Singapore Standards Council

SS 642 : 2019
(ICS 13.030.40)

SINGAPORE STANDARD

Code of practice for pneumatic waste conveyance system

Published by
Enterprise Singapore

SS 642 : 2019
(ICS 13.030.40)

SINGAPORE STANDARD

Code of practice for pneumatic waste conveyance system

ISBN 978-981-48-3563-3

This Singapore Standard was approved on 1 February 2019 by the Environment and Resources Standards Committee under the purview of the Singapore Standards Council.

First published, 2019

The Environment and Resources Standards Committee, appointed by the Standards Council, consists of the following members:

		Name	Capacity
Chairman	:	Prof Reginald Tan	*Individual Capacity*
Deputy Chairmen	:	Mr Dalson Chung	*National Environment Agency*
		Mr Norman Lee	*Individual Capacity*
Secretary	:	Ms Lee Mong Ni	*Enterprise Singapore*
Members	:	Mr Benedict Chia	*National Climate Change Secretariat*
		Dr Chiu Kuang Ping	*Singapore Water Association*
		Mr Alex Chong	*Agency for Science, Technology and Research*
		Mr Michael Ho	*Waste Management and Recycling Association of Singapore*
		Mr Jadhav Nilesh	*Nanyang Technological University*
		Ms Kavita Gandhi	*Sustainable Energy Association of Singapore*
		Mr Khor Seng Teng	*Hyflux Ltd*
		Mr Kok Yixiong	*Enterprise Singapore*
		Mr Kelvin Liew	*SembWaste Pte Ltd*
		Dr Lim Mong Hoo	*Individual Capacity*
		Mr Collin Lim Yew Tee	*Singapore Manufacturing Federation*
		Dr Pang Chee Meng	*PUB, Singapore's National Water Agency*
		Mr Steve Seah	*SP Group*
		Ms Yvonne Soh	*Singapore Green Building Council*
		Dr Song Bin	*Individual Capacity*
		Mr Tan Sze Tiong	*Housing & Development Board*
		Ms Jen Teo Pui Heng	*Singapore Environment Council*
		Mr Toh Chee Ming	*Singapore Chemical Industry Council*
		Mr Toh Eng Shyan	*Building and Construction Authority*
		Er. Alfred Wong	*The Institution of Engineers, Singapore*
		Mr Yap Ong Heng	*Ministry of Transport*
		Mr Yeo Lai Hin	*Energy Market Authority*
		Er. Yeow Mei Leng	*Association of Consulting Engineers, Singapore*

The Technical Committee on Solid Waste Management, appointed by the Environment and Resources Standards Committee and responsible for the preparation of this standard, consists of representatives from the following organisations:

		Name	Capacity
Chairman	:	Mr Dalson Chung	*Individual Capacity*
Deputy Chairman	:	Ms Melissa Tan	*Waste Management and Recycling Association of Singapore*
Secretary	:	Ms Lee Mong Ni	*Enterprise Singapore*
Members	:	Dr Edward Ang	*Building and Construction Authority*
		Mr Lam Yan Hoe	*National Parks Board*
		Mr Eddy Lau	*Singapore Green Building Council*
		Mr Kenneth Lim	*National Environment Agency*
		Dr Varughese Philip	*Agri-Food and Veterinary Authority*
		Mr Matt Stanelos	*Singapore Manufacturing Federation*
Co-opted Member	:	Mr Paul Tan Hang Meng	*Individual Capacity*

The Working Group on Pneumatic Waste Conveyance System, appointed by the Technical Committee to assist in the preparation of this standard, comprises the following experts who contribute in their *individual capacity*:

		Name
Co-Convenors	:	Mr Chang Tze Lum
		Mr Paul Tan Hang Meng
Secretary	:	Ms Christina Choong
Members	:	Mr Cheong Kong Chuan
		Mr David Heng
		Mr James Hung
		Mr Lawrence Liau
		Mr Sri Skanda Rajah S Ratnam
		Ms Tan Ai Li
		Mr Daniel T'ng
		Mr Tsang Pui Sum
		Ms Wan Siew Fung
		Dr Wong Teck Neng
		Ms Kristen Yeung Yu Ching
		Mr Yuen Yee Jing
Resource Members	:	Mr Mervin Ho
		Mr Ong Leng Teck
		Mr Tan Cheong Huat

The organisations in which the experts of the Working Group are involved are:

Atticus Consulting Pte Ltd
City Developments Limited
Colex Environmental Pte Ltd
Design International Architects
ENVAC Singapore Pte Ltd
Greenwave Solutions Pte Ltd
Housing & Development Board
JTC Corporation
Ministry of Manpower
Nanyang Technological University
National Environment Agency
Ngee Ann Polytechnic
PV Vacuum Engineering Pte Ltd
Stream Environment (S) Pte Ltd

Contents

Foreword

This Singapore Standard was prepared by the Working Group on Pneumatic Waste Conveyance System appointed by the Technical Committee on Solid Waste Management under the direction of the Environment and Resources Standards Committee.

The pneumatic waste conveyance system (PWCS) is an established technology first introduced in Europe in the 1960s and may be implemented in individual developments and/or across multiple types of developments. The PWCS is largely automated and service providers may monitor and operate multiple systems remotely. Over the last 20 years, there has been widespread adoption of PWCS in Singapore, which has brought about several benefits, namely reduced manual handling of waste, improved hygiene and well-being of workers, increase in value-added jobs and reduction of pests and odour nuisance in the environment.

This standard aims to ensure a level playing field for interested local and overseas manufacturers and suppliers by providing basic requirements for the design, construction and installation and set provisions for the proper use and maintenance of PWCS in Singapore. This would also provide greater assurance in terms of quality, reliability and durability to all the users of the system.

In preparing this standard, reference was made to the following publications:

1. BS 1703:2005 Refuse chutes and hoppers – Specification

2. BS 5906:2005 Waste management in buildings — Code of practice

3. SS 594:2014 Terminology for waste management

4. Technical guideline on boundary noise limits for air conditioning and mechanical ventilation systems in non-industrial buildings (2nd Edition, 2018)

Permission was obtained from the following organisations for the reproduction of their works:

- Housing & Development Board for the “Dos & Don’ts” signage for general waste.

- National Environment Agency for the “Dos & Don’ts” signage for recyclables and for materials from the *Technical guideline on boundary noise limits for air conditioning and mechanical ventilation systems in non-industrial buildings* (2nd Edition, 2018).

The figures included as examples in this Singapore Standard are collectively contributed by the Working Group members for the sole purpose of illustration. The inclusion of figures in this Singapore Standard does not connote any endorsement whatsoever of any product, service and/or design concept by the Working Group and Enterprise Singapore.

Acknowledgement is made for the use of information from the above publications / organisations and for the contributions by the Work Grouping Members.

This standard is expected to be used by real estate developers, consultants, designers, professional engineers, architects, PWCS providers, PWCS service contractors, facilities management professionals and relevant government agencies.

Attention is drawn to the possibility that some of the elements of this Singapore Standard may be the subject of patent rights. Enterprise Singapore shall not be held responsible for identifying any or all of such patent rights.

NOTE

1. *Singapore Standards (SSs) and Technical References (TRs) are reviewed periodically to keep abreast of technical changes, technological developments and industry practices. The changes are documented through the issue of either amendments or revisions.*

2. *An SS or TR is voluntary in nature except when it is made mandatory by a regulatory authority. It can also be cited in contracts making its application a business necessity. Users are advised to assess and determine whether the SS or TR is suitable for their intended use or purpose. If required, they should refer to the relevant professionals or experts for advice on the use of the document. Enterprise Singapore shall not be liable for any damages whether directly or indirectly suffered by anyone or any organisation as a result of the use of any SS or TR.*

3. *Compliance with a SS or TR does not exempt users from any legal obligations*

Code of practice for pneumatic waste conveyance system

1 Scope

This standard specifies the requirements for the design, construction, installation, testing and commissioning and maintenance of a pneumatic waste conveyance system (PWCS) that serves gravity chutes for general waste and recyclables generated from residential, commercial and mixed-use developments.

The scope of this standard covers the specifications and performance of the feeding and discharge system, conveyance system and collection station but excludes the requirements for waste collection vehicles and driveway design.

This standard does not include the requirements for:

– waste conveyance using a pipeline intervention gadget (PIG) concept;

– feeder for a full vacuum system; and

– the conveyance of pure food waste from food establishments.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5L	Specification for line pipe
API Standard 1104	Welding of pipelines and related facilities
ASHRAE 52.1	Gravimetric and dust-spot procedures for testing air-cleaning devices used in general ventilation for removing particle matter
ASHRAE 52.2	Method of testing general ventilation air-cleaning devices for removal efficiency by particle size
ASTM A234 WPB	Specification for piping fittings of wrought carbon steel and alloy steel for moderate and high temperature service
ASME B16.9	Factory-made wrought butt welding fittings
ASTM E1444	Standard practice for magnetic particle testing
ASTM E273-15	Standard practice for ultrasonic testing of the weld zone of welded pipe and tubing
DIN 30670	Polyethylene coatings of steel pipes and fittings – Requirements and testing
DIN 30722	Roller contact tipper vehicles, roller containers
EN-S235J2	Steel grade, mechanical properties, chemical composition, grade equivalent

IEC 61131-3	Programmable controllers – Part 3: Programming languages
ISO 16890-1	Air filters for general ventilation – Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)
SS 30	Manhole tops and surface-box tops
SS 568	Code of practice for confined space
SS 638	Code of practice for electrical installations (formerly CP 5)
SS 571	Code of practice for energy lockout and tagout

3 Terms and definitions

For the purpose of this Singapore Standard, the following terms and definitions apply.

3.1 Authorised examiner

A person approved by the Commissioner for Workplace Safety and Health under section 33 of the Workplace Safety and Health Act (Cap. 354A) for purpose of carrying out any prescribed examinations or test of any pressure vessels such as an air receiver.

3.2 Compactor

A machine or mechanism used to reduce the size of waste through compaction.

3.3 Container

An enclosed container or compactor container used for both general waste and recyclable in the PWCS.

3.4 Design life

The design life of a component is the period of time during which it is expected by its designers / manufacturer to work within its specified parameters; in other words, the life expectancy of the component. It is the length of time between placement into service of a single component and that component's onset of wear out.

3.5 General refuse/waste

Domestic waste and commercial waste but excludes industrial, hazardous and bio-hazardous wastes.

NOTE – "Refuse" and "waste" are used interchangeably in this document.

3.6 Gravity chute system

A vertical chute used for transferring refuse by gravity into a temporary storage section.

3.7 Maintainability

A measure of ease and ability for maintenance actions or activities to be carried out.

3.8 Major equipment and components

Significant equipment and components that affects the function of the PWCS.

3.9 Mixed-use developments

A residential and commercial premises.

3.10 Pneumatic waste conveyance system (PWCS)

An automated waste collection system where refuse is conveyed from within a development through a network of pipes to a centralised point for collection by means of differential air pressure.

3.11 PWCS owner

An entity that owns or has control over the PWCS (e.g. building owner, real estate developer, management corporation).

3.12 PWCS provider

A company/establishment that designs and supplies, integrates and installs components, equipment and systems for the effective functioning of the PWCS including the testing and commissioning of the whole system.

3.13 PWCS service contractor

A company/establishment with technical and engineering competency engaged to undertake the operation, maintenance and repair of the PWCS.

3.14 Qualified person

A person, as defined and required under the Building Control Act, who is registered as

a) an architect under the Architects Act (Cap. 12) and has in force a practising certificate issued under that Act; or

b) a professional engineer under the Professional Engineers Act (Cap. 253) and has in force a practising certificate issued under that Act.

3.15 Recyclables

Waste that may be recovered and processed into material suitable for the manufacture of a useful new product (e.g. plastic bottles, aluminium cans, paper, etc.).

3.16 Remote access

The monitoring of a PWCS from a location remote to the machine or process that enables condition monitoring of the system and to identify, alter parameters or correct faults or interruptions in the system by operating or activating critical controls of the PWCS from the remote location.

3.17 Shall

Indicates that the requirement is strictly to be followed in order to conform to the standard and from which no deviation is permitted.

3.18 Should

Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

4 General requirements

4.1 Design and planning considerations

4.1.1 General

4.1.1.1 The PWCS shall be a fully automated waste collection system designed to collect refuse from a refuse chute system or outdoor throw points through a conveyance pipe network to the collection station.

4.1.1.2 All works carried out on the PWCS shall be in compliance with all applicable current standards, code of practices, statutory and regulatory requirements. In areas not covered by the above-mentioned, the relevant Singapore Standards, overseas standards or international standards recognised by government authorities shall apply.

4.1.1.3 Based on the principles of hierarchy of controls, suitable engineering controls to reduce noise emission at the source should be implemented, such as installing suitable pneumatic silencers at the source of noise generation, pneumatic line outlets.

4.1.1.4 The noise level at the boundary of the estate nearest to the collection station and exhauster outlet shall comply with the requirements in Table 1.

4.1.1.5 Dust and odours shall be removed from the air that conveys the refuse before being discharged into the atmosphere.

4.1.1.6 The PWCS shall not cause nuisance to residents of the premises served or neighbouring premises when it is in operation.

4.1.1.7 Provisions shall be made for regular data logging of the system operating conditions and performance (see 8.3).

4.1.2 Planning

All stakeholders shall take reasonable practical steps to reduce, to as low as reasonably practicable, all foreseeable risks (including design risk) created in the workplace or inherent in any work processes. A risk assessment shall be conducted, implemented and communicated to address any safety and health risk posed to any persons involved in all work activities across all work processes. It is presupposed that this risk assessment is done in accordance with applicable statutory and regulatory requirements. For example, in planning the construction and installation of the PWCS, the following shall be undertaken by stakeholders for the protection of persons at work, not limiting to:

a) risk assessment and safe work procedure conducted and implemented for all work activities across all work processes in the workplace;

b) method statement to document sequence and description of the work process of each work activity;

c) evaluation of site and soil conditions and identify effective methods for earth retention and soil protection, thereby establish procedures to prevent trench collapse;

d) determine and document safe installation method;

e) adherence to all professional engineer designs; and

f) professional engineer design plans for trench excavation and slope protection in accordance with applicable safety standards.

4.1.3 Design for safety and maintainability

4.1.3.1 The PWCS provider shall consider in its design plan the risks construction, installation, operation and maintenance workers may be exposed to, and have the right skills, knowledge and experience to address safety and health issues arising from the design.

4.1.3.2 The design plan should include, but not be limited to, drawings, design details, specifications, materials, bill of quantities, and calculations relating to the PWCS.

4.1.3.3 Safety and health shall be taken into consideration at the start of the design process to eliminate all design risks throughout the life cycle of the PWCS from design, construction, installation, testing and commissioning, operation, maintenance and to its eventual decommissioning and removal or demolition.

4.1.3.4 As a PWCS system has few interfaces with other mechanical, electrical or plumbing systems, it shall be designed as a whole system to ensure that the system when integrated with the other systems, including its automatic controls, is effectively coherent and safe for use. The PWCS design and integration should result in a reliable system, therefore requiring a low level of intervention.

