Evaluation of a water mist system in real scale fire tests

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Real scale fire tests with a water mist system were recently carried out in the CSTB research center as part of the rehabilitation of the Radio France center. In order to preserve people and building safety, Radio France planned the installation of a fixed fire fighting system. Objective is to rise the maximum value of heat potential from 400 $MJ.m^{-2}$ to 600 $MJ.m^{-2}$, or even for some place to 1000 $MJ.m^{-2}$. This increase is required because the threshold of 400 $MJ.m^{-2}$ defined in French regulation cannot be followed in real conditions of working. However, the use of water mist becomes a problem in certain places, especially those overlooking in a non-closed circulation. One potential problem could be that the water mist can penalize the visibility and interfer with the people evacuation or the firefighters intervention.

In fact, water mists are well known to be good solutions for firefighting. Aside the benefit taken from an improved droplet evaporation ability, they present interesting shielding properties against thermal radiation. This has been long explained through absorption and scattering phenomena. However, this desired ability to attenuate infrared radiation when fighting against fires might become a problem for visibility concerns in the visible range when safe escape of people is sought or when firefighters want to get closer to the fire area. The question is : how much a water mist can penalize the visibility because of the direct interaction of water droplets with visible light on the one hand, and because of interaction between droplet injection and smoke dynamics, possibly resulting in a destratification of smokes on the other hand. To answer this question, experimental data are required.

For this reason, Radio France charged CSTB to realize an experimental study with real scale fire tests to evaluate the impact of water mist on conditions of people evacuation or firefighters intervention. A test compartment of 15 m by 15 m with a removable ceiling (with a maximum heigt of 6 m) was built in CSTB center. This installation makes it possible to study a large number of configurations, in particular a « double height » space (2.5 m and 4.7 m) in these tests. A high pressure water mist system was used with the same location of nozzles (and same nozzles) than the real configuration. During the tests, measurements of temperature, radiative fluxes and opacimetry were carried out at appropriate locations. In particular, opacimeters have been built combining a laser diode (emitting radiation at 635 nm) for the source and a photodiode for the detection of the transmitted signal. At laboratory scale, without fire and using low flow rate nozzles, these opacimeters have been tested, calibrated and comparisons have been done with numerical simulations. Located on given horizontal and vertical lines, they have produced experimental data on the loss of visibility during the step of fire development and after the activation of the nozzles. In the same time, visualisation of dedicated test patterns through visible camera have been registered, giving

complementary information on visibility.

Typical experimental results of the transmissivity in the visible range during a test are presented in figure 1 (transmissivity is the ratio between the signal received during the test and the reference signal when visibility conditions are optimum). In this test, the distance between laser diode and photodiode is 1.3 m and opacimeters were placed at three positions above the floor (0.9 m, 1.3 m and 1.7 m). The relation between transmissivity and visibility is given in figure 2. This is obtained by using Beer's law to calculate extinction coefficient and Jin's equation [1] to get a distance of visibility. The two levels at 5 m and 15 m correspond to the validity domain of the Jin's equation. Before mist activation, transmissivity is reduced to 50 % at 1.7 m due to smoke production and stratification. Mist activation involve a sudden fall of transmissivity and visibility to a very low level, explained by a destratification of smokes and opaque mixing between water droplets, water vaper and smoke. After the mist stop, visibility slowly rises with transmission levels close to a few percents.

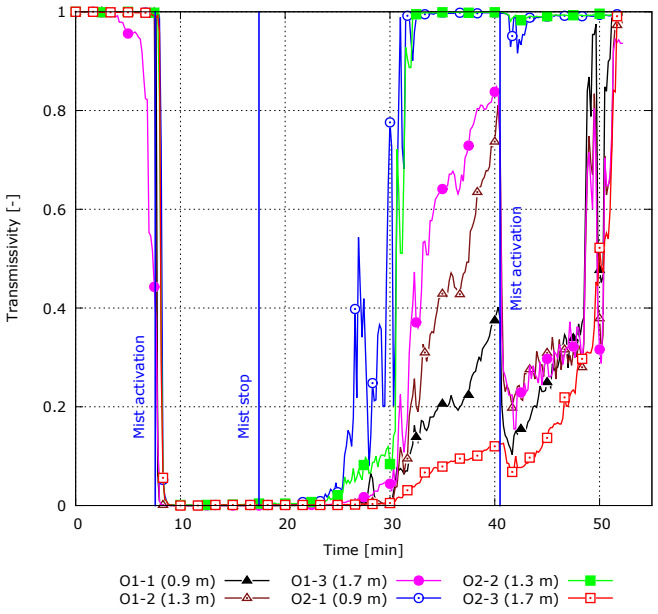

Fig. 1 – Transmission of visible radiation (wavelength of 635 nm) given as a function of time for various vertical positions

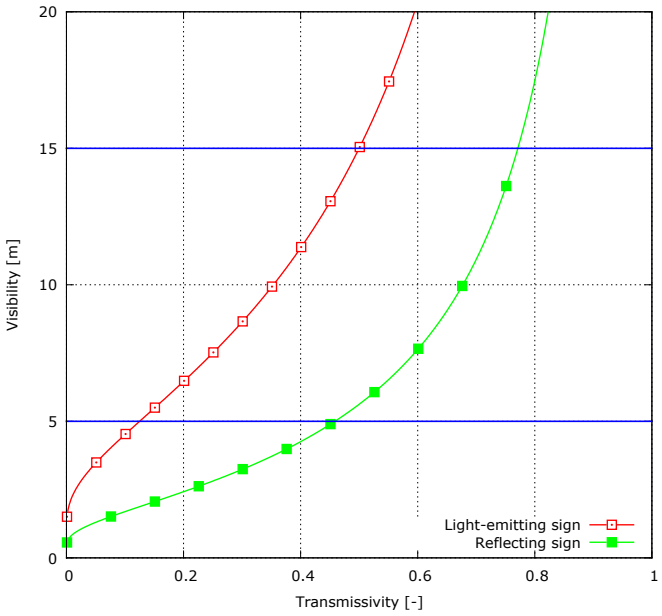

Fig. 2 – Distance of visibility given as a function of transmissivity of visible radiation (with a 1.3 m spacing between laser diode and photodiode)

The presentation will contain some introductory comments on tests objectives, then the experimental setup with the associated metrology will be briefly described. Experimental results will finally be discussed, including a detailed analysis of the influence of water mist on the temperature, radiative fluxes and opacimetry inside the test compartment.

Reference

[1] Jin, T. (2002). Chapter 4 : Visibility and human behaviour in fire smoke. *SFPE Handbook of fire protection engineering, Third Edition* : 2-42 : 2-53.