INDUSTRIAL FIRE JOURNAL

FOR PROFESSIONALS PROTECTING LIVES, ASSETS AND INFRASTRUCTURE WORLDWIDE

Fourth quarter 2015 issue no.102

www.hemmingfire.com

Testing time for Singapore's US$1.25 billion cable tunnel

In remembrance of things past

The sensitive approach to heritage building protection

Growing in confidence

The International Water Mist Conference in Amsterdam was officially the most successful ever, attracting 128 delegates from 21 countries. Jose Sanchez de Muniain picked out some of the highlights.

The mood was upbeat in Amsterdam with the water mist industry seemingly gaining in confidence in its market position against its traditional foe, water sprinkler technology.

Nevertheless many debates still revolve around whether water mist industry should emphasise its similarities with sprinklers – or its differences. Whilst the jury is still out on that question, delegates found comfort in water mist's increased adoption in some sectors such as in data centres, gas turbines and even residential care homes. And applications are certainly not confined to small installations, as the first application presentation efficiently proved.

Water mist has been used in the protection of cable tunnels for around 20 years and although a number of fire test scenarios exist such as CEN TS 14972, there are currently no standards for the sorts of large-scale cable tunnels that are feeding power to the mega-cities taking shape in Asia and the Middle East.

With existing test scenarios having an upper ceiling height limit of around 2.5 m as well as a longitudinal ventilation of 1m per second, what are the options when faced with a 6m-high tunnel with potential wind speeds of 5m per second?

This was the challenge faced by Fogtec when Singapore Power embarked on a US$1.25 billion programme to increase the power supply to Singapore city with a new 60m-deep, 35km-long cable tunnel, explained Ruediger Kopp, general manager, fixed systems, Fogtec.

The new tunnel runs from the Senoko power station to the north of the island and comprises an 18.5km north-south tunnel that is then intersected by a 16.5km east-west tunnel at its extremity.

An existing 1.7km tunnel running to the entrance of the new tunnel was built in 2005 and fitted with water mist technology. SP wanted to roll out the same fire protection solution to the rest of the new tunnel. 'The old tunnel had not been challenging because it was only 3.5m high, a reasonable size. Based on full-scale fire test results, high-pressure water mist could be implemented in this first section.'

The new tunnel, however, has a diameter of 6m and a maximum diameter of 9m at the shaft area, containing cable troughs carrying enclosed high-voltage cables and a number of junction points. Another significant hazard was presented by a service vehicle.

A fire protection concept was developed in cooperation with fire consultant Aecom and a full-scale test series was developed which took into account the hazards, the structure of the tunnel as well as ventilation speeds of up to 5m per second. The assessment criteria were set by Aecom with Singapore Power: the fire tests were conducted by fire test laboratory IFAB and the results evaluated by MPA. As well as evaluating water mist the test was designed to analyse the performance of linear heat detection cable.

Large-scale fire tests conducted by Fogtec for Singpore Power's new 35km-long tunnel. Central images, left to right: delegates at the Mercure Hotel, Amsterdam; Ruediger Kopp, Fogtec; Magnus Arvidson, SP Sweden; Willem Nater, Nater Gas & Vloeistofsystemen.

According to the scenario, nozzles were placed on the 6m-high ceiling along a 60m length comprising three sections. The central section was 33m and the lateral sections 16.5m each. Each section was activated simultaneously as per the proposed installation.

The first test scenario simulated a vehicle fire with a medium-sized class A fire on wooden pallets. The second fire test simulated a large class A unshielded open fire; and the third a class B liquid fire from the junction trays, where diesel was used as the test fuel.

As well as temperature measurements, visibility was also assessed to gauge potential conditions for assisting firefighters.

Detection time was set at less than 60 seconds for the class B fire and at 120 seconds for the class A fires. Five minutes after water mist activation temperatures should be below 60°C in order to enable firefighter attendance. 'It was also important that the upper part of the tunnel remained below 300°C throughout water mist activation time in order to ensure no damage to the tunnel structure.'

Summarising the results of the vehicle fire test Kopp explained that after an extended 3.5 minutes of pre-burn time the water mist was activated and all temperatures immediately decreased to 60°C . Interestingly, 10m downstream of the fire the visibility was 18m, which in a real situation would have allowed an emergency intervention even from the downstream side.

The criteria for the large fire test were also satisfied, although the higher smoke volume meant downstream of the fire visibility was 8m. An additional test was carried out where, in contrast to the other tests were ventilation speed was gradually reduced from 5m per second, the ventilation velocity was held at 5m per second. Even with the higher constant velocity the water mist system was successful.The class B scenario was successful too, this time with a 30m visibility.

The new tunnel is currently under construction and as a result of the tests it will include a total of 25,700 water mist nozzles installed in 33m-long sections with a total of 1,100 section valves operated by the detection system. Around 75km

of stainless steel pipes will eventually be installed.

