TERRAIN

TDMT1-TG | September 2011

Above Ground Drainage Systems

DUBAI MUNICIPALITY

Introduction

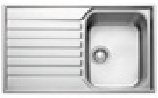
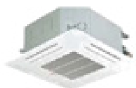
The requirement of a reliable and effective internal drainage system in today's developed world is expected and taken for granted.

The general perception of drainage systems is to remove human waste from a building with the least disruption and impact on our daily lives as possible. This perception is not completely wrong; however, the other main objective of a drainage system is to prevent foul odour ingress into the built environment and thus prevent the possibility of bacterial infection occurring.

The design of modern building drainage and ventilation systems has been developing since the 19th century to improve both the efficiency of the drainage systems and mitigate the escape of foul air into habitable areas.

We have become accustomed to using a variety of appliances, many of which require water to function and/or create waste water to facilitate our everyday lives.

A typical residential unit can require the collection and conveyance of waste water from:

Water Closets 	*Lavatory Basins* 	*Bath* 	*Showers* 	*Bidets* 
Kitchen Sinks 	*Dishwashers* 	*Washing Machines* 	*Wash down points* 	*Air Conditioning Units* 

The waste water from these appliances will be clean, contain detergents or be contaminated with harmful bacteria and pathogens.

General Drainage Considerations

In many of the developed areas of the world, national codes and standards have been developed to give guidance on the design and installation of drainage and ventilation pipework.

All the codes currently available are based on old research techniques and local best practices gained through experience. They all have the same common objective: to enable the Engineer to develop a practical design that will protect the drainage system's prime component, the water trap seal.

BS EN 12056-2:2000, Gravity drainage systems Inside buildings, has generally been used for as a basis for the information highlighted within this document.

To ensure that the waste water is collected and discharged out of the building safely, during both the design and installation processes, the following areas need to be considered:

Pipe sizing	*Ventilation system*
Pipework Materials	*Jointing*
Thermal Movement	*Gradients*
Access	*Pipework Testing*

1) Pipe sizing

Drainage systems have many types of appliances discharging into them. To help the engineer correctly design the drainage system, Discharge Units (DUs) and Drainage Fixture Units (DFUs) have been determined using probability distribution law to take into account the probability of use and discharge of individual appliances.

The total number of DUs required when incorporated into a mathematical formula will give an acceptable discharge flow rate that can be applied to a table to determine a suitable pipe size.

The total number of DFUs can be applied directly to a table to determine a suitable pipe size.

2) Ventilation system

All drainage pipework systems are full of air until an appliance is discharged; once this occurs, the air within the pipework fluctuates. These pressure fluctuations, if not balanced, can adversely affect the water trap seals; therefore, to limit pressure fluctuations, vent piping is traditionally employed.

3) Pipework Materials

There are a number of metallic and plastic materials that can be used for internal drainage systems. Each type of material has its own advantages and disadvantages. The material used should be appropriate for the drainage system being designed.

For example, the waste discharge from a number of appliances can discharge at a fairly high temperature due to human intervention or via a safety valve from a water heater. It is important to install pipework that will be able to collect and convey a high temperature discharge for a limited period of time.

Working temperatures of Terrain drainage pipework systems

82-160mm PVC-u, 76°C
30-50mm MuPVC, 80°C
Polypropylene traps 95°C

The above temperatures are based on a continuous flow; for MuPVC (Waste System) and Polypropylene (Traps), intermittent discharges of up to 100oC may occur, provided they are of less than two minutes.

4) Jointing

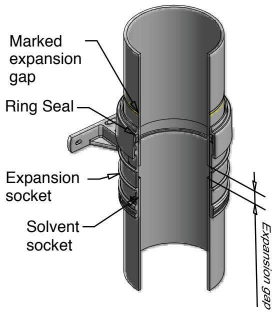
There are a number of ways that drainage pipework can be jointed, ranging from solvent welded connections, push fit, fusion welded and mechanical connections.

It is necessary to ensure that the jointing system adopted for the drainage system is suitable for the pipework material and the drainage system, along with the environmental conditions in which the pipework system is being installed.

5) Thermal Movement

All pipework materials will expand and contract with changes in temperature, both from ambient temperature and from the temperature of the waste discharge through the pipework.

The co-efficient of linear expansion of differing pipework materials will vary; however, the cumulative effects of thermal movement on an installed system can be considerable.



It is necessary to:

a) calculate the theoretical thermal movement distances to allow the pipework system to be designed to accommodate expansion, and

b) determine where the expansion joints are required and anchor these locations to the structure. The remaining pipework must be adequately supported and allowed to move.

6) Gradients

Any horizontal collector pipework should be designed and installed to the correct gradient and size to ensure that it is uniform, self-cleansing and efficiently carries away the maximum volume of matter which may be discharged into it.

The biggest problems occur when the collector pipework which has been designed and installed is too shallow.

7) Access

It is essential that adequate provision is made for the testing and maintenance of the above-ground drainage system. Suitable accessibility via access covers, plugs and caps should be provided to enable all traps, discharge pipes and stacks to be tested, cleaned and cleared of any obstructions as and when necessary.

Access points must be:

- air- and watertight
- quick and easy to remove
- fully accessible to facilitate cleansing.

Access points should be located:

- at the base of all soil and waste stacks above the spill-over level of the highest connection on a branch run, typically 1200mm above finished floor level
- at every change of direction, on vertical stacks and horizontal pipe runs
- at regular intervals on long horizontal runs, typically,
  - at 15m intervals on pipework up to110mm
  - at 24m intervals on pipework 160mm and above
- where more than 1 WC is connected to a branch.
- on all appliances, either via the trap or adjacent to the trap
- on multi-storey buildings at each floor level.

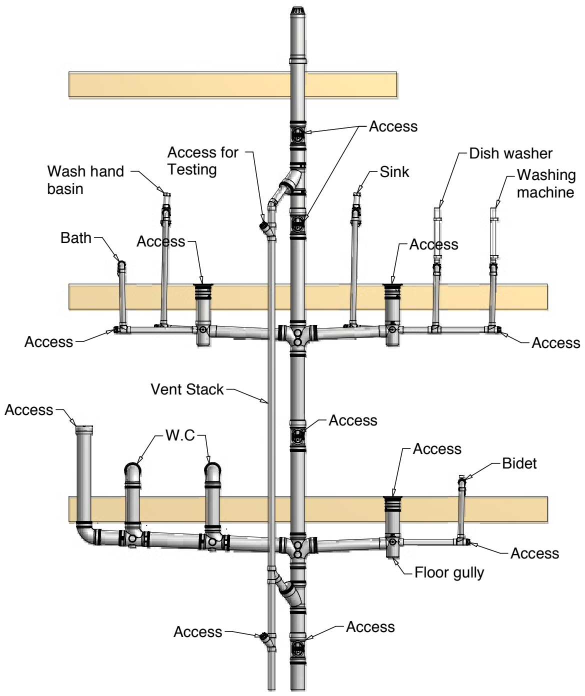
The size of the access point within a building should generally be the same size as the pipework, up to 160mm.

For larger pipework, 160mm access points should be adequate.

To summarize, a drainage system needs to be airtight and watertight; dirty water leaking or contaminated air entering into the built environment should be avoided at all costs.

- Leakages can be mitigated by ensuring that the product of choice is a robust engineered drainage system, fit for the purpose and installed correctly.
- Contaminated air within a habitable space can be prevented by ensuring that the drainage pipework system design is properly engineered to protect its prime function, the water trap seal.

