

DESCRIPTION

Method and equipment for detecting sealing deficiencies in drainage and vent systems for buildings.

The present invention relates to a method and equipment for detecting sealing deficiencies, such as defective water traps and other sealing failures, within the drainage and vent systems for buildings.

5 The purpose of a drainage system installed in a building is for conducting wastewater from sanitary appliances such as toilets, wash basins, bathtubs, etc into the sewer usually located in the underground of the building. In case of a multi-storey building, the drainage system has at least one vertical stack extending through the
10 floor of each store and branch pipes for conducting the wastewater from each of the sanitary appliances present on each floor into the vertical stack by means of connectors. The stack and/or branch pipes or even each individual sanitary appliance may have been provided with air admittance valves or other appropriate venting arrangements
15 and/or positive air pressure attenuator devices.

Water traps or water seals are generally used in relation with most sanitary equipment. Their purpose is to avoid fouled air coming from the sewer to be released into the environmental space or
habitable space. The water trap is usually consisting of a U-shaped or
20 bottle-shaped housings, generally connected to each of the sanitary appliances, and in which a certain amount of water remains in place sealing off the air from the stack and the sewer. Water closets have a water trap built into the fixture itself.

Under certain conditions, such as negative or positive air pressure conditions, the water traps could become disrupted which means that no sufficient amount of water remains in place to assure the sealing off from the discharge pipes and allowing fouled air from the sewer to enter into the habitable space. Such failures may result in pathogen transmission paths or system failure due to overpressure resulting in fouling the living space.

Venting of the drainage system is therefore important in order to prevent air pressure differentials in the system and in most of the systems use is of air admittance valves (AAV).

An air admittance valve (AAV) allows air to enter the drainage system through a one-way air valve when a sanitary fixture is operated and water flows through the pipes. When a column of waste water falls through the vertical stack, it entrains an airflow whose presence of necessity generates local suction or negative pressures. These are transmitted through the network and may lead to siphonnage of appliance water trap seals. In order to compensate for these negative pressures the membrane of the AAV is lifted temporarily and allows ambient air to enter the drainage system. The extent of these pressure fluctuations is determined by the fluid volume of the waste discharge. Excessive negative air pressure can siphon water from the water seals in the traps of sanitary appliances if no AAV are present.

On the other hand, if the air pressure within the drain becomes suddenly higher than ambient, this positive transient could cause wastewater (and air) to be pushed into the appliance, breaking the trap seal, with dire hygiene and health consequences. Positive air pressure attenuator devices have therefore been developed and proposed to reduce such risks of contamination, especially in high or multi-storey buildings.

The problem to be solved by the present invention is to locate or identify any possible deficiency in the drainage and vent system of a building and in particular the position of defective water traps, normally defined as traps having lost their water seal, or other defects in the building drainage systems, such as leaking junctions or fittings or defects resulting from blockage to the free passage of water and entrained air.

The purpose of the present invention is to propose a method and appropriate equipment to detect and identify such failures within a building drainage and vent system by virtue of their transient reflection coefficients. Indeed, such failures or defects present a
5 changed reflection coefficient to any incoming low amplitude air pressure transient when compared to the response applied to an accurate system layout.

Indeed, if there exists both a "defect free" database of system response to an applied transient and an accurate system layout,
10 then the location of any defect may be identified as the speed of propagation of any transient will be constant at the airborne acoustic velocity, thus yielding a time differential between reflected waves fronts detected at monitoring locations.

According to the present invention the equipment consist
15 in a transient generator connected to a portion of a vertical stack and a series of low pressure transducers also connected to the stack and capable of detecting and transmitting cycling positive/negative low air pressure wave reflections into electrical signals to be sent to a network database. Said method and equipment for detecting
20 deficiencies, such as leaks, in a drainage and vent system for buildings are configured and provided with means as set forward in the appended claims.