The main pipe will be pre-filled with water, with a jockey pump feeding the system to ensure discharge is not delayed after activation. Water supply will be provided through six pump stations along the tunnel.

Concluding, Kopp said that the project had proved the efficiency of water mist even in large scale cable tunnels with high-ventilation conditions. 'It is a good solution to protect cable tunnels in power network projects throughout the world and we hope this type of project will continue to grow.'

Still very much on the practical applications side Magnus Arvidson of SP Technical Research Institute of Sweden outlined some lessons that could be learned from existing water mist installations. Arvidson drew upon many case studies from the report SP Rapport 2014:30, *Water mist fire protection systems – an updated state-of-the-art report,* which is an update of an earlier 2001 report describing technical developments, experiments and summary of installation requirements for water mist, including both good and bad examples of real installations (only available in Swedish).

One positive example was the outcome of the fire that broke out on the Star Princess cruise ship on 23 March 2006, when the ship was en route from Grand Cayman to Montego Bay, Jamaica. It was carrying 2,690 passengers and over 1,000 crewmembers. The fire started on a balcony and resulted in one death and 13 smoke-inhalation casualties, as well as the destruction of 79 cabins and the damage of 204 cabins. The water mist in the cabins prevented the fire from developing into a major disaster. During the fire 168 nozzles activated and the system was in operation for four hours, discharging around 300 tonnes of water. Although eight of the 168 nozzles did not activate properly, mostly due to defective glass bulbs, the water mist system performed well even though the multiple operation of the nozzles resulted in pressure being lowered from 60 bar to 48 bar.

Many discussions revolve around the reliability of traditional sprinkler systems in comparison to water mist systems but unfortunately there is not enough field experience for a definitive answer. The only possible comparisons are through calculation and fault-tree analysis of system reliability. Arvidson has found only two relevant studies, one by FM Global[1] and another via an EU project[2] looking at cruise vessels.

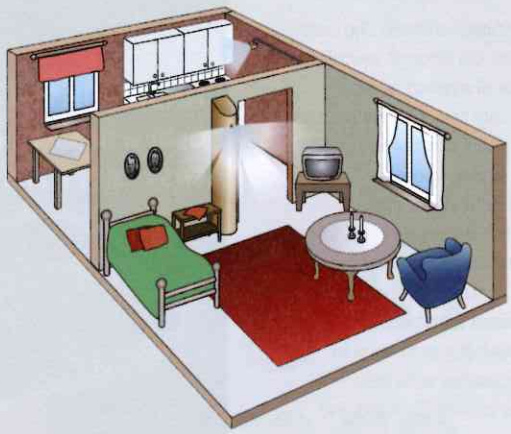
Looking at the results of these studies, Arvidson found that the reliability of sprinkler systems that are maintained annually is in the order of 94%, which is comparable to field experience. For systems maintained on a monthly basis, the reliability increases to 99.5%, which is comparable with field sprinkler experience in New Zealand and Australia where the level of inspection and controls of maintenance is high.

In the case of water mist systems, two sets of figures were outlined, one for 'generic' systems and one for 'improved' systems. Arvidson unfortunately could not find a definition for these terms. However, for an 'improved' system design; eg similar to the systems used on modern cruise vessels and which are maintained on a monthly basis, the reliability is comparable to a traditional sprinkler system. 'This is good news because now we know we can improve system reliability by more frequent system maintenance and improved system design,' concluded Arvidson.

In a survey carried out in 2012 Det Norske Veritas inspected the automatic nozzles on four passenger ships older than ten years. The results showed that between 30% and 67% of the nozzles that were tested did not activate, but the problems were associated with one particular make and type of nozzle.

A survey carried out by the Bahamas Maritime Authority on 80 ships found that 30% of the ships had single, non-functional nozzles; while 15% of the ships had multiple numbers of non-functional nozzles. These problems were assigned to blockage of internal filters with mineral deposits; build-up of scale and mineral deposits on the internal components; and corrosion of the internal components.

'The Bahamas went to the International Maritime Organization (IMO) with the recommendation that there should be regular testing of nozzles and that a minimum water quality should be specified by the manufacturer. Also, it should be possible to



270 mobile water mist sprinkler units have been installed in 39 nursing homes in Copenhagen. It is estimated that they have saved nine lives since their installation.

assess the water quality in the tank, pump unit and piping, and compared to manufacturer's water quality specification.'

Problems such as these are by no means restricted to water mist systems and Arvidson pointed out some large-scale recall and sprinkler replacement programmes in the USA. One such recall involved a sprinkler type with a faulty 'O' ring, which led to the replacement of 65 different models equating to 35 million sprinklers manufactured between 1982 and 2000.

There have also been problems with defective sprinkler glass bulbs. These are filled with a fluid that expands with heat and then breaks the bulb which in turn then activates the system. There have been examples where this fluid has disappeared, leading manufactures of both sprinkler and water mist nozzles to publish detailed installation and handling instructions for nozzles with fast-response glass bulbs.