To ensure that the pipework system is airtight and watertight the installation should be tested in accordance with the requirements of the local governing body and the code/standard that the system has been designed to.



Gravity Pipework Testing

Testing generally

(a) Inform the Main Contractor sufficiently in advance to give him a reasonable opportunity to observe tests.

(b) Check that all sections of installation are securely fixed and free from obstruction and debris.

(c) Ensure that all traps are filled with clean water.

(d) Carry out tests as specified. After testing, locate and remedy all defects without delay, and retest as instructed. Do not use smoke to trace leaks.

Keep a record of all tests and provide a copy of each to the Engineer.

The Installer is to allow for intermediate testing where work is to be concealed by other installations, final finishes and to suit phased handover of areas.

Initial Test

All internal pipework, and jointed external pipework, should be tested with air as soon as practicable after installation and before enclosing with shaft walls suspended ceilings, and so on.

Open ends of pipe should then be fitted with plugs, one of which must incorporate a tee-piece for connection to air pump and manometer Air should then be pumped until the manometer indicates the required pressure.

Pipes should then be tested by air pressure at 100mm wg (988PA), held constant for 5 minutes.

Final Test

On completion of installation and connection of all sanitary appliances, a further air test should then be carried out.

Pipes must be tested by air pressure at 38mm wg (375Pa), held constant for 3 minutes.

Test Certificate

A test certificate should be submitted following successful testing of the pipework (see following example). A water test may also be called for; this will only apply to horizontal runs of pipework and the section of pipework below the lowest sanitary appliance. The system should be filled up to the flood level of the lowest sanitary appliance or 6m head.

Example Test Certificate

Project Name:	....
	....
Name of Contractor/	....
Sub-Contractor	....
Section under Test:	....
	....
Nature of Test:	....
Air	....
Pressure	....
Duration	
Materials and installation in accordance with the specification:	Yes/No
Signatures for Contractor/ Sub-Contractor	....
Witness:	....
Date of Test:	....

Drainage Design Principles

The European Standard EN 12056-2, 2000 has the status of a British Standard.

Gravity drainage systems inside buildings.

The BS EN 12056 is made up of the following 5 parts:

Part 1: General and performance requirements

Part 2: Sanitary pipework, layout and calculation

Part 3: Roof drainage, layout and calculation

Part 4: Wastewater lifting plants, layout and calculation

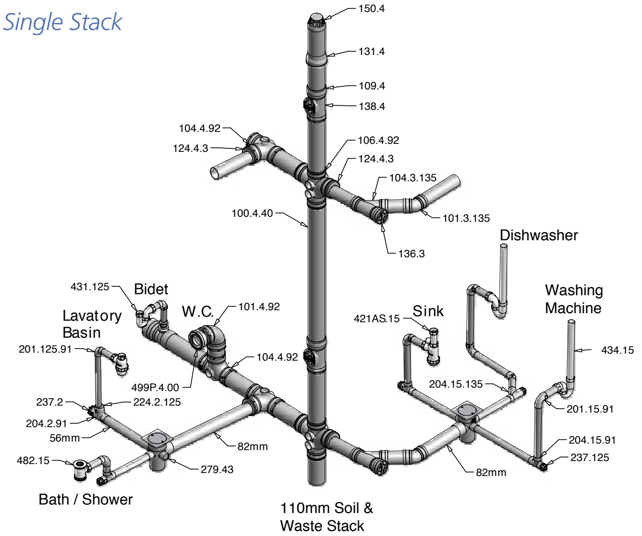
Part 5: Installation and testing instructions for operation, maintenance and use

Part 2 gives guidance on the minimum design requirements for internal building sanitary drainage systems.

The standard highlights four types of drainage system:

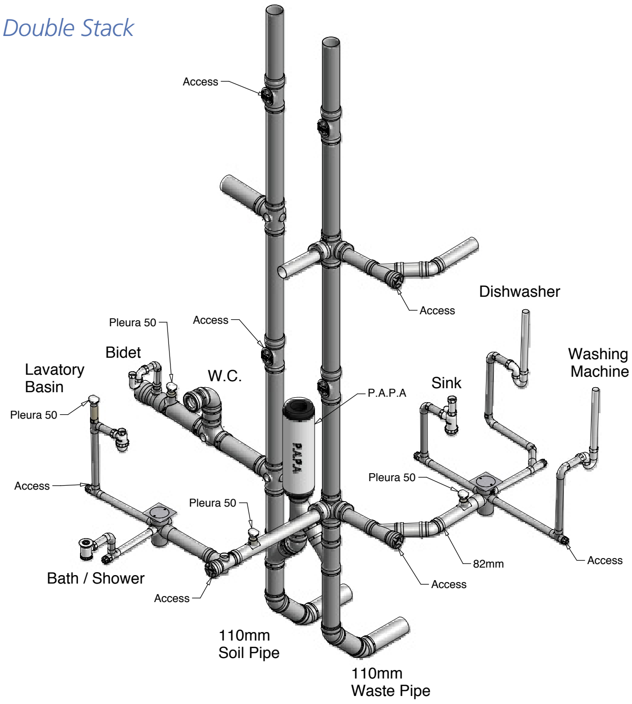
1. **Single stack system with partly filled branch discharge pipes**
   - Sanitary appliances connected to partly filled branch discharge pipes are designed with a filling degree of 0.5 (50%) and are connected to a single discharge stack.
2. **Single discharge stack with small bore discharge branch pipes**
   - Sanitary appliances are connected to small discharge pipes. The small bore discharge pipes are designed with a filling degree of 0.7 (70%) and are connected to a single discharge stack.
3. **Single stack system with full bore branch discharge pipes**
   - Sanitary appliances are connected to full bore discharge pipes. The full bore branch discharge pipes are designed with a filling degree of 1.0 (100%) and each branch discharge pipe is separately connected to a single discharge stack.

Single Stack



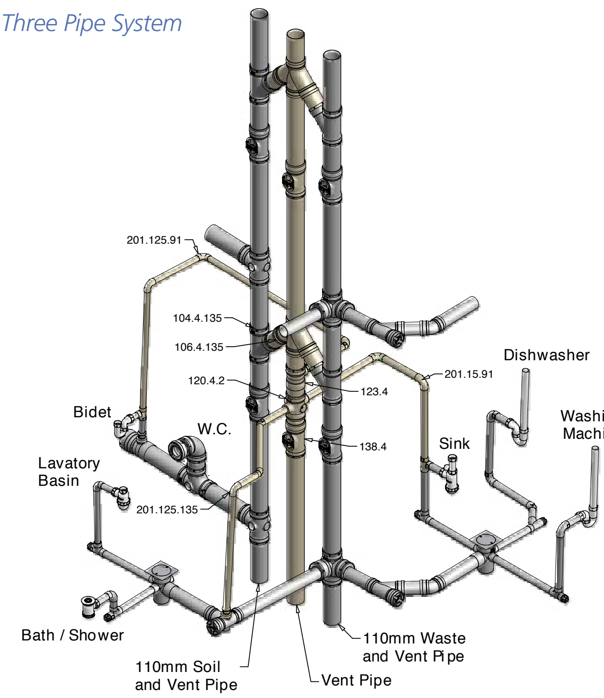
4. **Separate discharge stack system**
   - Drainage systems type I, II and III may also be divided into black water stack serving WCs and urinals, and a grey water stack serving other …
   - Appliances

Double Stack



To limit air pressure fluctuations in a discharge system, ventilation pipework is traditionally employed; this is based on best practice experience to restrict the pressure fluctuations to +/- 375 N/m2. This equates to approximately a 25mm seal loss.

