ABCB

PRELIMINARY IMPACT ANALYSIS

PROPOSAL:

To amend Sections 6.10 Air Admittance Valves (AAVs) and 6.11 Pressure Attenuators of AS/NZS 3500 Part 2; 2018

NCC REFERENCE: For revisions or amendments to existing National Construction Code (NCC) referenced documents, provide additional information	**Volume One:**	N/A
	Volume Two:	N/A
	Volume Three:	C1.3, CV2.2, C2.3 and C2.4

PROPONENT:	Nominating organisation:	Studor Australia
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DATE OF PIA: To differentiate between versions include the document date and/or version number	Date:	21/04/2020
	Version:	3
	Status:	DRAFT

NATURE AND EXTENT OF THE PROBLEM:

The existing technical installation requirements contained in AS/NZS 3500: 2018 Part 2 Sections 6.10 and 6.11 dealing with the installation of Air Admittance Valves (AAVs) and pressure attenuators does not reflect current industry knowledge and installation practices for both AAVs and pressure attenuator devices (See attachment 1).

The performance for both of these products has been evolving over time and is considered by industry as accepted practices, however the standard has not kept pace with the evolution of these products.

As with all complex technologies, the experience gained over time has identified that where continuous flows from cooling towers and or swimming pools back wash pressure attenuators should not be used on that stack.

OBJECTIVES:

The objective of the proposed change is to enable the standard to reflect common industry installation practices which will provide for improved levels of safe ventilation performance from AAVs and pressure attenuators within sanitary plumbing and drainage systems in buildings.

OPTIONS:

There is considered to be three options to address this issue:

Option 1 - No change

The option to leave the existing technical installation standards in place without change.

Option 2 – Non-regulatory

A non-regulatory option would consider explanatory information within the standard to advise practitioners

Option 2 - Regulatory change through AS/NZS 3500.2

The option for change will deliver enhanced technical standards that will enable proven best practice principles for compliant improved design meeting regulatory compliance. The proposed change will deliver a more flexible pathway for design principles that are based on known product performance.

IMPACT ANALYSIS (OF ALL OPTIONS):

The impacts of the three options outlined above are considered below.

Option 1 - No change

This option will continue to deliver a working venting system for building drainage designs, but will not reflect known best practice and will not deliver cost efficiencies that may be available through other options.

Option 2 – Non-regulatory

Whilst a non-regulatory approach would provide guidance to plumbing practitioners on what is considered best practice, it is considered that this option would not appropriately resolve the issues outlined or deliver the cost efficiencies that may be available through other options.

Option 2 - Regulatory change through AS/NZS 3500.2

The proposed enable a more flexible and efficient application for the installation of AAVs and pressure attenuators as standalone installations, or within a combined design for complex high-rise building drainage systems. This option is considered to enable more flexible and cost effective options for the design and installation of sanitary plumbing and drainage systems. The proposed change considered under this option is based on known, tested installation practice.

Clause 6.10 Air Admittance Valves

There is limited change to current requirements where some cost savings can be made with the reduction of an AAV only where an integral AAV-Trap fitting is used when incorporated into a group of fixtures as a group vent. In this case the existing approved minimum flow rate for that group must be met. AAV's must continue to meet the existing minimum airflow capacities for trap vents, group vents, branch drain vents or discharge stacks.

Clause 6.11 Pressure Attenuators

The known cost savings delivered by this proposed change are based on a comparison between the commonly used systems of sanitary plumbing and drainage venting in multi-storey buildings. The known cost comparative separations are based on maximum drainage flow rates where installations of up to 10, 15, 25, and 26+ floors to greater than 90 floor levels are considered.

The systems used for cost comparison are common and in use today;

1. A Reduced Velocity Aerated Stack Systems using High Density Polyethylene HDPE pipe material of 160mm and 110mm diameter pipe sizes.
2. Fully Vented Modified Stack System (A common pathway which evolved from the traditional Fully Vented Systems which were the forerunner of Single Stack, Single Stack Modified, Accelerated Stack Systems, and now the Pressure Attenuator Approach).
3. Positive Pressure Reduction Devices now known as Pressure Attenuators (Systems for 100mm 150mm)

A comprehensive detailed analysis has been attached.

1. There is no additional cost to be incurred by industry or government for the revised sections 6.10 Air Admittance Valves (AAVs) and 6.11 pressure attenuators. These products are currently used and well understood by the industry.
2. There are substantial benefits with a more flexible pathway for a compliant design when venting drainage systems in buildings using the revised Pressure Attenuator pathway.
3. A substantially reduced environmentally building footprint from the reduction of drainage pipe material when both AAVs and Pressure Attenuators are used in an integrated design.
4. A quantifiable reduction in both material and labour costs forms the basis of the attached cost comparison document; "Total Price Comparison" this is based on the existing provisions for Pressure Attenuators and current industry design and installation options.
5. If change were accepted it would reinforce and improve the existing cost advantage for meeting regulatory compliance when compared against existing design and install options.

Both Air Admittance Valves and Pressure Attenuators must meet critical performance outcome, which are reinforced and maintained through the certification as WaterMark Certified product.

- Air Admittance Valves - AS/NZS 4936:2002
- Pressure Attenuators - WMTS463: 201

TRANSITIONAL MEASURES

The transitional measures are not considered to be required. Both products are well known to the industry as they have been in use for many years with through the reference in AS/NZS 3500.2. These products are well known and used of many years.

CONSULTATION:

The proposed change has the positive support of industry stakeholders who have been identified in the support documentation required by this process. There has not been any negative feedback to the proposal.

Manufacturers continually communicate with the plumbing industry and are well connected with plumbing practitioner within the design and installation sectors.

In addition a listing of plumbing experts and consultants have supported the proposed change.

Stakeholders consulted on include:

- Standards Australia's WS-014 committee
- ABCB's Plumbing Code Committee
- State plumbing regulators from South Australia and Victoria.
- Institute of Plumbing Australia.
- Several plumbing consultants.
- Plumbing Product Industry Group.
- Master Plumbers and Mechanical Services Association of Australia.
- Heriot Watt University, Edinburgh.
- IAPMO Australia.

The draft amendment to AS/NZS 3500.2 is intended for release for public consultation in the first half of 2020.

CONCLUSION AND RECOMMENDED OPTION:

It is the intent that Option 2 delivers a more concise and more easily understood set of rules for the installation of both AAVs and Pressure Attenuators for both simple and complex drainage systems

In regards to the Air Admittance Valves. Section 6.10 of AS/NZS3500.2:2018

The proposed changes to this section are minor and are aimed at reducing with simple adjustments any chance of a non-compliant installation practice. The proposed changes are based on known venting performances with the technology being proven and well understood by the industry.

The added commentary regarding the use of AAVs on grease interceptor devices needs to be reinforced to the industry. This is not the case in the existing standard.

The use of the integral trap and AAV vent as a group vent removes any duplication of venting where that vent is at the head of the group of fixtures and meets the airflow capacity required.

