CFD Simulation for Water Pipe Penetration through walls in case of Fire

*†George Xu[1], Zhengwei Ge[2] and S.C. Wu[3]

[1]Institute of High Performance Computing, A*STAR, Singapore.
[2]Parsons Brinckerhoff Pte Ltd, Singapore
[3]State Key Lab. of Traction Power, Southwest Jiaotong University, Chengdu 610031, China

*Presenting author: xu_xiangguo@ihpc.a-star.edu.sg
†Corresponding author: xu_xiangguo@ihpc.a-star.edu.sg

Abstract

According to the Fire code stipulated in Singapore, HVAC water pipes made of non-combustible material shall be no more than 150mm in diameter, when they penetrate structure walls. If the pipe size exceeds 150mm, it shall be located within a protected duct or shaft. Such requirements are for the sake of preventing the hot plume with extremely high temperature, in case of a fire emergency scenario, from penetrating the cracked pipes so as to compromise the strength of structure walls.

As advanced materials and treatment technologies have been developed and adopted in water pipes design, the modern water pipes should be more durable in such a harsh situation. Thus it is necessary to review the code requirement in this respect. In addition, the fire size may vary from building types. For the mass rapid transport (MRT) station of concern, the estimated fire size is usually no more than 1 megawatt corresponding to a luggage fire scenario. To align with energy efficient and sustainable design strategy, it is preferable to use larger pipes to deliver condensed water and chilled water required for HVAC system. All these form the rational for the applied research work to justify the possibility to adopt bigger water pipes without compromising the fire safety in train building design.

One chilled water pipe and one condensed water pipe, both of which are proposed for a MRT station design, have been selected in the investigation. The chilled water pipe is made of a 6.6 mm steel layer protected by a 0.6 mm thick galvanised steel layer with a 50 mm thick insulation layer made of polyurethane in between. While the condenser water pipe is made of a 6.9 mm thick steel layer with no insulation. Three operational conditions, pertaining to the water status within water pipes, have been numerically tested, i.e. no water in pipe, still water in pipes and running water in pipes.

Computational Fluid Dynamics (CFD) models for the two types of water pipes have been created and simulated, subject to a MRT fire scenario (capped the fire size at 1 Megawatt). Steady-state analyses have been carried out with the full consideration of heat conduction between solid materials and the fluid flow, heat convection and radiation in fluid flow. The maximum temperatures for different material layers were calculated and analysed, as compared to the softening/melting points of respective materials. Based on our parametric studies, the maximum surface temperatures are for below the softening/melting points of proposed metal pipes. This implies that for a MRT fire, the fire would not be able to pass through the proposed steel-type water pipes penetrating through the walls and floors, even without a protected duct or shaft around the pipes. In particular for the case with water running through pipes, which is regarded as the most practical operation condition in MRT stations during the event of a fire, the least thermal impacts are observed in the simulations. With the research findings in this study, we successfully convince the government agency to grant the permission to design team to adopt the water pipes larger than 150mm in MRT buildings, and to justifiy the fire code requirement for the MRT station design in this respect.

Keywords: CFD, Fire Safety, Structure Fire