An embodiment of an installation provided with the equipment according to the invention will be described hereafter, by
25 way of an example only, with reference to the accompanying drawings, in which

Figure 1 is a schematic representation of a simple stack drainage system in a multi-storey building;

Figure 2 is a schematic representation of a double stack
30 drainage system in a multi-storey building;

Figure 3 is a detailed view of a stack portion provided with a build-in fitting capable of receiving a transient generator;

Figure 4 is an identical view as figure 3 with the transient generator connected to the fitting;

35 Figure 5 is an exploded view of a fitting provided with a three port rotatable valve;

Figures 6 and 7 are alternate embodiments of the transient generator.

As shown in Figure 1 a drainage system of a multi-storey building is represented in a simplified manner and comprises a vertical stack discharge pipe 1 to which are connected a series of drain pipes 2 coming from each floor and in which discharge sources 3 from the respective floors may be drained. Said discharge source may be any sanitary appliance such as water closets, floor drains, sinks, showers, bidets or the like.

Between each discharge source 3 and the drainpipes 2, the plumbing generally includes U-shaped water traps 4 or the like.

The liquid and/or liquid/solid discharges from the discharge sources 3 are delivered through their respective traps 4 into the drainpipes 2 and subsequently through the vertical stack pipe 1 to be finally delivered to the sewer 5.

The complete system is vented to the surrounding atmosphere by means of air admittance valves 9 generally provided at the upper extremity of the stack pipe 1 but may also be incorporated in the housing of the water seals. As already explained, the drainage system should preferably also be equipped with positive air pressure attenuator devices (not shown).

According to the present invention, the vertical stack 1 is provided, at appropriate locations, with at least one fitting 6, representing a mechanical device designed to be inserted in-line with the drainage stack 1. The fitting 6 is provided with a connection 21 between the interior space of the stack 1 with the output section of an transient generator 20 as represented in figures 4, 6 and 7 and will be described later. At proximity of each fitting 6, the stack 1 is also provided with low pressure transducers 7 which are capable of recording the air pressure variations such as transient response of the drainage network and are connected to a central data acquisition system integrated into a building.

The figure 2 represents a more complex drainage system with a main stack pipe 1 and a secondary stack pipe 11. Similar drain pipes 12 discharge waste water/solids from the discharge sources 13

into the stack pipes 1 and 11. The secondary stack pipe 11 is connected to the main stack pipe 1 by means of a connection pipe 8.

At appropriate locations, similar fittings 6, for connecting the transient low air pressure generator 20, and low pressure transducers 7 are installed.

The transient low air pressure generator 20 is generally a mechanical device consisting of a moveable surface sealed against an outer container or cylinder, for example a piston 23 or bellows, whose moveable surface is operated by means of an electromechanical device capable of a controlled, reciprocating action.

As represented in figure 4, the generator 20 is attached to the stack 1 by means of a fitting 6, which is provided with a threaded connection 21 to the generator 20. The generator 20 as a generally cylindrical body containing an inner chamber 28 and a piston 23 capable of moving the air contained in the chamber 28 with an adequate velocity and/or frequency into the interior space of the stack section 1.

The fitting 6 is represented on the figures 3, 4, 6, 7 and more in detail on figure 5 and is consisting in a mechanical device designated to be inserted in-line with the drainage stack 1 and to provide a connection means 21 to the output of the generator 20.

As shown on figure 5, such a fitting mechanism is realised as a three-port valve 22 capable of rotation within the fitting 6. The valve 22 is provided with two diametrically opposed apertures 24 corresponding with the diameter of the vertical stack 1 and with one lateral opening 26 located at the position of the connection means 21 with the generator 20.

Rotation of the valve 22 is accomplished with any external mechanical or electromechanical actuator, which does work against a mechanical containing mechanism, for example springs or weights, which return the valve 22 to the failsafe condition represented in figures 3 and 5, in the event of a power failure. The travel provided by the actuator 20 limits the rotation of the valve 22 and prevents rotation greater than about 90°.