In regards to the Pressure Attenuators. Section 6.11 Pressure Attenuators.

This proposed change supports the critical partnership required from the commercial plumbing contractors and the professional engineering designers who are responsible for the final designs required to service commercial multistorey developments.

The design pathways offered by the proposed changes are aimed at ensuring a compliant installation is met. The change is underwritten by the research of Heriot Watt University Edinburgh and published in the "Best Practice Guide". This Best Practice Guide forms the basis for change.

The proposed changes to this section are clearly more complex and range to more than 90 floor levels. The pipe loadings are based on the maximum Fixture Unit Loads (FUL) of the building drainage system. Maximum (FUL) ensures the install will perform as designed. This sector of the plumbing construction industry are well aware of their responsibility and obligation to deliver compliant performing drainage systems in complex commercial buildings. These proposed changes deliver that outcome.

As Option 2 delivers an overall net benefit when compared with the other options, this option is recommended for adoption.

IMPLEMENTATION AND REVIEW:

Option 2 will at all times meet the Performance Requirements of the NCC.

The proposed changes to both 6.10 Air Admittance Valves and 6.11 Pressure Attenuators will be a seamless transition from the existing technical standard. The change will not require any form of formal future review as the technology is already in use by industry As is the case today, all products are under constant review by the industry and it would be the supply industry that monitors existing product and product performance. Over time adjustments will be made either at product certification level or at regulatory compliance.

LIST OF ATTACHMENTS:

Provide a list of attached supporting documents.

- **Appendix A - SCHEDULE OF MAJOR CHANGES**
- **Appendix B – Table 6.11.3**
- **Attachment 1: Best Practice Guide" for (Positive Pressure Reduction Device)**
- **Attachment 2: Price comparison**

Appendix A: SCHEDULE OF MAJOR CHANGES

Clause / Ref	Proposed Change	Justification / Reason for Change	Cost / Impact implications
6.10 Air Admittance Valves			
6.10.1 **Air admittance valves general**	Air admittance valves conforming with AS/NZS 4936 may be used in sanitary plumbing systems including laboratory chemical, and grease waste pipe systems for trap vents, group vents, stack vents and to ventilate branch drains. They shall not be used for the upstream venting of a main drain, or a boundary trap ground vent, or to vent a grease interceptor device.	The atmospheres where consideration for the use of AAVs such as grease interceptors and where aggressive chemical waste systems are vented needs mention. AAVs cannot be used for Boundary Trap Ground Vents (BTGVs) or Grease Interceptor devices. In the case of grease interceptor devices vents must be open to atmosphere. They can be used on waste systems discharging to grease interceptors or chemical neutralisers.	Cost Impact is positive because it helps prevent non-compliant installs that need to be rectified. This delivers technical knowledge and support for the installing industry. It reinforces the limitations that need to be clearly understood. This is not the case in the existing Standard.
6.10.2 **Requirements for use**	(d) An air admittance valve may be used to terminate a single stack system vent, and sized in accordance with Table 6.10.2 (b). Multiple air admittance valves may be used to achieve the required fixture unit loading. (see Fig 1)	(d) An air admittance valve can be used to vent a single stack systems provided it complies to the flow rate specified in Table 6.10.2	(d) All the changes here deliver workable tested the options for simplification of install. Some cost reduction can be achieved without any negative performance outcomes from the install. Importantly it also prevents confusion on - site as to what complies, therefore reduction in costs.
	(e) Air admittance valves that form part of a fixture trap may be used as a group vent provided the airflow capacity is not less than that specified in Table 6.10.2(a) for the fixtures within that group.	(e) This is a change has no negative impact on the install performance. This is a common sense approach to a simple change where provided the Valve delivers the required airflow then the need for a duplication of venting capacity is not required	(e) It has a cost saving with a reduction in vent valves required to deliver a working compliant venting system.
	(g) AAVs fitted to the connecting branches and stacks shall have a combined airflow rating greater than the requirement of the total	(g) This is an area where the intent is not clearly understood by the industry. This clarification delivers a clearly defined principle for the designer, the installer and those involved with regulatory	(g) Some cost reduction can be achieved by the need to install an additional vent for no effective purpose.

Clause / Ref	Proposed Change	Justification / Reason for Change	Cost / Impact implications
	stack fixture unit loading.	oversight. The used of Multiple valves to deliver the required airflow rate enables a more balanced and improved vent performance.	This change is to clarify and further support the industry understanding of the options available.
6.10.3 Location of Air Admittance Valves	(b)located to allow a replacement air flow as specified by the flow rate of the valve;	(b) This is an area where the existing standard fails to deliver a defined level of accountability to the designer and installer. The valve must be supplied with the correct replaceable volume of air.	(b) Some cost reduction may be achieved. This change is to impact, clarify and further support the industry understanding of the importance of being accountable for the install performance.
	(c) provided with ventilation openings when located in a wall space or roof space to allow a replacement airflow as specified by the flow rate of the valve;	(c) Again as with (b) This is an area where the existing standard fails to deliver a basic principle to the designer and installer. The valve must be supplied with the correct replaceable volume of air. This is critical when installed in a confined space.	(c) This if not compliant has a cost impact. Impact aimed at clarifying the importance of a basic understanding to support the industry meeting a compliant install performance without the need for rectification of work...
6.10.4 Installation of Air Admittance Valves	(d) installed in areas where the ambient temperature does not vary below 0°C or above 60°C unless the AAV is manufactured to perform outside these temperatures.	(d) The removal of the water temperature as a restriction was never the intent. The valve only comes into contact with the ambient air temperature and this change clarifies that position.	(d) This change does deliver a cost saving by enabling the use of an AAV. This proposed change is based on years of existing successful installs that continue to perform. Failure of the valve when installed where water discharge from a commercial washer exceeding 60 degree is not a known problem. For that matter the same can be said for roof spaces that may also spike through the temperature restriction at times.
	(e) installed not more than 1000 mm below the flood level of the fixture to which it is connected, or when installed on a branch not more than 1000mm	(e) Again this rework is to ensure a base principle is clearly understood. This is not the case with the existing standard. The trap seal to be protected must be within a known space for it to	(e) Any rectification from a non-performance of a valve has a cost. This cost can be a monitory cost or a cost to the performance of the install.

