SA Water

Engineering

Technical Guideline

TG 0531 - Gravity Network Ventilation Design

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Only the current revision of this Guideline should be used which is available for download from the SA Water website.

Significant/Major Changes Incorporated in This Edition

Nil.

This is the first issue of this Technical Guideline.

Document Controls

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Approvers

Role	Signature and Date
Responsible Discipline Lead Mark Papadimitriou	18/03/2021 X Mark Papadimitriou Signer's Name Signed by: PA004117
Manager Engineering Quality and Innovation Matthew Davis	18/03/2021 X Signer's Name Signed by: DA003681
Senior Manager Engineering Services Richard Gray	22/03/2021 X Signer's Name Signed by: GR001964

Reviewers

Role	Name	Revision	Review Date
Jacobs Technical Lead	Josef Cesca	0.1	June 2020
SAW Wastewater Engineering Review	Teresa Qiu	0.1	29 June 2020
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Executive Summary

This Technical Guideline has been developed to assist in the design of ventilation for gravity sewer networks, and determination of what network ventilation infrastructure is required to better manage and reduce odour risks.

Understanding ventilation is important to determine where odours may be released from a sewer and its effect on corrosion within the sewer. Hydrogen sulphide (H_2S) generation in the sewer coupled with ventilation will result in odour release, and H_2S in the sewer headspace and low ventilation can cause sewer corrosion.

Sewers naturally aspirate, drawing air in as the water moves downhill dragging the air with the waterflow. This natural aspiration also provides some degree of aeration as the oxygen in the headspace is transferred to the sewage. However, if the oxygen transfer is insufficient to keep the sewage aerobic, anerobic decomposition of the waste occurs and sulphides are generated that can result in H_2S being released to the head space. When the airflow in the sewer becomes restricted the air is released to atmosphere and causes offensive odour issues. Sewers require ventilation to promote aerobic conditions and release odour to atmosphere in a controlled way at locations where pressure in the headspace increases. Without sufficient appreciation of this, sewer vents can be poorly located or end up being removed making the problem worse. Pressurisation of the sewer can also cause issues with boundary traps being sucked out or blown in.

Conditions that result in pressure changes in the sewer headspace are:

- Significant changes in flow level within the sewer, for example at a rising main discharge
- The presence of a siphon or wet well
- Abrupt changes in sewer size or grade
- The introduction of flow from a significant sidestreams at a junction

Along with providing air release to avoid pressurisation of the sewer, sewer ventilation systems are generally designed to meet one or more of the following objectives:

- To reduce septicity in the sewer by maintaining a supply of oxygen (reaeration)
- To dry unsubmerged sewer walls to control sulphide-initiated corrosion
- To reduce H_2S concentration in the sewer atmosphere
- To control odour emissions and minimise the risk of receiving odour complaints
- To reduce hazards to maintenance personnel through countering the development of a toxic and/or explosive atmosphere.

This Guideline outlines the details of the following network ventilation infrastructure, including their application, the associated risks and issues and design criteria:

- Induct/educt vents
- Passive/active carbon filters
- Dampers and throttling valves
- Air curtains
- Fan stations

Natural ventilation via a series of alternately sited induct and educt vents is generally satisfactory for venting branch and trunk sewers. It should be installed for systems where sewage is normally fresh (i.e. mainly domestic wastewater and sewer grades are reasonably steep and frequent branch sewer junctions allow air inflow) or does not tend to be stale or septic and the sewer is not in close proximity to odour sensitive areas. Most sewers incorporate some method of natural ventilation, however there are situations where it is not sufficient.

Mechanical ventilation may be required for some larger trunk sewers and where septic sewage exists, and should be used in situations where:

- Sewage is always septic
- Sewage is either stale or septic and flow turbulence (sewer drops) cannot be avoided
- Sewage is slow flowing or ponding (flat grades) and likely to be stale or septic,
- In locations where frequent odour problems are likely to occur and odour treatment and/or stack dispersion is critical

In some instances, installation of natural or mechanical ventilation systems alone is sufficient to minimise the risk of odour complaints from a sewer network. However, in areas where emissions from the sewer have a negative impact on surrounding receptors, the installation of mechanical ventilation with odour treatment of extracted air may be warranted. Depending upon the scale required, an odour control system can require significant capital investment and ongoing operation and maintenance costs. Therefore, SA Water requires a robust decision making process to determine when odour control is deemed necessary. This Guideline outlines drivers for odour control and the assessment of odour control requirements at sewage pump stations and for new developments.

The Table below provides a quick reference guide for the design of ventilation in gravity sewer networks to better manage and reduce odour risks, as covered in this Guideline.

Design Consideration	Reference
Headspace requirements for natural ventilation	Section 3.3.1
The use of controlled versus uncontrolled natural ventilation	Section 3.3.2
Design requirements for locating vents for natural ventilation	Section 3.3.3
Induct and educt design	Section 4.23.3.4
Carbon filter application and risks	Sections 4.3.1 and 4.3.2
Application of passive carbon filters	Section 4.3.1.1
Application of active carbon filters	Section 4.3.1.2
Design criteria for passive and active carbon filters	Section 4.3.3
Requirements for dampers and throttling valves	Section 4.4
Suitability of air curtains	Section 4.5
The use of fan stations and the associated risks/issues	Sections 4.6.1 and 4.6.2
Design criteria for ventilation (fan stations) on sewers	Section 4.6.3.1
Basis for sizing air flows for sewer ventilation (fan station)	Table 4-5
Ventilation rates for sewage pump stations	Section 4.6.3.2
Guidelines for use of natural and mechanical ventilation	Section 5.4
Drivers for odour control	Section 6.2
Assessment of general odour control requirements	Section 6.3.1
Odour control assessment - risk factors and ranking guidance	Table 6-1
Odour control requirements at sewage pump stations	Section 6.3.2
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1 Introduction

SA Water is responsible for operation and maintenance of an extensive amount of sewerage infrastructure.

This guideline has been developed to assist in the design of ventilation for gravity sewer networks, and determination of what network ventilation infrastructure is required to better manage and reduce odour risks.

1.1 Purpose

The purpose of this guideline is to provide guidance for the design of ventilation for gravity sewer networks, and determination of what network ventilation infrastructure is required to better manage and reduce odour risks.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
AC	Activated carbon
HRT	Hydraulic Retention Time
H_2S	Hydrogen Sulphide
ID	Internal Diameter
OCS	Odour Control System
OD	Outer Diameter
O&M	Operation and Maintenance
PDWF	Peak Dry Weather Flow
SA Water	South Australian Water Corporation
SPS	Sewage Pumping Station
TG	SA Water Technical Guideline
TS	SA Water Technical Standard
WSAA	Water Services Association of Australia

1.3 References

1.3.1 Australian and International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
1	Water Services Association of Australia (WSAA), 2017. Sewerage Code of Australia. WSA 02-2002-2.2 Sydney Water Edition Version 4.
2	H_2S Control Manual, 1989 – Technological Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works. *Hydrogen Sulphide Control Manual: Septicity, Corrosion and Odour Control in Sewerage Systems*. Volume 1. Melbourne and Metropolitan Board of Works.
3	US EPA, 1985. *Design Manual: Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants*. Centre for Environmental Research Information.

1.3.2 SA Water Documents

The following table identifies the SA Water guidelines and other similar documents referenced in this document:

Number	Title
4	TG 0530 – Sewer Network Hydraulic Design Consideration to Minimise Network Odour Impact

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
Green dome	Low pressure activated carbon (AC) filters installed at ground level designed to capture odours and volatile gases from air vented pump stations, air release valves, sewers and tanks.
Trunk Sewer	Sewers with a nominal diameter of greater than 600mm
Branch Sewer	Sewers with a nominal diameter between 375mm and 600mm
Reticulation Sewer	Sewers with a nominal diameter 100mm to 300mm
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g. AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
Responsible Discipline Lead	The engineering discipline expert responsible for TG0531 defined on page 3 (via SA Water's Representative)

2 Scope

This guideline has been developed to assist in the design of ventilation for gravity sewer networks, and determination of what network ventilation infrastructure is required to better manage and reduce odour risks.

Each of the following design aspects are outlined in a separate section in the Guideline:

1. Natural ventilation design
2. Details of network ventilation infrastructure and design criteria, including:
    a. Induct/educt vents
    b. Passive/active carbon filters
    c. Dampers and throttling valves
    d. Air curtains
    e. Fan stations
3. The need for natural versus mechanical ventilation in the sewer
4. The need for odour control

3 Natural Ventilation Design

3.1 Introduction

Understanding ventilation is important to determine where odours may be released from a sewer and its effect on corrosion within the sewer. Hydrogen sulphide (H_2S) generation in the sewer coupled with ventilation will result in odour release, and H_2S in the sewer headspace and low ventilation can cause sewer corrosion.