4.1.3.5 In designing for maintainability, factors not limited to the following should be taken into consideration at the design stage:

a) Accessibility of equipment and sufficient workspaces for onsite work;

b) Provisions for work safety;

c) Ease and effectiveness of carrying out routine maintenance and repair work;

d) Ease and effectiveness of clearing blockages; and

e) Equipment replacement after design lifespan.

4.1.3.6 All components in the PWCS shall be replaceable.

4.1.4 Type of waste

4.1.4.1 The PWCS shall be designed to handle domestic waste, commercial waste and recyclables. Domestic waste includes food waste and general waste from residential premises. Commercial waste includes general waste from offices, shopping malls and hotels. All waste should be bagged before being discarded in the PWCS. The allowable bagged waste size shall be at least 300 mm and not larger than 80% of the conveyance pipe diameter.

4.1.4.2 Bulky waste and recyclables that do not fit the PWCS hopper shall be handled manually or discarded by conventional means.

4.1.4.3 This list shows examples of types of waste that are not suitable to be used in a PWCS and is not exhaustive:

– Bulky and heavy objects;
– Bulky glass objects;
– Construction and renovation debris;
– Liquids, especially those that are flammable, biological and chemical-based;
– Hazardous materials;
– Burning objects;
– Long, slender and foldable objects.

4.2 Roles and responsibilities

4.2.1 PWCS owner

The PWCS owner shall

a) appoint Qualified Person(s) to incorporate the PWCS infrastructure into proposal plans for the development. This generally includes refuse chutes, discharge valve rooms, routing of conveyance pipes, inspection manholes and collection station.

b) appoint a competent PWCS provider to design in detail, build, install and/or maintain the PWCS.

c) ensure Qualified Person(s) is appointed to verify design compliance and witness the work in progress and endorse the final testing and commissioning of the PWCS.

d) appoint a competent PWCS service contractor to oversee the operation and maintenance of the PWCS.

e) ensure the PWCS is in operation and maintained regularly.

f) ensure the original copy of the PWCS operation and maintenance manual and records of the service reports are readily available for traceability and accountability of all works performed on the system.

4.2.2 Qualified Person (QP)

The QP shall:

a) design and layout the PWCS infrastructure into the development proposal and ensure the PWCS complies with this standard prior to the commencement of the project. It is presupposed that this is done in accordance with applicable statutory and regulatory requirements.

b) check and endorse the shop drawings submitted by the PWCS provider for compliance with this standard.

c) conduct periodic supervision of the PWCS installation, ensuring that the entire PWCS and its components comply with the approved shop drawings and performance requirements as outlined in this standard, especially for the buried conveyance pipe network.

d) supervise and verify that the final testing and commissioning is conducted according to the testing and commissioning checklist.

e) endorse or acknowledge on the final testing and commissioning report.

f) submit all necessary certifications or reports to the relevant authorities upon completion of the works.

4.2.3 PWCS provider

The PWCS provider shall:

a) design the PWCS to comply with this standard.

b) submit all shop drawings, relevant calculations, component and materials selection to the QP(s) for compliance verification.

c) submit all test reports, certificates for components and materials to the QP(s) for compliance verification.

d) supervise and document the PWCS installation.

e) prepare documentation to facilitate verification inspection by QP(s) and the relevant authority inspection and testing and commissioning verification works.

f) keep records of work progress and completed works for inspection, in particular for concealed installations.

g) provide a testing and commissioning checklist.

h) conduct the final testing and commissioning under the supervision of the QP(s).

i) prepare the documentation of the final testing and commissioning for the PWCS owner and relevant authority.

j) provide a copy of the operation and maintenance manual and as-built drawings to the PWCS owner upon completion of final testing and commissioning.

4.2.4 PWCS service contractor

The PWCS service contractor shall:

a) be in charge of planning, servicing and execution of the maintenance programme (see Annex A).

b) be in charge of troubleshooting the PWCS.

c) ensure that only competent maintenance staff are allowed to operate and participate in the maintenance programme.

5 Feeding and discharge system

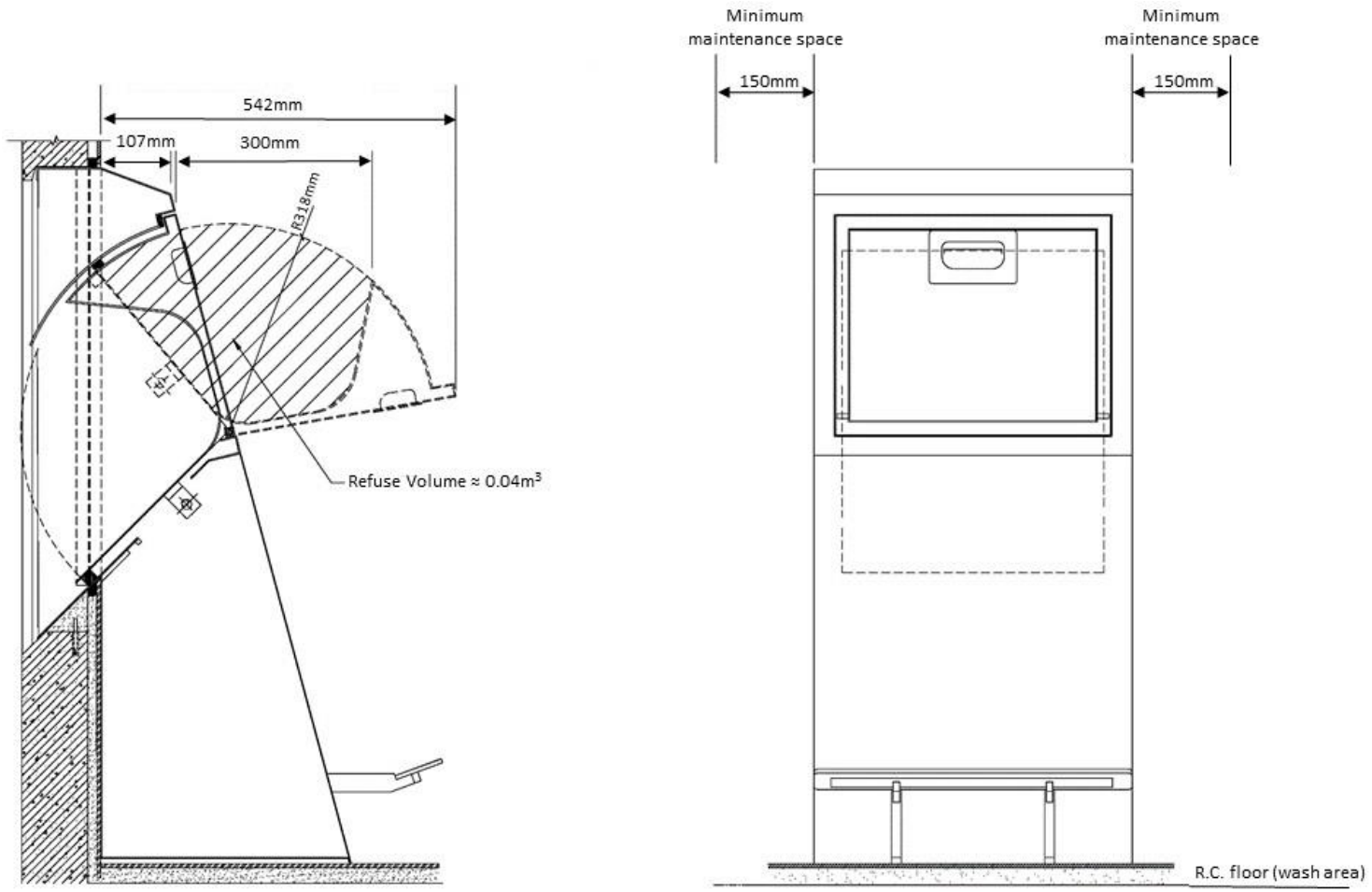
5.1 General

The PWCS shall enable the gravity chute system, conveyance pipe network and containers to collect two main categories of waste: general waste and recyclables.

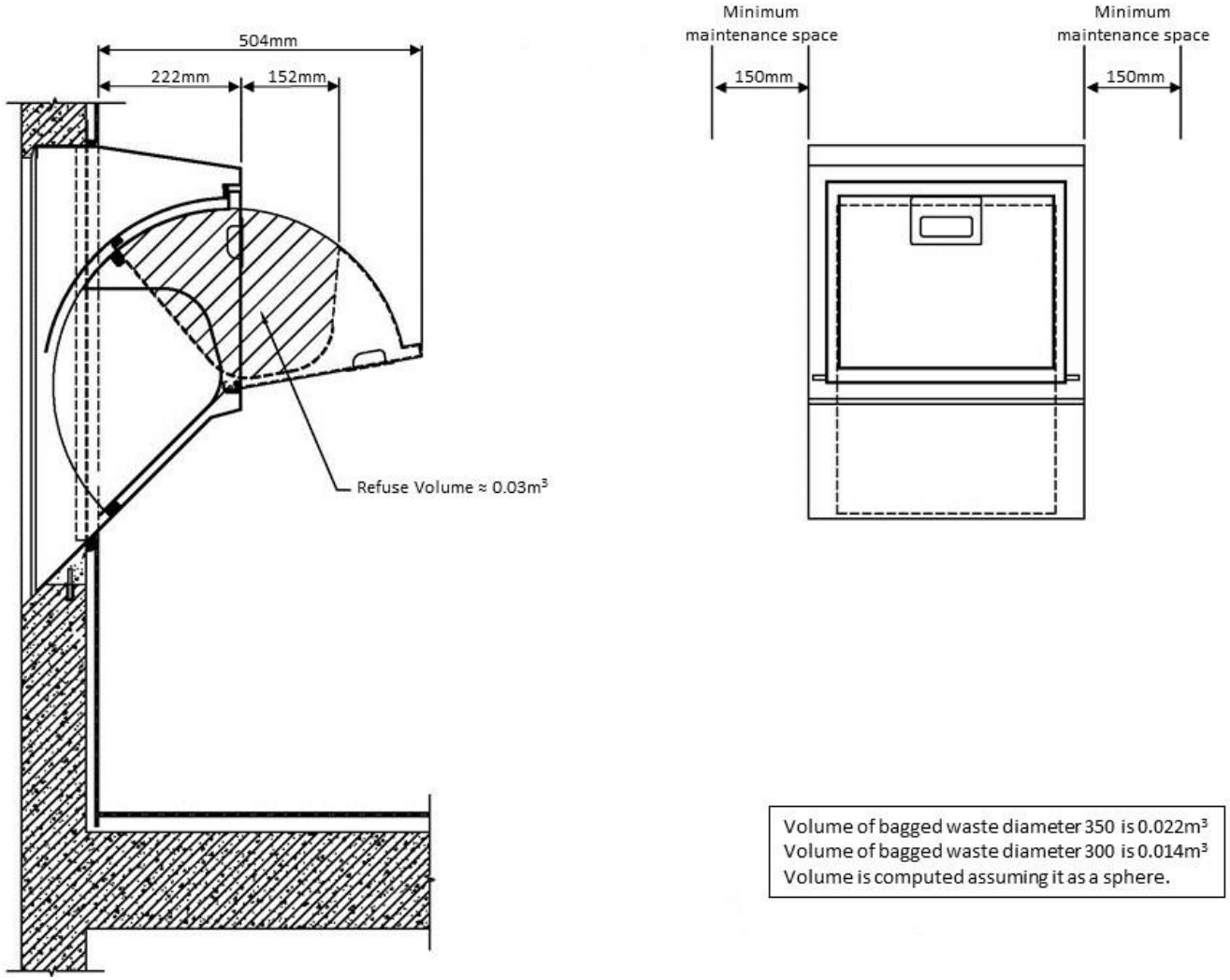
5.2 Refuse hopper

5.2.1 The refuse hopper shall have a front opening. The chute hopper door shall be air-tight and designed for self-closing, soft-closing and be fire rated in accordance with the prevailing fire code for which it is located.

5.2.2 The opening of the chute hopper shall be full volume-controlled to restrict large or long items from entering the chute. The volume of the chute hopper shall be designed for a bagged waste size of at least 300 mm and not more than 80% of the conveyance pipe diameter (see Figure 1). This will allow the disposal of bagged waste of typical sizes, and prevent oversized waste from choking the hopper and the chute.



(a) Chute hopper with foot pedal



(b) Chute hopper without foot pedal

Figure 1 – Examples of chute hopper

5.2.3 For hoppers in common areas, there should be sufficient space between the general waste hopper and the recyclable waste hopper to allow for maintenance access (see Figure 2).

5.2.4 All hoppers shall be clearly labelled with “General Waste” and “Recyclables”. The labels shall be made of durable material and placed not more than 100 mm above the respective chute hopper. Example of labels and signage for chute hopper is given in Figure 2.