Arvidson listed a number of case studies involving water mist installations that had gone wrong. A high pressure system installed in an old Swedish wooden church accidentally discharged nitrogen into a 10m^2 basement. The caretaker went to inspect but retreated back up the stairs after feeling dizzy, which saved his life. History nearly repeated itself at the same installation one and a half year's later when a firefighter walked down to the basement to investigate an alarm. Again he felt something was wrong and retreated. In this case the pipe coupling had separated where the cutting ring on a coupling had been wrongly marked.

In another case a pump unit had stopped operating as a result of the filter being blocked. It turned out municipal works outside had led the water to contain more particulates than usual. In another instance, an inspector had noticed the spacing of the nozzles in an installation didn't match the data sheet. Instead of installing additional nozzles, the installer revised the data sheet to fit the installation. On another occasion an installer suggested for cost reasons that the system should be connected to the water supply for the sprinkler system of the building, which resulted in nozzles clogging up because of the lower water quality.

'What can be learned from these cases? The most important part is system reliability. We have limited field experience and have to trust from the fault-tree analysis that there potentially is a higher probability [of failure] in comparison to traditional sprinkler systems. But shorter maintenance schedules may be a solution. As for nozzle functionality, we can see a need for revision of laboratory test procedures because it is obvious that the problems we have seen in practice we have not seen during lab tests. Regular field testing should be required and [we must acknowledge that] nozzle glass bulbs are very vulnerable.' Water quality and filter quality should be supervised and filter design improved to overcome problems with clogged filters. 'My conclusion is that we all have the responsibility and we can't blame a single person or company.'

It wasn't just fixed water mist systems that were in the limelight during the two-day conference and Willem Nater of Nater Gas & Vloeistofsystemen presented an ingenious mobile water mist unit that is increasingly being taken up to protect vulnerable people in care homes in Scandinavia.

The mobile water mist sprinkler unit comprises a multiple detector, pump, 130-litre tank, a nozzle, control panel and GSM (global system for mobile communication) module.

The system is designed for the typical room of an elderly or disabled person who is not physically capable of escaping a room on fire. Upon activation the system sends out a voice message to DECT phones and/or an SMS message to relevant personnel – emergency services, care home staff or neighbour – whilst discharging water mist for up to 15 minutes if not manually stopped before by carers.

The units are ideally placed in a room along the middle of the wall, although there is the option to install the unit around a corner and place the nozzle separately in the optimum location. Installation time is two to three hours, maintenance cycle is yearly. The system is certified to cover at least 25m^2 and can be equipped with optional extra nozzles each protecting another 25m^2, said Nater: 'If it is a larger area we could add a second or third unit.'

The Q1 was built in accordance to guidance (*Easily installed automatic extinguishing system*) written by the Swedish Rescue Services Agency and Norwegian Directorate for Civil Protection and Emergency Planning.

The technology was selected by the city of Copenhagen following recommendations by the social services and emergency services, who wanted to stem the number of fire deaths of elderly or disabled people, where survivability was doubtful even through the use of alternative technology such as sprinklers. 'Three minutes' survival time is all you have in that room and if you are relying on glass bulb technology, it is already quite late.'

The project started in Copenhagen in 2012. The city had a number of aging unsprinklered buildings and it had been estimated that it would cost 15 million euros (US$16 million) to install sprinklers in the residential homes.

A tender was put together for the manufacture and installation of 270 units, and today the Q1 mobile water mist units are in 39 of Copenhagen's 45 nursing homes. Copenhagen has had the units for two and a half years now and according to the fire service nine lives have since been saved. In one case the Q1 extinguished a small fire caused by stuffed toys on a hot plate in a nursing home. The cleaning up entailed only two sweeps with a water vacuum cleaner and one air dehumidifier in use over two days.

Currently 1,350 units have been built and installed, with over 100 reported activations. None of the 100 activations have been found faulty.

Nater concluded by saying these small-scale and mobile water mist fire protection units are increasingly being used in industrial applications for temporary, small scale and/or local fire hazards such as in changing rooms in nuclear power plants, localised hazards in the paper manufacturing industry, and even Lithium-ion battery rooms in ships.

The 16th International Water Mist Conference will take place 21-22 September 2016 in Vienna, Austria. The call for papers will be released on 1 February 2016 and abstracts should be received before 31 May 2016.
The 2016 conference will feature the IWMA Award for Young Talents, a prize for the best master thesis about fire protection with water mist. For more information visit www.iwma.net.

1. Xu, Shuzhen and Fuller, David, Water Mist Fire Protection Reliability Analysis, FM Global.

2. Lohtmann, Phillip, Kar, Apurba, Breuillard, Antoine, Probabilistic Framework for Onboard Fire Safety – Reliability and Effectiveness Models of Passive and Active Fire Safety Systems, January 13, 2011.