Technical paper

Above ground drainage and vent systems
A steady state or unsteady state system?

Steve White

Technical Director DWV
Aliaxis High-Rise Building Solutions
United Kingdom
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Abstract

Understanding the differences between steady state or unsteady state discharges in drainage is of critical importance in designing high-rise or complex drainage systems. Codes are based on steady state and empirical data, which is indicative but does not get the full picture of the system performance especially for high-rise buildings. Drainage systems are inherently unsteady, due to the unsteady flows of water, where the time dependency depends upon the random operation of the appliances connected to the system. The movement of the entrained air within a building drainage and vent system is readily identified as two-phase flow phenomenon driven by the shear forces between the appliance water discharge and the air within the system at atmospheric pressure. The unsteady nature of the water flows inevitably result in an unsteady entrained airflow where the changes in airflow demand, as a result of the random discharges of the system appliances, communicate the propagation of low amplitude air pressure transients both negative and positive.

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Introduction

Drainage systems are unsteady state systems, due to the time dependency and random discharge profiles of the waste and solids discharging into it. The waste, air and pressure regime all move at different speeds within the system. Codes for drainage systems are based on drainline carry principles, the ability of the system to move water and waste out of the system, which dictate the size of pipes, slopes and gradients and loadings/flowrates used to design a system, but what is not accounted for is the time dependency of the flow conditions which make the system unsteady.

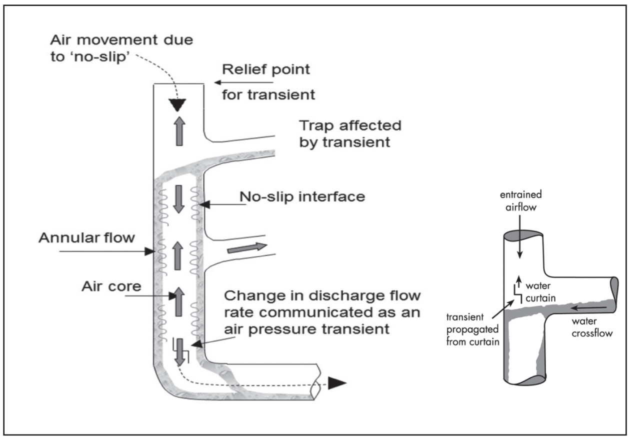

Figure 1.
Water and air flow in a stack

Steady State

A steady state flow refers to the condition where the fluids, air and water properties in the system do not change over time. This would for example be for a single discharge, where the waste and water in a straight vertical stack have reached their terminal velocity, until it reaches the base of the stack, with no other discharges, or within a siphonic roof drainage system when the flow within the pipe is constant. This would mean that the flows in the drainage system are constant and flow for a number of minutes with no changes.

The steady state pressure response profile is the profile that underpins codes and guidelines, however it is more applicable for a low-rise building where it is unlikely that more than one discharge would occur at the same time and the pipe periods and communication of the pressure transits the time dependency is less of a factor.

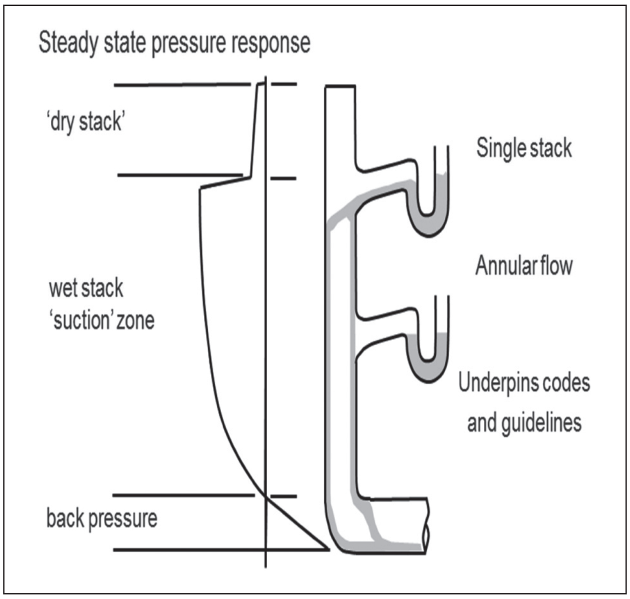

Figure 2.
Steady state pressure profile

Unsteady State

An Unsteady state flow refers to the condition where the fluid properties in the system do change over time. For example; the early stages in a siphonic roof drainage system before the flow becomes full flow and constant.

In building drainage and vent systems for high-rise and complex systems the state of the conditions is changing due to the multi-phase, multi-component flows, (multiple flushing) entering the system. These changes in condition for fluid, water and air as well as solid flows make an unsteady flow condition.

Entrained airflows, where the time dependency arises as the result of shear forces between the discharged water flows, annular flow in the vertical stacks and the air core within annular flow.