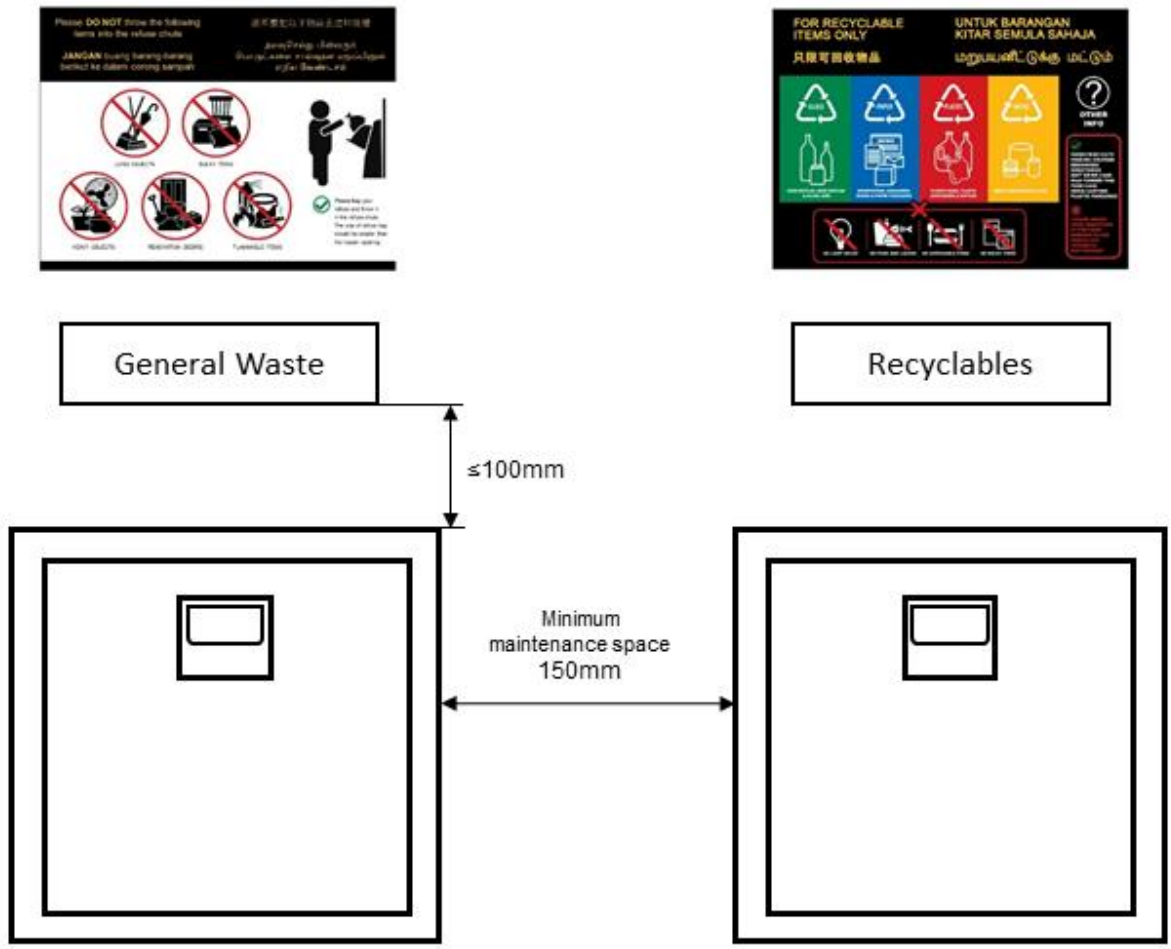
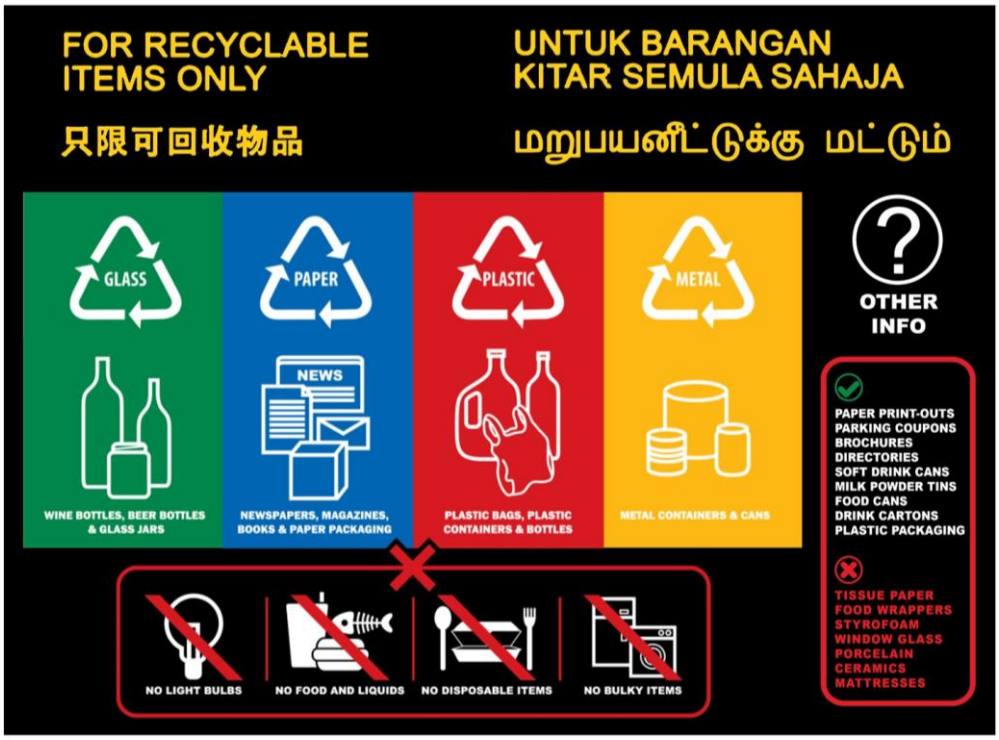


Figure 2 – An example of label positions for typical refuse hoppers

5.2.5 There should also be a warning sign to highlight the “Dos & Don’ts” for the type of refuse and recyclables to be disposed into the respective hopper. These signs should be placed above the labels. An example of the “Dos and Don’ts” sign is provided in Figure 3 and Figure 4.

Image courtesy of the Housing & Development Board

Figure 3 – Signage for general waste



Note: this diagram is under review. Refer to https://www.nea.gov.sg for the latest diagram.
Image courtesy of the National Environment Agency

Figure 4 – Signage for recyclables

5.3 Refuse chute

5.3.1 General

The refuse chute system shall comprise the vertical chute and the air-tight volumetric control hoppers. It shall be made of reinforced concrete or equivalent material and should not be a load-bearing structure.

5.3.2 Requirements

5.3.2.1 There shall be a break-fall incorporated into the design of the temporary storage section just before the discharge valve. The inclination angle from vertical shall not be more than 30^{o} (see Figure 5) to protect the equipment connected below the chute and to minimise the blockage at the storage section.

5.3.2.2 The cross-section of the chute shall be round or square with rounded corners.

5.3.2.3 For a refuse chute that is round, the minimum internal diameter shall not be less than 600 mm. For a refuse chute that is square with rounded corners, the cross-sectional area shall not be less than 0.3 m^2.

5.3.2.4 A chute-interface section shall be provided to interface with the temporary storage section. The chute interface angle to achieve this transition shall not be less than 60^{o} from the horizon.

5.3.2.5 The chute shall terminate at the roof of a building. The chute shall be cross-ventilated at the top with at least two openings of not less than 0.15 m^2 each. The top section of the chute shall be made accessible to facilitate the safe conduct of maintenance.

5.3.2.6 Where the roof is used as a terrace or garden, attention shall be paid to the siting of the refuse chute, the location of the ventilation openings and the maintenance space requirement to minimise any smell nuisance. Ventilation openings shall be located at least 2.1 m above roof level. If required, a wind and rain shield may be installed.

5.4 Flushing system

5.4.1 There shall be a flushing system to wash and flush the whole length of the chute. The system should allow for 45 to 60 litres per minute of water to be discharged onto the internal surface of the chute to ensure effective cleaning.

5.4.2 The control panel for the flushing system and the actuation of the flushing function shall be located in the discharge valve room.

5.4.3 There shall be a provision within the control panel to allow the PWCS control to activate the flushing/washing function when necessary or in the event of a fire inside the temporary storage section.

5.4.4 The flushing system shall be activated by the PWCS or manually with controlled access. The flushing system shall be interlocked with the PWCS control on the discharge valve to ensure the discharge valve is closed when flushing is activated.

5.4.5 The fluid drainage point shall be located at the bottom of the temporary storage section. The drainage discharge flow rate shall not be less than the chute flushing flow rate.

5.4.6 The fluid shall be discharged into the gully trap located in the discharge valve room. Fluid shall not be discharged into the conveyance pipe network.

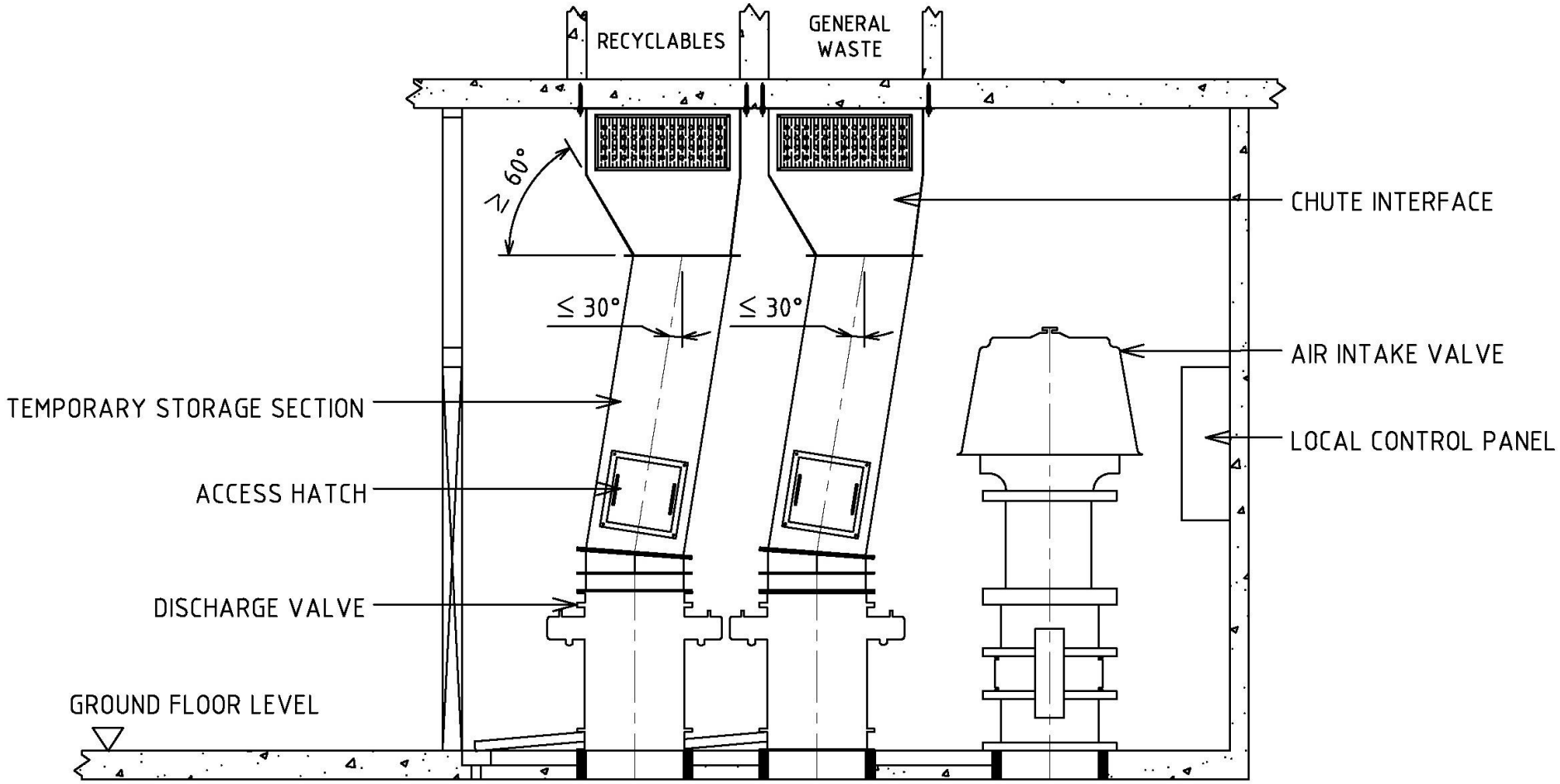


Figure 5 – An example of break-fall design on the temporary storage section

5.5 Temporary storage section

5.5.1 General

The temporary storage section allows for refuse to be stored above the discharge valve before the discharge cycle is activated. It includes the chute interface and connects the refuse chute to the PWCS through the discharge valve.

5.5.2 Requirements

5.5.2.1 The temporary storage section shall be made of stainless steel type 304L or higher grade and with a minimum thickness of 4 mm.

5.5.2.2 It shall have provision for air intake into the system to ease refuse transfer into the pipe network and reduce vacuum build-up in the refuse chute. Appropriate measures such as air treatment devices (e.g. odour filters) or a one-direction flap, shall be installed where necessary to ensure foul smells or unpleasant odours do not emit from the temporary storage section.

5.5.2.3 There shall be an access hatch with a clear opening of at least 350 mm by 350 mm (see Figure 5) to facilitate the clearing of foreign objects.

5.5.2.4 The temporary storage section shall be installed with a refuse-level sensor to detect high level refuse build-up and blockages. An alarm shall be activated when the refuse reaches 1.5–2 m from the valve plate.

5.5.2.5 The refuse-level sensor, when activated, shall override the regular periodic timing of the refuse discharge cycle.

5.5.2.6 A heat sensor shall be installed to activate the chute flushing system when a fire is detected in the temporary storage section.

5.6 Discharge valve (DV)

5.6.1 General

DV is the mechanism that discharges the refuse into the conveyance system. The most common type of feeding mechanism is the pneumatic-actuated DV.

5.6.2 Requirement for a pneumatic-actuated DV

5.6.2.1 The DV shall be normally-closed and air-tight to enable the system to attain its optimum vacuum performance level or designed operating pressure.

5.6.2.2 The DV shall have a clear opening equal to the internal diameter of the waste conveyance pipe.

5.6.2.3 The DV shall be designed to withstand the impact of falling refuse.

5.6.2.4 Sensors shall be installed at the DV to indicate the valve plate open and closed position. The open and closed position of the valve plate shall be indicated on the DV control panel.

5.6.2.5 A compressed air filter shall be installed to ensure that clean, dry compressed air is fed to the pneumatic cylinder.

5.7 Air intake valve

5.7.1 General

An air intake valve admits the required amount of air into the system to convey refuse from various collection points to the central collection station.

5.7.2 Requirements

5.7.2.1 The air intake valve may be pneumatically or electrically operated and shall be sized appropriately based on the system's requirements.

5.7.2.2 The air intake valve shall be equipped with an appropriate air filter silencer to reduce the noise of air entering the system during operation. The noise level shall meet the requirements in Table 1.

Table 1 – Noise limits for PWCS near residential units
(Information is extracted from *Technical Guideline on boundary noise limits for air conditioning and mechanical ventilation systems in non-industrial buildings*)

Noise limits (reckoned as the equivalent continuous noise level over 15 min) in dB(A)		
Day (7 am to 7 pm)	Evening (7 pm to 11 pm)	Night (11 pm to 7 am)
65	60	55

5.7.2.3 The noise measurement should be made at the same level as the noise source. Examples of the locations of the noise measurement are shown in Figure 6.

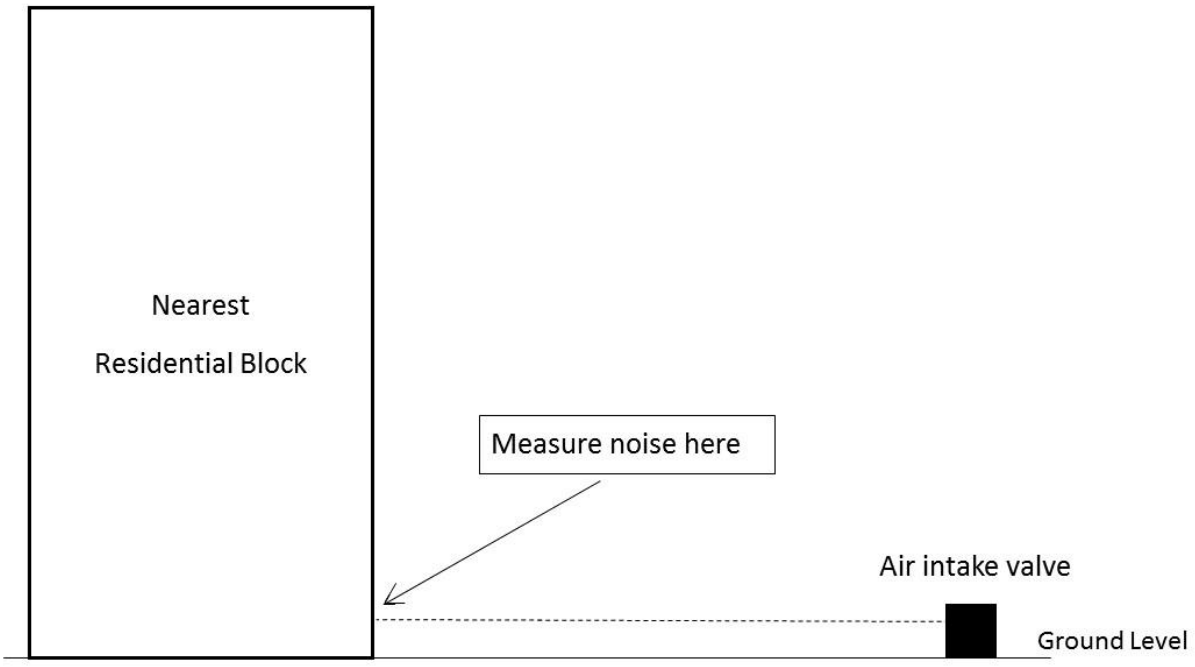


Figure 6 – Location of noise measurement for an air intake valve at the ground level

5.7.2.4 In the presence of background noise, the adjusted value for the maximum permissible noise limit shall be obtained by adding the correction factor corresponding to the difference between the maximum permitted level and the background noise level, set out in Table 2, to the higher of the two noise levels.