Clause / Ref	Proposed Change	Justification / Reason for Change	Cost / Impact implications
	below the flood level of the lowest fixture connected to the branch.	work and the install to perform as designed.	
6.11 Pressure Attenuators	The purpose of change in this section is to upgrade the installation practice to a revised Table 6.11.3 "Location of Attenuators" This change is reinforced by global best practice and the research and development from Heriot Watt University Edinburgh. All the data supporting this change is published by Heriot Watt In a "Best Practice Guide"	The biggest change in this project is to reflect the specification delivered in the Revised "Best Practice Guide" for a Positive Pressure Reduction Device Published by Heriot Watt University April 2018. The change will deliver substantial design options and cost savings for Multi-Level drainage and venting systems in buildings.	Substantial cost savings can be achieved here. For further information see the "Total Cost Comparison" Doc.
6.11.1 **Pressure Attenuators General**	1. The use of pressure attenuators is not limited by building height. 2. Attenuators are not suitable for use on stacks subject to continuous flows from draining of cooling towers or swimming pool back wash.	Clarification. Based on the Best Practice Guide Data. This is clearly the most critical change of all to be considered. It delivers a revised design outcome that has been proven and known over time and existing best practice. This proposed change for the location and placement of Pressure Attenuators in building drainage systems is based on maximum flow loadings as specified in the existing Australian Standard, 3500 Part 2 2018. The driver for change delivers a substantial cost benefit and a more flexible design option for complex drainage systems in buildings. The data based on the published Best Practice Guide enables the existing 50 floor level restriction to be removed.	Substantial cost savings can be achieved here. A measured reduction in construction cost. A measured reduction with the environmental footprint of the building plus a substantial cost saving on meeting regulatory compliance. It can also deliver effective solutions where existing alternatives for drainage options are failing.

Clause / Ref	Proposed Change	Justification / Reason for Change	Cost / Impact implications
		The placement of Pressure Attenuators to achieve this performance is clearly detailed in both Section 6.11.3 Location of Pressure Attenuators and the following Table 6.11.3 with further description contained in Figure 6.11.3. This is a new restriction placed on the use of Pressure Attenuators. It has been identified that where substantial continuous flows are discharged into a stack where the flows are well beyond the maximum flows of any drainage system, then the performance of Pressure attenuators is diminished. This is a fault not unique for Pressure Attenuators only. It is recommended and stated in the standard that this practice will not be compliant.	
6.11.2 Installation of pressure attenuators	(d) Attenuators shall be installed as close as possible to the stack, with minimum changes of direction, and the maximum distance of pipework from the stack to the attenuator shall not exceed (2) meters.	Note; This section has been completely redrafted. This is an area where substantial change is being introduced. The need for clarification is based on feedback from both the design and the industry contractor sectors. (d) This rewording clarification is aimed at ensuring the attenuator is installed within clearly defined positions. This is designed to ensure the attenuator delivers the design performance at all times. This was not clearly stated in the existing standard.	(d) Cost impact NIL. This simple design adjustment ensures that the installation utilising Pressure Attenuators will continue to deliver a uniform design outcome for the installation at all times even when faced with maximum hydraulic loadings.
6.11.3 Location of pressure attenuators	(a) Pressure attenuators shall be installed in accordance with Table 6.11.3 Note The term accessible has been removed.	(a) Table 6.11.3 Location of Pressure Attenuators along with Figure 6.11.3 have been reconfigured to ensure there is a clear understanding of the location of attenuators in all complex drainage designs. This was not the case in the existing standard. The need for accessibility of the Attenuator is	(a) This simple design adjustment ensures that the installation utilising Pressure Attenuators will continue to deliver a uniform design outcome for the installation at all times even when faced with maximum hydraulic loadings.

Clause / Ref	Proposed Change	Justification / Reason for Change	Cost / Impact implications
		redundant. There is no known failure of the device.	
	b) Attenuators at the base of the stack shall be installed above the no-connection zone and below the first branch in accordance with 6.11.3 (c)	(b) This is not new but re worded to ensure the message is clearly understood.	
	(c) The junction on the stack for the attenuator shall be no more than (3) meters below the flood level of the lowest fixture on the branch directly above.	(c) This is a further clarification on the need to ensure the attenuator is paced where the design performance will be met.	
	(d) A stack 3 or more floors above the base or a graded offset shall be treated as a new stack and attenuators installed in accordance with Table 6.11.3.	(d) This change is aimed at ensuring that the attenuators when installed above a graded offset are reconfigured to Table 6.11.3. That is reset as the stack base. This was not clear in the existing standard.	
	(e) Attenuators are only required where a vertical stack rises through 3 or more floors. NOTE: Graded stack offsets are to be read as a stack base.	(e) This addition is to ensure that attenuators are only installed on stacks where the stack being served only rises is through 3 or more floors. This is a critical element for the correct placement of Attenuators in both simple and complex drainage design. The Best Practice Guide is the basis for this change.	
Table 6.11.3 Location of Attenuators	Note; A new Table has been incorporated here for the locations of Attenuators. This is based on the Best Practice Guide for the Installation of Pressure Attenuators.	This is the key change proposed. The change is based on an evolving understanding of the performance of attenuators in complex drainage systems. The change here is detailed in the revised Best Practice Guide.	Substantial cost savings can be achieved here. Further information attached on the overall cost and efficiencies to be gained are covered in the attached documentation.

Appendix B – Table 6.11.3

Note; The wording used in the Table 6.11.3 below has been re-developed to ensure any confusion is removed when selecting the correct Pressure Attenuator locations in a drainage systems of a building.

Table 6.11.3 Location of pressure attenuators

Number of floor levels served by the stack above base or offset	Location of pressure attenuators
3–10 Floors	One unit at the base of the stack.
11–15 Floors	One unit at the base of the stack and one half way
16–25 Floors	One unit at the base of the stack, one unit 5 floors up, then one unit half way between the remaining floors above 5.
26+ Floors	Two units in series at the base of the stack, then one unit on every 5 floors to the 25th then one every 10th floor thereafter.

Attachment 1: A Best Practice Guide

(Revised and Updated April 2018. Published by Heriot Watt University Scotland. UK