The air pressure regime and entrained transient airflows within the building drainage and vent system result from the random discharges throughout the system, surcharges at the base of the stacks or offsets, as well as external factors such as wind effect, all have an impact on the pressure regime.

The unsteady condition and the associated pressure transients can be summarised as:

Low amplitude air pressure transients are propagated as a result of any change in operating conditions or as a result of external events that are communicated to the network.

1. Increases in stack downflow entrain an increased airflow and this propagates a suction or negative transient,
2. Reductions in entrained airflow velocity at a local surcharge generate positive transients,
3. Pressure fluctuations in the sewer may propagate into the network as either positive or negative transients,
4. Wind shear over roof stack terminations will also generate transient oscillations within the network.

With a multiple discharge, the pressure profile below is more representative of a drainage system profile for negative pressures than the steady state profile.

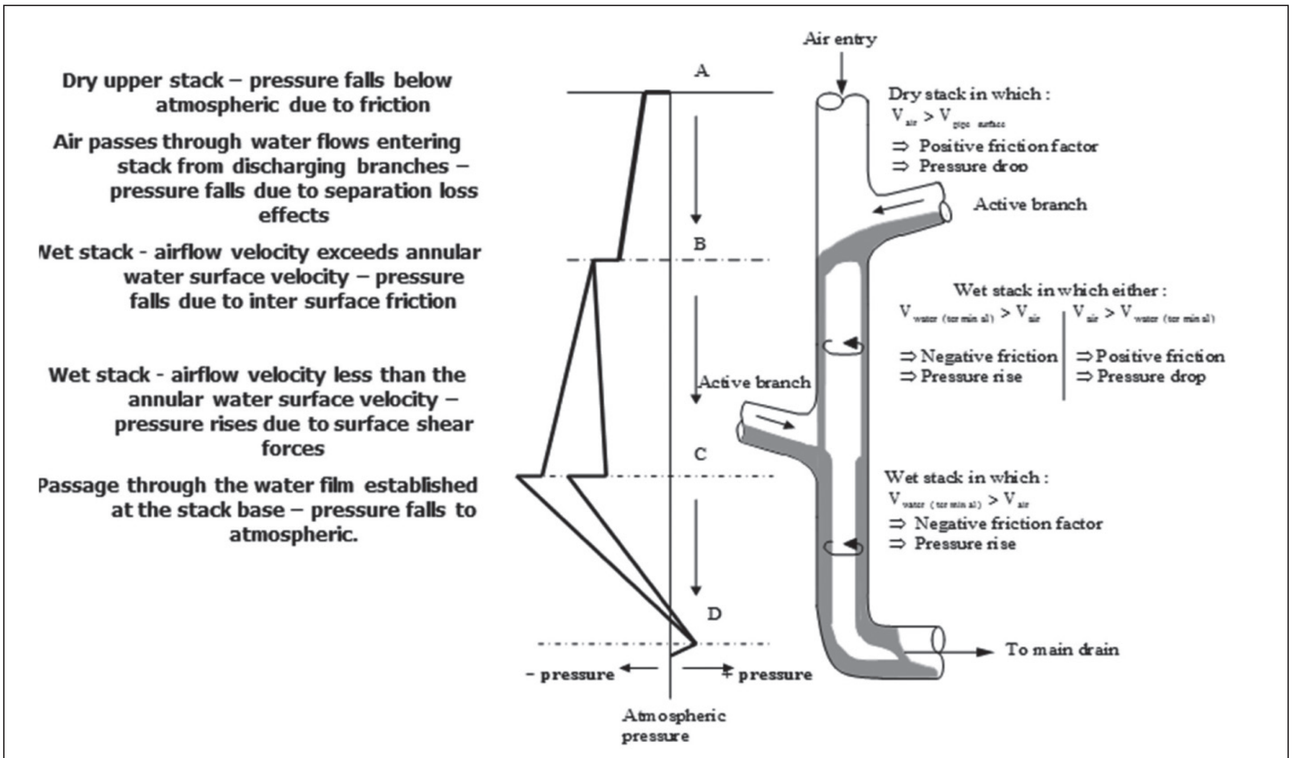

Figure 3.
Unsteady state pressure profile

Conclusion

A drainage system is unsteady, due to the way the system is used. Each flush of a W.C is a different event. When multiple flushing occurs throughout the stack this changes the conditions of flow as well as the air and transient regime.

In high-rise and complex systems the factor of time dependency becomes a great issue due to the distance of communication and the pipe periods involved. Therefore a drainage system has to be seen as an unsteady state system.

Steve White
Technical Director DWV
Aliaxis High-Rise Building Solutions

MSc (Ir.) Marc Buitenhuis MTD
Research Engineer Hydro-Dynamics
Aliaxis

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