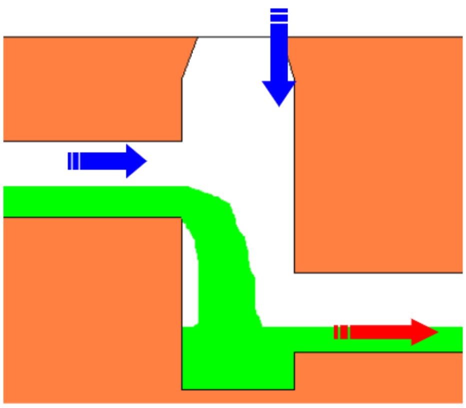
There have been several empirical algorithms proposed for predicting natural ventilation air movements, the most popular being the Pescod & Price Equation [5], but these have not been widely used for the ventilation of sewers as the results have been mixed. Design of natural ventilation systems have sometimes failed to protect nearby residents from escaping odours and in many cases the vents have been either closed or forced ventilation systems installed.

The natural forces influencing ventilation are a fine balance between:

- Relative density between sewer air and outside air
- Wastewater flow induced drag
- Friction on pipe walls
- Changes in barometric pressures along a sewer
- Wind velocities over ventilation stacks

These 5 basic mechanisms that affect sewer ventilation are shown in Figure 3-1.

This Section describes the need for sewer ventilation and the basic rules for natural ventilation in gravity sewers.

Mechanism	**Explanation**
Friction drag by flowing sewage 	• Air is dragged with sewage • During high flows the water level rises above the outlet forcing the air to escape through the manhole

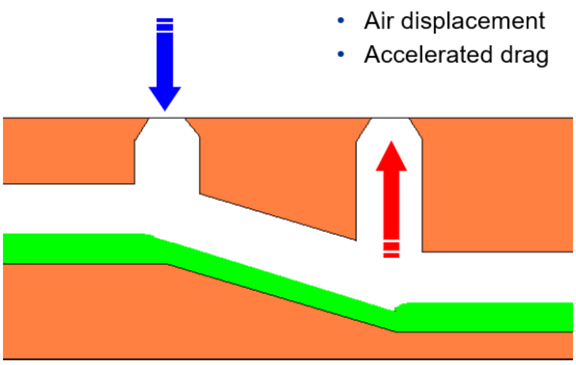
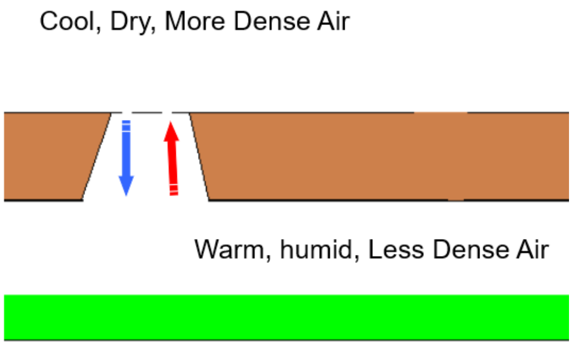
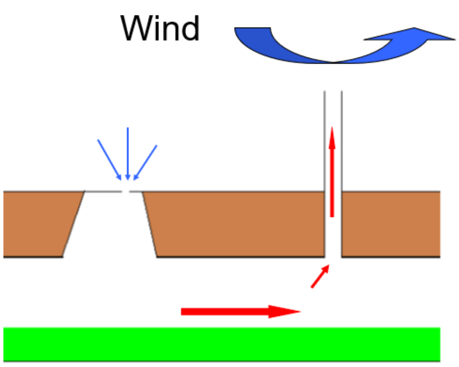
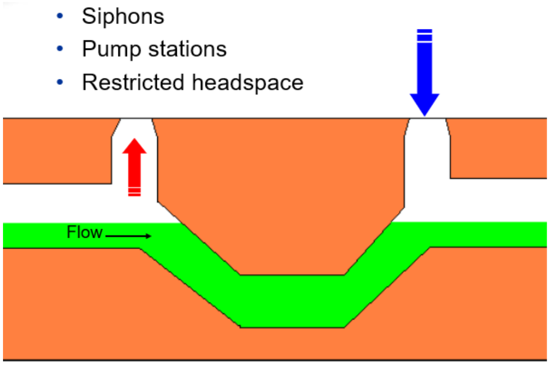
Mechanism	Explanation
Changes in water velocity and depth 	• Sewage accelerates down the steep incline and slows at the bottom forcing excess air out
Temperature gradients and buoyancy 	• Occurs particularly at night with low flows warm air escapes through manholes and vents and sometimes is displaced with colder more dense air
Wind eduction 	• Wind moving across vents will cause a venturi effect sucking odorous air out. • High pressure situation can also pressurise sewers which will cause odour escape downstream. • This is less of a problem as winds will dilute odours. Exceptions are high initial odour concentrations and / or weak winds, which result in impacts on community.
Bottlenecks 	• Bottle necks restrict headspace and occur at sewage pump stations (SPS), siphons without an air jumper, and manholes. • All the air must escape at these locations

Figure 3-1 Mechanisms Affecting Sewer Ventilation

3.2 The Need for Ventilation

Sewers naturally aspirate, drawing air in as the water moves downhill dragging the air with the waterflow. This natural aspiration also provides some degree of aeration as the oxygen in the headspace is transferred to the sewage. However, if the oxygen transfer is insufficient to keep the sewage aerobic, anerobic decomposition of the waste occurs and sulphides are generated that can result in hydrogen sulphide gas (H_2S) being released to the head space. When the airflow in the sewer becomes restricted the air is released to atmosphere and causes offensive odour issues. Sewers require ventilation to promote aerobic conditions and release odour to atmosphere in a controlled way at locations where pressure in the headspace increases. Without sufficient appreciation of this, sewer vents can be poorly located or end up being removed making the problem worse. Pressurisation of the sewer can also cause issues with boundary traps being sucked out or blown in.

Conditions that result in pressure changes in the sewer headspace are:

- Significant changes in flow level within the sewer, for example at a rising main discharge
- The presence of a siphon or wet well
- Abrupt changes in sewer size or grade
- The introduction of flow from a significant sidestreams at a junction

Figure 3-2 below demonstrates the natural path of air released from a sewer caused by a restriction from a siphon and a SPS.

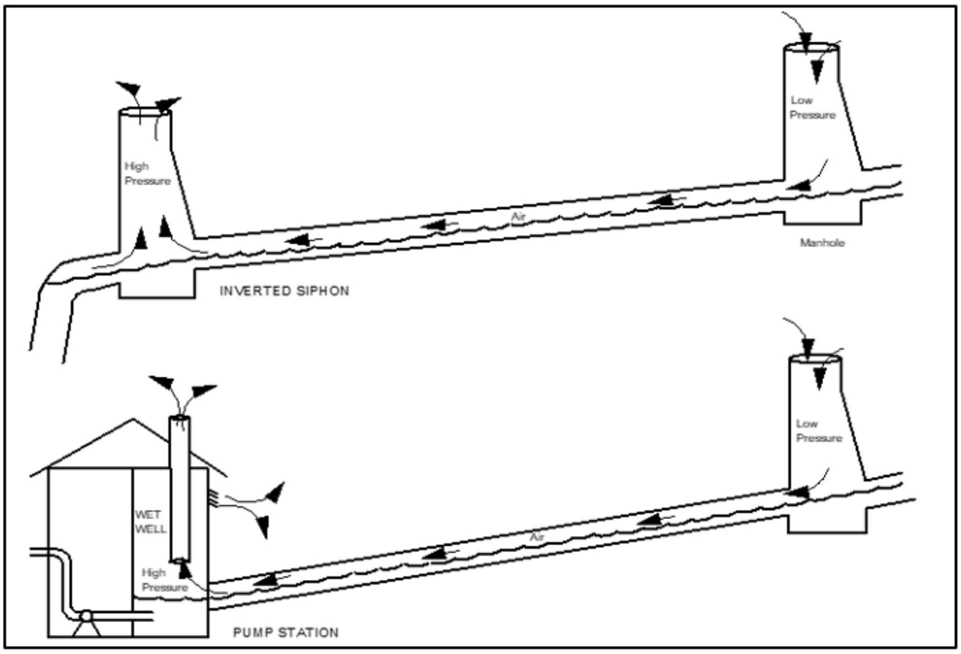


Figure 3-2 Sewer Ventilation at Siphons and SPS

Along with providing air release to avoid pressurisation of the sewer, sewer ventilation systems are generally designed to meet one or more of the following objectives:

- To reduce septicity in the sewer by maintaining a supply of oxygen (reaeration)
- To dry unsubmerged sewer walls to control sulphide-initiated corrosion
- To reduce H_2S concentration in the sewer atmosphere
- To control odour emissions and minimise the risk of receiving odour complaints
- To reduce hazards to maintenance personnel through countering the development of a toxic and/or explosive atmosphere.

3.3 Basic Rules for Natural Ventilation Design in Gravity Sewers

It is preferable to employ natural ventilation patterns to promote air movement in a gravity sewer. Natural ventilation of sewers is achieved through the installation of vents along a sewer, with inducts to allow fresh air to enter the sewer and educts to allow release of air from the sewer.

The minimum headspace requirements and basic rules for locating of vents are outlined below.

3.3.1 Headspace Requirements for Natural Ventilation

To ensure the efficiency of natural ventilation of a sewer, the Water Services Association of Australia (WSAA) Sewerage Code of Australia [1] recommends that an air space be retained at either the peak dry weather flow (PDWF) or the design flow.