HERIOT WATT UNIVERSITY

Water Academy

A Best Practice

For: A Positive Pressure Reduction Device

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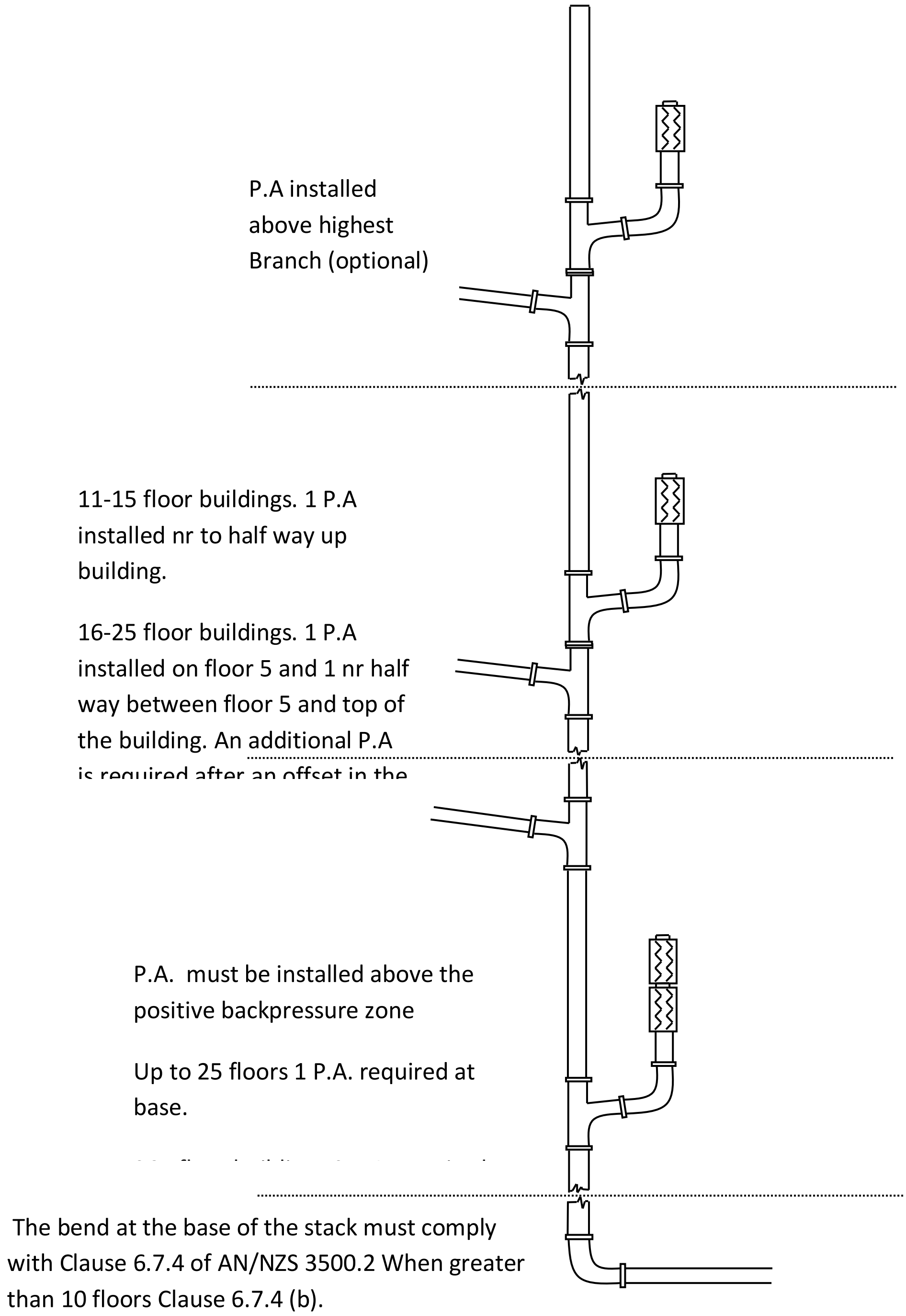
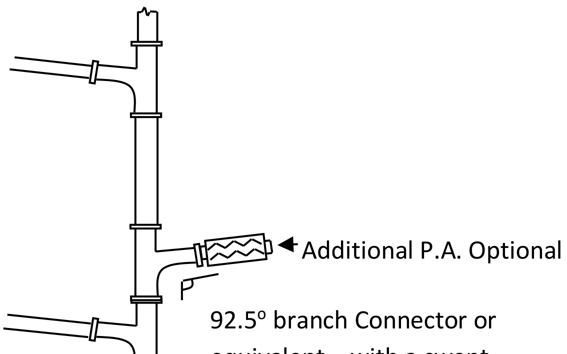
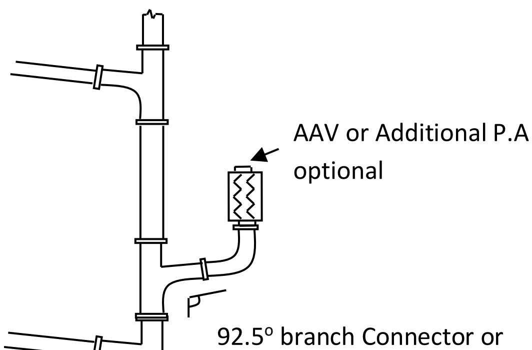
Revised and updated

April 2018

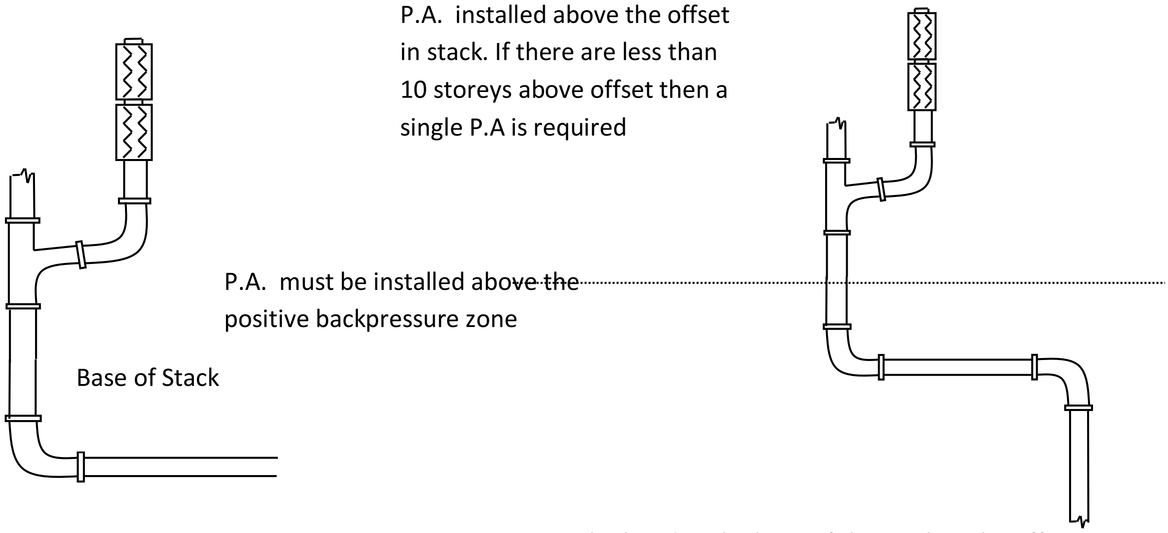
Pressure Attenuators (P.A) design and Installation options for meeting the Performance Requirements of the National Construction Code Volume Three, the Plumbing Code of Australia.







General P.A. installation detail – horizontal



The bend at the base of the stack must comply with Clause 6.7.4 of AN/NZS 3500.2

The bend at the base of the stack at the offset must comply with Clause 6.7.4 of AN/NZS 3500.2

Pressure Attenuator installation at base and offset in stack

Pressure Attenuators (P.A) design and Installation options for meeting the Performance Requirements of the National Construction Code Volume Three, the Plumbing Code of Australia.

Pressure Attenuator Design Table

3 - 10 floors	**One unit on the base***
11 - 15 floors	**One unit on the base and one half way***
16 - 25 floors	**One unit on the base, one unit on floor 5, one Halfway between the remaining floors above floor 5***
26+ floors	**Two units in series on the base, then one unit on every 5th floor to the 25th floor, then one every 10th floor thereafter***
Offsets	**One unit must be installed above an offset serving 3 to 10 floors and the offset read as the base of the stack. Two units must be installed above an offset serving more than 26+ floors above.**

Note 1: Calculations are based on the Maximum loading FU for DN100 stack 1000FU (12.1l/s) and Maximum loading FU for DN 150 2400FU (18.8 l/s)

Note 2: When serving more than 10 floor levels the bend at the base of the stack must comply with Clause 6.7.4 (b)

Note on revisions to this guide

The STUDOR Pressure Attenuator (PA).™ has revolutionised the air pressure transient alleviations in buildings since its inception in the late 1990s and it's availability on the market since the early 2000s. As a new device it offered protection against positive pressure transients which hitherto was not possible. Over the years confidence has grown in the device and its use is now widespread globally.

