement: A water droplet should ideally evaporate inside the fire plume to be most effective in cooling and inerting the flames. If a droplet is flowing upwards together with the gases inside the plume, it will be in contact with the hottest part, and will evaporate fastest. If the droplet finally is losing its upwards momentum inside the fire plume, it will fall back driven by gravity. It is then possible to utilize the unevaporated droplet twice as long as if it was introduced from above.