- Option A - Air space at PDWF
    - At PDWF, the depth of flow shall be not more than 60% of the pipe diameter i.e. a minimum air space equivalent to 40% of pipe diameter at PDWF
- Option B - Air space at design flow (this option caters for future growth or phased development)
    - At design flow, the depth of flow shall be not more than 70% of pipe diameter i.e. a minimum air space equivalent to 30% of pipe diameter at design flow.
- Option C – No air space at design flow and ratio of PDWF to pipe full capacity does not exceed 0.6.

It is noted that there are also conditions in a sewage network that can cause a pipe to surcharge completely restricting the sewer headspace (such as a rising main release location) that also need to be considered.

Option A is the preferred approach.

3.3.2 Controlled and Uncontrolled Natural Ventilation Systems

Natural ventilation can be achieved using uncontrolled or controlled systems [2].

An uncontrolled natural ventilation system consists of alternating short induct and tall educt vents, designed to maximise the effect of wind flow and air relative density effect. In these systems air flow in each adjacent section of sewer is in opposite directions with each educt vent pulling most of the air from the upstream section and the remainder from the downstream section (against sewage flow). A downside of having air and sewage flow in opposite directions downstream of educts is that the relative velocity of air increases and thus H_2S emissions and evaporation also increase. The combination of higher H_2S concentration and higher humidity increases the possibility of wet walls and corrosion. Figure 3-3 provides a graphical representation of uncontrolled ventilation.

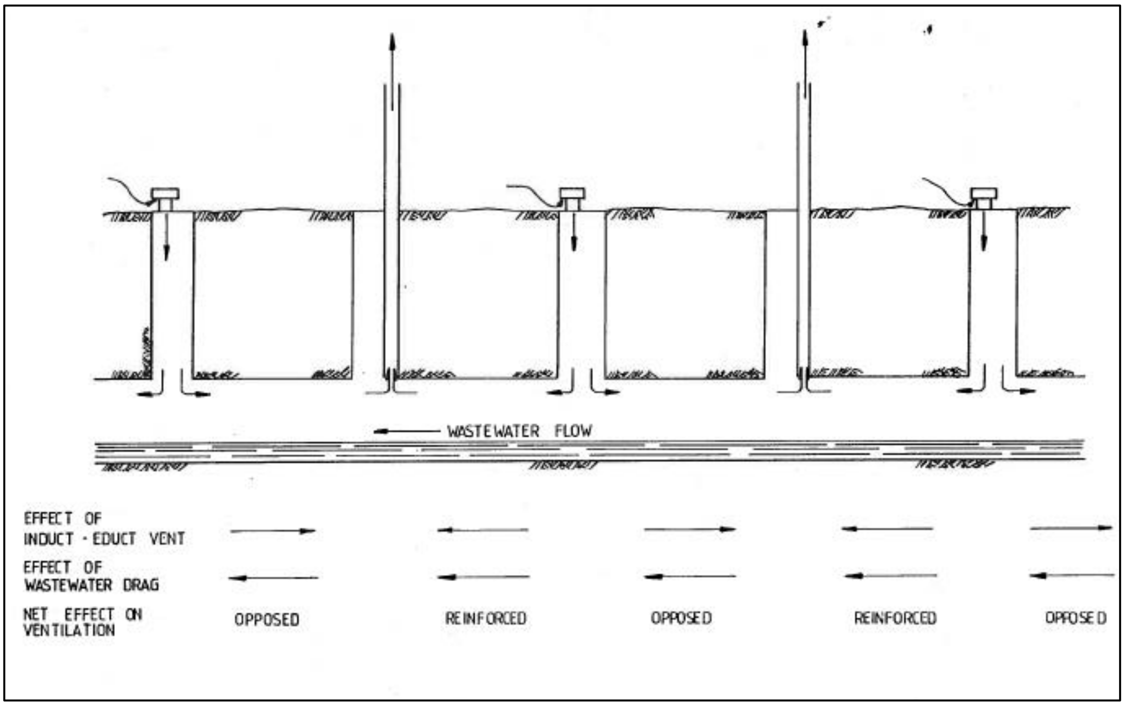


Figure 3-3 Uncontrolled Natural Ventilation [2]

Controlled natural ventilation systems are designed to encourage airflow in the direction of sewage flow. Each ventilation shaft is divided into educt and induct zones using suitable ducting and bulkheads to prevent short-circuiting of air flow. These systems have lower relative velocity between the liquid and vapour phase, which minimises H_2S emissions and evaporation. The use of flexible bulkheads promotes total air exchange in each ventilated section, aiming to minimise the build-up of H_2S and humidity in the air flowing through the sewer. However, the use of these bulkheads adds additional complexity to sewer design and additional maintenance requirements and are not commonly employed. Figure 3-4 provides a graphical representation of controlled ventilation.

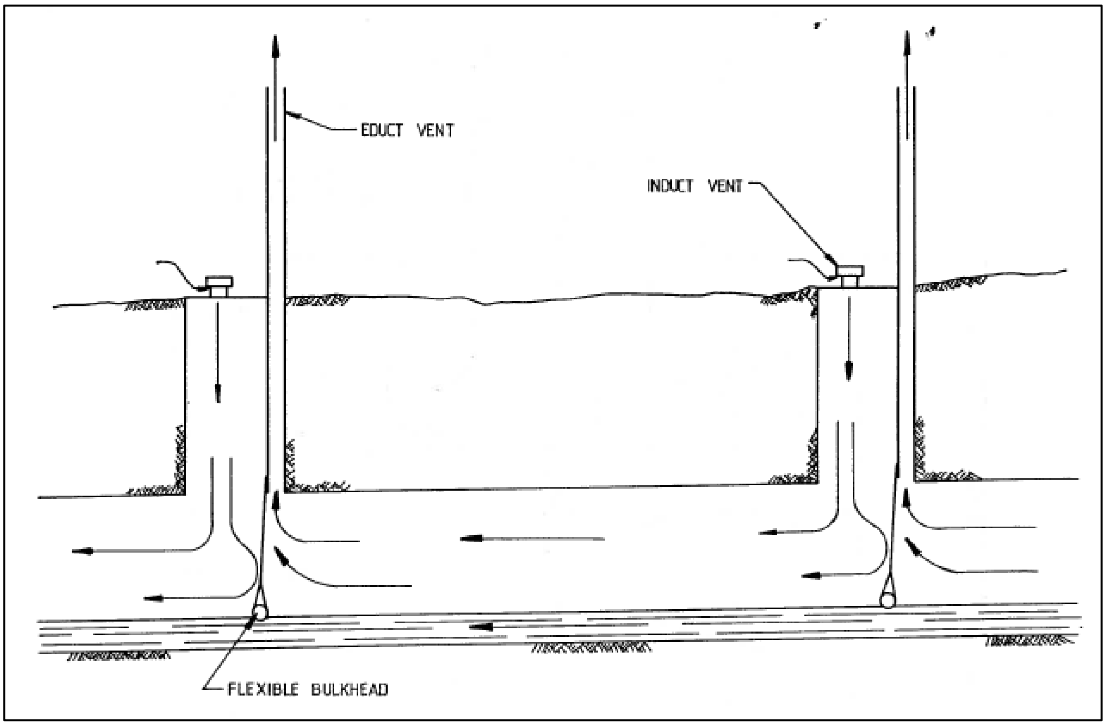


Figure 3-4 Controlled Natural Ventilation [2]

3.3.3 Locating Vents

The maximum recommended nominal spacing of vents along a trunk or branch sewer is 400m [1]. Inducts are required where the incoming sewers do not provide enough movement of free air to avoid pressurisation

The siting of vents must also consider the hydraulic conditions in sewers to ensure proper ventilation. In addition to the above maximum nominal spacing, vents shall also be installed on trunk, branch and reticulation sewers at the following locations:

- At rising main discharge manholes
- At siphons (see Figure 3-1):
    - Educt shall be installed at the upstream end of a siphon, immediately upstream of where surcharging of the sewer occurs
    - Induct downstream of the siphon
- Where sewer grade changes significantly (see Figure 3-1):
    - Induct at the top of the slope
    - Educt at the bottom of the slope. For large or trunk sewers, a passive carbon filter can be preferable to an uncontrolled educt[1].
- At SPS
- Educt vents or air valves are typically fitted at high points in pipelines and rising mains that are running full to prevent build-up of gases [4].

Consideration should also be given to the following when locating vents [1]:

- Locate vents above the 1:20 year flood level or else the base to be built up to flood level
- Locate vents outside the zone of influence of future sewer inlets
- Locate vents on high ground above the level of adjacent inhabited areas
    - When high ground is not available, vents should be located at the most exposed sites, or in places where full advantage can be taken of high wind velocities;
    - Vent locations near tree canopies should be avoided, as these can detain odour and inhibit good dispersion of odours leaving the vent. If a vent needs to be amongst trees, the stack height should be at least 3 m above the canopy.
- Locate vents as far as practicable from houses and other habitable areas, especially where buildings are likely to be more than one storey high.

