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Technical Bulletin 8

Terminal Velocity

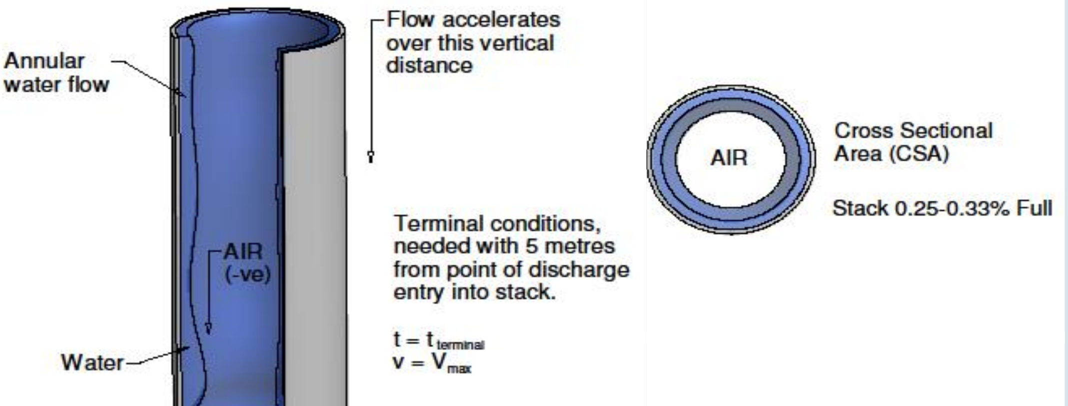
When not in use, a drainage pipework system is only filled with foul air; the surrounding built environments are protected from the escape of the foul air by installing air-tight traps with a water seal to individual sanitary appliances.

As waste water is discharged via the appliances into the drainage system, it is collected and conveyed to the drainage stack via branch drains; at the same time air starts to get entrained into the waste water flow up to 15 times the volume of the waste water discharge.

When the waste water enters the drainage stack it may fill the cross section of the stack at the point of entry. This will depend upon the flow from the drain into the stack, the type of stack fitting, the diameter of the drainage stack and any flow down the stack from upper levels.

Upon entering the drainage stack, the waste water accelerates downwards by the force of gravity at 9.81 m/s^2.

In a very short distance the waste water will form a sheet around the inner wall of the pipe; this is known as annular flow. In some instances it can form a diaphragm across the pipe for short periods. Generally, solids will fall down the centre of the pipe.



Water Flow Profile

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The acceleration of the annular flow continues until the frictional force exerted by the internal wall of the drainage stack equals the force of gravity; this is known as the maximum velocity and is termed ‘terminal velocity’. The distance required to reach terminal velocity is known as ‘terminal length’.

Research has proved that terminal velocity is attained between 3 – 5 metres from the point of entry into the stack, travelling at a maximum velocity of 5m/s. The terminal velocity at the base of a 100-story stack is only slightly and insignificantly greater than the velocity at the base of a 3-story stack. Therefore waste water will reach terminal velocity if it enters any stack above five metres, be it a 3-storey villa or a 100-storey apartment block.

It is the entrainment of air that causes negative (-ve) pressure in stacks to act on waste branches and traps. Likewise, at a transition area, such as a base of stack bend, it is the velocity and volume of water hitting the bend and becoming turbulent that will cause a reflected positive (+ve) air pressure wave to propagate through the stack. Traps are sensitive to both the +ve and –ve air pressure fluctuations.

The height of the building is not relevant to the velocity of the water in a stack, provided that this height of the stack is greater than five metres. As designers, we design to flow rate limits for different sizes of stacks. Therefore, the key issue when designing drainage stacks **is not** to control the velocity of the falling water but to control the effect that the falling water has on the air movement within the stack, that is, the generation of both +ve and –ve pressures. This requires a strategy of introducing air at the point of need for dissipating –ve pressures and dissipating, or attenuating at the point of need, for +ve pressures.

The importance of all the extensive research and testing that has been carried out on terminal velocity in drainage stacks is that it demonstrates that water falling in a stack from a great height generates greater velocities at the base of the stack.

In conclusion:

- Terminal velocity for waste water in a stack is typically up to 5m/s.
- Terminal velocity is reached after waste water has fallen within 5m.
- Terminal velocity of waste water is the same for a 3-storey villa and for a 100-storey apartment block.
- Control the +ve and –ve air pressure fluctuations caused by terminal velocity.
- Control –ve pressure by introduction air at the point of need.
- Control +ve pressure by dissipating or attenuating the pressure at the point of need.

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