Three Pipe System



Traditionally, to overcome air pressure fluctuations, Drainage Engineers have designed systems to incorporate additional stack and branch ventilation pipework.

When designing a drainage system it is necessary to consider local / regional design requirements that have developed through good practice experience to suit the type of buildings being developed, and incorporate climatic and cultural needs.

1) Types of fittings to be used:

Suction (negative pressure [–ve]) is produced in the discharge stack; its magnitude is affected by the radius or slope of the branch inlet.

A large radius (swept) or 45º entry will minimize the amount of suction; square entry connections will have the opposite effect.

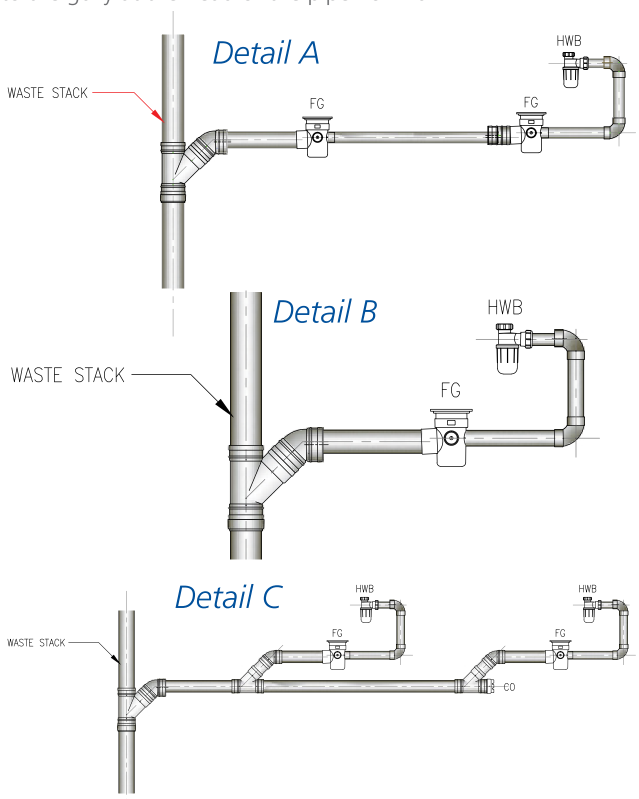
The type of fittings to be installed need to be considered very early on in the design as they can have an effect on the sizing requirements of the system.

Floor Gullies

Due to local customs, floor gullies are a major component of the drainage system within the Middle East region.

The floor gullies are installed at the head of branch drains which connect directly to the main waste / foul stacks; if the trap within the gully is not kept fully charged with water then foul air will enter the built environment.

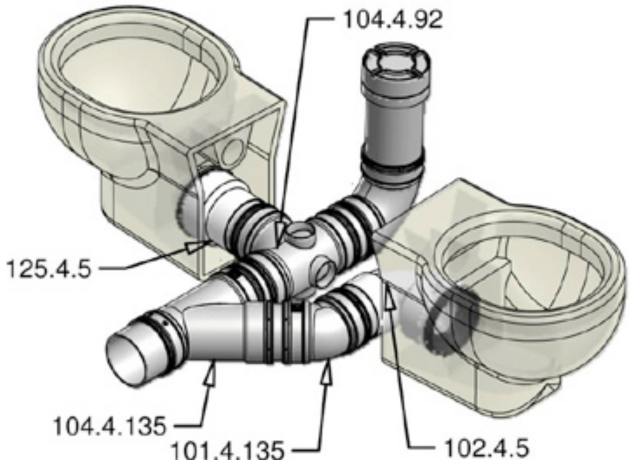
Generally, floor gullies are located at the head of a branch drain; therefore access should be provided through the gully or adjacent to the gully at the head of the pipework run.



It is not permitted to make a direct connection from one floor gully to another floor gully, (detail A). Gullies should connect either direct to a stack (detail B) or discharge separately into a branch drain (detail C).

2) Crossflow

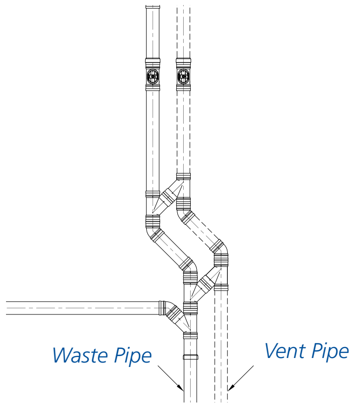
A number of rules apply to prevent the discharge from one branch connection into a directly opposed branch connection. No connection zones are illustrated in section ND.3.3.3 of the standard.



3) Offsets

Sections NC 2.4 and ND 3.5.4 of the standard give guidelines on the use of offsets in the drainage stack.

Offsets in the wet portion of a stack should be avoided. If offsets are to be introduced, large radius bends should be used; venting should be provided above and below the offset.



4) Traps

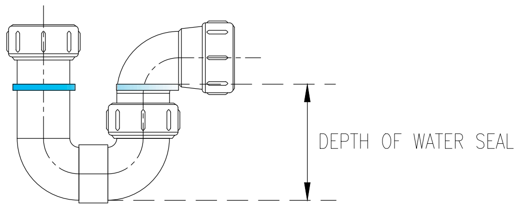
Traps should be designed to ensure that

- deposits do not accumulate
- they are fully accessible, and capable of being removed / dismantled
- they are attached immediately beneath its outlet, or as close as possible
- there is no reduction in cross-sectional area
- they are self-cleansing
- there is no more than one trap on the discharge pipe work from any appliance.

Minimum depth of trap seals

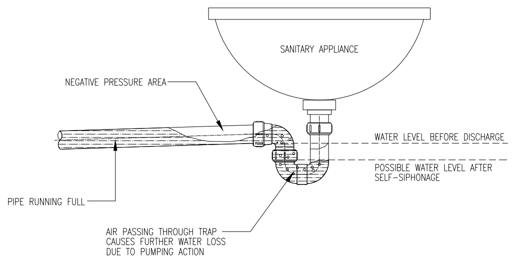
- 75mm – WHB, SINK, BIDETS, URINAL, WM, DW
- 50mm – SHOWER, BATH, FLOOR GULLY, WC

A minimum 50mm of water is all that protects the built environment from potentially harmful sewer gases "and particulates". Therefore a competent designer must consider this trap seal and protect it from being compromised.



Trap seals can fail due to one or more of the following reasons:

Self siphonage is generally a problem for wash basins only. It is caused by the pipe work running at full bore, causing negative pressure in the pipework, and resulting in the trap being pulled.



Induced siphonage is a common problem when more than one appliance is connected to a branch waste pipe. When one appliance is discharged full bore it creates negative air pressure which can cause suction on the other appliance, resulting in the trap being siphoned.

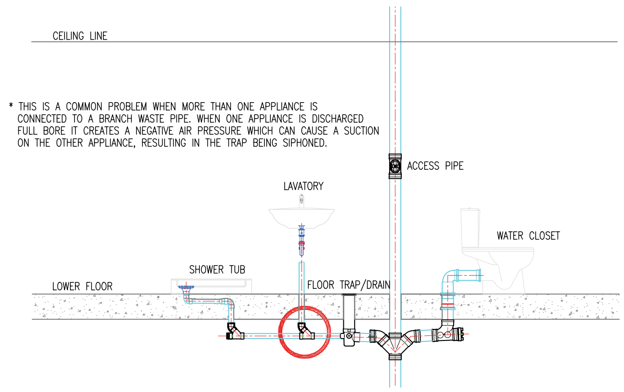


Table 6 and table 9 from BS EN 12056-2 2000 detail the standard detail the minimum requirements for branch discharge pipework for primary vent and secondary vent pipework systems.