The fitting 6 is capable of directing the output of the generator 20 either upwards or downwards into the drainage stack 1. Upon completion of the testing or detection process, the fitting 6 must

return to a failsafe condition of uninterrupted vertical transport in the drainage stack 1.

The valve 22 provides two "closed" configurations, the first one when the valve is rotated anti-clockwise (arrow A in figure 5), which situation is represented in figure 4 and which is closing off the upper side of the stack 1, and the second one when the valve 22 is rotated clockwise (arrow B, not represented) closing off the lower side of the stack.

In case no generator 20 is installed or when the detection process is completed, a locking plug 25 (figure 3) is used and adapted to the connection means 21 of the generator 20 providing the locking of the valve 22 into a failsafe configuration when inserted. By means of appropriate thread diameters at the plug 25/valve 22 connection means 21, the locking plug 25 can only be inserted when the valve 22 is in a failsafe configuration which means that the apertures 24 are in-line with the inner diameter of the stack 1.

The overall dimensions of the three port fitting 6 will be similar to current stack dimensions. It will be cylindrical in section with a full passing-through diameter corresponding to the stack diameter. In case a stack was considered with diameter 150 mm, then the most likely overall dimension of the fitting would be in the range of 225 to 250 mm. The device could be sleeved to allow use with smaller diameter stacks which would have the advantage that only one size device need to be produced and marketed together with the inset sleeves.

The figures 6 and 7 represent alternative embodiments of the generator 20. According to the figure 6 the connection means 21 is in the shape of a 90° elbow and the generator 20 is positioned parallel to the stack 1 in order to save space if needed. The figure 7 shows an embodiment of generator 20 in which the piston 23 is part of a pleated cylindrical membrane 27 containing the chamber 28 in which the air transient is generated and directed through the connection means 21 and the three port valve 22 of the fitting 6 towards the lower part of the stack 1, passing nearby the pressure transducer 7.

The identification of drainage network defects, through the use of positive or negative air pressure transients, requires thus

additional equipment to that normally found in a building drainage and vent system. The introduction of the transient will require mainly two additional components:

- a dedicated system junction, such as the fittings 6 and
- 5 - a transient low air pressure generator 20.

Both components may be incorporated into a single device, or may exist as separate devices. If they were incorporated into a single device, then the device(s) would be installed in fixed location(s) within the drainage network. If they exist as separate

10 devices, then the system junctions or fittings 6 would be installed in fixed locations and the transient generator(s) would be moved from one location to an other within a complex network to facilitate testing.

In any case, the pressure transient generator 20 will be capable of introducing a positive, negative or cycling

15 positive/negative pressure wave by either the action of a piston, fan, bellows, membrane or other moving surface within the device that allows system/air interaction, or a connection to a stored pressure source. The generation of the air transient will, in any case, be repeatable and/or produced by a sine wave oscillation.

20 The design of the permanent fittings 6 and the generator 20 will ensure that no cross contamination or leakage of the drainage system gas into the habitable space can occur during connection, operation or disconnection of the equipment. The design of a stored pressure source, if used, will exclude the possibility of backflow into

25 the vessel when exhausted.

The method for defect identification thus includes the following processes and equipment:

- A detailed system layout is required, drawn from building design or a specific survey;
- 30 - A means of introducing a low amplitude air pressure transient into the building drainage and vent system will be utilised to propagate a pressure wave into the network. The response of the defect free system to this transient will be recorded by a number of pressure transducers 7 strategically located at various nodes around the network. This
- 35 response will define the system and will be used as a base against which to compare responses from the same network following use and

the appearance of defects. The defect free database will be stored for future reference as part of the identification methodology.