This revision to the best practice guide is a result of the experience gained in designing pressure alleviation systems over the past 15 years and reflects best practice among designers and specifiers.

The unique design of the device is independent of flow rate in the system, however it was thought best to relate the installation of devices to fixture units, as is the norm for all other building drainage products. In the main this has been achieved by extensive simulation of different flow scenarios in AIRNET - a computer model capable of simulating pressure transients and flows in building drainage systems (Swaffield, 2010). The flow scenarios used have been those relating to maximum flows expected for a given pipe diameter.

While flowrate and pressure transient magnitude are important, the distribution of devices is also dependant on the propagation velocity (speed of sound) which governs the transit of the pressure wave through the system. An overarching principle being that, for two devices installed at different locations along the stack, the second device should open before the first one has completed filled and pressurised.

This updated guide reflects both the need for professionals to relate a design to the fixture units and hence flowrate expected in the system and also the distribution of devices to ensure sequential operation of devices to maximize protection.

Dr. Michael Gormley

June 2017

Introduction

The Pressure Attenuator (P.A.) provides protection for the building drainage system against unwanted positive air pressure transients generated within the system during normal system operation. When used in conjunction with air admittance valves (AAVs), which provide relief for negative air pressure transients, the two offer a means of protecting the system against both positive and negative air pressure transients which can cause depletion of the water trap seal and thus compromise system integrity.

This Best Practice Guide covers everything that a designer and installer will need to know when incorporating the P.A. into the design of any building drainage system. This includes a brief explanation of the causes and consequences of air pressure transients in building drainage systems; the control and suppression methods available; the performance characteristics of the P.A. and how it works within the system; and finally, recommended installation guidance to achieve optimum functionality of the P.A as a means of active pressure control.

Causes and behaviour of air pressure transients in building drainage systems

Air pressure transients generated within the building drainage system obey the same mechanisms that govern transient generation and propagation in any fluid carrying system. In general terms, pressure transients are generated as a consequence of changes to the flow conditions at some point within the system and are the means by which such changes are communicated throughout the system (Swaffield, 2010). The Joukowsky expression provides the fundamental relationship between pressure rise, wave speed, fluid density and flow velocity:

$$\Delta p = -\rho c \Delta V \quad (1)$$

Where Δp is pressure change, ρ is the fluid density, c is the wave speed and ΔV is flow velocity change. The significance of the negative sign means that pressure increases with a decrease of velocity, and vice versa.

Within the building drainage system, air pressure transients are generated due to changes in the entrained airflow as a consequence of changes to the annular water downflow initiated by the random discharge of system appliances. Increasing annular downflow generates an enhanced entrained airflow which reduces the system pressure. Slowing-down or stopping the airflow, due to some blockage of the passage of air caused by the formation of a water curtain by either wastewater flowing from a branch into the stack or by the change of flow direction at an offset or the stack base, generates positive air transients (Swaffield *et al.*, 2004). Pressure fluctuations from external events, such as surcharging of the main sewer, can also generate transients within the system. These low-amplitude air pressure transients, whose magnitude are dependent upon the rate of change of system conditions, are transmitted and or reflected at all boundaries within the system including open terminations, connections to the sewer, appliance trap seals, and pipe junctions. An *open-ended pipe*, such an open stack termination, has a reflection coefficient of -1, while a *closed-ended pipe*, such as an appliance trap seal, has a reflection coefficient of +1. Changes in the system characteristics, such as a change in diameter or the inclusion of a pipe junction, will alter the transmitted wave and induce a reflection. The reflection and transmission coefficients at a junction of n number of pipes, are given, respectively, as:

$$C_R = \frac{\frac{A_1}{c_1} - \frac{A_2}{c_2} - \frac{A_3}{c_3} - \ldots - \frac{A_n}{c_n}}{\frac{A_1}{c_1} + \frac{A_2}{c_2} + \frac{A_3}{c_3} + \ldots + \frac{A_n}{c_n}}$$

(2)

and

$$C_T = \frac{\frac{2A_1}{c_1}}{\frac{A_1}{c_1} + \frac{A_2}{c_2} + \frac{A_3}{c_3} + \ldots + \frac{A_n}{c_n}} \quad (3)$$

Where C_R is the junction reflection coefficient, C_T is the junction transmission coefficient, A is the pipe cross-sectional area, and c is the wave speed. What portion of the transient is reflected and transmitted, is dictated by both the pipe material (which affects wave speed) and pipe diameter. The time taken for a transient to travel to a reflecting boundary and return to its source is known as the pipe period and is given by the expression:

$$pipe\ period = \frac{2L}{c} \quad (4)$$

where L is the pipe length and c is the wave speed.

For most stack to branch situations this relates the division of a pressure transient to the ratio of pipe cross sectional areas, however when a P.A. is included in the design the division is much greater since the P.A. also operates on the wave speed (c in equation 2-4 above). This is means that in a fully vented system using traditional pipe junctions a parallel vent pipe of at least 200 mm and a length of 100 m would be required to achieve the same reduction in positive air pressure transient.

Consequences of air pressure transients in building drainage systems

While the air pressure transients generated within the building drainage system are of low amplitude, they are, however, responsible for compromising system integrity and enabling cross-contamination of habitable space through the destruction of water trap seals. Negative air pressure transients are capable of depleting the water trap seal by either induced or self-siphonage by creating a suction pressure within the pipe adjacent to the trap. Positive air pressure transients are capable of displacing the water trap seal upwards towards the appliance which will either force air through the water seal into the appliance, or if of sufficient magnitude, cause the water seal to be completely displaced into the appliance, leaving the trap wither wholly or partially depleted.

A depleted trap seal permits airflow both into and out of the drainage system, thus allowing foul air to exit the system and enter habitable space.

Control and suppression of air pressure transients

Air pressure transients are an unwanted consequence of normal system operation and, although unavoidable, it is possible to protect water trap seal integrity through the correct alleviation of any pressure fluctuations. Traditionally, this has been approached through passive solutions which rely on the provision of cross connections and vertical stacks vented to atmosphere. However, this approach, while both proven and traditional, has inherent limitations (Swaffield, 2006). The key to maintaining a balance of pressure within the building drainage system is to provide pressure relief as close to the source as possible; long pipe runs and remote vent terminations lead to delays in the arrival of relieving reflections and therefore compromise system integrity. More recently, active solutions to the control and suppression of air pressure transients have been developed providing necessary localised relief.