Table 6, BS EN 12056-2 – Branch discharge with primary vent (System III)

Appliance	Dia. DN	Min. trap seal depth (mm)	Max. length (L) of pipe from trap outlet to stack (m)	Pipe gradient	Max. no. of bends	Max. drop (H) (m)
Limitations for unventilated branch discharge pipes, system III						
Washbasin, bidet (30mm diameter trap)	30	75	1.7	2.2[1)]	0	0
Washbasin, bidet (30mm diameter trap)	30	75	1.1	4.4[1)]	0	0
Washbasin, bidet (30mm diameter trap)	30	75	0.7	8.7[1)]	0	0
Washbasin, bidet (30mm diameter trap)	40	75	3.0	1.8 to 4.4	2	0
Shower, bath	40	50	No Limit[2)]	1.8 to 9.0	No Limit	1.5
Bowl urinal	40	75	3.0[3)]	1.8 to 9.0	No Limit[4)]	1.5
Trough urinal	50	75	3.0[3)]	1.8 to 9.0	No Limit[4)]	1.5
Slab urinal[3)]	60	50	3.0[3)]	1.8 to 9.0	No Limit[4)]	1.5
Kitchen sink (40mm diameter trap)	40	75	No Limit[2)]	1.8 to 9.0	No Limit	1.5
Household dishwasher or washing machine	40	75	3.0	1.8 to 4.4	No Limit	1.5
WC with outlet up to 80mm[6)]	75	50	No Limit	1.8 min	No Limit[4)]	1.5
WC with outlet greater than 80mm[6)]	100	50	No Limit	1.8 min	No Limit[4)]	1.5
Food waste disposal[7)]	40 min	75[8)]	3.0[3)]	13.5 min	No Limit[4)]	1.5
Sanitary towel disposal unit	40 min	75[8)]	3.0[3)]	5.4 min	No Limit[4)]	1.5
Floor drain	50	50	No Limit[3)]	1.8 min	No Limit	1.5
Floor drain	50	50	No Limit[3)]	1.8 min	No Limit	1.5
Floor drain	100	50	No Limit[3)]	1.8 min	No Limit	1.5
4 basins	50	75	4.0	1.8 to 4.4	0	0
Bowl urinals[3)]	50	75	No Limit[3)]	1.8 to 1.9	No Limit[4)]	1.5
Maximum of 8 WC's[6)]	100	50	15.0	0.9 to 9.0	2	1.5
Up to 5 spray tap basins[9)]	30 max	50	4.5[3)]	1.8 to 4.4	No Limit[4)]	0

Table 9, BS EN 12056-2 – Branch discharge with secondary vent (System III)

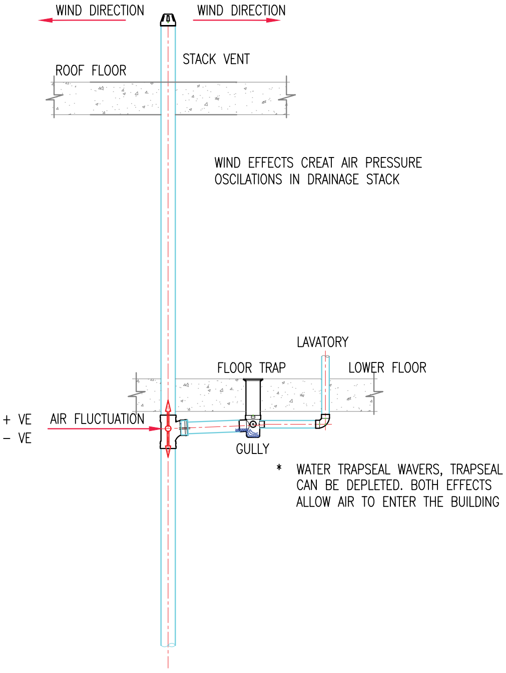
Appliance	Dia. DN	Min.trap seal depth mm	Max. length (L) of pipe from trap outlet to stack m	Pipe gradient	Max. no. of bends	Max. drop (H) m
Limitations for unventilated branch discharge pipes, system III						
Washbasin, bidet (30mm diameter trap)	30	75	3.0	1.8 min	2	3.0
Washbasin, bidet (30mm diameter trap)	40	75	3.0	1.8 min	No Limit	0
Shower, bath	40	50	No Limit[2)]	1.8 min	No Limit	No Limit
Bowl urinal	40	75	3.0[3)]	1.8 min	No Limit[4)]	3.0
Trough urinal	50	75	3.0[3)]	1.8 min	No Limit[4)]	3.0
Slab urinal[3)]	60	50	3.0[3)]	1.8 min	No Limit[4)]	3.0
Kitchen sink (40mm diameter trap)	40	75	No Limit[2)]	1.8 min	No Limit	No Limit
Household dishwasher or washing machine	40	75	No Limit[3)]	1.8 min	No Limit	No Limit
WC with outlet up to 80mm[6) & 14)]	75	50	No Limit	1.8 min	No Limit[4)]	1.5
WC with outlet greater than 80mm[6) & 14)]	100	50	No Limit	1.8 min	No Limit[4)]	1.5
Food waste disposal[7)]	40 min	75[8)]	3.0[3)]	13.5 min	No Limit[4)]	3.0
Sanitary towel disposal unit	40 min	75[8)]	3.0[3)]	5.4 min	No Limit[4)]	3.0
Bath drain, floor drain	50	50	No Limit[3)]	1.8 min	No Limit	No Limit
Floor drain	70	50	No Limit[3)]	1.8 min	No Limit	No Limit
Floor drain	100	50	No Limit[3)]	1.8 min	No Limit	No Limit
5 basins[9)]	50	75	7.0	1.8 to 4.4	[2)]	0
10 basins[9) & 10)]	50	75	10.0	1.8 to 1.9	No Limit	0
Bowl urinals[9) & 11)]	50	70	No Limit[3)]	1.8 min	No Limit[4)]	No Limit
More than 8 WC's[6)]	100	50	No Limit	0.9 min	No Limit	No Limit
Up to 5 spray tap basins[9)]	30 max	50	No Limit[3)]	1.8 to 4.4	No Limit[4)]	0

The Dubai Municipality standard notes for building drainage require separate ventilation for individual appliances that are located more than 1.5 metres from the receiving soil/waste stack or in accordance with BS EN 12056:2000, Part2 table 6 and table 9.

Evaporation of traps occurs with infrequent use of the appliance / gully; this can lead to the total loss of the trap seal.

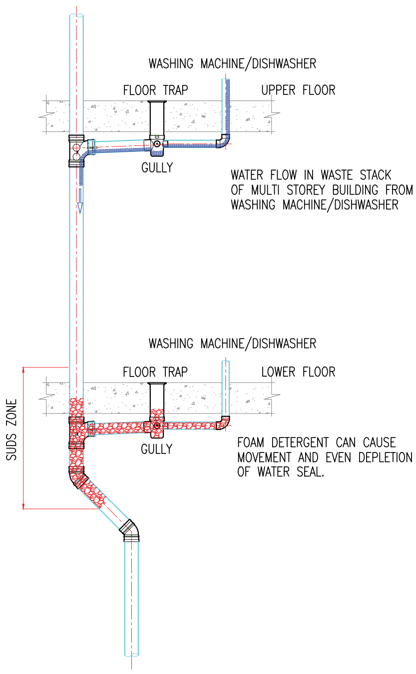
A/C systems provide dry air at varying velocities, making open grated gullies and appliance traps susceptible as the air will suck up any moisture and compromise the trap seal.