While there are no hard and fast rules for where to avoid installing inducts, the following risk factors should be considered when they apply, either on their own or in combination:

- Proposed induct is near residences
- Locations where the sewer is at risk of being pressurised:
    - Such as the following;
        - SPS
        - drop structure
        - sudden change in grade from steep to shallow
        - sudden reduction in sewer size near the proposed location and there are few or no educts or sidestreams immediately upstream

[1] This is due to SA Water's past experience with educts under these conditions releasing significant odour. Note that a passive carbon filter may need to be changed to an active version if air flow in the sewer reduces.

  - The sewer joins to a trunk sewer downstream which is minimally ventilated
  - The sewer has been lined with a plastic liner, making it less leaky and so magnifying air pressure surges.
  - Pressure monitoring of the sewer could help diagnose if this is an issue before the induct is installed.

3.3.4 Vent Design

Vent design is outlined in Section 4.2.

Ventilation infrastructure and equipment should be made from non-corrosive materials [4]. The use of uncoated mild steel or galvanised mild steel should be avoided.

4 Network Ventilation Infrastructure and Design Criteria

4.1 Introduction

There are numerous types of infrastructure associated with sewer ventilation, including:

- Inducts/educt vents
- Passive/active carbon filters
- Dampers and throttling valves
- Air curtains
- Fan stations

This Section provides a description of each of the items above, along with details of their application, associated risks and any relevant design criteria.

4.2 Induct/Educt Vents

Vent shafts are typically above ground structures that either:

- Admit air into the sewer system (induct vents) to reduce the likelihood of sewage becoming septic or corrosive and causing odour issues; or
- Allow odours to escape (educt vents) and be dispersed

The combination of these vents promotes natural draft from the ground-level induct to the tall stack educt.

4.2.1 Inducts

SA Water's standard induct vent stands 1.2m high, and contains louvres to facilitate entry of air into the sewer. The maximum allowable offset distance from the vented sewer or structure to an induct is 20m. Figure 4-1 shows a photograph of an induct and an isometric drawing. SA Water's standard general arrangement for an induct vent is shown on Drawing 4005-20007-05.

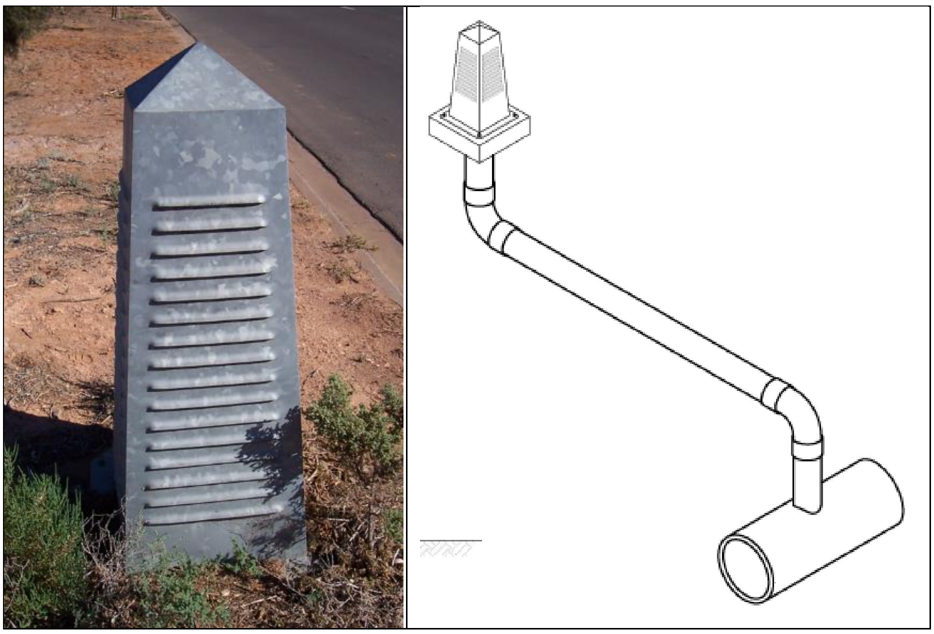


Figure 4-1 Induct

Note that the standard induct uses a DN100 connection pipe; it may be necessary to increase the number of inducts or else increase the size of the connection pipe for trunk sewers to provide for their ventilation requirements.

New inducts are to be fitted with dampers to allow throttling of inlet air. In the case of existing inducts, dampers can be retrofitted as required. Where air measurements will be required at an induct, design shall include a PVC stub flange on top of the retrofitted damper to enable attachment of a temporary extension pipe (during commissioning only) to facilitate induct airflow measurements and negative pressure readings. These requirements are shown in Figure 4-2 below [4].

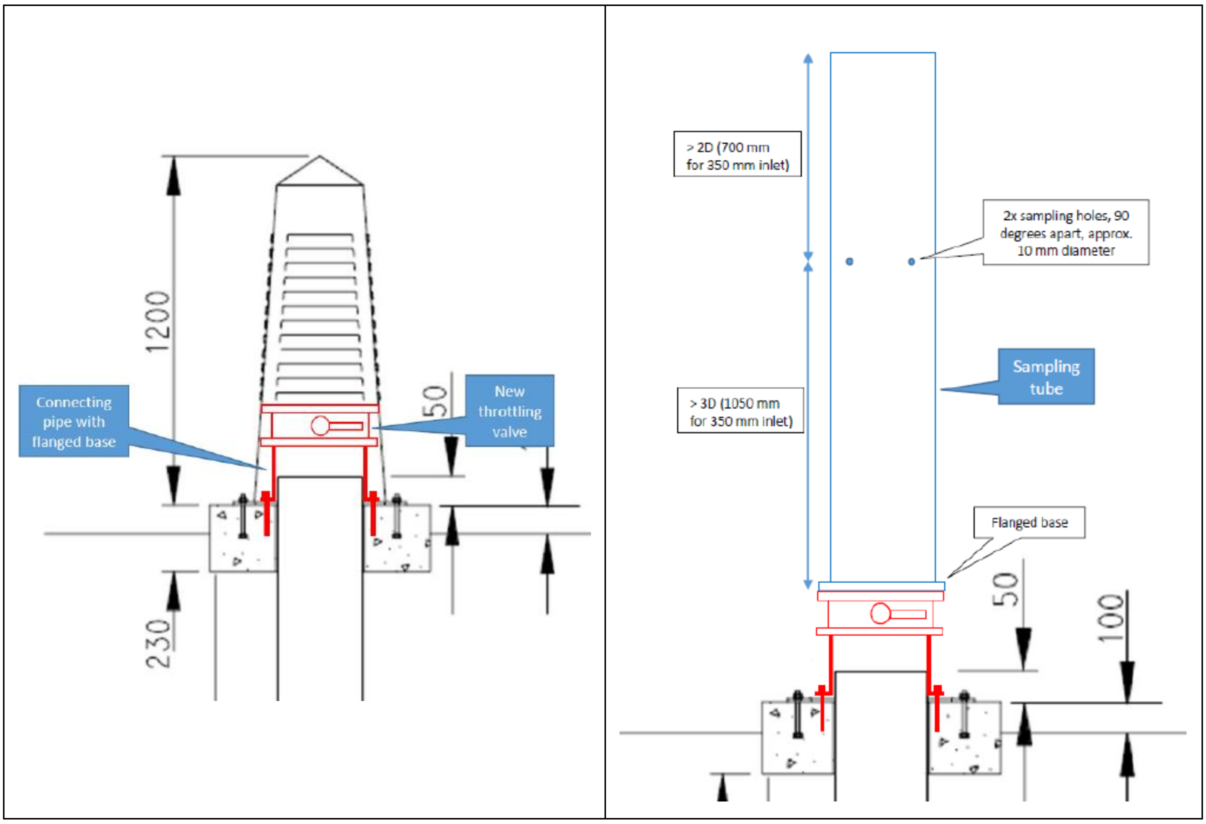


Figure 4-2 Retrofitting of Damper on Existing Induct and Fitting of Temporary Extension Pipe

4.2.2 Educts

SA Water standard educts are 15m tall with a diameter of 300mm and are constructed from either glass reinforced plastic or stainless steel [4]. The maximum allowable offset distance from the vented sewer or structure to the educt is 20m.

Unpainted stainless steel vents are recommended for better durability and lower maintenance. However, painting of vents may be required for aesthetic reasons.

SA Water's standard general arrangement for an educt vent is shown on Drawing 4005-20007-06.

4.2.3 Risks/Issues

Risks and issues associated with ventilation of the sewer using inducts/educts are as follows:

- Uncontrolled systems may generate air flow in the opposite direction to the wastewater flow downstream of educts, resulting in reduced effectiveness and sometimes an increase in odour emissions [2].
- System may not work reliably due to low sewage gas temperatures or a lack of wind passing over the vents. Wind driven rotary cowls may increase draft, however they are not always effective [4].

- Natural ventilation by inducts and educts is generally not sufficient for corrosion control as ventilation rates are not high enough to maintain dry pipe walls, thus all exposed surfaces should be manufactured from non-corrosive materials [1].
- Inducts can operating as educts under different flow scenarios in the sewer, which can result in odour emissions close to ground level.

4.2.4 Design Criteria

4.2.4.1 Location

Guidelines for locating inducts and educts are outlined in Section 3.3.3.