Negative air pressure transients, which communicate the need for more air and represents a suction force, can be alleviated by air admittance valves (AAVs) which, responding directly to the local pressure conditions, opens as the pressure falls to allow inward relief airflow, hence limiting the pressure excursions experienced by the water trap seal. To avoid compromising system integrity by allowing foul sewer gases to enter the building, the AAV is designed with a fail-safe mechanism which ensures that it remains closed when not in use or when the local pressure exceeds atmospheric. AAVs can be installed locally to the water trap seal or at the stack termination to avoid the need for a roof penetration.

Positive air pressure transients, which communicate the need to reduce the airflow and represents a pushing force, can be alleviated by variable volume containment attenuators (such as the P.A.) which absorb the airflow driven by positive air pressure transients. The P.A., consisting of a variable volume bag that expands under the influence of a positive pressure transient, is capable of reducing the magnitude of a positive air pressure transient by up to 90% (Swaffield *et al.*, 2005a, 2005b) by providing an alternative route which diverts and attenuates the system airflows gradually due to the significantly reduced wave speed within the P.A due to the properties of its elastic pipe construction. Designed as a collapsible reservoir, the variable volume bag provides an additional volume unseen by the system when the pressure regime at that point is sub-atmospheric, which absorbs the extra air induced by the positive air pressure transient.

Guidance

This section sets out the recommended installation guidelines when using the P.A to compliment the work of the AAV to provide protection against low amplitude air pressure transients in building drainage systems. This guidance is provided to achieve optimal performance of the P.A in attenuating positive air pressure transients based on its design parameters and is not intended as a substitute for good system design.

Performance characteristics

Each Pressure Attenuator has a capacity of 4 litres. Its design allows optimised functionality while ensuring design flexibility and ease of installation. Figure 1 shows the effect of a P.A on an applied positive air pressure transient.

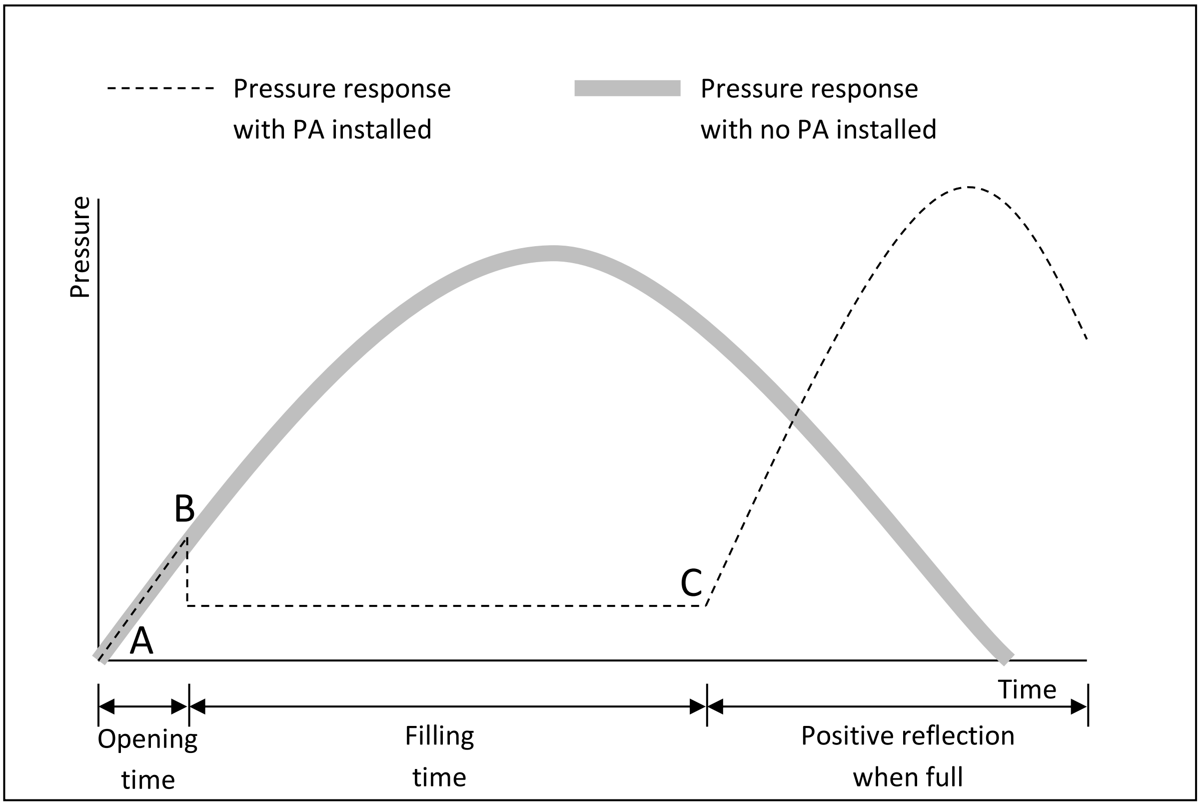


Figure 1: Example of Pressure Attenuator operation on an approaching positive air pressure transient

As the positive air pressure transient approaches, it is divided by the junction formed by the stack and the inlet to the P.A. Referring back to Equations 2 and 3, part of the transient will be reflected back along the pipe in the direction it originated, part will be transmitted beyond the junction, but the majority will be diverted into the P.A. (this is due to the special properties of the P.A. construction). The time between point A and B on Figure 1 shows the difference in time between the initial wave generation and the opening time of the reservoir. On opening, the air enters the reservoir which appears as an open end to the system generating a negative reflection which is propagated back towards the junction and into the stack. The negative reflection is superimposed with the incoming positive transient which has the effect of "clipping" the peak positive pressure wave, as shown in the trace from B to C. When the reservoir is full and becomes pressurised to its maximum, point C, it will act like a dead end and generate a positive reflection of the transient. The time between the opening of the reservoir and when it reaches full capacity, between point B and C, is the filling time of the reservoir and is a function of both the displaced air volume and the rise time of the positive air pressure transient. In the example shown in Figure 1, the capacity of the single device is not sufficient to completely dissipate the applied positive pressure transient as can be seen by the generation of the positive reflection at point C when the reservoir becomes full. The following section discusses the considerations necessary when locating the devices within a system and determines the need for additional volume capacity and device distribution.

Locating devices

Figure 1 demonstrates two important factors in deciding the optimum location for P.A. within the building drainage system. First, with reference to the trace of the positive air pressure transient without the P.A. installed, it shows that the pressure wave develops over specific time duration. Unhindered, the pressure wave develops to a magnitude determined by its distance from the source. The inclusion of the P.A. clips the initial peak pressure wave at a time which is a function of its location within the system which appears as a change in the system pressure response at a time equal to the pipe period of the P.A. plus its opening time. If the P.A. had been located further from the source of the positive air pressure transient then the pressure wave would have been allowed to develop to a greater magnitude before the clipping effect of the P.A. would take effect. Therefore, the closer the P.A. is to the source of the positive air pressure transient, the more effective it will be at providing the necessary pressure relief. Second, if there is insufficient capacity provided by a single device, as indicated by the positive reflection generated at point C once the reservoir had reached full capacity, then additional devices should be installed in close proximity to operate as quickly as possible in order to fully alleviate the propagating transient. In addition, the P.A. has been designed to allow interconnection of several devices in series, to a maximum of 4 units (i.e. capable of providing up to sixteen litres of extra capacity), if necessary to increase available volume.