Changes in stack / waste pipework direction can cause foaming of detergents and consequent pressure fluctuation.



Wind blowing across roofs can produce pressure fluctuations in the vicinity of parapets and corners of the building, creating pressure fluctuations within discharge and ventilation stacks.

If practicable extend the vent pipe 2 metres above the roof and terminate the pipework with a vent cowl.

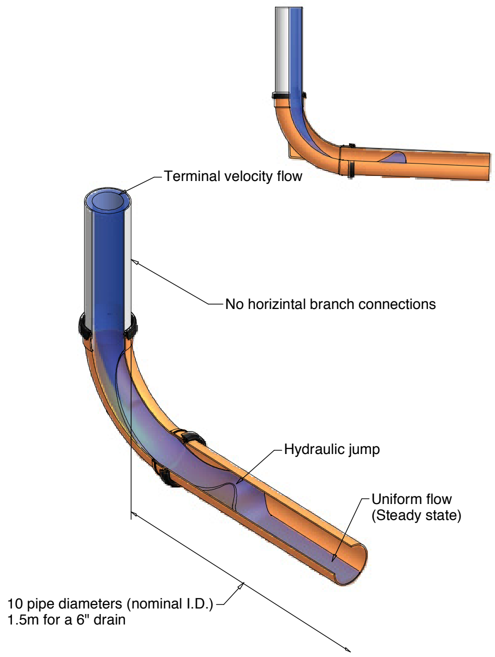


5) Base of stack design considerations

As the waste water discharge in a drainage stack reaches the base of the stack, it will need to change direction to flow horizontally into either a high level collector drain or into the below ground drainage system.

The flow velocity in the horizontal drainage pipework will be controlled by the installed gradient and pipe diameter; this will be significantly less than the velocity of the vertical drainage stack.

At the base of the drainage stack the waste water discharge undergoes a rapid de-acceleration in velocity, creating an increase in the depth of the flow at the change of direction. This increase in depth is generally sufficient to fill the cross sectional area of the pipe.

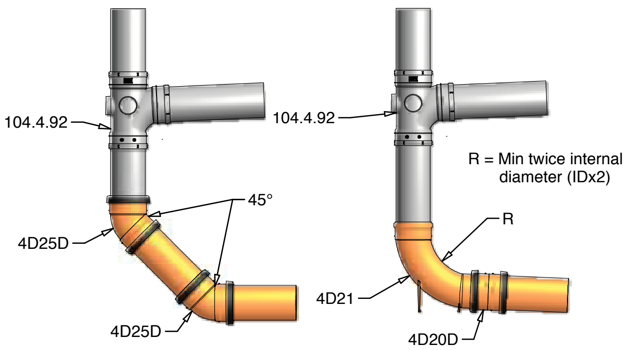


This phenomenon is known as the "hydraulic jump". The distance at which the hydraulic jump occurs varies from immediately at the stack change of direction up to ten times the diameter of the stack downstream.

This is dependent upon:

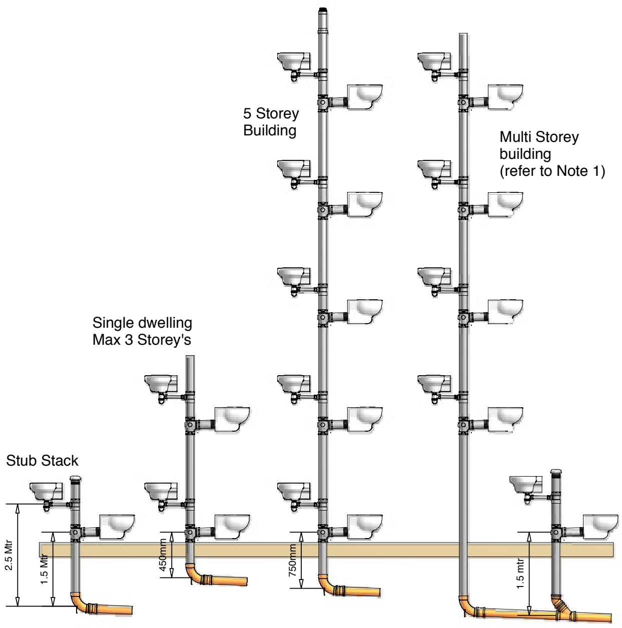
- entrance velocity
- depth of water that may already exist within the horizontal drainage pipe
- roughness co-efficient of the pipe
- pipe diameter
- pipe gradient
- bend formation at the base of the stack

Prefered Installation *AlternativeInstallation*



The surged flow condition will extend until the frictional resistance of the pipe reduces the velocity to the designed flow condition.

To mitigate the air fluctuation problems associated at the base of the drainage stack, section ND 3.5.2 of the standard recommends that the following design details be incorporated:



- For buildings over 5 storeys high, connect the ground floor separately.
- For buildings over 20 storeys high, connect both the ground and first floor separately.

Pipework Sizing

BS EN 12056-2:2000 utilizes the discharge Unit method for calculating gravity drainage systems.

This provides a probability based on the evaluation of the probable system loading.

To date, all national guides are based on probability evaluations that allow Steady State Flow (continuous flow) calculations to be made.

Based on these calculations, national codes limit the water flow rates to ensure that a maximum negative pressure is maintained within the system.

There are a number of items a designer needs to know before attempting to size the drainage system for a building:

- Building Height (assuming it has been finalised)
- Building Use (assuming it has been finalised)
- Number of Appliances (assuming it has been finalised)
- Discharge Units
- Typical Frequency
- Venting System

The building height, use and number of appliances can be determined from the architectural building sections and general layouts.

The discharge units, typical frequency and venting system need to be developed and calculated by the Drainage Engineer.

Discharge Units are common to most appliances and have been determined mathematically to take into account the probability of use and discharge of individual appliances. The total number of discharge units can be used in a mathematical formula to determine an acceptable flow rate.

Appliance	System III DU l/s
Wash basin, bidet	0.3
Shower without plug	0.4
Shower with plug	1.3
Single urinal with cistern	0.4
Urinal with flushing valve	-
Slab urinal	0.2*
Bath	1.3
Kitchen sink	1.3
Dishwasher (household)	0.2
Washing machine up to 6kg	0.6
Washing machine up to 12Kg	1.2
WC with 4.0L cistern	**
WC with 6.0L cistern	1.2 to 1.7***
WC with 7.5L cistern	1.4 to 1.8***
WC with 9.0L cistern	1.6 to 2.0***
Floor gully DN 50	0.3
Floor gully DN 70	1.0
Floor gully DN 100	1.3

NB: Figures for the Floor Gully are available (system IV figures would generally be used)

The frequency factor is a variable should be used when determining the pipework system flow rate based on the frequency of use of sanitary appliances for different building functions.

Table 3, BS EN 12056

Usage of appliances	K
Intermittent use, e.g. in dwelling, guest-house, office	0.5
Frequent use, e.g. in hospital, school, restaurant, hotel	0.7
Congestred use, e.g. in toilets and/or show-ers open to public	1.0
Special use, e.g. laboratory	1.2

Calculating the flow rate

Qww = is the expected flow rate of waste water in part or in the whole drainage system.