Table 2 – Background noise correction factor
(Information is extracted from *Technical Guideline on boundary noise limits for air conditioning and mechanical ventilation systems in non-industrial buildings*)

Difference between 2 noise levels in dB(A)	Correction Factor in dB(A)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	Nil

5.7.2.5 All valves shall be provided with sensors to indicate its open and closed positions.

5.7.2.6 The valve shall be air-tight in the fully-closed position to enable the system to attain its vacuum performance level or optimum operating pressure.

5.7.2.7 When a pneumatic actuated valve is used, a compressed air filter shall be installed to ensure that clean and dry compressed air is delivered to the pneumatic cylinder.

5.7.2.8 The air intake for the valve shall not be taken from enclosed spaces such as lift lobbies, corridors or utility rooms.

5.7.3 Control system

5.7.3.1 The control panel shall be used to house components required for the proper operation of the system (e.g. the control, converter, programmable logic card, power supply, etc.).

5.7.3.2 Where the control panel is located in the throw point bunker it shall be rated IP67. For the control panel above ground, it shall be rated at least IP65.

5.7.3.3 All wiring shall comply with the requirements in SS 638. It is presupposed that the electrical installations are in accordance with applicable statutory and regulatory requirements.

5.8 Discharge valve (DV) room

5.8.1 General

The DV room is located at the bottom of a refuse chute and houses the chute interface, temporary storage sections, discharge valves, air intake valve, where necessary, sensors and instrumentation, together with its accessories and controls. See Figure 7 for an example of a typical DV room layout. It shall be locked at all times to prevent unauthorised access and usage.

5.8.2 Requirements

5.8.2.1 The DV room shall have a clear height of at least 3 m. There shall be a clearance of at least 200 mm all around the equipment in the DV room.

5.8.2.2 The DV room shall be able to withstand a minimum of 2 kN/m^2 of negative pressure. Measures shall be taken to prevent over pressurisation of the system beyond the design parameters of the DV room.

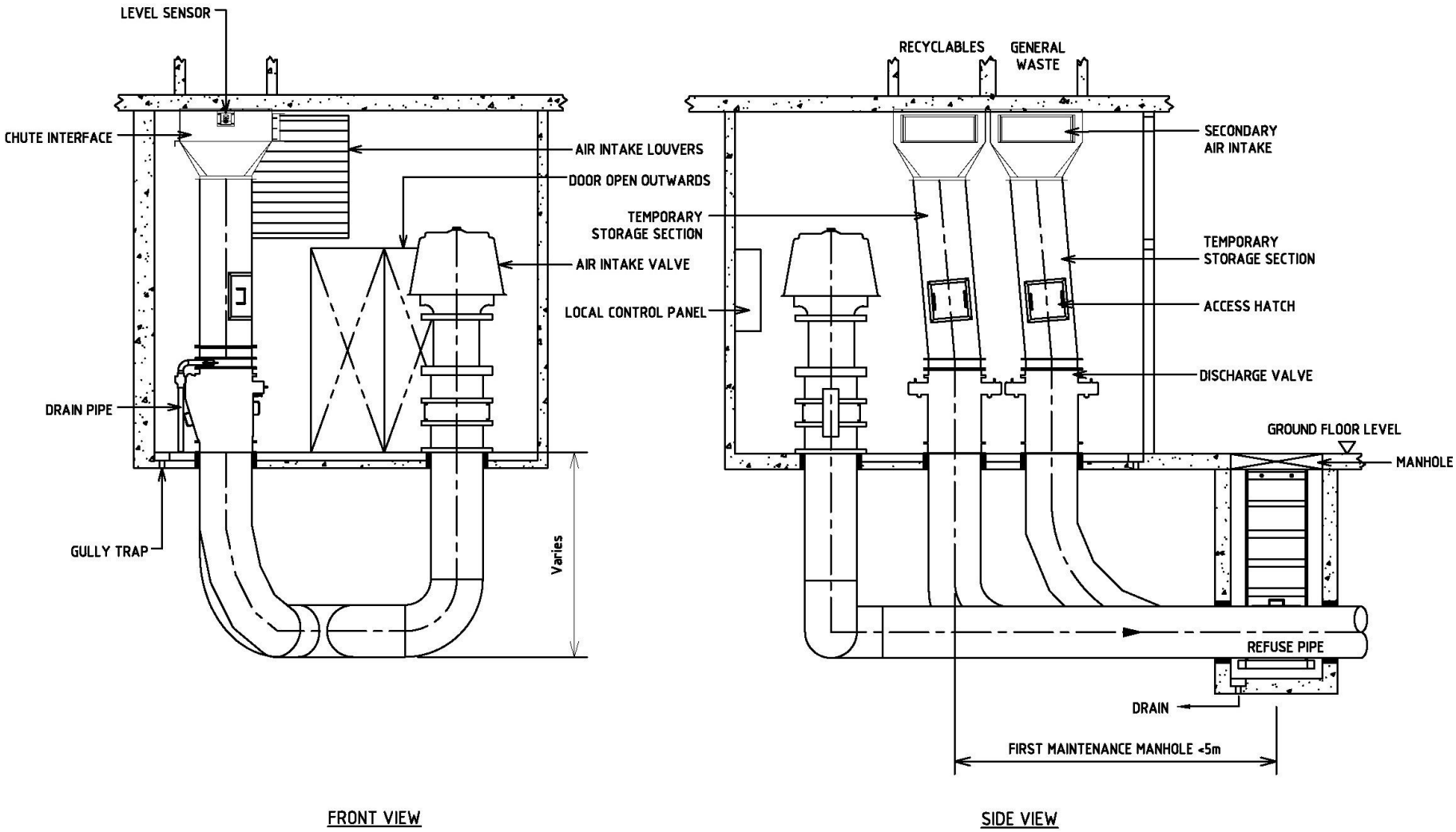


Figure 7 – An example of a discharge valve room layout

5.8.2.3 The air intake louvres provided shall have a minimum free area of 0.6 m^2 and a minimum free area of 1.2 m^2 if an air intake valve is installed within the room.

5.8.2.4 Air intake louvres and air intake valves shall not be sealed or blocked at all times, to provide pressure relief and prevent a possible build-up of negative pressure within the room.

5.8.2.5 There shall be provisions for acoustic treatment of the room for air movement noise, refuse impact noise, and mechanical noise generated in the DV room where necessary.

5.8.2.6 Access to the DV room shall be sufficient for the safe movement of equipment and a 240-litre wheeled-refuse bin in and out of the room.

5.8.2.7 Protective guards shall be provided for all moving parts in the DV room to prevent accidental injury.

5.8.2.8 The first manhole/pipe access immediately after the discharge valve room shall not be more than 5 m from the end of the bend (see Figure 7).

5.8.2.9 The DV room shall have a reasonably sufficient working area with no obstruction that hinders maintenance (see Figure 8 and Figure 9). The working space shall be ventilated.

5.8.2.10 The walls of the DV room shall be lined with tiles or other impervious materials.

5.8.2.11 There shall be provisions for room lighting, an electrical power supply point, and a water supply point for washing and drainage (e.g. gully trap and floor trap) appropriate for the system.

5.8.3 Control system

5.8.3.1 A control panel shall be used to house components required for the proper operation of the DV (e.g. power supply, the control switches, converter, programmable logic card, etc.). The control panel shall be rated at least IP65.

5.8.3.2 The control panel shall be used to control and monitor the operating condition of the following equipment:

a) Discharge valve;

b) Temporary storage section; and

c) Air intake valve (if installed).

5.9 Outdoor throw points

5.9.1 General

Where outdoor throw points are provided, they shall automatically convey refuse to the collection station through a buried pipe network via a temporary storage section (see 5.5) and a discharge valve (see 5.6).

5.9.2 Requirements

5.9.2.1 The outdoor throw point hopper(s) shall be full volume-control type and designed to limit the maximum refuse size measured in all directions to no more than 80% of the actual internal diameter of the conveyance pipe of the system.

5.9.2.2 The hopper shall be designed for self-closing and soft-closing.

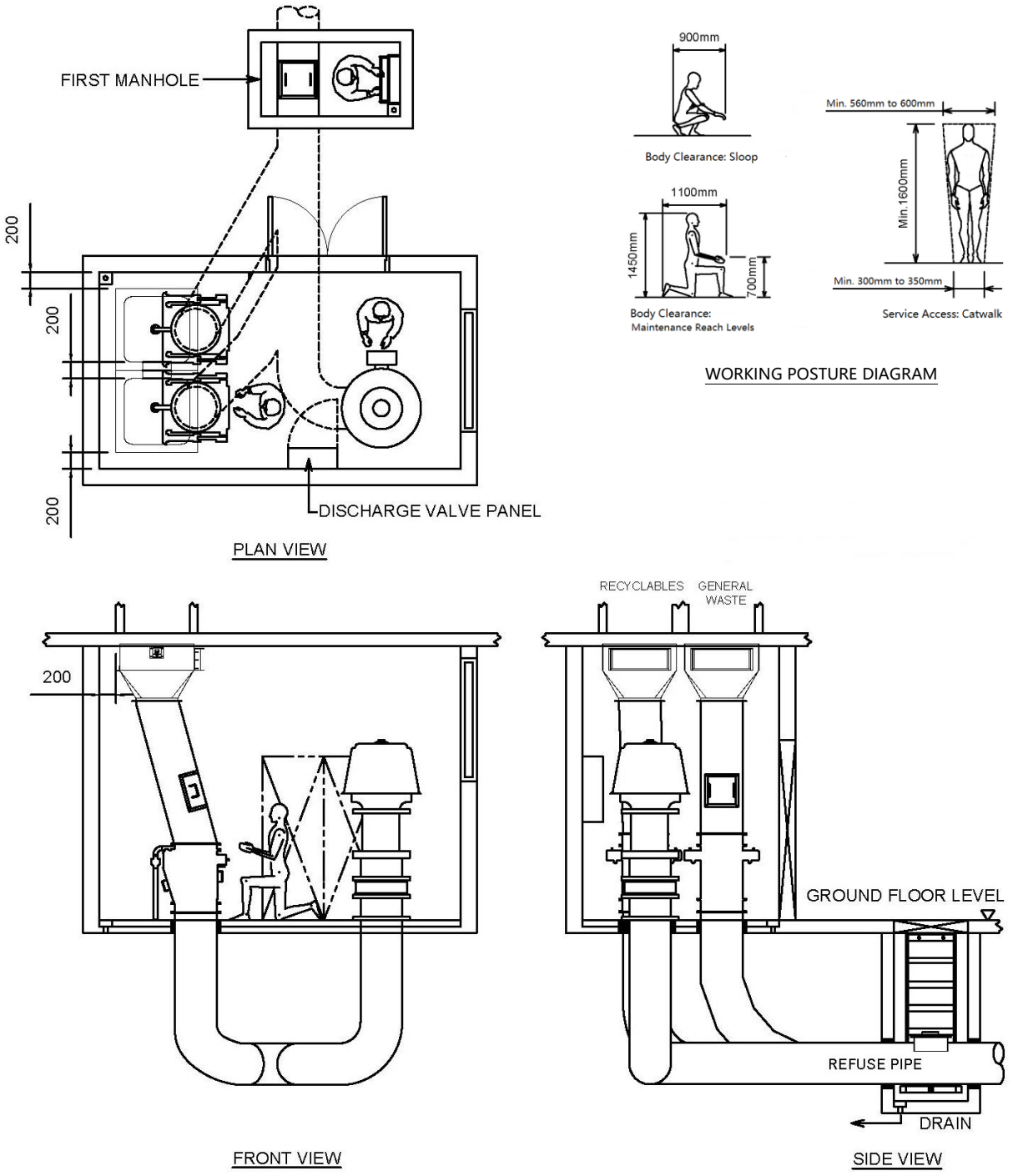


Figure 8 – An example of working space within the DV room (normal arrangement)

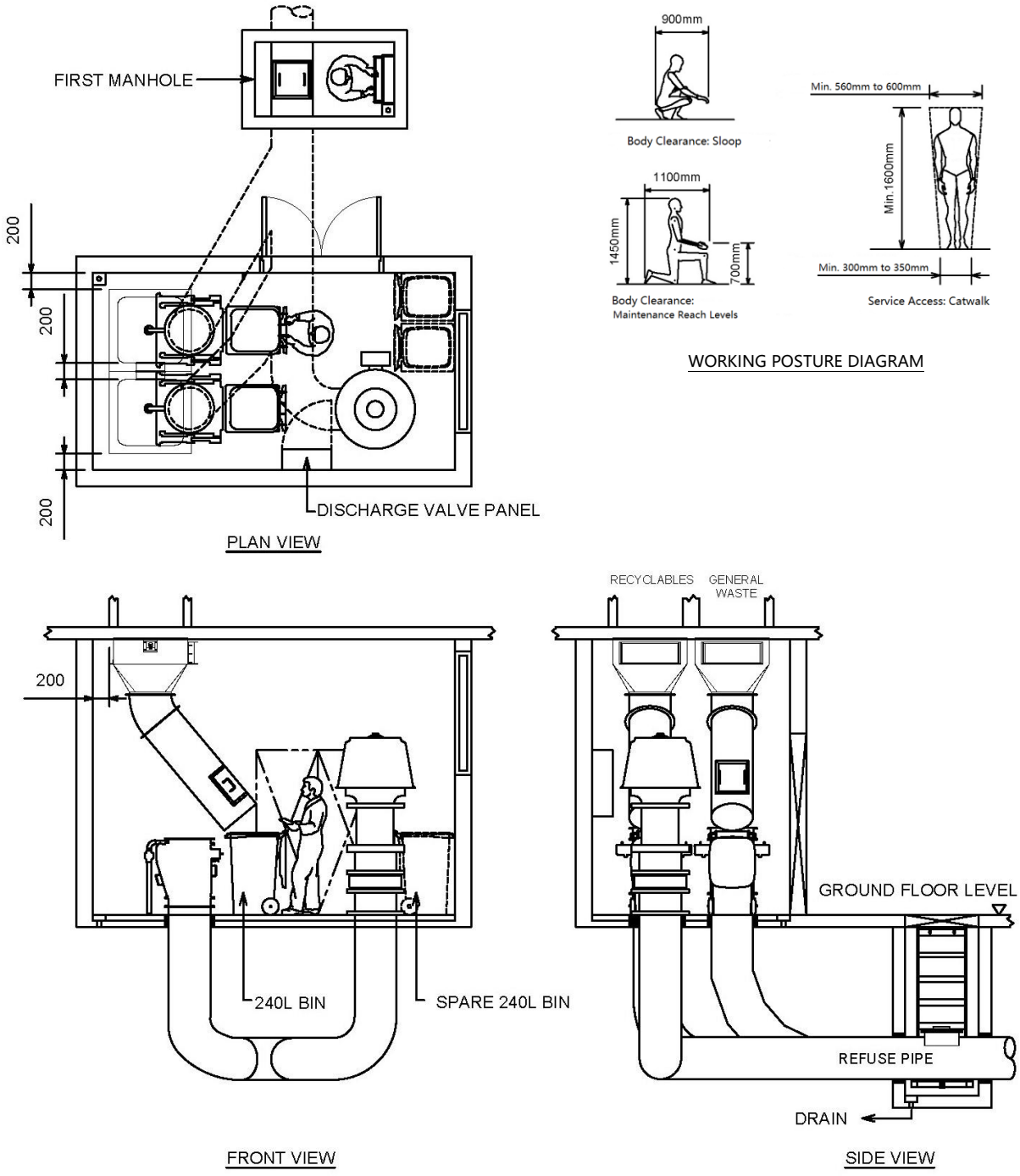


Figure 9 – An example of working space within the DV room (contingency arrangement)

5.9.2.3 Outdoor throw points shall be labelled according to 5.2.4. The Dos and Don'ts signage shall be displayed appropriately.