Base of stack

The base of the stack is the most likely place for a blockage in the airflow to occur. As the distance between the base of the stack and the top stack termination is the maximum distance possible within the system, then a blockage at this location will lead to the greatest possible pressure rise. It is therefore recommended to use two P.A. in series at the base of the stack. The devices should be located below the first branch connected to the stack as shown in Figure 2a. Note that is it still recommend that branches in the lower part of the stack be connected directly to the horizontal drainage and not to the main stack.

Stack offsets

Offsets within the vertical stack, which in the past were wrongfully thought to “slow down” the water flow in tall buildings, can also be the cause of significant positive pressure transients as they forcibly change the flow direction. It is recommended to use two P.A. in series directly above any stack offset as shown in Figure 2b.

Top of stack

It is optional to have a P.A. located immediately below the top of the stack above the highest branch in the building, Figure 2c. It should be noted that this point does not need to be at the top of the building, but merely above the last branch. The system can be terminated with an AAV to provide ventilation, and a P.A. to assist in attenuating any positive transients in the system.

Distributed locations

As the operation of system appliances, which discharge wastewater into the system and hence govern the conditions necessary for air entrainment and pressure transient propagation, are entirely random, it is virtually impossible to predict where the greatest area of risk in the system will be. Given also, that the volume of extra air within the system, as a result of the propagating positive pressure transients, is dependent upon airflow rate, blockage closure time, and the system pipe period; all of which will change, then to accommodate these uncertainties, P.As. should be distributed strategically throughout the height of the stack. To ensure adequate system coverage, the recommended spacing interval has been set to 50% of the corresponding filling time of the device when subject to the test positive pressure wave as set out in the P.As. performance specification (ASSE, 2009). With a fill time of 0.125 second, this equates to a spacing of 20 m intervals up the height of the stack, i.e. 0.5(0.125 s x 320 m/s). For a building with a single storey height of 4 m, this would equate to a P.A.being installed every five floors, see Figure 2d

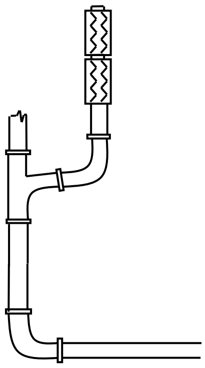


Figure 2 (a) General P.A. installation

detail at base of stack. The bend at the base of the stack must comply with Clause 6.7.4 of AN/NZS 3500.2

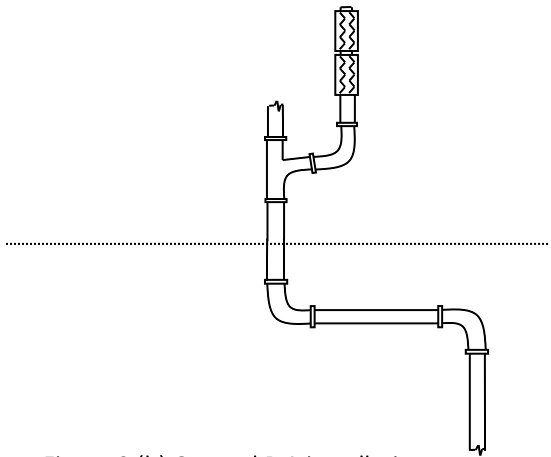


Figure 2 (b) General P.A installation at offset in stack. The bend at the base of the stack must comply with Clause 6.7.4 of AN/NZS 3500.2

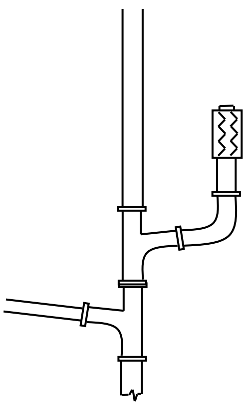
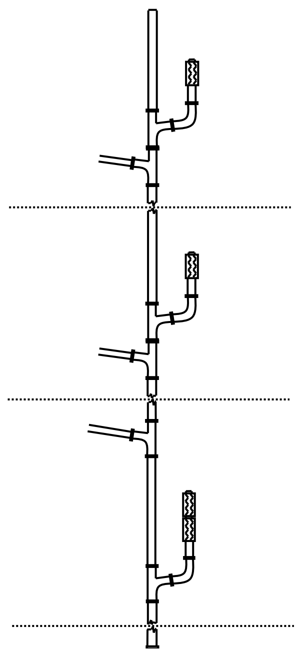


Figure 2(c) P.A· at top of Stack



gure 2 (d) P.A Installation in buildings with more than 10 storeys.

Figure 2: Recommended installatic

offset; (c) at the top of the stack; and (d) at distributed locations up the stack

Number of Devices

The number of devices installed in a system depends on the height of the building and the risk of air pressure transients being generated. This can be determined, in the main, by the use of the building, and in particularly the intensity of usage. Therefore a stadium design, while perhaps not being exceptionally tall may require more P.A. due to the expected surges from sanitary appliances at peak usage times. Table 1 below shows the minimum number of P.A. to be installed in buildings to maintain pressures within desired limits.

Design and Installation options meeting the Performance Requirements of the Plumbing Code of Australia.

Table 1. Pressure Attenuator Design Table

3 - 10 floors	**One unit on the base***
11 - 15 floors	**One unit on the base and one half way***
16 - 25 floors	**One unit on the base, one unit on floor 5, one Halfway between the remaining floors above floor 5***
26+ floors	**Two units in series on the base, then one unit on every 5th floor to the 25th floor, then one every 10th floor thereafter***
Offsets	**One unit must be installed above an offset serving 3 to 10 floors and the offset read as the base of the stack. Two units must be installed above an offset serving more than 26+ floors above.**

Note 1: Calculations are based on the Maximum loading FU for DN100 stack 1000FU (12.1l/s) and Maximum loading FU for DN 150 2400FU (18.8 l/s)

Note 2: When serving more than 10 floor levels the bend at the base of the stack must comply with Clause 6.7.4 (b)

References

American Society of Sanitary Engineers (ASSE) 2009 Performance requirements for positive air pressure attenuators for sanitary drainage systems.

Swaffield, J.A. (2006). “Sealed building drainage and vent systems – an application of active air pressure transient control and suppression”, *Building and Environment*, **41**, 1435-1446.

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Attachment 2: Price comparison

The projected cost savings based on this attached document are indicative only, as each site design variations impact on both costs and the environmental footprint. The attached cost document is referred to by the industry as a guide only at the design and planning stage prior to finalising the preferred method.