4.2.4.2 Sizing

Educt vents should have a diameter equal to that of the sewer for sewers with a diameter of less than 300mm. Greater than this, they need to be specifically designed [8]. Melbourne Retail Water Agencies indicate that 300mm would be suitable for all of the network for sewers up to DN750, as the default vent diameter that is normally selected is approximately half the diameter of the sewer. The vent sizes used in Sydney and Melbourne are summarised in Table 4-1. While vent sizes are not explicitly stated by Sydney Water for sewers larger than DN300, it is reasonable to assume that the vent size is a fraction of sewer size for larger sewers and maxes out around 400 mm as it does in Melbourne.

Table 4-1 Educt Diameter Selection

<table>
<tr><th rowspan="2">Sewerage Main Size DN</th><th colspan="2">Vent Diameter (mm)</th></tr>
<tr><th>MRWA*</th><th>Sydney Water</th></tr>
<tr><td>225 to 300</td><td>150</td><td>225 to 300</td></tr>
<tr><td>300 to 375</td><td>150</td><td rowspan="4">Custom</td></tr>
<tr><td>450 to 525</td><td>225</td></tr>
<tr><td>600 to 750</td><td>300</td></tr>
<tr><td>>750</td><td>Custom#</td></tr>
</table>

* Melbourne Retail Water Agencies.

Could be up to 400 mm.

Table 4-2 shows outer diameter (OD) and internal diameter (ID) for different sized vents when made with SS316 steel.

Table 4-2 Educt Diameters (SS316)

Vent Diameter (mm)	Vent OD (mm)	Vent ID (mm)	Vent Wall Thickness (mm)
150	168.3	146.4	11.0
225	273.1	254.6	9.3
300	323.9	304.8	9.5

For height, vents should be at least 2 m higher than adjacent buildings and any proposed building having development approval [8]. Table 4-3 lists maximum stack heights based on vent diameter and maximum wind speed. Two different wind speeds are available for design.

Table 4-3 Educt Vent Heights

Vent Diameter (mm)	Maximum Height (m)	
	56 m/s wind [1]	89 m/s wind [2]
150	14	9
225	18	12
300	18	14
>300	Custom – up to 16 m high.	

Notes

1. For areas with a high degree of protection (e.g. built-up area – large, tall and closely spaced buildings)

2. For highly exposed areas.

4.2.4.3 Materials of Construction

Vent shaft material shall be designed for a minimum 50 year service life, and meet the following requirements [8]:

- For vents located in coastal environment (within 1 km of coastline), vents and cowls shall be made of 316 stainless steel. An alternative grade having a minimum PREN of 24 may be used.
- For vents located in inland environment (further than 1 km of coastline), vents and cowls shall be made of 304 stainless steel. An alternative grade having a minimum PREN of 18 may be used.
- Hot dipped galvanised structural members shall only be used external to the vents and in places where rusting can readily be detected and maintenance repair can be carried out. Alternative is 304 stainless steel.

4.2.4.4 General Requirements

- Educts should be fitted with a mesh panel to stop birds and other unwanted items entering the sewer.
- The use of unshielded, low, open-topped inducts stacks is not advised due to wind effects which result in reduced air inflow. If ground level inducts are unacceptable, shielding, vanes or special terminals should be installed as a minimum measure [2].
- All vents shall have a sample port for anemometer access to facilitate air flow measurement, and a door with a minimum opening 115 x 55 mm to facilitate H_2S monitoring. Both shall be located no higher than 1.5m from ground level.
- For larger educt vents, a balance between aesthetics and air flow is required, as reduced vent diameters can cause a large increase in the airway pressure drop, leading to reduced airflow [2].
- For educt vents in sensitive locations, dispersion of gases from the vent must be enough to reduce the odour concentration to an acceptable level. This can be determined using a risk assessment approach to evaluate the risk of sulphides in the sewer headspace and odour release from the vents. If there is a risk of adverse odours then further investigation needs to be conducted to develop solutions that mitigate the risk. Solutions may include the installation of forced ventilation or passive activated carbon filters.

4.3 Passive/Active Carbon Filters

4.3.1 Description and Application

Carbon filters are vessels containing activated carbon (AC) media that are installed on sewer vents to treated H_2S laden air prior to discharge to atmosphere. AC is effective in removing odorous compounds and volatile organic compounds from airstreams. AC media physically adsorbs organic odorants then acts as a catalyst in the oxidisation of H_2S to disulphide. The effectiveness of this process may be enhanced by impregnating the AC with other compounds such as copper based compounds or caustic based compounds such as sodium hydroxide or potassium hydroxide. Following oxidation, the disulphide is physically adsorbed by the AC. Over time, the adsorption sites become fully occupied by contaminated molecules. At this point the AC is spent, no longer providing effective odour control, and must be replaced. Spent AC can also become a source of odour as the absorbed compounds react to form dimethyl disulphide and become released from the AC.

Air can be delivered to a carbon filter via the following two methods:

- By natural ventilation patterns in the sewer, which is referred to as a passive system
- Under forced ventilation using a fan, which is referred to as an active system

4.3.1.1 Passive Carbon Filters

There are two types of passive AC filters – those installed in educts, and low pressure AC filters.

Figure 4-3 shows a passive AC filter on at the top of an educt, however it is noted that these can also be installed at ground level. Historically, SA Water has installed passive carbon filters on educts upon receipt of odour complaints, with the aim of treating air prior to its discharge. However, in practice the pressure required to drive the air through these filters is more than at other release points along the sewer (upstream or downstream of the filter location) meaning that the effect is similar to blocking this educt. In practice this can create the impression that the problem has been solved but in effect the problem is just moved to another location. Installing AC filters on top of vents also creates issues with for maintenance and working at heights so are not recommended.

Figure 4-3 Passive AC Filter on Educt

Low pressure AC filters, or “green domes”, are AC filters installed at ground level designed to capture odours and volatile gases from air vented pump stations, air release valves, sewers and tanks. Green domes are designed with a large surface area to achieve a low face velocity and thus a low pressure drop through the media, to encourage air from the sewer to exit via the green dome. Figure 4-4 shows a green dome.

Figure 4-4 Low Pressure Carbon Filter (Green Dome)

The use of green domes must be considered on a case by case basis, as there must be adequate pressure in the sewer (at least 30 – 50 Pa) to push air through the AC media, as well as no vents or locations where air can preferentially exit the sewer in the vicinity. One application may be at rising main discharges or pump stations, as the pressure in these locations is generally quite high and air cannot usually migrate to other locations with a lower pressure drop.

As green domes require a minimum pressure to operate and need to be maintained to retain filtering capacity, and so are more complicated than an educt vent, they should be considered only where there is no option for an educt vent. This could include cases such as tall developments where odours from the vent could impact people at vent height (e.g. apartment blocks, hotels), or city "canyons" which create poor wind flow and stop the odour from the vent adequately dispersing. It is emphasised though that sufficient pressurisation of the sewer is the first requirement to qualify green domes as an option.

4.3.1.2 Active Carbon Filters

Active carbon filters consist of a fan and an AC filter, and should be installed at ground level to allow easy access to mechanical equipment for maintenance purposes, and for monitoring of AC media.

Active carbon filters could also be located at the top of an educt through the use of an axial fan installed in the educt, however this is not recommended due to poor accessibility for maintenance and monitoring.

4.3.2 Risks/Issues

The risks and issues associated with passive AC filters are as follows:

- The installation of passive AC systems on educts has a similar impact to blocking vents, and is not recommended as a longer-term strategy for odour control. Air flow through the carbon filter can be negligible, as the pressure in the sewer is generally not adequate to push all air flow through the AC. Odour issues are moved to other areas of the network where air can escape, and there is increased corrosion risk due to the restricted educts causing the downstream sewer H_2S concentrations to become more concentrated.
- Passive carbon filters on educts cannot be easily monitored or maintained, and work at heights is required to change media cannisters.
- In low sewer air pressure conditions, there is a risk that the carbon layer may restrict the air flow resulting in out-gassing elsewhere along the network. Alternatively, in high pressure surge conditions there is a risk of fluidisation of the AC media, resulting in H_2S escaping untreated through the green domes. For this reason an appreciation of the potential pressures and airflows involved is required prior to the selection of the appropriate filter size. While fluidisation could be minimised through design, e.g. make the AC unit wider to reduce air speed or narrower to increase the weight of the carbon in the airstream, these can be impractical in locating the filter and facilitating air flow, respectively. A simpler approach is to have a downflow filter but this type of design would require a way to remove excess water and moisture before reaching the filter. The recommended

maximum velocities to prevent fluidisation in an up flow filter is 0.25m/s and could be as high as 0.35m/s in a downflow filter.

- If green domes are not maintained and media changed over as required, there is a risk of discharge of odorous air at ground level.