5.9.2.4 The temporary storage section shall be installed with sensor(s) to detect high refuse level and blockages. An alarm shall be activated when the refuse reaches 1.5–2 m from the valve plate. The refuse-level sensor, when activated, shall override the regular periodic timing of the refuse discharge cycle.

5.9.2.5 The handle on the hopper opening shall be 900 mm to 1100 mm from the ground level.

5.10 Outdoor throw points bunker

5.10.1 General

The outdoor throw point bunker is located at the bottom of each pair of outdoor throw points. It houses the discharge valves, chute interface section, temporary storage sections, sensors and instrumentation, together with its accessories and controls.

5.10.2 Requirements

5.10.2.1 The bunker shall have a clear height of at least 1.8 m. The wall and base of the bunker, including the cover, shall be watertight and there shall be a sump pit provided at the base to aid dewatering work during maintenance.

5.10.2.2 There shall be a clearance of at least 200 mm all around the equipment in the bunker and there shall have reasonably sufficient working area with no obstruction that hinders maintenance.

5.10.2.3 The access manhole to the bunker shall be watertight and be big enough to allow for the replacement of equipment housed within the bunker.

5.10.2.4 Provisions shall be made for electrical power supply point(s).

5.10.2.5 Air intake valve should not be housed in the outdoor throw point bunker.

5.10.3 Control system

5.10.3.1 The control panel shall be used to house components required for the proper operation of the system (e.g. the control, converter, programmable logic card, power supply, etc.).

5.10.3.2 Where the control panel is located in the throw point bunker it shall be rated IP67. For control panel above ground, it shall be rated at least IP65.

5.10.3.3 All wiring shall comply with the requirements in SS 638. It is presupposed that the electrical installations are in accordance with applicable statutory and regulatory requirements.

5.10.3.4 The control panel shall be used to control and monitor the operating condition of the following equipment:

a) Discharge valve;

b) Temporary storage section; and

c) Air intake valve (if installed).

6 Conveyance system

6.1 Conveyance pipe

6.1.1 All refuse conveyance pipes shall be made of mild steel complying with API Specification 5L Grade B or equivalent. The nominal diameter of the pipes shall range from 400–500 mm and the pipe thickness sized according to the volume of waste (see Table 3). Refuse conveyance pipes that are buried shall have a nominal diameter of at least 500 mm. Critical bends shall be designed with provisions for replacements.

Table 3 – Recommended minimum pipe thickness for mild steel (low carbon steel) API 5L Grade B pipe

Volume per day (L)	Tonnage per day (tonnes)	Minimum pipe thickness (mm)	Minimum elbow thickness (mm)
Up to 15,000	Up to 3	7.14	9.52
15,001 to 25,001	Above 3 to 5	9.52	14.27
25,001 to 37,500	Above 5 to 7.5	12.7	17.48
37,501 to 50,000	Above 7.5 to 10	14.27	20.62

6.1.2 The material selected should provide sufficient strength to withstand self-weight, external load, maximum suction pressure, external and internal corrosion, and internal abrasive and impact erosion from the repeated conveyance of refuse and recyclables over its design life. Seamless and longitudinal welded pipes and elbows are suitable for this purpose.

6.1.3 The pipes, bends and pipe branches shall increase in thickness and/or use wear-resistant material at critical locations of the refuse pipe network to cater for the expected erosion caused by the movement of refuse traveling inside and to ensure that the pipe network remains functional over its design life.

6.1.4 All conveyance pipes shall be tested for vacuum leaks and be endorsed by a QP. A vacuum leak test shall be carried out based on 25 kPa (initial pressure) and it shall not increase by more than 5 kPa within an hour across every 50 m of pipe tested.

6.2 Pipe joints

6.2.1 General

6.2.1.1 The refuse conveyance pipe shall be joined by means of full penetration weld performed by 6G welders certified by a BCA's Approved Training and Testing Centre.

6.2.1.2 The maximum internal protrusion of weld into the pipe internal shall be limited to 3 mm. A flange joint shall be used for connecting bi-materials or for replacement purposes. All flange joints shall be accessible for repair and replacement.

6.2.1.3 Where pipes are buried, welded joints should be wrapped in polyethylene (PE) tape.

6.2.2 Welding of pipes

6.2.2.1 All welding done on conveyance pipes shall meet the requirements of API 1104 or equivalent. All welding procedures specification, complete with procedure qualification record, shall be reviewed and endorsed by a third-party inspection agency or certified welding inspector before implementation.

6.2.2.2 All production welding shall be performed by a certified welder in accordance with the respective approved welding procedure. Random inspection surveillance of all welding stations, including weld quality, weld cleaning, weld bead profile, weather protection and electrode storage, shall be conducted during production welding.

6.2.2.3 The PWCS provider shall engage a non-destructive test laboratory accredited by the Singapore Accreditation Council (SAC) to test the weld joints on the conveyance pipe. The type of non-destructive welding test shall use the magnetic particle method (according to ASTM E1444, or equivalent) or ultrasonic method (according to ASTM E273-15, or equivalent). The test frequency shall be at least 75% of the total welding joints done on site.

6.2.2.4 Weld repairs shall be limited to 30% of the weld length for a partial repair or 20% of the weld length for a full penetration repair. A full penetration repair weld is limited to once only. Unsuccessful repairs shall be cut out and welded again. Any cracks or suspected cracks shall not be accepted and shall be cut out. In each of these cases, the complete weld shall be removed and welded again.

6.3 Pipe fittings

6.3.1 All pipe bends shall be manufactured in accordance with ASTM A234 WPB, ASME B16.9, or equivalent, where applicable. Fabricated components, such as long bends and Y-joints, shall conform to the material standards of the straight pipe.

6.3.2 Pipe bends shall be fabricated by induction bending using steel material with enhanced wear resistance where applicable.

6.3.4 The turning radius of the first bend from the discharge valve to the conveyance pipe network shall not exceed 1.5 times the pipe diameter, and the bending radius of all pipes shall range from 1.5 to 4 times the pipe diameter. The conveyance pipe elevation angle shall not exceed 30^{o} for a climb and 45^{o} for a descent.

6.3.5 A Y-joint shall not have a merging angle exceeding 45^{o}. Where applicable, the conveyance pipe with higher refuse load should be the receiving side of the branch. The receiving side of the conveyance pipe shall be designed to withstand greater impact and abrasion at the pipe branch.

6.4 Construction of pipe network

6.4.1 General

There are two types of schemes used for the construction of PWCS conveyance pipes: buried pipe network scheme (buried pipes) and the suspended pipe network scheme.

6.4.2 Buried pipe network scheme

6.4.2.1 Buried conveyance pipe shall be encased all around with grade 30 concrete and with steel reinforcement. The minimum thickness of the concrete shall be 200 mm. The steel reinforcement shall be designed to minimise fissure and tensile cracks in the concrete. Prior to concrete haunching, the mild steel conveyance pipe shall be protected externally with polyethylene pipe wrap in accordance with DIN 30670 or equivalent.

6.4.2.2 The preferred construction method for buried conveyance pipe shall allow for its future replacement.

6.4.2.3 Conveyance pipes shall be laid outside buildings wherever practicable.

6.4.2.4 An underground conveyance pipe in an open area shall be supported with adequate piling foundation constructed according to a geotechnical engineer’s design requirements. The buried conveyance pipe foundation shall be adequately designed to protect against vehicle loading from the top as well as settlement.

6.4.2.5 Where a conveyance pipe passes under a building, a pipe trench or bunker room shall be provided for the pipe to be installed and for its future replacement. For areas with structural slab elements, a buried conveyance pipe may be laid in a trench formed by tucking down the structural slab or used with concrete pipe sleeve for straight pipes. In this construction design, the conveyance pipe shall be placed close to the floor level. When laying a buried conveyance pipe in public areas, prior approval shall be sought from relevant authorities.

6.4.2.6 If the conveyance pipe has to pass through a basement wall to an external open ground, provisions shall be made for the design to take care of differential settlement and to reduce the risk of shear fracture to the pipe.

6.4.3 Suspended pipe network scheme

6.4.3.1 A suspended conveyance pipe shall be coated with an anti-corrosion primer in a factory prior to its delivery to the site. The pipe shall be adequately supported to withstand the conveyance impact force at pipe branches and bends.

6.4.3.2 The support system shall be made of steel material complying with EN-S235J2 grade, or equivalent. The support system shall be hot-dipped galvanised, or painted with a good-grade anti-corrosion coating.

6.4.3.3 An anti-vibration rubber sheet, or equivalent, shall be provided at the pipe support to isolate vibration due to the operation of refuse conveyance and prevent structure-borne noise transmission.

6.4.3.4 The acoustic insulation shall be designed to meet the required noise control level of the surrounding. Special treatment of the acoustic insulation shall be applied to the maintenance hatches to provide easy access for maintenance purposes.

6.4.3.5 A suspended pipe shall maintain a minimum clearance of 300 mm between the underside of the slab and the top of the conveyance pipe for maintenance access.

6.4.3.6 All conveyance pipes shall be clearly marked with an arrow indicating the direction of flow. The markings should be located in positions such that they are readily visible to personnel in the facility from the point of normal approach or shall be at intervals of not more than 10 m for straight pipes.

6.4.3.7 QP(s) shall supervise and witness the testing of the suspended pipe support.

6.5 Inspection chamber and inspection openings

6.5.1 General

6.5.1.1 Inspection chambers and inspection openings are located where refuse is likely to accumulate and block the conveyance pipe, including, but not limited to, pipe fittings in the conveyance pipes.

6.5.1.2 Inspection chambers and inspection openings shall be provided at intervals of not more than 50 m. There shall be an inspection chamber not more than 3 m after every y-joint.

6.5.1.3 The underground inspection chamber shall be located away from any driveway, heavy traffic area, nearby commercial and/or private activity area, low-lying area that is prone to flooding, near to main entrance, near to lift lobby and near to other mechanical and electrical services area.

6.5.1.4 A working platform with cat ladder access shall be provided for suspended conveyance pipe inspection opening/access that is located over critical areas such as high-traffic walkway, vehicle ramp, carpark, commercial and/or private activity area, high ground, water feature, etc.

6.5.1.5 There shall be an inspection chamber for every pipe bend that is more than 30^{o}.

6.5.1.6 There should be an inspection chamber at every pipe incline that is more than 20^{o}.

6.5.1.7 There shall be at least one inspection chamber that reaches the lowest point of the conveyance pipe in every PWCS.

6.5.1.8 The PWCS inspection chamber shall not be shared with other services.

6.5.1.9 Inspection chambers that allow human access shall have an internal clearance of at least 1.4 m by 1.2 m and a minimum height of 1.8 m. For chambers that house replaceable piping components and for chambers with provision for replacement of piping components, sufficient space shall be provided accordingly (see Figure 10).

6.5.2 Construction

6.5.2.1 The wall and base of the inspection chamber, including the cover, shall be watertight and there shall be a sump pit provided at the base to aid dewatering work during maintenance.

6.5.2.2 A water sealant shall be applied to any pipe conduit or any other pipe penetrating the walls of the inspection chamber to prevent water ingress into the chamber.

6.5.2.3 An aluminium or galvanised cat ladder shall be provided inside the inspection chamber. It is presupposed that the use of ladders for work at height is in accordance with applicable statutory and regulatory requirements.

6.5.2.4 All inspection chambers shall be sized up accordingly to allow for future replacement of equipment, other than the refuse pipe.

6.5.2.5 All inspection chamber covers shall be watertight, with a clear access opening as follows:

a) For an inspection chamber equal to or more than 2 m deep, clear access opening shall be 600 mm by 600 mm; and

b) For an inspection chambers of less than 2 m deep, clear access opening shall be 1200 mm by 1200 mm.

6.5.2.6 Before any concrete is laid for the construction of any inspection chamber cover or manhole cover, the QP(s) shall ensure that

a) where the inspection chamber is constructed under carriageways or vehicular access areas, a heavy duty manhole cover which complies with the Singapore Standard SS 30 Grade A1 shall be used;

b) where the inspection chamber is constructed under turfed areas or pedestrian footways, a medium duty manhole cover which complies with the SS 30 Grade B shall be used; and

c) The manhole cover shall have the words “PWCS” and “SS 30” embossed. The words shall have a minimum height of 50 mm.

6.5.2.7 Where applicable, the inspection chamber opening shall be raised at least 100 mm from the external ground/soil level.

