Technical paper

DWV systems for fire safety
Metal vs Plastic

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Abstract

This paper describes fire safety of plastic DWV pipe systems in high-rise buildings. How a fire builds up through four stages and how a passive fire system compartmentalises and limits the spread of fire and smoke in order for the active fire system to take over. It describes the difference between metal DWV systems and plastic DWV systems when it comes to fire safety.

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High-rise building solutions

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Introduction

Fire safety protection is critical in developing high-rise buildings. Fire is a grave threat to people and property. High-rise buildings present unique challenges not found in traditional low-rise buildings: longer egress times and distance, fire department accessibility, smoke movement and fire control, and the need for more complex evacuation strategies. Piping systems are at the heart of a building and play a critical role in ensuring fire safety. As more and more people live in a single building connected to a single system, the need for a safe and reliable sanitary system increases.

Active and passive fire protection

Inside buildings there are two types of fire protection systems, Active Fire Protection and Passive Fire Protection, and both systems should actively work together in the event of a fire.

Active fire protection is a group of systems that require action in the event of a fire. This action can be manual, like a fire extinguisher, or automatic like a sprinkler system. When fire and or smoke is detected these system put out or slow the growth of the fire until firefighters arrive.

Passive fire protection is a group of systems that compartmentalize a building through the use of fire-resistance rated walls and floors, keeping the fire from spreading quickly and providing time to escape for people in the building.

Fire compartmentation

Passive fire protection via compartmentation is important for life safety and property protection by dividing a building into smaller blocks, vertical fire resistant walls and horizontal fire resistant floors, to limit the fire spread and gain time. Compartmentation plays an important role in a building when the active system of the fire area is no longer able to control the fire. Fire in a building evolves in four stages.

Incipient stage
The incipient stage begins when heat, oxygen and a fuel source combine and have a chemical reaction resulting in fire. This is also known as "ignition" and is usually represented by a very small fire which often goes out on its own, before the following stages are reached. Recognizing a fire in this stage provides your best chance at suppression or escape.

Growth stage
The growth stage is where the structures fire load and oxygen are used as fuel for the fire. There are numerous factors affecting the growth stage including where the fire started, what combustibles are near it, ceiling height and the potential for "thermal layering". It is during this shortest of the four stages when a deadly "flashover" can occur; potentially trapping, injuring or killing firefighters.

Fully developed stage
When the growth stage has reached its max and all combustible materials have been ignited, a fire is considered fully developed. This is the hottest phase of a fire and the most dangerous for anybody trapped within.

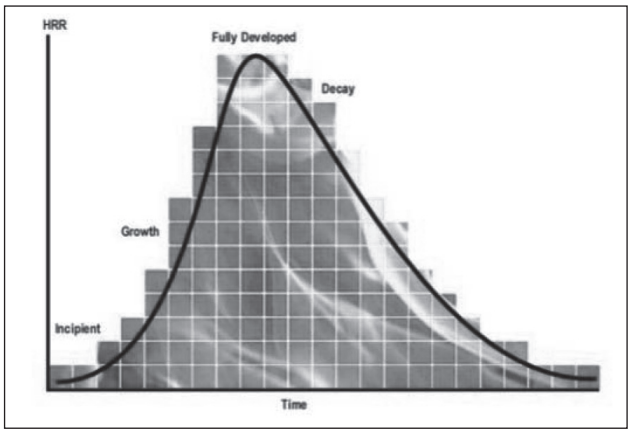

Figure 1.

Decay
Usually the longest stage of a fire, the decay stage is characterized a significant decrease in oxygen or fuel, putting an end to the fire. Two common dangers during this stage are first - the existence of non-flaming combustibles, which can potentially start a new fire if not fully extinguished. Second, there is the danger of a backdraft when oxygen is reintroduced to a volatile, confined space.

Compartmentation during growth stage

A fire out of control occurs when the fire is at the flashover stage where everything that is combustible in a room is inevitably lost and one can only try to save the neighbouring rooms or buildings.

Burnable hot gases are concentrated below the ceiling and are heated up due to the fire in the room. When this mixture of gases is hot enough, the flashover happens and a "wave" of fire rolls along the ceiling.

A flashover does not occur in every fire compartment. The fuel must have sufficient heat energy to develop flashover conditions and the fire must have sufficient oxygen.

Plastics vs metal and fire safety

Although most metal pipes are classified as Non-Combustible, and plastic pipes as Combustible, one needs to have a closer look at which drain, waste and vent (DWV) pipe material may be advantageous for life safety in a building fire.

It is important to note that in most fire safety codes, the objectives are not on prevention of fire, but rather on the spread of fire. In other words, construction practices are specified with regard to fire safety that if a fire should break out for some reason, that the building construction practices should be such that this fire is compartmentalized to remain in the compartment of origin, thus allowing sufficient time for fire suppression activities to occur such as fire sprinklers or fire department response.

It is generally conceded that most combustible pipes will be consumed fairly quickly in a fire but does that create a large fire safety risk for the remainder of the building? The answer is no.

The reason it does not is through very effective fire stopping. Fire stopping is the process of applying tested materials and systems to the underside of floors or on both sides of walls whereby the penetration for the pipe will not allow passage of heat or flame to adjacent compartments. It can be argued that fire stopping devices such as collars actually work more effectively with combustible pipe than they would for metal pipe. This is because these devices tend to sever off a combustible pipe very early in a fire as the intumescent material rapidly expands and fills the hole left by the consumed pipe. The end result is a collar fastened to the floor or wall surface that contains a large amount of charred material which is resistant to the passage of flame or significant heat. They are effectively like a lump of coal protecting the hole during the fire and will typically offer sufficient protection.

Fire stopping metal pipe is also somewhat common but works much differently. Since the metal pipe will not be consumed during the fire, the focus of fire stopping is simply to seal off the annular space between the pipe's outside diameter and the hole interior. Mineral wool and firestop caulking can achieve this but there are two concerns with these systems.

One is that the mineral wool plus caulking will not prevent a high level of heat transfer from one compartment to the next through the very conductive metal pipe. Temperature increases on the unexposed side of a pipe penetration can easily exceed 180°C with uninsulated metal pipe. Having this hot stove pipe effect can actually inadvertently ignite combustible materials on the unexposed side of a fire and thus allow continuity of the fire beyond the separation.

Secondly, the most common manner of joining cast iron pipes today is through the use of a rubber, steel mesh sleeved mechanical joint couplings. During a fire, the rubber component of these couplings will be consumed which will potentially create openings in a cast iron stack (vertical pipe) and thus allow fire to enter the pipe interior and breach the separation by spreading to the unexposed side.

Figure 2.
Promat fire collars for passive fire protection

Conclusion

Plastic is considered to be a modern and better material for DWV systems for many reasons like weight, costs, durability and sustainability. As these are all very relevant aspects of a high-rise building, the fire safety of its inhabitants should be a high priority as well. This paper highlights that also for passive fire safety a plastic DWV system has benefits over a metal DWV system.

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