- A transient generator 20 will be capable of propagating a pressure transient of less than trap seal depth into the network; this limit will ensure that the testing is not damaging to the integrity of the network's trap seals. This pressure transient generator 20 will be based on the ability to generate into, or connect to, the system, to give a timed pressure pulse. It will require a dedicated system junction 6 and will be wholly sealed so that no cross contamination may occur as a result of the transient application. Under normal use, the transient identification of dry trap seals and other defects will be activated at regular intervals during quiescent system operation periods or as a result of operative concern as to the integrity of the network, possibly triggered by user dissatisfaction;
- The pressure response to the applied transient will be compared to the database of stored system response and the divergence of pressure response results, as recorded by the network of pressure transducers 7, will be used to identify the location of the defect seal.

More practical information about the method according to the invention is given hereafter.

The rotation of the three port valve 22 inside the fitting 6 in either clockwise or anticlockwise direction, provides in each case an air-path from the internal chamber 28 of the generator 20 through the three port valve 22 into the drainage network situated respectively above or below the fitting 6.

Rapid movement of the piston 23 or volume change within the chamber 28 of the generator 20 generates a pressure transient that propagates from the generator 20 throughout the selected drainage network. Its passage is recorded by the pressure transducer 7 located adjacent to or part of the fitting 6.

The pressure transient propagates throughout the network at the acoustic velocity in air of approx. 320 m/s. It is reflected at each and every pipe termination. These reflections in turn propagate back to the source of the transient at the generator 20 and contribute to a pressure versus time signature recorded at the location of the fitting 6 by the pressure transducer 7.

Each pipe termination has a characteristic reflection coefficient. For example a dead end has a +1 reflection coefficient while an open end to atmosphere has a -1 reflection coefficient. Partial blockages or leaking terminations have reflection coefficients that lie between these limits.

If the generator 20 is operated in a perfect network with no dry trap defects or leakage's, then the pressure transducer 7 records a baseline defect free signature over a time period which is short and determined by the overall length of the network and the acoustic velocity. This is likely to be a small number of seconds at maximum.

If the system develops a defect, such as a trap dried out, then the pressure transducer 7 will record a different signature pressure trace. The point of diversion will be at the time at which the reflection from the altered pipe end termination arrives at the transducer. Comparison of this defect trace with the stored defect free signature yields that time and hence as the wave speed is known the distance to the defective trap is identified. Reference to the drainage network layout then identifies the location of the defect.

An additional test for defect location would be to generate during building commissioning a comprehensive set of signature traces for both defect free and controlled defect locations on each floor. Numerical comparison of a subsequent defective system signature against this dataset would also identify the location of the defective trap.

In addition to identifying dry traps, it now appears that it is also possible to identify partially closed pipe terminations which could have implications for the identification of defective AAV's if such exists.

According to the present invention, the network under test itself acts as the conduit for the transmission of the test transient so that no other network piping or fittings are required. The equipment consists mainly of the following elements:

- a transient generator 20 that will utilise a fluid/structure interaction to generate a transient;
- a three port rotatable valve 22, within the fitting 6, that will allow the transient generated by the generator 20 to travel in either direction

in the drainage system vertical stack 1;

- a three port casing and stack connector or fitting 6 that will be compatible with existing stack components, and

- low pressure transducers 7 located adjacent to the connector 6 and
5 connected to a central data acquisition system that will be whenever possible integrated into the building.

In case the air transient generator 20 is provided with a piston 23 being moved following a sine wave oscillation instead of a pulse, it should be possible to provide an equipment which is non-
10 invasive, which means that it is no more compulsory to isolate or close-off a section of the drainage stack in order to realise the faulty trap detection.

The description and the drawings of the present application are merely an example of how the method and the
15 equipment could be worked out but any other equivalent means are possible without departing from the features set forward in the appended claims.