6.5.2.8 All inspection openings for suspended pipes shall always be accessible for maintenance work.

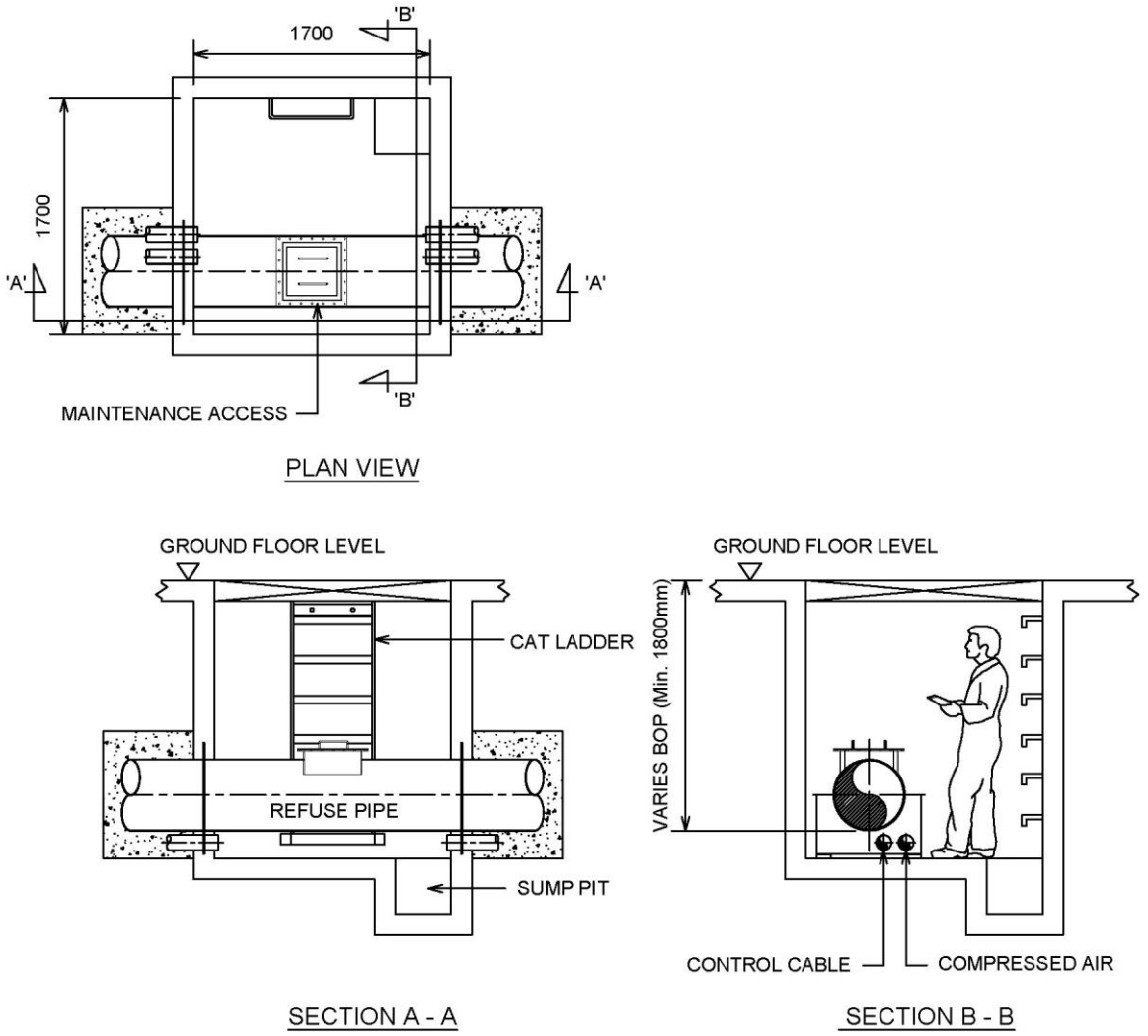


Figure 10 – An example of an inspection chamber layout

6.6 Compressed air tubing network

6.6.1 General

6.6.1.1 Compressed air tubes shall be replaceable and made of a material that is able to withstand a minimum static pressure of 10 bar or 1.5 times of operating pressure, whichever is higher.

6.6.1.2 Compressed air tubes shall be able to withstand up to 1.5 times the maximum working pressure.

6.6.2 Construction

6.6.2.1 The compressed air tubing network should be routed above ground, and should not be placed inside plastered ceiling board areas and inside or above other mechanical equipment rooms. If the compressed air tubes have to be routed inside plastered ceiling board areas, it shall be made of a more durable material such as stainless steel, galvanised steel and copper material.

6.6.2.2 The main joints and valves in the air tubing network shall be placed near to accessible areas and not be obstructed by other M&E services. The compressed air tubing network shall be fitted with isolation valves to segregate the network into zones, to facilitate checking for air leaks and to contain leaks to a minimum affected area.

6.6.2.3 All compressed air tubes shall be concealed, except for those inside the mechanical rooms, collection stations and DV rooms.

6.6.2.4 Buried compressed air tubes shall be laid inside conduits with a suitable size and turning radius.

6.6.2.5 Buried compressed air tubes should not have any joints buried. If this is unavoidable, the joint shall be located at maintenance chambers that are more easily accessible.

6.6.2.6 Adequate isolation valve(s) shall be provided for maintenance purposes.

6.6.2.7 The compressed air tubes shall be fully flushed out before connecting to the components at the end of the line. The entire compressed air system shall be tested at its maximum working pressure and shall not have a pressure drop of more than 10% within one hour.

7 Collection station

7.1 General

7.1.1 The PWCS collection station, conventionally known as bin centres, houses the waste diverter, waste-air separator, vacuum exhauster, dust filtration system, odour filtration system, compactor, container and control panel. Provisions shall be made for a vacuum exhauster room and a filter room (see Figure 11).

7.1.2 The collection station shall be accessible to refuse collection vehicles and sited at a location where it should not cause nuisance to neighbouring premises. It is presupposed that the design requirements for the collection station are in accordance with applicable statutory and regulatory requirements.

7.1.3 Separate containers shall be provided for the collection of general waste and recyclables. Containers for general waste and recyclables shall not be interchangeable.

7.1.4 The collection station shall be kept dry and clean at all times with provisions for a scupper drain.

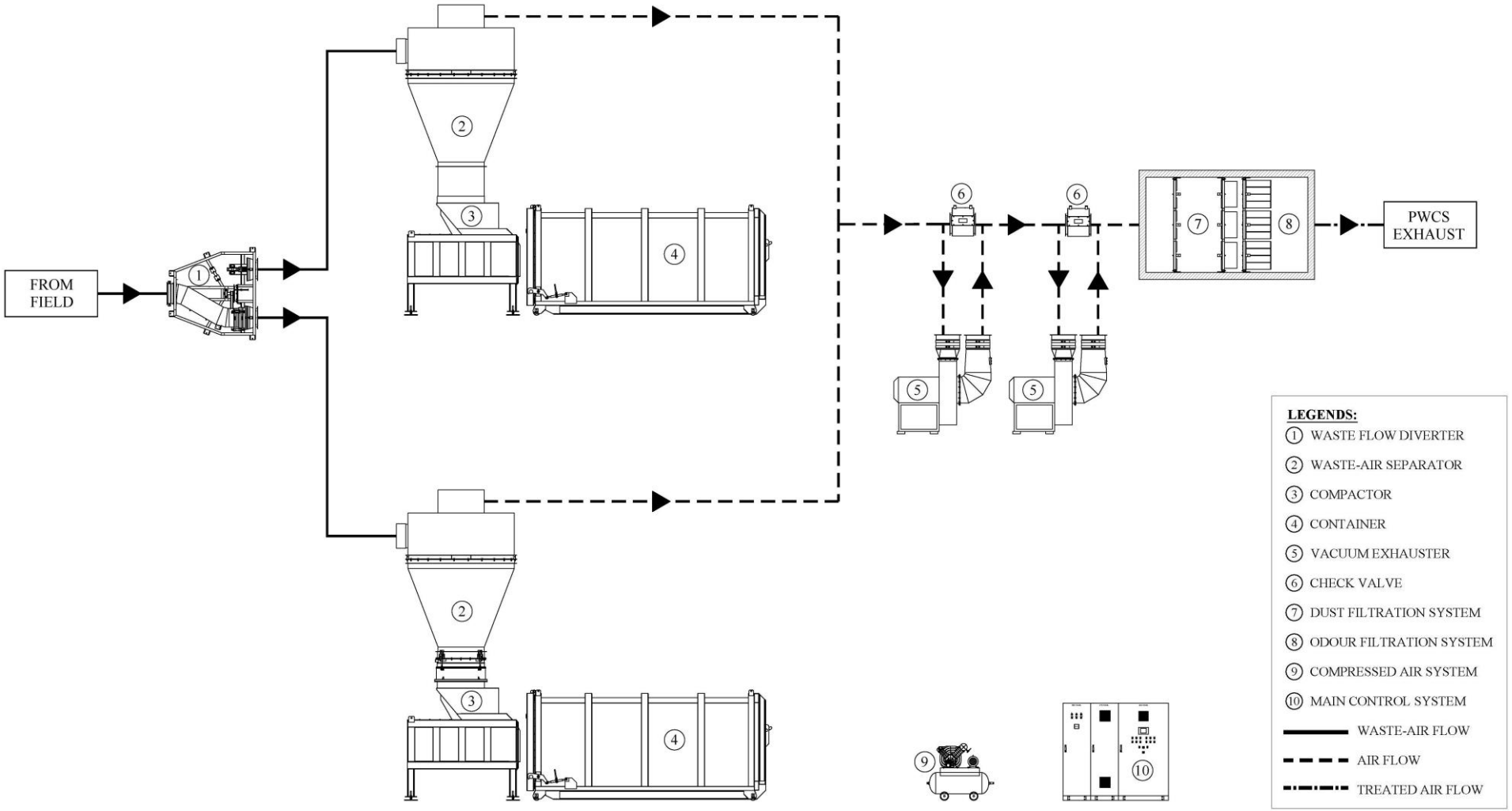


Figure 11 – Schematic diagram of a collection station

7.1.5 Noise control measures shall be implemented for the collection station and exhaust outlet to comply with the noise limits given in Table 1. The noise measurement should be made at the same level as the noise source. An example of the location for noise measurement is shown in Figure 12.

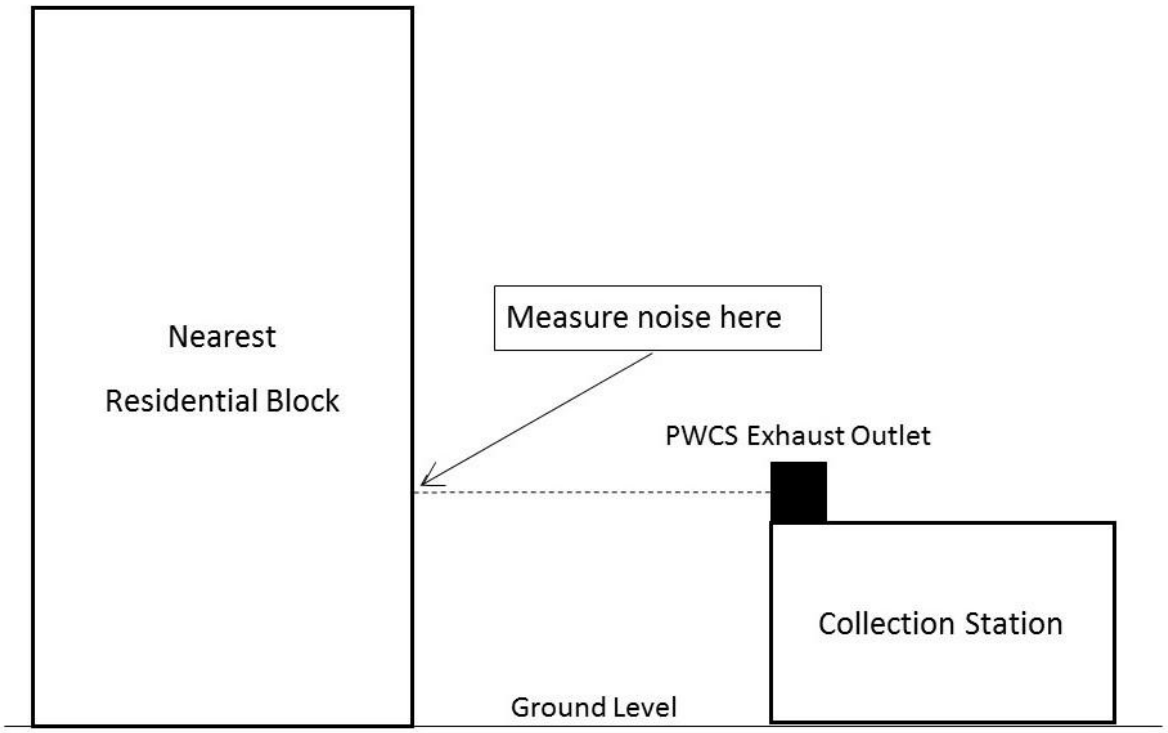


Figure 12 – Location of noise measurement for the exhaust outlet at the collection station

7.1.6 The noise level at the container hall within the collection station shall not exceed 90 dB(A) (see Figure 13). The duration of time people work in the workplace shall be limited based on the permissible exposure limits stipulated in applicable statutory and regulatory requirements.

7.2 Waste flow diverter

7.2.1 General

The waste diverter valve should be positioned upstream of the waste-air separator. The function of the waste flow diverter is to divert general waste and recyclables to their respective waste-air separator and containers.

7.2.2 Requirements

7.2.2.1 The section of the waste flow diverter valve in contact with the waste should be made of the same material as the conveyance pipe system. The pipe thickness at this section should depend on its design life, waste load and waste-air speed.

7.2.2.2 Where isolation valves are used, the material of the gates shall be made of stainless steel with a minimum grade 304.

7.2.2.3 The outer diameter of the waste flow diverter pipe shall be equal to that of the conveyance pipe system.

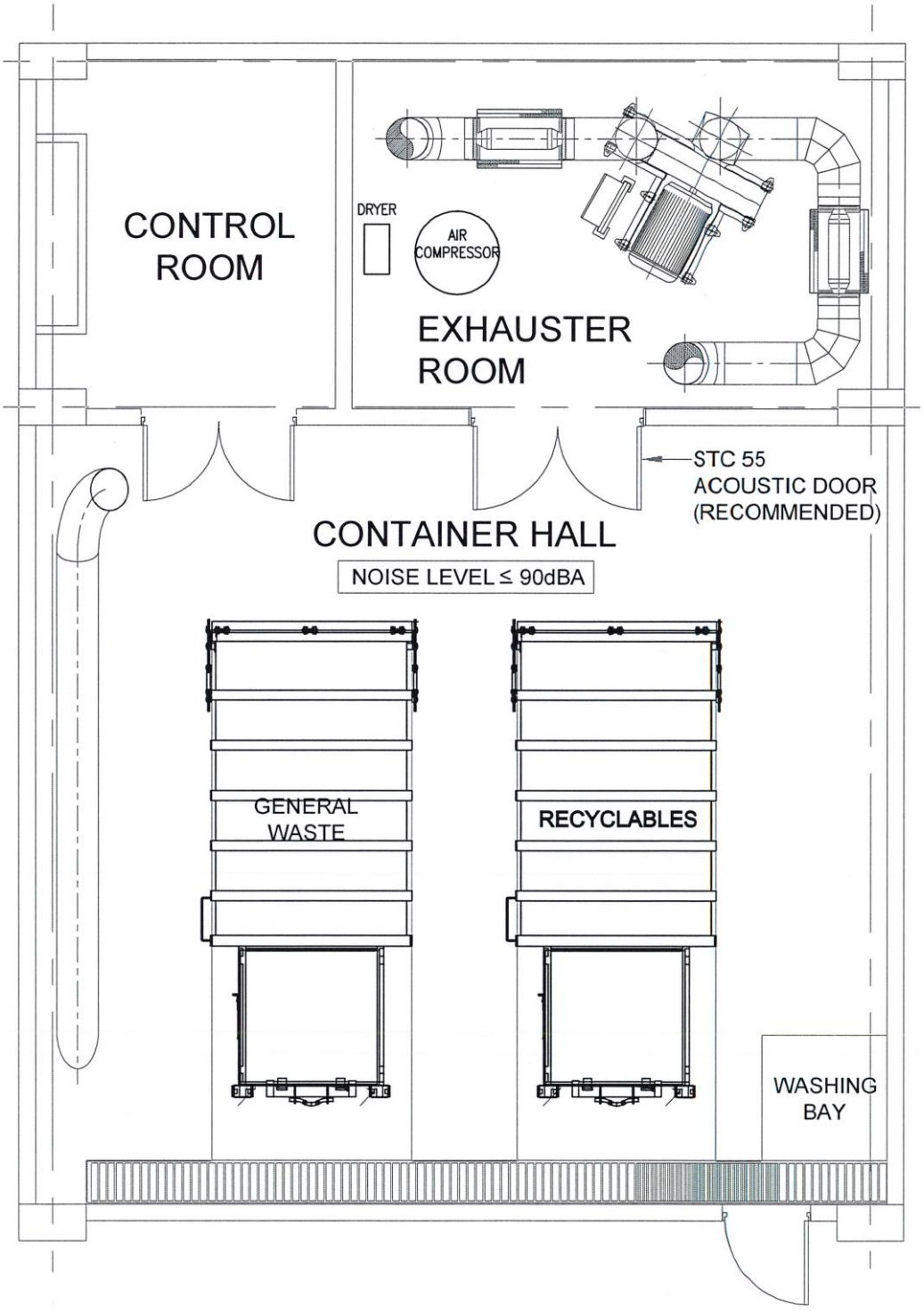


Figure 13 – Acoustic requirements at the container hall

7.3 Waste-air separator system

7.3.1 The waste-air separation system shall be designed to separate a mixture of waste and air without disturbing the collected waste. It may exist in a form of a circular, cyclonic tapered cone design to facilitate mixture separation or other forms of separation that are equivalently effective. This is optional for containers collecting recyclables.