The risks and issues associated with active AC filters are as follows:

- Filters are not maintained and spent AC media is not replaced, resulting in odour breakthrough and the possibility of odour complaints, as well as corrosion of surrounding structures and equipment as a result of the discharge of untreated H_2S. SA Water has a standard maintenance regime for Green Domes, so in this case the real risk is not following the procedure.
- If media becomes clogged and remains this way, there will be increased wear on the fan, and fugitive leakage could occur from any gaps where air can escape. Media blockages can be detected by monitoring either air flow, power draw, or pressure drop across the carbon. As an alternative to monitoring online, instruments can be installed on the filter (e.g. non-powered rotameter or pressure gauge) for local inspection during routine checks by field personnel.
- Absence of remote alarms or monitoring, leaving the filter offline and sewer assets unventilated for an extended period.

While there are potential issues with carbon filters, any risks they pose need to be considered in the context of the situation where the filters might be applied. Table 4-4 shows an example of how the pros and cons of a carbon filter might be evaluated against the existing non-controlled vent.

Table 4-4 Example Evaluation of Carbon Filters for Specific Situations

Situation	Action	Pros	Cons
Induct identified as source of odour	Do nothing	• Air is still free to enter sewer. • Low maintenance.	• Odour is able to escape. • Induct may not actually be needed if acting as an educt.
	Change to PAC filter	• Odour release ceases. • Air can still leave sewer if it needs to (filter will restrict this to some extent*)	• May restrict or stop air inflow*. • Need to maintain filter.
Educt: • releases significant odour, or • higher development (e.g. apartments) has occurred around it.	Do nothing	• Air is still free to leave sewer. • Low maintenance.	• Educt is not meeting design if odour is detectable. • Odour impact will be beyond educt design for elevated properties.
	Change to passive Green Dome filter	• Odour release ceases. • Air can still leave sewer (filter will restrict this to some extent) • Educt gone – lower visual impact	• May restrict or stop air outflow. • Need to maintain filter.
	Change to active Green Dome filter	• As for PAC filter – stops odour and no visual impact. • Fan ensures air is drawn from sewer.	• Need to maintain filter and fan. • Carbon may be exhausted earlier than for a passive filter.

Notes: * Air inflow can be improved if filter is designed with dampers that allow air to enter sewer bypassing the carbon, but close when outgassing occurs and direct air through the carbon.

4.3.3 Design Criteria

Design guidance for the use of active and passive carbon filters is as follows:

- The suitability of a passive carbon system consisting of a green dome must be considered on a case by case basis. The pressure drop across the green dome must be understood, along with the pressure in the sewer, and there must not be any other openings in the sewer with less resistance than for the green dome or air will preferentially leave the sewer via them without treatment.
  - Vendors will usually recommend one or two filter designs suitable for the sewer of interest. These will either come with the pressure drop indicated, or it can be calculated from the height of the carbon and the pressure drop / unit height specified by the carbon manufacturer. This will inform on fan selection for an active filter, and indicate the pressure required in the sewer for a passive filter.
  - Differential pressure loggers can be hired or purchased for the purpose of monitoring pressure in the sewer to use in selecting a passive filter. It is recommended that logging be done for at least a week during dry conditions and not during holidays or special events that would alter typical wastewater flows.
- For active carbon systems, ensure that sewer will not be under strong negative pressure as a result of fan operation. Ensure there is a suitable induct location to facilitate air movement.
- The design criteria for sizing AC units is included in SA Water's Technical Specification for Activated Carbon Filters.

See also Section 4.6.3.2 for guidance on design of SPS fan stations, which will affect the size of active carbon filters.

4.4 Dampers and Throttling Valves

Dampers and throttling valves should be installed at the following locations in the sewer:

- At inducts to control the volume of air entering the sewer (see Figure 4-2)
- At the inlet and outlet of fans extracting air from the sewer to enable throttling of the air flow

The head-loss across the dampers all depends on the type chosen, the setting selected, and the prevailing conditions in the sewer. A single blade damper can offer very low head-loss when open or near-open, though if the air flow increases due to changes in the sewer, the head-loss will also increase. To compensate for the variable nature of sewer systems, sometimes electrically actuated dampers are used, or weighted dampers when power and control cables are out of reach.

All dampers installed should be volume control dampers, consisting of a Table D butterfly valve, constructed from Grade 316 stainless steel with a lockable lever [4] and EPDM seals. They should be of robust, light weight construction designed to withstand 2 to 3 times the designed air flow and static pressure, and should be free of rattles, fluttering or slack movement, and capable of adjustment over the necessary range without excessive self-generated noise or the need for special tools. Dampers should be located where they are easily accessible to operators.

Blades should be without sharp edges and sufficiently rigid to eliminate movement when locked. Blades minimum thickness shall be 1.6 mm. The shafts should not be in a vertical position to prevent condensate entering bearings.

Volume control dampers should be capable of being adjusted and locked in the following blade positions: "Open", "10° to open", "20° to open", "30° to open" and "Closed". The positions should be clearly and permanently labelled.

4.5 Air Curtains

Air curtains are commonly used in management of air flow in mechanical ventilation systems to separate a common headspace into zones to provide control of ventilation patterns within the space. The flexible bulkhead shown in Figure 3-4 shows an example of where an air curtain may be installed.

Curtains are generally constructed from rubber sheeting/strips and are bolted to the sewer to keep them in place.

Curtains have been installed in the sewer in Orange County in USA, however their use in the sewer is not very common or widespread, largely due to the associated issues they cause outweighing the benefits. Curtains restrict the movement of solids in the sewer and can rip off during high flows. Installation and inspection of the curtains also requires confined space entry, and there is a high likelihood that once these curtains are installed they will not be inspected or maintained.

It is not recommended that air curtains are used in management of forced ventilation systems in the sewer. Although, there will be unique cases where an air curtain is the most practical solution or only option despite the disadvantages that come with it. Even so, air curtains should be considered a last resort and not the preferred solution.

4.6 Fan Stations

4.6.1 Description and Application

Fans stations are used to provide mechanical or forced ventilation to draw air from the sewer or SPS. Air can be discharged directly to atmosphere through an educt vent or treated in an odour control system (OCS) prior to discharge. The need for odour control is discussed in Section 6.

Educts allow air to escape from the sewer, but installation of a fan to pull air from a sewer will increase the length of sewer that is ventilated, by inducing a greater negative pressure inside the pipe. As shown in Figure 4-5, air will be pulled to the extraction point both in the direction of sewage flow, and against sewage flow. The extent of the negative pressure zone of influence in the upstream direction is generally greater due to air being pulled in the same direction as flow. The zone of influence is proportional to the extraction rate and the volume of air moving in the sewer.

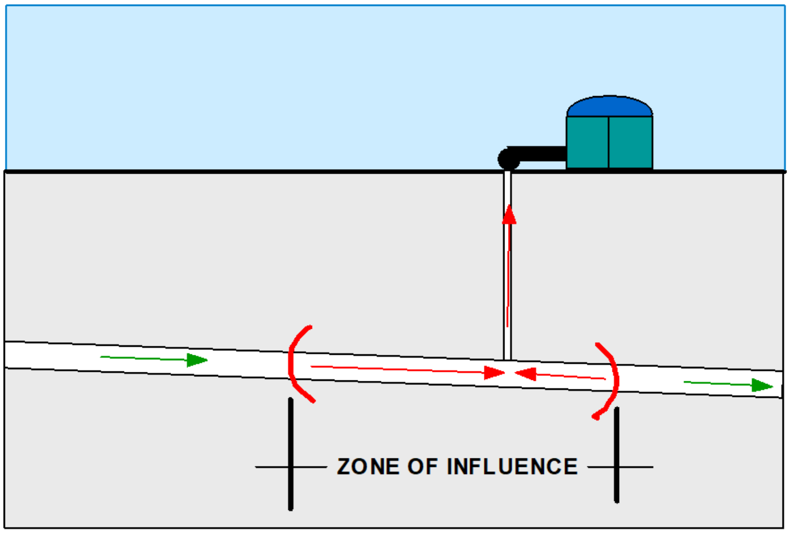


Figure 4-5 Fan Station Zone of Influence

Fan stations are generally used for odour control purposes as they provide control over where foul air exits the sewer. They are not as successful for corrosion control as it is difficult to draw enough air through a sewer to eliminate moisture on sewer walls. Although it varies from case to case, successful implementation would require fan stations to be only a few hundred metres apart, as air drawn into the sewer quickly becomes saturated and can no longer absorb moisture from the sewer walls. It is noted that SA Water's older fan stations were installed on trunk sewer for asset protection, as was the practice at the time. This would be impractical to implement today, as the spacing would result in many fan stations on a long trunk, the height required to disperse odour without treatment might make them an eyesore, and the cost for treating air from multiple stations would be prohibitive.

Fan stations are often installed to extract foul air from SPSs. Depending on SPS design, air should be extracted from the wet well itself, along with any nearby control manholes and sewer chambers. SAW only has SPSs with fan stations that have an OCU attached to treat the discharged air.