CLAIMS

1. Method for detecting sealing deficiencies within a
5 drainage and vent system for buildings comprising at least one main
vertical stack (1) to which are connected a series of drain pipes (2)
coming from each floor for draining the discharge outlet of sanitary
appliances, said discharge outlet being generally provided with water
traps (4) and the drainage system being eventually provided with air
10 admittance valves or other appropriate venting arrangements and
positive air pressure attenuator devices,
the method being characterised by the following steps
- introducing a low amplitude air pressure transient into the drainage
and vent system of a building in order to propagate a pressure wave
15 into the network of the drainage system;
- recording the passage of said transient by means of an air pressure
transducer located near the introduction area of the transient;
- recording the successive pressure reflections of the transient from
each drain pipe (2) of the network of the drainage system;
20 - establishing a pressure versus time signature recorded by the
pressure transducer and sending those signals to a central data
acquisition system.

2. Method according to claim 1, characterised in that the
25 pressure transient propagates throughout the network at an acoustic
velocity and is reflected by each and every pipe termination of the
network so as to establish a characteristic reflection coefficient for
each pipe termination.

30 3. Method according to claim 1, characterised in that it is
performed initially in a perfect network with no dry trap defects or
leakage's so that the pressure transducers record a baseline defect free
signature over a given period of time which is determined by the
overall length of the network and the acoustic velocity of the air
35 pressure transient into the drainage system.

4. Method according to claim 1, characterised in that during a subsequent testing operation, the baseline defect free signature is compared with the actual situation and in case a different signature of the pressure trace is recorded, the point of diversion will
5 be determined at the time at which the reflection from the altered pipe end termination arrives at the air pressure transducer so that the comparison of this defect trace with the stored defect free signature yields that time and, as the wave speed is known, the determination of the distance from the pressure transducer to the defective trap or seal.

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5. Equipment for carrying out the method according to claim 1 in a drainage and vent system of a building comprising at least one vertical discharge pipe or stack (1) to which are connected a network of drain pipes (2) coming from each floor and in which
15 sanitary appliances or discharge sources (3) may be drained, said equipment comprising at least one air transient generator (20) connected to the stack (1) and at least one pressure transducer (7), located adjacent to the generator (20), capable of recording the transient response from the drainage network.

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6. Equipment according to claim 5, characterised in that the air transient generator (20) is connected to the stack (1) by means of a fitting (6) designed to be inserted in-line with the stack and providing a connection means (21) between the output of the generator
25 (20) and the interior space of the stack (1).

7. Equipment according to claims 5 and 6, characterised in that the fitting (6) comprises a three-port valve (22) provided with two diametrically opposed apertures (24), corresponding to the
30 diameter of the vertical stack (1), and one lateral opening (26), located at the position of connecting means (21) with the air transient generator (20).

8. Equipment according to claim 7, characterised in that
35 the rotation of the three-port valve (22) within the fitting (6) in either clockwise or anti-clockwise direction, provides an air-path from the

internal chamber (28) of the generator (20) through the three-port valve (22) into the interior space of the stack (1) and the drainage network situated respectively above or below the fitting 6.

5 9. Equipment according to claim 5, characterised in that the pressure transducer (7) is a low air pressure transducer capable of recording the air transient passage in the stack (1) and the subsequent reflection received from each drain pipe (2, 12) of the drainage network and to transmit such information by means of electrical
10 signals to a central data acquisition system.

 10. Equipment according to claims 5 and 7, characterised in that the fitting (6) is provided with means securing the return of the three-port valve (22) to a failsafe position upon completion of a
15 testing or detection process which means that the apertures (24) return in line with the interior diameter of the stack (1) automatically after completion of the testing process.

 11. Equipment according to claims 5 and 6, characterised
20 in that the connection means (21) of the fitting (6) is closed off with a locking plug (25) when the transient generator (20) is removed, said locking plug (25) ensuring the failsafe position of the three-port valve (22).

25 12. Equipment according to claim 5, characterised in that the air transient generator (20) comprises a cylindrical body with an inner chamber (28), the air of which can be displaced by means of a piston (23) generating the air transient to be directed through the connection means (21) towards the interior space of the stack (1) and
30 the selected drainage network section.

 13. Equipment according to claim 12, characterised in that the piston (23) generating the air transient is moved according to a sine wave oscillation.