7.3.2 The waste-air separator should be made of a material that is erosion-resistant with high abrasive strength.

7.4 Dust filtration system

7.4.1 General

Dust and deodorising filters shall be provided to filter dust and foul odours from the air conveying the refuse before the air is discharged to the atmosphere. The dust filtration system shall include an effective air and dust treatment system. Each filter panel of 600 mm by 600 mm should not handle more than 2000 m^3/h of air flow. The dust treatment system may either be a two-stage dust filter or a water scrubber system.

7.4.2 Two-stage dust filter system

7.4.2.1 The two-stage dust filter normally consists of a pre-filter and a media filter. A washable pre-filter system is required to wash out large coarse materials that are trapped. It may be in the form of a water scrubber system. The media filter shall comply with ASHRAE 52.1 to be effective.

7.4.2.2 The two-stage dust filters, shall achieve minimum 85% efficiency (according to either ASHRAE 52.2 or ISO 16890-1). A differential pressure gauge or sensor shall be installed to measure the pressure difference across the dust filters. This differential pressure will be used to determine the change of filters.

7.4.3 Water scrubber system

7.4.3.1 The water scrubber system shall achieve a minimum efficiency reporting value (MERV) of 11 and relative humidity (RH) not exceeding 60% during normal operation. Proper drainage and demister shall be provided.

7.4.3.2 A differential pressure gauge shall be installed across downstream carbon filter to measure the effectiveness of the water scrubber system. The differential pressure shall not exceed 1 kPa.

7.4.4 Dust filter room

7.4.4.1 The dust filter room shall house the dust filtration system and the odour filtration system. It shall be able to withstand a pressure of 2 kPa with a minimum internal clear height of 1.8 m. The size of the room shall be designed to accommodate the number of filter panels required and have sufficient working space.

7.4.4.2 Control measures should be put in place to prevent the accumulation of dust and remove all sources of ignition to prevent possible dust explosion.

7.4.5 Other requirements

7.4.5.1 Dust filters should be changed when the pressure difference between gauges reaches 500 Pa. Differential pressure gauges should be calibrated annually.

7.4.5.2 The media filter should be replaced every six months. Alternatively, refer to the differential pressure gauge to determine the change frequency.

7.5 Odour filtration system

An odour filtration system is also known as an odour treatment system. A gas-phased filter or other environmentally friendly efficient means shall be put in place to remove foul odours. The deodorisation method should target foul smell contaminants generated from waste.

7.6 Stationary compactor

7.6.1 For a PWCS not using a compactor container, a stationary compactor shall be provided to compress and pack the refuse collected from the waste separator into a waste container. The compactor is fitted with devices to push/pull a ram.

7.6.2 The stationary compactor's compaction ratio shall be of at least two to three times depending on the density and type of the waste.

7.6.3 A drain outlet shall be provided to drain out liquid inside the waste. It shall be connected to the gulley trap inside the collection station.

7.7 Container

7.7.1 The container shall be designed and built in accordance with DIN 30722 and shall be inspected annually and certified fit for operation by workshops accredited by the Singapore Accreditation Council (SAC).

7.7.2 The containers shall be labelled "General Waste" and "Recyclables" on both sides respectively. The containers shall be fully painted in:

a) green (colour code Pantone 350c) for the general waste container; and

b) blue (colour code RAL 5005 signal blue) for the recyclables container.

7.7.3 The base plate of the container shall be made of at least 6 mm thick mild steel plate.

7.7.4 The container may be designed to allow the manual disposal of general waste/recyclables.

7.7.5 To facilitate maintenance of the container, an access hatch may be provided at the side of the container and shall be a clear opening of at least 500 mm by 500 mm. Warning labels shall be clearly displayed at all access hatches.

7.7.6 The access hatch at the side of the container shall not be used when the system is in operation.

7.7.7 The PWCS shall be automatically cut off before the hook can be engaged for haulage operation of the container. This may be done by activating a manual button or gantry control system.

7.8 Vacuum exhauster

7.8.1 General

A vacuum exhauster, connected either in series or parallel, creates a suction pressure and air flow in the conveyance pipeline. It is usually isolated in the exhauster room due to the noise produced when in operation.

7.8.2 Requirements

7.8.2.1 The minimum energy performance standards (MEPS) for the motor in the vacuum exhauster shall be driven by a variable frequency drive (VFD) with a motor rating of at least IE2.

7.8.2.2 The vacuum exhauster shall be designed to meet the static pressure losses over the maximum distance of the conveyance pipe system for the design air flow.

7.8.2.3 The performance of the vacuum exhauster to convey refuse in the pipes shall be tested in accordance with 8.1.

7.8.2.4 The access to the vacuum exhauster shall not be obstructed at all times for replacement of the fan and for other maintenance purposes.

7.8.2.5 A standby unit of the vacuum exhauster shall be provided and shall be operational at all times.

7.9 Exhauster room

7.9.1 The exhauster room enclosure, including acoustic doors, shall meet a minimum sound transmission coefficient (STC) of 55 (see Figure 13).

7.9.2 Mechanical ventilation shall be provided to prevent the equipment in the exhauster room from overheating and to keep the room temperature below 40^{o}C.

7.9.3 Pipe silencers shall be provided to attenuate noise in the exhaust air pipe or duct to an acceptable level. It shall be of mild steel construction and able to withstand the positive or negative pressures of the PWCS when it is operated at the maximum air speed or pressure. It shall be designed and constructed, and placed within the exhaust air pipe network to have little or no turbulence.

7.9.4 The exhaust air shall not be discharged into any enclosed areas or areas that will trap the exhaust air. Where the exhaust air pipe discharge outlet is exposed to the weather, it shall be designed to prevent the ingress of rainwater.

7.10 Compressed air system

7.10.1 The compressed air system shall include an air compressor and a compressed air tubing network to support all pneumatically operated valves and shall be designed with sufficient capacity, pressure and flow rate to ensure the efficient and uninterrupted operation of the PWCS refuse collection cycle.

7.10.2 The operation of all air receivers in the PWCS system shall comply with statutory requirements for inspection by an authorised examiner.

7.10.3 The compressed air system has to deliver dry compressed air using suitable devices such as an air dryer and air cooler system, etc.

7.11 Pipe network in the collection station

7.11.1 Waste conveyance pipe

The waste conveyance pipe is the section from the waste diverter to the waste-air separator. This section shall be equivalent to the material, size and thickness of the waste conveyance pipe system just before the waste diverter.

7.11.2 Air pipe

7.11.2.1 The air pipe is the section of pipe network from the waste-air separator to the air treatment room.

7.11.2.2 This section of the pipe shall be made of stainless steel of at least grade 304 with a minimum thickness of 2 mm or equivalent performance. The diameter of the air pipe shall be designed according to the static pressure requirement of the system and able to withstand an operating pressure of at least negative 30 kPa.

7.11.3 Exhaust pipe

7.11.3.1 The exhaust pipe is the section of the pipe network from the air treatment room onwards.

7.11.3.2 The exhaust air pipe network design, size and construction shall be in a manner that ensures the smooth flow of air through it with minimum turbulence.

7.11.3.3 The exhaust air pipe diameter shall not be smaller than the refuse conveyance pipe diameter. It shall be constructed of hot-dipped galvanised mild steel with a minimum thickness of 3 mm. Smooth round bends or segmented bends shall be provided for the pipe turns and shall have a minimum radius of 1.5D. It shall be structurally strong to withstand the operating pressures of the PWCS.

7.11.3.4 Where segmented bends are used, each segment angle shall not exceed 15^{o} to ensure a smooth bend is constructed.

7.12 Valves and other equipment

7.12.1 Main valve

The main valve may be provided for every system and used to open or close the transport air stream during system start.

7.12.2 Non-return valve

A non-return valve is to be provided for exhausters connected in series to prevent backflow between exhausters. The number of non-return valves required will depend on the number of exhausters installed. The exhauster may be connected either in series (see Figure 14) or in parallel (see Figure 15).

7.12.3 Isolation valve

The isolation valve (with position sensor) shall be used with the waste-air separator to isolate a section or sections of the air pipe network depending on the air-flow intended direction, such as flow diversions between the separators or containers. It may also be used to isolate sections of the pipe during maintenance.

7.12.4 Air speed measuring device

7.12.4.1 Air speed measuring device shall be provided for every system. This device may be in the form of a venturi pipe, mass flow meter, pitot tube, etc. The air speed measuring device shall be pre-calibrated before installation.

7.12.4.2 Where a venturi pipe is provided for air speed monitoring and control, its location within the exhaust air pipe net shall be along a section with straight air flow, with little or no turbulence, to ensure accuracy in the differential pressure metering and air speed control.

7.13 Main control system

7.13.1 General

7.13.1.1 A control system shall be provided, and be located at the collection station. The control system shall be a computerised or programmable logic controller (PLC) based system that monitors, controls and operates the entire PWCS without any operator intervention under normal system operating conditions. It shall provide the means for programming and operating the PWCS in the most optimised, efficient and energy-saving manner.

7.13.1.2 All electrical and electronic components (including the programmable logic controller) shall use original equipment manufacturer (OEM) parts.

7.13.1.3 A communications system shall be incorporated into the system to automatically and immediately alert the PWCS owner and PWCS provider of any faults or breakdowns detected in the system so that repair work may be promptly arranged.

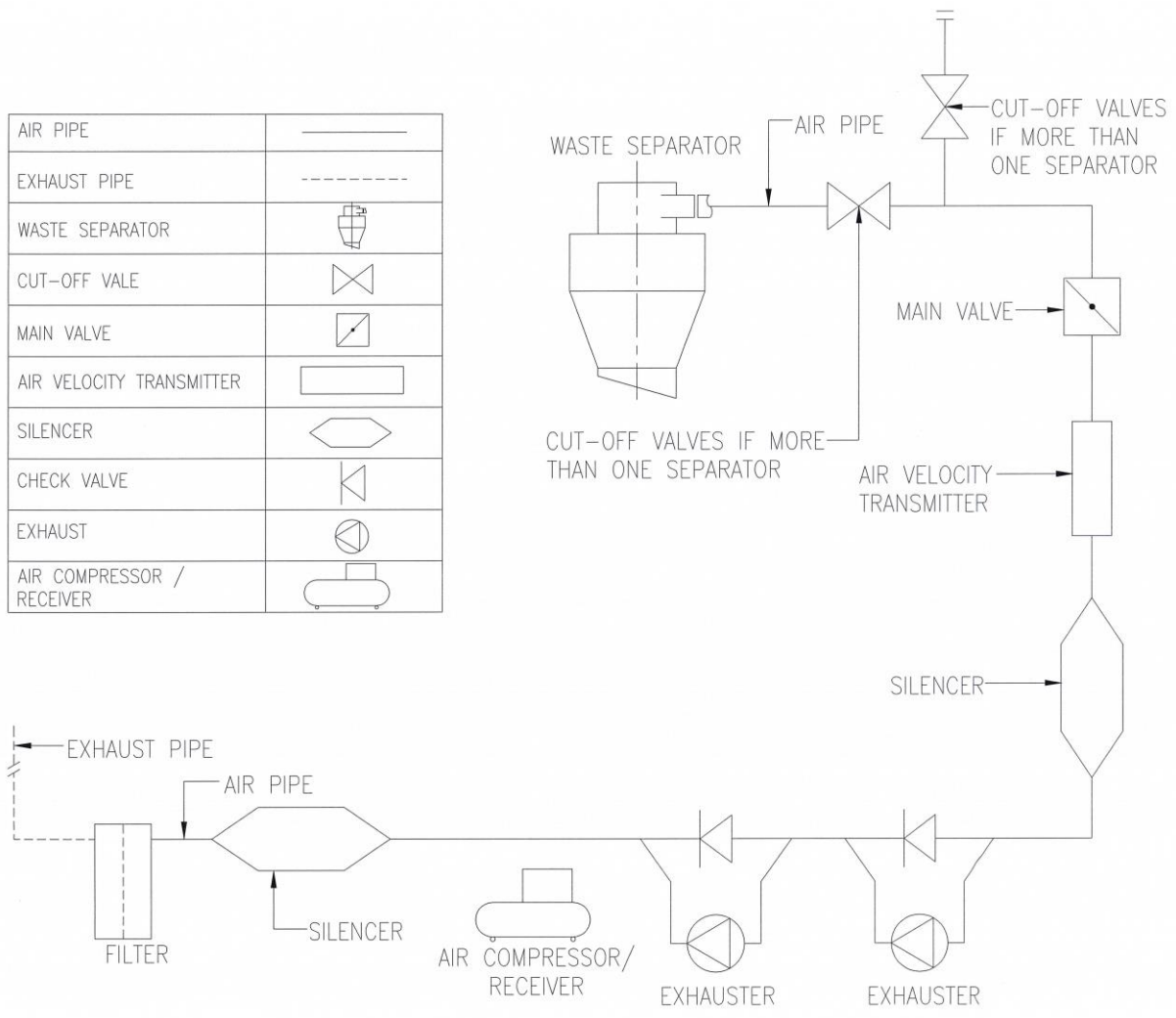


Figure 14 – An example of an exhaust air pipe layout (in series)