EXAMPLE

20-storey building with two lower floors discharged separately

- *2 WC* *2 x 1.5 = 3.0*
- *4 WHB* *4 x 0.3 = 1.2*
- *2 Bath* *2 x 1.3 = 2.6*
- *2 Sink* *2 x 1.3 = 2.6*
- *2W/mc* *2 x 0.6 = 1.2*

***= 10.6** DUs/floor*

10.6 x 18 floors = 190.8 DUs/floor

Based on a frequency of use of K, 0.7 the following flow rate calculation can be determined:

$0.7\sqrt{190.8}$

Qww = 9.67l/s

Stacks should not flow at more than 0.25% to 0.33% full to ensure that a maximum negative pressure is maintained within the system.

Based on the calculated flow rate of 9.67l/s, the vertical stack can be sized using either Table 11 or table 12 from BS EN 12056-2.

Table 11, BS EN 12056: Stack with primary venting

Stack & Stack Vent	System I, II, III, IV Q max (L/s)	
DN	Square # entries	Swept entries
60	0.5	0.7
70	1.5	2.0
80*	2.0	2.6
90*	2.7	3.5
100**	4.0	5.2
125	5.8	7.6
150	9.5	12.4
200	16.0	21.0

Table 12, BS EN 12056: Stack with secondary venting

Stack & Stack Vent	Secondary Vent	System I, II, III, IV Q max (L/s)	
DN	DN	Square # entries	Swept entries
60	50	0.7	0.9
70	50	2.0	2.6
80*	50	2.6	3.4
90*	50	3.5	4.6
100**	50	5.6	7.3
125	70	7.6	10.0
150	80	12.4	18.3
200	100	21.0	27.3

It is important to take into account local requirements that are based on experience, Dubai Municipality have recommended the following minimum stack sizes for buildings greater than 7 storeys'.

Soil Pipe	150mm
Waste Pipe	150mm
Vent Pipe	100mm

Sizing of branch pipes and low gradient collector pipework

The standard gives guidance on the minimum sizes for branch pipework from individual appliances.

- 32mm - wash basin, bidet, drinking fountain
- 40mm - sink, bath, shower, urinal, sanitary towel macerator
- 50mm - food waste disposal unit, floor drain
- 100mm - WC

When calculating the size of the low gradient collector pipework it is necessary to add the discharge units from the stacks discharging into the pipework system and not the calculated flow rates determined to size the individual stacks.

The depth of flow in the collector pipe should not be more than 70% full to ensure that there is a free flow of air through the system. The low gradient pipework should be installed to a fall that promotes a self-cleansing velocity for the size of pipe chosen.

There is a relationship between the pipe diameter, flow rate, velocity and gradient which can be mathematically calculated or determined from Table B1 and Table B2 'Capacity of Drains' from BS EN 12056-2 2000.

Table B.1 - Capacity of drains, filling degree 50%, (h/d = 0,5)

Slope i cm/m	DN Qmax L/s	100 v m/s	DN Qmax L/s	125 v m/s	DN Qmax L/s	150 v m/s	DN Qmax L/s	200 v m/s	DN Qmax L/s	225 v m/s	DN Qmax L/s	250 v m/s	DN Qmax L/s	300 v m/s
0,50	1,8	0,5	2,8	0,5	5,4	0,6	10,0	0,8	15,9	0,8	18,9	0,9	34,1	1,0
1,00	2,5	0,7	4,1	0,8	7,7	0,9	14,2	1,1	22,5	1,2	26,9	1,2	48,3	1,4
1,50	3,1	0,8	5,0	1,0	9,4	1,1	17,4	1,3	27,6	1,5	32,9	1,5	59,2	1,8
2,00	3,5	1,0	5,7	1,1	10,9	1,3	20,1	1,5	31,9	1,7	38,1	1,8	68,4	2,0
2,50	4,0	1,1	6,4	1,2	12,2	1,5	22,5	1,7	35,7	1,9	42,6	2,0	76,6	2,3
3,00	4,4	1,2	7,1	1,4	13,3	1,6	24,7	1,9	39,2	2,1	46,7	2,2	83,9	2,5
3,50	4,7	1,3	7,6	1,5	14,4	1,7	26,6	2,0	42,3	2,2	50,4	2,3	90,7	2,7
4,00	5,0	1,4	8,2	1,6	15,4	1,8	28,5	2,1	45,2	2,4	53,9	2,5	96,9	2,9
4,50	5,3	1,5	8,7	1,7	16,3	2,0	30,2	2,3	48,0	2,5	57,2	2,7	102,8	3,1
5,00	5,6	1,6	9,1	1,8	17,2	2,1	31,9	2,4	50,6	2,7	60,3	2,8	108,4	3,2

Table B.2 – Capacity of drains, filling degree 70%, (h/d = 0,7)

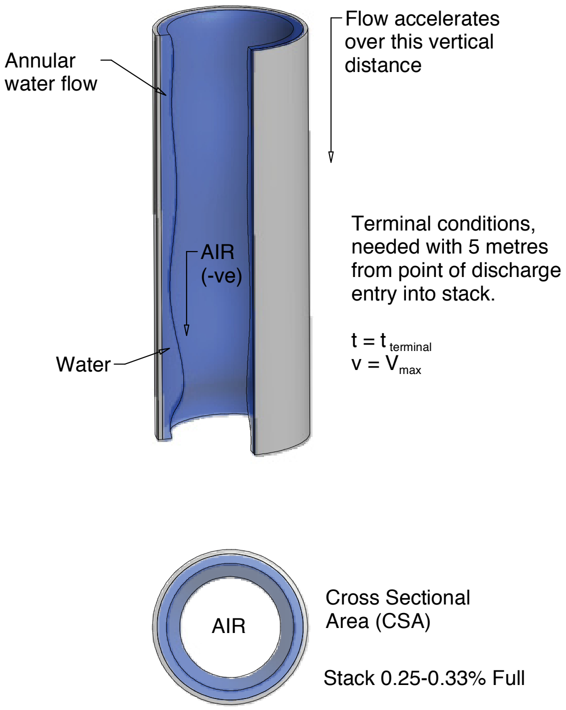
Slope i cm/m	DN Qmax L/s	100 v m/s	DN Qmax L/s	125 v m/s	DN Qmax L/s	150 v m/s	DN Qmax L/s	200 v m/s	DN Qmax L/s	225 v m/s	DN Qmax L/s	250 v m/s	DN Qmax L/s	300 v m/s
0,50	2,9	0,5	4,8	0,6	9,0	0,7	16,7	0,8	26,5	0,9	31,6	1,0	56,8	1,1
1,00	4,2	0,8	6,8	0,9	12,8	1,0	23,7	1,2	37,6	1,3	44,9	1,4	80,6	1,6
1,50	5,1	1,0	8,3	1,1	15,7	1,3	29,1	1,5	46,2	1,6	55,0	1,7	98,8	2,0
2,00	5,9	1,1	9,6	1,2	18,2	1,5	33,6	1,7	53,3	1,9	63,6	2,0	114,2	2,3
2,50	6,7	1,2	10,8	1,4	20,3	1,6	37,6	1,9	59,7	2,1	71,1	2,2	127,7	2,6
3,00	7,3	1,3	11,8	1,5	22,3	1,8	41,2	2,1	65,4	2,3	77,9	2,4	140,0	2,8
3,50	7,9	1,5	12,8	1,6	24,1	1,9	44,5	2,2	70,6	2,5	84,2	2,6	151,2	3,0
4,00	8,4	1,6	13,7	1,8	25,8	2,1	47,6	2,4	75,5	2,7	90,0	2,8	161,7	3,2
4,50	8,9	1,7	14,5	1,9	27,3	2,2	50,5	2,5	80,1	2,8	95,5	3,0	171,5	3,4
5,00	9,4	1,7	15,3	2,0	28,8	2,3	53,3	2,7	84,5	3,0	100,7	3,1	180,8	3,6

Air Dynamics

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.