Total Price Comparison

	Sovent 160mm	Sovent 110mm	Fully Vented Modified	Studor System
8 Floors	N/A	$6,306.55	$4,298.89	$3,406.39
40 Floors	N/A	$30,156.01	$19,850.68	$16,964.31
70 Floors	$65,731.63	$52,539.01	$49,196.97	$38,606.78
90 Floors	$84,387.83	$67,461.01	$63,118.91	$48,867.00

SCHEDULE OF PIPE & FITTINGS

HDPE STACK - FIXED IN DUCT

SOVENT STACK SYSTEM 160mm

Stack Only - Materials and Labour Cost

HDPE PIPE (m)		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$54.80	0	$0.00	0	$0.00	165	$9,042.00	211	$11,562.80

PVC PIPE (m)		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
150	$48.94	0	$0.00	0	$0.00	0	$0.00	0	$0.00

EXPANSION JOINT		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$69.08	0	$0.00	0	$0.00	71	$4,904.68	91	$6,286.28

TEST GATE		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$72.84	0	$0.00	0	$0.00	71	$5,171.64	91	$6,628.44

VENT COWL		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
150	$73.81	0	$0.00	0	$0.00	1	$73.81	1	$73.81

AERATOR FITTING		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$311.82	0	$0.00	0	$0.00	70	$21,827.40	90	$28,063.80

HDPE-PVC ADAPTOR		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$57.68	0	$0.00	0	$0.00	70	$4,037.60	90	$5,191.20

FUSION COUPLING		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$60.02	0	$0.00	0	$0.00	280	$16,805.60	360	$21,607.20

FIRE COLLAR/PENETRATION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
160	$55.27	0	$0.00	0	$0.00	70	$3,868.90	90	$4,974.30

TOTAL	$0.00	TOTAL	$0.00	TOTAL	$65,731.63	TOTAL	$84,387.83

SCHEDULE OF PIPE & FITTINGS

HDPE STACK - FIXED IN DUCT

SOVENT STACK SYSTEM 110MM

Stack Only - Materials and Labour Cost

HDPE PIPE (m)		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$42.90	23	$986.70	96	$4,118.40	165	$7,078.50	211	$9,051.90

PVC PIPE (m)		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$41.75	0	$0.00	0	$0.00	0	$0.00	0	$0.00

EXPANSION JOINT		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$52.98	9	$476.82	41	$2,172.18	71	$3,761.58	91	$4,821.18

TEST GATE		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$60.54	9	$544.86	41	$2,482.14	71	$4,298.34	91	$5,509.14

VENT COWL		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$26.89	1	$26.89	1	$26.89	1	$26.89	1	$26.89

AERATOR FITTING		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$247.00	8	$1,976.00	40	$9,880.00	70	$17,290.00	90	$22,230.00

HDPE-PVC ADAPTOR		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$57.68	8	$461.44	40	$2,307.20	70	$4,037.60	90	$5,191.20

FUSION COUPLING		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$50.52	32	$1,616.64	160	$8,083.20	280	$14,145.60	360	$18,187.20

FIRE COLLAR/PENETRATION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
110	$27.15	8	$217.20	40	$1,086.00	70	$1,900.50	90	$2,443.50
		TOTAL	$6,306.55	TOTAL	$30,156.01	TOTAL	$52,539.01	TOTAL	$67,461.01

SCHEDULE OF PIPE & FITTINGS

PVC STACK - FIXED IN DUCT

FULLY VENTED MODIFIED STACK SYSTEM

Stack Only - Materials and Labour Cost

PVC PIPE (m)		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$40.22	52	$2,091.44	237	$9,532.14	0	$0.00	0	$0.00
150	$48.94	0	$0.00	0	$0.00	411	$20,114.34	527	$25,791.38

BEND 45°		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$26.23	2	$52.46	8	$209.84	0	$0.00	0	$0.00
150	$37.99	0	$0.00	0	$0.00	14	$531.86	18	$683.82

JUNCTION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100x100	$46.07	10	$460.70	48	$2,211.36	0	$0.00	0	$0.00
150x100	$66.58	0	$0.00	0	$0.00	70	$4,660.60	90	$5,992.20
150x150	$75.30	0	$0.00	0	$0.00	14	$1,054.20	18	$1,355.40

EXPANSION JOINT		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$68.50	9	$616.50	41	$2,808.50	0	$0.00	0	$0.00
150	$103.47	0	$0.00	0	$0.00	71	$7,346.37	91	$9,415.77

TEST GATE		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$68.50	9	$616.50	41	$2,808.50	0	$0.00	0	$0.00
150	$103.47	0	$0.00	0	$0.00	71	$7,346.37	91	$9,415.77

VENT COWL		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$26.89	1	$26.89	1	$26.89	0	$0.00	0	$0.00
150	$73.81	0	$0.00	0	$0.00	1	$73.81	1	$73.81

FIRE COLAR/PENETRATION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$27.15	16	$434.40	83	$2,253.45	0	$0.00	0	$0.00
150	$55.27	0	$0.00	0	$0.00	146	$8,069.42	188	$10,390.76
		TOTAL	$4,298.89	TOTAL	$19,850.68	TOTAL	$49,196.97	TOTAL	$63,118.91

SCHEDULE OF PIPE & FITTINGS

PVC STACK - FIXED IN DUCT

STUDOR SYSTEM

Stack Only - Materials and Labour Cost

PIPE		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$40.22	27	$1,085.94	116	$4,665.52	2.5	$100.55	3	$120.66
150	$48.94	0	$0.00	0	$0.00	200	$9,788.00	256	$12,528.64

BEND 45°		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$26.23	1	$26.23	7	$183.61	11	$288.53	13	$340.99

JUNCTION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100x100	$46.07	9	$414.63	47	$2,165.29	0	$0.00	0	$0.00
150x100	$66.58	0	$0.00	0	$0.00	81	$5,392.98	103	$6,857.74

EXPANSION JOINT		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$68.50	9	$616.50	41	$2,808.50	0	$0.00	0	$0.00
150	$103.47	0	$0.00	0	$0.00	71	$7,346.37	91	$9,415.77

TEST GATE		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$68.50	9	$616.50	41	$2,808.50	0	$0.00	0	$0.00
150	$103.47	0	$0.00	0	$0.00	71	$7,346.37	91	$9,415.77

VENT COWL		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$26.89	1	$26.89	1	$26.89	0	$0.00	0	$0.00
150	$73.81	0	$0.00	0	$0.00	1	$73.81	1	$73.81

FIRE COLAR/PENETRATION		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
100	$27.15	8	$217.20	40	$1,086.00	0	$0.00	0	$0.00
150	$55.27	0	$0.00	0	$0.00	70	$3,868.90	90	$4,974.30

POSITIVE AIR PRESSURE ATTENUATOR		8 STOREY		40 STOREY		70 STOREY		90 STOREY	
Size	Rate	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
	$402.50	1	$402.50	8	$3,220.00	11	$4,427.50	13	$5,232.50

TOTAL	$3,406.39	TOTAL	$16,964.31	TOTAL	$38,633.01	TOTAL	$48,960.18