4.6.2 Risks/Issues

The risks and issues associated with fan stations are as follows:

- Fans stations result in extraction of much larger volumes of air than natural ventilation. If air is untreated and an odorous spike of air passes through the sewer, there is a greater risk of receiving odour complaints. The need for treatment of extracted air must be considered when installing a fan station.
- Fan stations do not generally provide effective corrosion control.
- Care must be taken to ensure that metallic fans and equipment which may produce sparks are not used in situations where explosive gas mixtures may be present. Hazardous area classification and electrical instrument selection process should strictly follow Australian Hazardous Area Standards AS/NZS 60079 and AS/NZS 4761 for assessing competency of workers undertaking the installation work [4].
- Fan stations pose a risk for noise complaints from nearby receptors if not well designed
- Forced ventilation should not be used in areas where surcharging is an issue
- Excessive negative sewer pressure can drain water seals

4.6.3 Design Criteria

4.6.3.1 Sewers

Educt fan sizing must accurately account for all air flows into each sewer section, as optimal operation requires a balanced system. Under-estimation of air flows will result in incomplete exhaustion of sewer air.

There are multiple bases that can be used to size a fan station for sewers, indicated in Table 4-5 below. Each will give a different air flow, but there should be some similarity between them. It is up to the designer in the end to make a choice that is practical to solve the specific sewer problem, but not oversized to avoid unnecessary expense.

Table 4-5 Basis for Sizing Air Flow of Sewer Fan Station

Basis	Guidance
Empty Sewer	Size fan to achieve a velocity of 1-2m/s in the empty sewer pipe.
Half-Full Sewer	Determine the extraction rate based on a headspace air velocity that is 50% of the sewage velocity. This will intercept moving air and provide a zone of influence both upstream and downstream of the extraction point.

Basis	Guidance
	An air velocity that is only 35% of the sewage velocity decreases the zone of influence and will not provide adequate extraction from both directions.
Velocity Parity	Set the air velocity to be equal to the surface wastewater to reduce turbulence in the sewer air and the rate of escape of odorous gases [2]. To calculate air flow, select the headspace cross-sectional area that either corresponds to ADWF, or the flow rate prevalent when odour complaints if this is happening.

Design must ensure that there are adequate inducts to avoid generating an excessive vacuum on the sewer. Inducts should be located to avoid short-circuiting of incoming air to the fan station.

In some cases, the inducts may become a release point for odour if the ventilation system fails. While alarms and good management practices should keep downtimes to a minimum, if an induct is particularly problematic for odour release during downtimes, then inducts with self-closing dampers should be considered. These can either be electrically actuated, with solar panels an option where power is not available. Also, self-closing dampers using a mechanism such as weights, springs, or flaps can be installed.

4.6.3.2 Sewage Pump Stations

When sizing a fan station for a SPS, consideration should be given to the areas that require ventilation. Generally, areas where the headspace is connected to the wet well should be allowed for in ventilation design. These areas could include control manholes, connecting sewers, overflow structures, and any other chambers.

Separate extraction points may be required for separate areas if there is not a suitable path for air to flow to one extraction point under all flow conditions. Separate extraction points may also be required where there is a preferential flow path but it compromises air extraction from certain areas. The extraction points may use flow modulating valves or a manual type valve. The extraction points should also have test ports so that the air flow can be verified.

Covers for pump stations, manholes and access hatches should be designed to minimise air leakage by using rubber seals and being positively secured with bolts or a locking mechanism. The extraction rate from a SPS should allow for the following:

- 6 to 12 air changes per hour (ACH) in unmanned wet wells, manholes and chambers.
- Up to 12 ACH in areas where personnel may enter.
- The extraction rate shall be 25% greater than peak wet weather flow entering the wet well.
- A negative pressure of at least 10Pa is achieved in the wet well.

SA Water generally adopts 6 ACH for wet well ventilation, and 12 ACH for hazardous area ventilation (e.g. where personnel may enter). These practices are generally consistent with the above guidance when the basis used for air flow sizing is considered. However, when SA Water uses 6 ACH, the volume of the wet well, upstream sewer pipe, control manhole, and any other immediately connected chambers are included, meaning that the air flow sizing by SA Water generally meets or exceeds the guidance.

4.6.3.3 General

- Ensure that due consideration has been given as to whether extracted air requires treatment prior to discharge to minimise risk of odour complaints (see Section 6).
- Fans produce noise that can result in complaints and damage the hearing of operators. Managing noise should be considered during the design stage. It is outside of the scope of

this document to advise on action for this matter - the reader is referred to SA Water's *Environmental and Heritage Management Plan* for appropriate guidance.

5 Natural and Mechanical Ventilation

5.1 Introduction

Natural and mechanical ventilation are used to promote air movement in sewer systems. This air movement assists with odour management, but is less effective for corrosion control. This Section compares natural and mechanical ventilation and explains the reasons ventilation is suitable for odour control and short coming of ventilation as a form of corrosion control. Guidelines are also provided to assist in determining whether natural or mechanical ventilation is required on a sewer system.

5.2 Comparison of Natural and Mechanical Ventilation

As outlined in Section 3.1, natural ventilation uses natural forces to create air flow into, through and out of sewers. These forces include temperature and buoyancy of air, drag from sewage flow and wind velocity over ventilation stacks. Some of these forces may counteract each other and it is common for the net force to be least when the need for ventilation is the greatest.

Most sewer systems incorporate natural ventilation as a minimum; however, generally, it is not possible to achieve all objectives of ventilation (as outlined in Section 3.2) with natural ventilation alone, particularly odour and corrosion control. Some deficiencies of natural ventilation include [2]:

- Air flows are not accurately predictable in quantity or direction due to variable natural driving forces. In particular, it is not possible to maintain zero mean sewage surface air relative velocity for minimisation of H_2S emissions and evaporation from the sewage surface.
- Air flows tend to be the least reliable under conditions when corrosive conditions are likely to be worst, for example where the sewer surcharges.
- As vents are linked via a common sewer headspace, odour emissions can occur at multiple locations, particularly when sulphide levels are at their worst.
- The maximum ventilation rate that can be achieved is generally 1-2 air changes per hour, compared to 5 or more air changes per hour for mechanical ventilation.
- In summer, air flows and conditions are such that wall drying for corrosion control is not practicably achievable.
- Natural ventilation cannot be relied upon to provide a safe atmosphere for workers in the sewer.

The major strength of natural ventilation systems are that they are simple and inexpensive to install, operate and maintain. Where odour and corrosion are not an issue, there is no driver to move away from natural ventilation of sewers. Forced ventilation systems use fans or other mechanical equipment to produce air flow into, through and out of sewers. A key objective of forced ventilation systems is to control the movement of air into and exiting from the sewer. Being able to control where air leaves the sewer makes mechanical ventilation useful where odour control is required. Where possible, mechanical extraction points should be selected in locations that are removed from nearby sensitive receptors, as this can alleviate the need for treatment of air prior to discharge. Further details on mechanical ventilation are provided in Section 4.6.

5.3 Odour Control vs Corrosion Control

One of the objectives for sewer ventilation systems identified in the H_2S Control Manual (1989) [2] is reducing the H_2S concentration in the sewer atmosphere, thus controlling corrosion. It may be feasible to design ventilation systems to achieve this objective, however there are limitations that can make this impractical. In order to have measurable results, the sewer atmosphere would need to be frequently and completely replaced by fresh air. This is likely to be uneconomical and would require large volumes of odorous air to be disposed of [3].

Another objective for sewer ventilation systems is to dry sewer walls to control sulphide-initiated corrosion; however, there are limitations to achieving this objective as well. In most cases, adopting ventilation to maintain dry sewer walls is not practicable as the relative humidity of ventilation air rapidly increases along the sewer. Relative humidity of the sewer atmosphere must remain below 80-85% to avoid condensation of moisture on the walls, therefore the length of sewer downstream of a ventilation station is constrained by the distance for air to reach this limit. Depending on the total length of the sewer, this could result in a large number of ventilation stations required and high operating and maintenance costs [9].

These two points highlight that ventilation systems alone may not be effective for corrosion control. Therefore, ventilation is more likely to be installed to control odour emissions or in cases where only very localised corrosion control is sought.

5.4 Guidelines for Application

Natural ventilation via a series of alternately sited induct and educt vents is generally satisfactory for venting branch and trunk sewers. Mechanical ventilation may be required for some larger trunk sewers and where septic sewage exists [1].

Natural ventilation should be installed for systems where sewage is normally fresh (i.e. mainly domestic wastewater and sewer grades are reasonably steep and frequent branch sewer junctions allow air inflow) or does not tend to be stale or septic and the sewer is not in close proximity to odour sensitive areas. Most sewers incorporate some method of natural ventilation, however there are situations where it is not sufficient.

Mechanical ventilation should be used in the following situations:

- Sewage is always septic
- Sewage is either stale or septic and flow turbulence (sewer drops) cannot be avoided
- Sewage is slow flowing or ponding (flat grades) and likely to be stale or septic,
- In locations where frequent odour problems are likely to occur and odour treatment and/or stack dispersion is critical [2].

5.5 Design Considerations

Design considerations for natural ventilation are outlined in Section 3.3.

Design consideration for mechanical ventilation are outlined in Section 4.6.3.

6 The Need for Odour Control

6.1 Introduction

In some instances, installation of natural or mechanical ventilation systems alone is sufficient to minimise the risk of odour complaints from a sewer network. However, in areas where emissions from the sewer have a negative impact on surrounding receptors, the installation of mechanical ventilation with odour treatment of extracted air may be warranted. Depending upon the scale required, an OCS can require significant capital investment and ongoing operation and maintenance (O&M) costs. Therefore, SA Water requires a robust decision making process to determine when odour control is deemed necessary.