On entering the drainage stack, the waste water accelerates downwards by the force of gravity at 9.81 m/s2.

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 (plug) across the pipe for short periods.

Large pressure fluctuations can be created as a result of the movement of the plugs. This is one of the factors governing the number of appliances that can be connected to a stack of a given size (refer to table 11, stack with primary venting, and table 12, stack with secondary venting).

Solids tend to fall down the centre of the pipe and are discharged very rapidly.

Pipes are designed to run at a maximum of 33% full to restrict the negative and positive air pressure fluctuations to +/-375/N/m2 (+/-375pa or +/-37.5mm/wg).

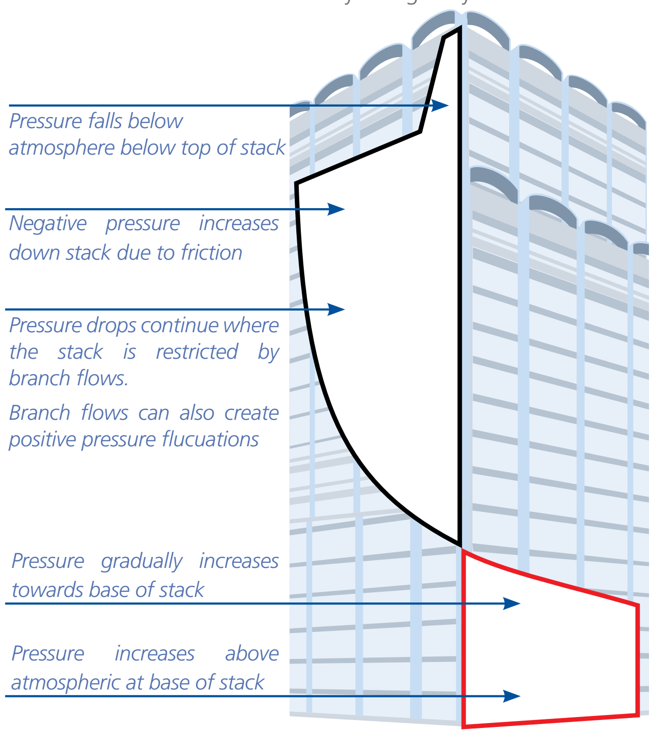
The acceleration of the annular flow continues until the frictional force exerted by the internal wall of the drainage stack equals the force of gravity; this is known as the maximum velocity and is termed terminal velocity. The distance required to reach terminal velocity is known as "terminal length".

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-storey stack is insignificantly greater than the velocity at the base of a 3-storey stack. *Therefore waste water will reach terminal velocity if it enters any stack above 5 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 the height of this stack is greater than 5 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.

When designing a drainage system for high-rise towers, it is essential that we manage the positive and the negative pressures that can be created due to velocity and gravity.



Typical Pressure Profile in a Multi-Storey Building

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 a 100-storey apartment block.
- Control the +ve and –ve air pressure fluctuations caused by terminal velocity.
- Control –ve pressure by introducing air at the point of need.
- Control +ve pressure by dissipating or attenuating the pressure at the point of need.
- The flow of air within the drainage pipework system is equally as important as the flow of water to maintain a safe and hygienic drainage system.

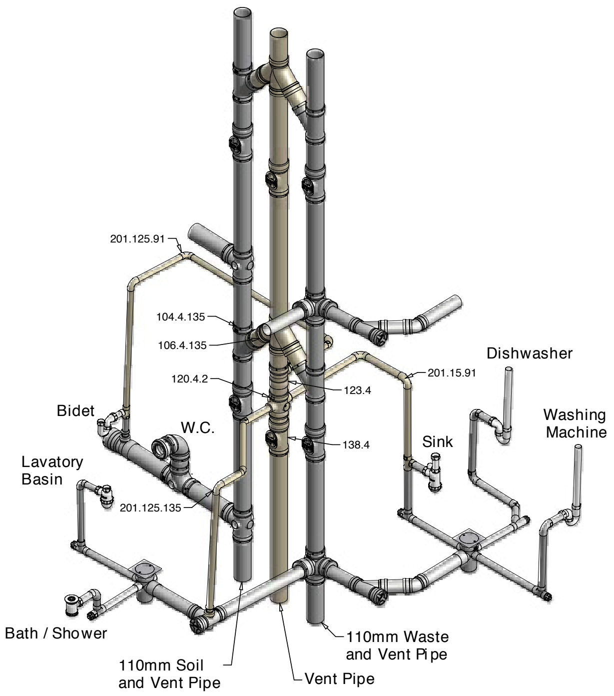
Air Fluctuations

- Negative pressure fluctuations are low amplitude, high-speed air pressure waves and can reduce the local ambient pressure in drainage pipework below 500Pa.
- Typically positive air fluctuations are low amplitude, high-speed air pressure waves and can travel up to 320m/s within a drainage stack.

Secondary Venting

Traditionally the installation of a secondary ventilation stack and branch pipework system has been incorporated into drainage design and installations to overcome air fluctuations.

Secondary ventilation pipework is costly to install and, more importantly, can be an inefficient solution, as the time lag to communicate an increase or decrease in the ambient pipework air-flow may result in an unsafe drainage pipework system.



BS EN 12056-2:2000 gives guidance on the minimum size of vent pipework to be utilized in a drainage system, based on a maximum designed flow rate for a particular sized drainage pipe, refer to table 6 and table9 for branch pipework and table 12 for drainage stacks with secondary venting.

Single stack drainage systems for high rise buildings

Research

Studies to date have been based on Steady State Flow (constant flow) and deal with negative pressure. This is how all national codes have developed, typically based on 15-20-storey stacks.

Drainage systems are non Steady State systems; discharges are totally random.

A soil or waste stack is only in a steady state when it is at rest; the flow of fluid within the system constantly changes with time; drainage systems are therefore in an unsteady (transient) state.

Pioneering research is being carried out at Herriot Watt University, Edinburgh, Scotland in association with **STUDOR**®.

Research is based on transient state flow of fluid in drainage systems for buildings up to and beyond 50 storeys.

Water flows over 2l/s can entrain 8-15 times more air than water volume which can create air fluctuations in excess of 500Pa (50mm wg, minimum size of trap).

This research has shown that in high-rise buildings air fluctuations are continually oscillating between positive and negative while the system is in use.

To maintain a state of equilibrium in a drainage pipework system it is necessary to respond to an increase or decrease in air pressure. This response time is critical in protecting trap water seals.

D1 Tower, Dubai, UAE

Studor valves and P.A.P.A. are installed in D1 Tower, an 80 floor Luxury residential building, providing a simplified, but efficient drainage ventilation system.

The Terrain Pleura range is an alternative ventilation system offering a unique solution for high-rise buildings.

The range consists of Pleura 50 and Pleura 100 valves and a Positive Air Pressure Attenuator, P.A.P.A.™ unit.