This Section will provide guidance on the following:

- Drivers for odour control
- Assessment of odour control requirements at SPS
- Assessment of odour control requirements for new developments

6.2 Drivers for Odour Control

Historically, odour control has been dealt with in a reactive manner, with odour complaints the driver for implementation of odour control measures. This approach is valid for existing sewers, as customer feedback provides an indication of where investment should be made. However, in areas of new development or when changes in a network are made that impact upon an existing sewer, this approach is not suitable.

Odour risks are generally higher for new developments for the following reasons:

- Initially developing areas only having a low number of connections, causing long hydraulic retention time (HRT) which results in higher sulphides
- Proximity to sensitive receptors who have invested in new properties and are more sensitive to odour issues
- Sometimes these development result in a pressure sewer system or a daisy chain arrangement of pump stations, which causes long HRT

It is no longer suitable to design sewers without proactive management of potential odour issues. In areas of new development, residents have generally paid significant amounts for their new homes and have an expected level of service to meet the outlaid costs. If these expectations are not met through decreased aesthetics resulting from odours, complaints are likely. It has also been seen that in existing communities where there has been a history of ongoing, unresolved odour issues, residents may be more sensitive to any odour release (even when initial ongoing issues have been resolved) and complain more readily than receptors in areas where odour release is less common.

The main driver for the need for odour control in new developments[2] or in areas where sewer conditions change is the presence of sensitive receptors near outgassing locations where H_2S levels in released air are considered offensive. The need for odour control may be avoided if the sewer is designed in a manner to avoid accumulation of H_2S in the headspace and outgassing near receptors. Guidance regarding the design of sewers to minimise release of H_2S into the headspace is provided in SA Water's *Technical Guideline TG0530 – Sewer Network Hydraulic Design Considerations to Minimise Network Odour Impact*.

[2] See Section 6.3.3 for odour assessment information specific to new developments.

6.3 Assessment of Odour Control Requirements

A risk-based odour assessment is required to determine a suitable approach to manage odour risks at SPS, and for new developments and areas of existing sewer where conditions may change.

A general method is outlined, followed by more specific details for SPSs, and new developments/areas of existing sewer where conditions may change.

6.3.1 General Method

1. Review of proposed network or SPS operation.
2. Identification of areas (or hot-spots) where there is potential for odour risk.
3. Identify whether odour issues appear to be systemic (throughout part of a network) or localised.
4. If considered necessary, undertake more detailed analysis using sulphide generation modelling or other tools to predict the H_2S levels that could occur.
5. Rank the risks likely in each area using a system of ranking such as that outlined in Table 6-1.

Table 6-1 Risk Factors and Ranking Guidance

Potential Risk Factor	Ranking Parameter	Risk Category		
		Low	**Medium**	**High**
Potential for outgassing	Presence of significant sewer headspace airflow restriction	No restrictions in the sewer headspace	Potential restriction such as flooded inlets at manholes or, a shallow grade after a long steep grade in sewer	Complete restrictions such as siphons or pump stations
Distance to closest sensitive receptor from outgassing location	metres	>100	<100	<50
Number and type of nearby receptors	Number of receptors within 100m	<2	2 - 10	>10 or close to school, church, hospital or public building
Upstream HRT in rising mains	Hours	<2	2 - 4	>4
Presence of upstream daisy chain SPS	-	No	Up to a few chains contributing significant flow	Multiple chains contributing most of the flow
Presence of trade waste customers	-	A small portion of flow with insignificant sulphide levels	Likely to contribute a level of sulphides that will increase sulphides	Will contribute to the level of sulphide due to high BOD, temperature, or low pH
Low connections at start up	Proportion of ultimate flow at start up	No	~50%	<20%
For SPS	Wet well size	<1.5m dia.	1.5 - 2m dia.	>2m dia.
For SPS – Time between pump starts at min flow	Hours	<1	1 - 2	>2

Potential Risk Factor	Ranking Parameter	Risk Category		
		Low	Medium	High
Dissolved sulphide levels in sewage[1]	mg/L	<0.5	0.5 - 3	>3
Peak H_2S concentration in headspace[1]	ppm	<5	5 - 15	>15
Notes: 1. This information may not be available if more detailed analysis is not undertaken				

6. Determine an overall risk ranking for each odour hot-spot
7. For areas where risk ranking is medium to high, undertake further investigations to consider whether controls are necessary
8. Where odour issues are systemic or corrosion is an issue, consider whether chemical dosing[3] is a more suitable solution than air extraction and odour treatment
9. For localised odour issues, select a suitable odour control solution
10. Prioritise odour control works based on risk ranking

Further details on selection of suitable odour control technology can be obtained via SA Water Wastewater Expertise.

6.3.2 SPS

Where the risk-based odour assessment above indicates that odour control is required at a SPS, the following can be used as general guidance on the type of system installed:

- Low risk – natural ventilation
- Small SPS with medium or high risk – active green dome, provided all other openings where untreated air may escape can be blocked to avoid short-circuiting of untreated air. If a green dome is not suitable, consideration could be given to an active AC filter.
- Large SPS with medium to high risk – a dedicated OCS is required, such as a biofilter or a biotrickling filter with AC polishing

6.3.3 New Developments

Where the risk-based odour assessment above indicates that odour control is required at certain locations along a sewer in a new development or in areas of existing sewer where conditions are altered, the factors in Table 6-2 can be used as general guidance for determining odour control requirements.

Table 6-2 Odour Control Requirements

Odour Risk Category	Risk Factors		Outcome
	RM HRT (hours)	Receptors	
Low	<2	-	Use natural ventilation (e.g. educt).
Medium	2 - 4	Within 50 m of vent	OCS is required. Passive system may suffice.
High	>4	Within 100 m of vent	OCS is required. Active system required if odours could leak with a passive system.

[3] The operation of the SPS would need to be taken into consideration along with the location of the specific odour problem in evaluating chemical dosing. It should be noted that intermittent pumping by the SPS does not necessarily preclude chemical dosing as an option.

The type of treatment system installed for medium and high risk locations will need to be considered on an individual basis, and will depend upon the air flow and contaminant level to be treated. Guidance regarding selection of OCS is provided in SA Water's *Technical Guideline Part C Odour Control Technology Selection*.

Green domes are one type of odour control that could be used in a new development setting, particularly in the early phase of the development when the number of active connections is a fraction of the planned total. Screening criteria to determine if a green dome could be installed for a particular SPS are shown in Table 6-3.

Table 6-3 Screening Criteria for the Installation of Passive Green Domes on SPSs

Criteria	Value
Situations that might be suitable for green domes	• Assessed as medium or high risk based on Table 6-2. • Only temporary odour control is needed, or the need for a final odour control installation is still under assessment. • An educt is not desirable or not practical (i.e. multi-storey houses or apartments near the SPS). • Odour control is required and there are limitations to accessing power and/or water.
SPS wet well size	< 180 m^3 * (This equates to a maximum well diameter of ~4 m)
Wet well containment	• The wet well is well-sealed or able to be sealed. • If there are openings that cannot be sealed for any reason, an active carbon filter is more suite for the SPS.
Carbon service life	• Follow these steps: 1. Determine the average air flow through the green dome. If there is no basis, assume it to be half ADWF. Convert the air flow rate to m^3/s. 2. Determine the average H_2S concentration. If there is no basis, use the average for another SPS in the network with similar characteristics. 3. Calculate the H_2S load: Load (kg/mth) = Air_flow *(m^3/s)* x H_2S_conc *(ppm)* x 3.67924 4. Calculate the carbon service life#: Service Life (mths) = 133 / Load • It is up to SA Water to determine what is an acceptable carbon service life. Frequent carbon changeout creates work for field crews, can annoy residents, and runs the risk of odour impacts during servicing. • A service life of 6 months might be considered the minimum that is acceptable, as there are other carbon filters that are larger in size and so can offer longer periods of operation before carbon changeout. • Locations that are more distant from a service depot should have a longer service life to reduce travel times by field crews.
Maximum wastewater inflow	Less than 400 L/s.
Sewer configuration	• No vents attached to the sewer in the immediate vicinity of the SPS.

Notes:

* Assumes a wet well ACH of 8 and maximum green dome air flow of 400 L/s.

Assumes the largest elimination capacity of a green dome is 133 kg H_2S.

7 References

No.	Reference
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2	H2S Control Manual, 1989 – Technological Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works. Hydrogen Sulphide Control *Manual: Septicity, Corrosion and Odour Control in Sewerage Systems. Volume 1*. Melbourne and Metropolitan Board of Works.
3	US EPA, 1985. *Design Manual: Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants*. Centre for Environmental Research Information.
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5	Pescod and Price, 1982. Major factors in sewer ventilation. *Journal of the Water Pollution Control Federation, 54(4),* 385-397.
6	Hurse, T.J. and Ochre, P. (2008). *The Lost Art of Sewer Ventilation*. Journal of the Australian Water Association.
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9	Thistlethwayte, D.K.B. 1972. *The Control of Sulphides in Sewerage Systems*. Ann Arbor Science. Ann Arbor. MI.