- The Pleura valves allow air to enter the drainage at the Point of Need (PoN), when negative pressures are created.
- The valves open before -75pa and will balance the internal air pressure between 0-250pa.
- BS EN 12056 test at 380pa/38mmwg.

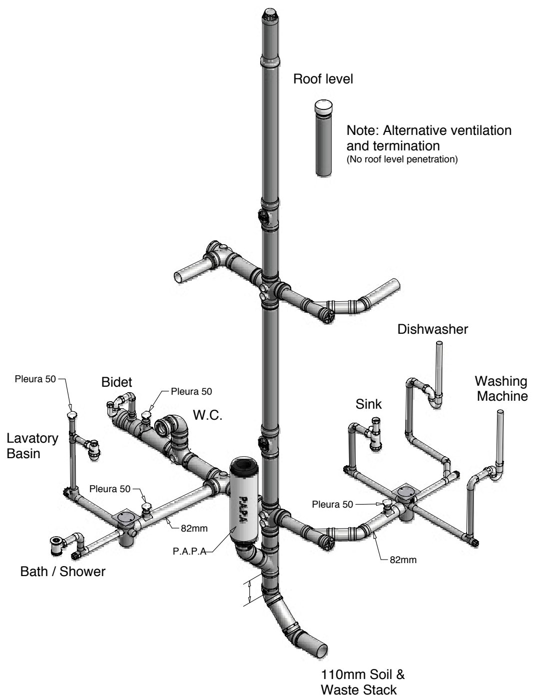
The P.A.P.A. has been designed to accommodate positive air pressure fluctuations.

- Working like a bladder the P.A.P.A. can react in 0.2 seconds to attenuate low amplitude, high-speed air pressure waves.
- As the internal air pressure begins to balance, the P.A.P.A. will release air back into the system at 12m/s.
- The P.A.P.A acts like a water hammer arrester, only for air.

The Terrain Pleura range provides a plumbing ventilation solution that improves the balance of positive and negative air pressures that are generated within the pipework system. This in turn mitigates loss of trap seals, a major symptom of unbalanced air pressures.

The Terrain Pleura valves and P.A.P.A. replace extensive vent piping, resulting in:

- a considerable reduction in pipework
- reduced labour costs associated with installation and time
- fewer spatial requirements within risers
- less risk to Public Health with an engineered system
- performance benefits due to improved ambient air pressures
- major cost savings.



Pleura valves sizing Guidelines

BS 12056-2:2000

Air valves for branches (6.4.3)

- Where Pleura valves are used to vent branches or appliances, they must comply with Table 10. For system III the required air (Qa) is 2 x the total calculated flow (Qtot).
- For system IV (two-pipe system) the required air is 1 x the total calculated flow.

Example

- *2 WC* *2 x 1.5 = 3.0*
- *2 WHB* *2 x 0.3 = 0.6*
- *1 Bath* *1 x 1.3 = 1.3*

= 4.9 DUs

Frequency factor (k) for Residential = 0.7

0.7√4.9 = 1.55l/s (Qtot)

1.55 l/s x 2 = 3.1L/s of air required (Qa)

Air valves for drainage stacks (6.5.3)

Where Pleura valves are used to ventilate stacks they must comply with Table 10

Example

40-Storey Building

- *4 WC* *4 x 1.5 = 6.0*
- *2 WHB* *2 x 0.3 = 0.6*
- *2 Bath* *2 x 1.3 = 2.6*
- *2 Shower* *2 x 0.4 = 0.8*
- *2 Sink* *2 x 1.3 = 2.6*
- *2 W/mc* *2 x 0.6 = 1.2*

= 13.8 x 36

= 496.8 DUs

Frequency factor (k) for Residential = 0.7

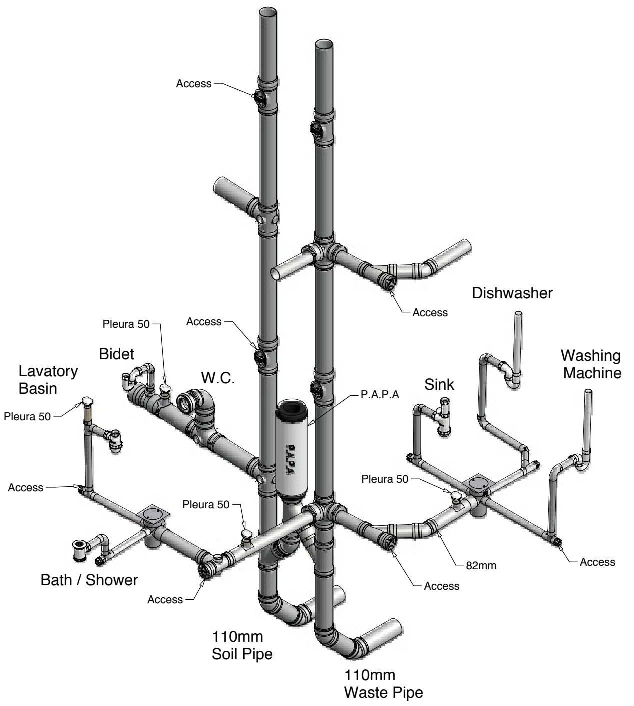
0.7√496.8 = 15.6 l/s (Qtot)

15.6 l/s x 8 = 124.8 L/s of air required (Qa)

The Terrain Pleura valves utilize active air pressure control, allowing the air to enter the drainage pipework system at the point of need.

- Terrain Pleura 100 Air flow capacity, 32 l/s
- Terrain Pleura 50 Air flow capacity, 5.7 l/s
- The Terrain P.A.P.A. (Positive Air Pressure Attenuator) mitigates the problems of positive pressures (transients, back pressure) within drainage systems of multi-storey developments.
- Terrain P.A.P.A. volume capacity, 3.785 litres

The Terrain Pleura range of products are non-mechanical devices and do not require maintenance. When installed with the Terrain drainage system the products are guaranteed for the lifetime of the pipework system.



The advantages

- The Terrain Pleura range, when installed with the Terrain above-ground drainage pipework system, provides an alternative drainage ventilation solution to mitigate the loss of water trap seals.
- Incorporated as an alternative solution to venting individual appliances that are located more than 1.5m from the receiving stack.
- Can be used as an alternative solution to venting individual appliances that are located more than 1.5m from the receiving stack
- Air enters the drainage pipework system at the point of need to quickly balance air pressure fluctuations.
- The range can be retro-fitted into an existing drainage system to solve problems.
- The Terrain Pleura range is guaranteed for lifetime equivalent to that of the drainage system in which it is installed.
- The complete system can achieve significant cost savings through a reduction in material requirements and reduced installation times.

Terrain Technical Support & Documentation

- Specification Documents
- Technical Bulletins
- CAD Product Details
- Technical Guides
- Product Literature
- On-site 'tool box' training with installers to support specification compliance

Polypipe Gulf FZ LLC

Dubai Media City
Loft Office No. 03
Entrance A, 4th Floor
Office no. 404
P.O. Box 502320, Dubai
United Arab Emirates
Tel: +971 (0)4 454 8328
Fax: +971 (0)4 454 2949

international@polypipe.com
www.polypipegulf.com

Polypipe Terrain

New Hythe Business Park
College Road
Aylesford
Kent
ME20 7PJ
United Kingdom
Tel: +44 (0)1622 795200
Fax: +44 (0)1622 716796

commercialenquiries@polypipe.com
www.terraindrainage.com