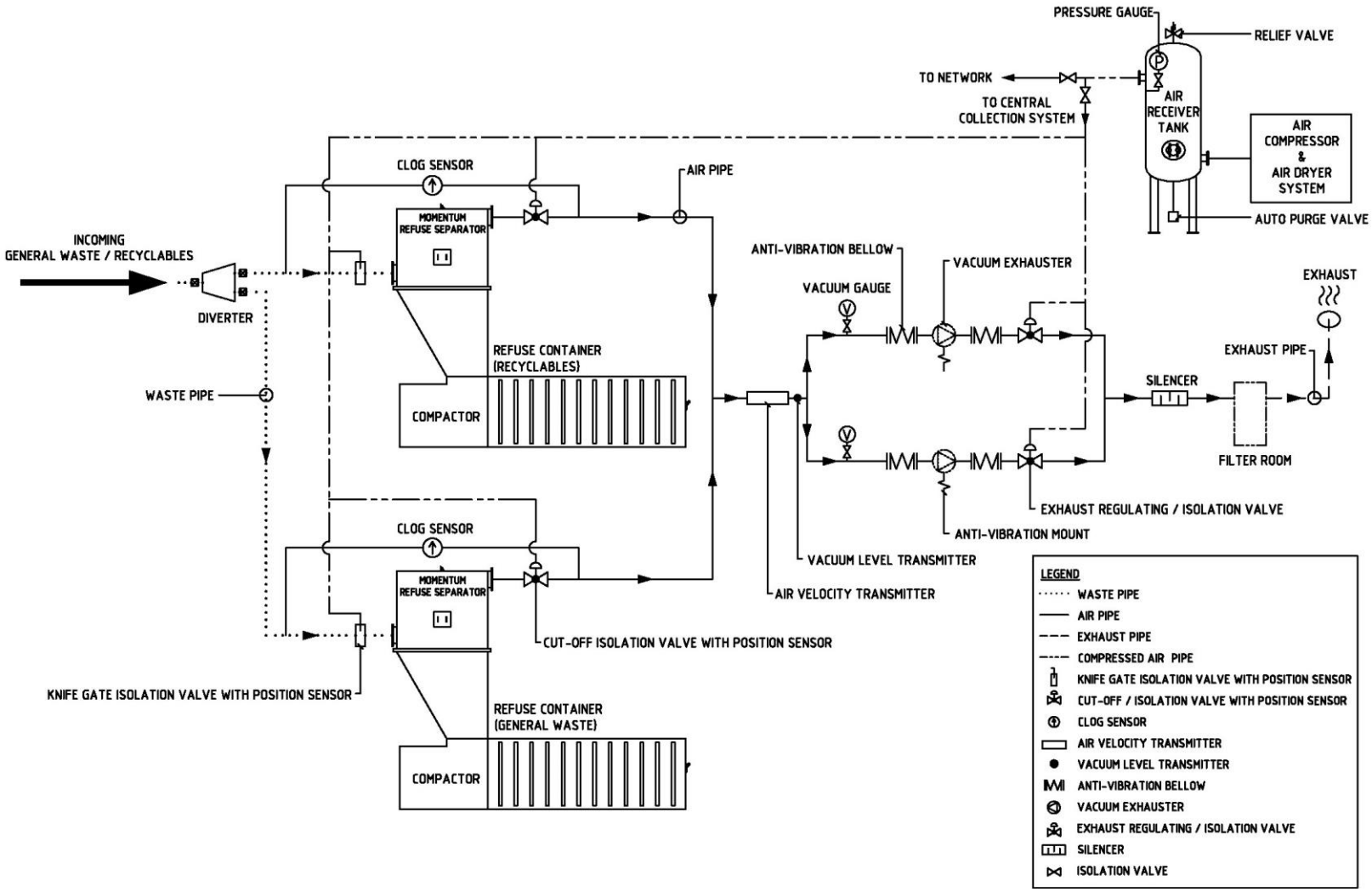


Figure 15 – An example of an exhaust air pipe layout (in parallel)

7.13.1.4 The control program shall be aligned with the international standard IEC 61131-3 and it shall be adaptable to suit local equipment or requirements by project-specific functionality.

7.13.1.5 The PWCS should be designed with circuits that are capable of manually isolating the part of the PWCS undergoing any form of maintenance and servicing that may involve risk of injury.

7.13.1.6 A file with a chronological history of all system events, such as alarm/fault, system cycles, energy consumption, shall be stored in memory for viewing through the display unit. The data displayed shall provide for date/time indication of each event that occurred.

7.13.2 Remote access

7.13.2.1 A remote monitoring and control system shall be provided. It shall make use of the telecommunications infrastructure for a reliable off-site monitoring and control station to be set up and shall include safety features and controls for remote operator access, operation and use.

7.13.2.2 Where a remote access system is considered for inclusion, the system design should reduce or eliminate the risk brought about.

7.13.2.3 Where a remote access system is provided, specific control measures, in addition to those normally required for safe operation of the PWCS, shall be incorporated to prevent risks to operators or maintenance staff while the PWCS is operated remotely.

7.13.2.4 Any risks that may arise from the remote access facility should be identified and mitigated with specific control measures via the conduct and implementation of risk assessment and safe work procedures to safeguard against the hazards that cannot be eliminated by design, taking into account all conditions of use and foreseeable misuse. Wherever possible, safety should be ensured by means of design changes rather than procedural arrangements.

7.13.2.5 During any manual maintenance of the PWCS, besides the implementation of lockout-tagout procedures, the system should be interlocked with a total cut-off of remote signals under any circumstance that may lead to an unexpected start up.

7.13.2.6 Any changes made to the system from remote access may lead to a hazard if not properly communicated and logged. Such changes should be properly and simultaneously communicated and logged to prevent incorrect information.

7.13.2.7 The remote access system should include ways to prevent unauthorised access as this affects safety.

7.13.2.8 The means of switching off should be under the control of persons performing such maintenance. Suitable provisions shall be made so that precautions may be taken to prevent any equipment from becoming unintentionally or inadvertently reactivated during maintenance.

7.13.3 Operator panel or human-machine interface (HMI)

An operator panel shall be provided for setting parameters and display/presentation of system status, air speed and alarms in the system. The operator panel shall also be used for manual operation of the system. Air pressure instruments shall be used to monitor the refuse transport air speed, as well as the container status, visual indications.

7.13.4 Backup power supply unit

A battery backup power supply unit (UPS) of suitable capacity shall be provided for the PLC to prevent data loss if the main power supply fails.

7.13.5 Emergency stopping devices

7.13.5.1 The PWCS should be designed and constructed with stopping devices to stop the relevant equipment and any of its connected components. Stopping devices shall include emergency switching and emergency stops. The emergency stop button shall be fail-safe-stop and key or password reset.

7.13.5.2 All operating equipment of the PWCS (e.g. exhauster room, cyclone separator system etc.) shall be provided with a stopping device for immediate switch-off of the PWCS to prevent a direct or a possible hazard.

7.13.5.3 An emergency "STOP" button shall be provided at the main control system and where mechanical movement of electrically or pneumatically or hydraulic actuated equipment may give rise to danger.

7.13.5.4 The emergency stop device should be clearly visible, not obstructed and easily accessible, and usable regardless of the operating mode to immediately cut off electrical supply and all energy sources to end dangerous condition without introducing additional risks. The emergency stop mechanism, when activated, shall be capable of allowing the use of safety features such as emergency lights in the activated mode. The emergency stop mechanism has to stay active until the machine is reset by means of an appropriate procedure that is protected against accidental operation.

8 Operation and maintenance

8.1 Final testing and commissioning

8.1.1 The PWCS shall be tested and commissioned as a complete system by the PWCS provider in the presence of a QP and an appointed representative from the PWCS owner. All components and equipment shall be operational and functional prior to testing and commissioning of the system.

8.1.2 A functional test on all the mechanical and electrical components/equipment and safety features, alarms shall be conducted during the final testing and commissioning of the system.

8.1.3 The conveyance pipe, whether buried or suspended, shall also be visually inspected and cleared of water, sediments, sludge and any form of obstruction.

8.1.4 A full-load conveyance test shall be conducted from the furthest discharge valve of each branch to the collection station. Bags weighing 4 kg each shall be disposed into the temporary storage section until the high-level refuse sensor is triggered. All bags disposed into the system shall be accounted for in the container at the collection station.

8.1.5 A copy of the final testing and commissioning report for the PWCS, endorsed by the QP(s), shall be submitted to PWCS owner and the relevant authority for retention. All defects noted during the inspection and tests shall be rectified. An example of the testing and commissioning checklist is given in Annex B.

8.2 Operation and maintenance manual

8.2.1 The PWCS provider shall provide the operation and maintenance manual to the PWCS owner after system acceptance.

8.2.2 The operation and maintenance manual shall include, but is not limited to, the following:

a) System overview, description and safety features including a schematic diagram of the whole system.

b) Technical data/catalogue

i) A complete set of technical specification, catalogue, and operational manuals for major components, equipment and its accessories. This should include information on the safe use of the equipment.

ii) Equipment manuals should state the equipment model and selected options for each piece of equipment requiring maintenance as well as the maintenance actions necessary.

c) Equipment and supplier list – A summary of equipment, components, spare parts, consumable parts, special tools and their suppliers' contact information. A list of replacement intervals for major equipment should be included (see Annex C).

d) Control system documentation – Control system manuals should include the electrical wiring diagram, layout of the control panel and control parameters.

e) Operational manual – This should include emergency shut-down operation instructions, start-up/reset instructions and other operating parameters.

f) Safety precautions for all work processes in the operation and maintenance of the PWCS.

g) Troubleshooting guide

h) System maintenance – The maintenance plan shall include the scope, schedule of inspection and servicing, periodic testing and calibration, if required, and any other work to ensure the proper functioning of the PWCS (see Annex A).

i) As-built drawings – The drawings should include the piping network diagram, feeding system (compressed air network) diagram, collection station diagram and the control schematic diagram. These diagrams should cover details like conveyance pipe routing, positions of inspection manholes, layout of equipment in the collection station, electrical cable routing, etc. The piping network diagram should include the pipe material data. If buried conveyance pipes are laid in trenches under structural slab elements, their locations shall be clearly indicated in drawings. The allowable methods of hacking and reconstruction of the structural slabs shall also be made available.

j) Testing and commissioning documentation – This should include equipment manufacturers' test certificates, where applicable, and testing and commissioning reports.

k) Contact information – A list of key contact numbers for emergency situations, maintenance and breakdown service.

l) User guide for residence including the Dos and Don'ts of the proper use of the PWCS.

8.3 Operation considerations

8.3.1 A data log on the system operating conditions and performance shall be kept for at least one year and shall include the following:

a) Type of faults;

b) Type of alarm activated (e.g. differential pressure for filters);

c) Number and timing of system cycle; and

d) Energy consumption.

8.3.2 The information in the data log shall be remotely accessible by the PWCS owner, PWCS provider and PWCS service contractor.

8.3.3 In the event of a blockage or partial breakdown of the system, only the affected part of the system shall be isolated where possible to allow the central system to continue to serve other parts of the system.

8.3.4 In the event of a breakdown of the whole PWCS or prolonged shutdown of any part of it, measures shall be in place for waste diversion facilities inside the ground floor waste chambers, manually collecting the waste and disposing the waste to the collection station.

8.4 Safety considerations

8.4.1 Risk assessment

A risk assessment shall be conducted prior to any maintenance, inspection, cleaning, clearing of clogs, repair and servicing performed on any part of the PWCS including confined spaces. Where there is any work involving machinery or equipment, a lockout tagout procedure shall be established and implemented according to SS 571.

8.4.2 Use of personal protective equipment (PPE)

8.4.2.1 Suitable and adequate PPE shall be used for workplace hygiene and health-related hazards, for example, dust protection for persons working in an air treatment room and when clearing blockages and noise hazards.

8.4.2.3 Hearing protections shall be provided and maintained to correctly fit the user and shall attenuate the user to sound pressure below 85 dB(A), over an 8-hr work day consistent with the permissible exposure limit for noise.

8.4.2.4 The noise reduction rating (NRR) of the hearing protection shall be taken into account to attenuate the user to sound levels below 85 dB(A). If necessary, a double layer of hearing protection for the purpose of attenuation should be provided.

8.4.3 Other safety considerations

8.4.3.1 Warning signs on the use of hearing protection shall be displayed in the collection station where work areas emit excessive noise.

8.4.3.2 Human access in a refuse conveyance pipe, manhole and refuse chute, if necessary, shall comply with applicable statutory and regulatory requirements for confined spaces and SS 568 Code of Practice for Confined Spaces. Before any attempt to enter or work in a confined space, it is important to assess the need to enter a confined space and consider other alternatives or other methods based on the hierarchy of controls without entering the confined space.

8.5 Maintenance and repair considerations

8.5.1 Maintenance and repair of equipment and PWCS components shall, in general, include checking, necessary adjustment and calibration, cleaning, greasing, oiling, painting, supply and replacing of any parts or equipment and disinfection measures.

8.5.2 Regular and proper maintenance of equipment is necessary to maintain system efficiency and effectiveness within its design life.

8.5.3 The PWCS service contractor responsible for the maintenance plan and the identified maintenance staff should be competent and trained in the operation and maintenance of the PWCS (see 8.7).

8.5.4 A schedule for preventive maintenance work shall be prepared with reference to the maintenance plan given by the PWCS provider and take into account the additional maintenance requirements stated in this standard.

8.6 Maintenance and service records

A service report shall record all repairs, calibration, replacement work and inspection or maintenance carried out on the system and shall be made available to the PWCS owner and the PWCS service contractor. This report shall be kept with the PWCS owner and serve as a reference for operation and maintenance of the system and for better traceability and accountability of all works performed on the system.

8.7 Training

8.7.1 The PWCS owner shall ensure that the appointed PWCS service contractor and/or maintenance staff are trained. The PWCS provider shall provide a comprehensive training programme on the operation and maintenance of the PWCS.

8.7.2 The training programme for the PWCS service contractor and maintenance staff shall include all technical and operational aspects of the system, functions of the various components, safety and health precautions related to the use and maintenance of the system (e.g. lockout tagout procedures, use of PPE), details of the maintenance plan and troubleshooting processes and an on-site familiarisation training.

Annex A
(informative)

Recommended maintenance programme

A.1 Maintenance services are provided by the PWCS provider or the PWCS service contractor appointed by the PWCS owner. Maintenance services should include, but are not limited to the following:

a) Fix and tighten loosened bolts and nuts, doors, electrical components and wiring, etc.

b) Lubricate and grease rollers, pins, bearings, hinges, etc.

c) Check and rectify motor starter contact.

d) Check and adjust belt tension.

e) Check and replenish oil level.

f) Check and adjust detector or sensor location and clean detectors or sensors, etc.

g) Check for excessive wear of moving parts.

h) Check for any damage, leakage, abnormal vibration or noise.

i) Clear accumulated fluid, debris or dust.

j) General cleaning of system equipment.

k) Replace filters.

l) Replenish consumable items etc.

m) Check that the gully traps at the DV rooms and outdoor throw point bunkers are not blocked.

n) Check that the louvers at the DV rooms are not blocked.

A.2 Maintenance of equipment are provided according to manufacturer's recommendation, with special attention to the following items:

a) Discharge valve/air intake valve.
   - Inspect all sensors used in the feeding system regularly.
   - Clean louvers regularly and check for blockage.

b) Dust and odour filtration system.
   - Filters should be replaced at least every six months (based on 3-hour use per day).

Annex B
(informative)

Sample testing and commissioning checklists

B.1 For blocks

Pneumatic Waste Conveyance System
Testing and Commissioning Checklist - Block

Location: _____ Date : _____

Block: _____

Development / Block details

S/N	Item	Development type	Waste volume per day in m^3		General waste chute	Recyclables chute	Chute flushing system	Remarks
			General waste	Recyclables				
1	Installed / Specified / Declared in Inspection Request Form							

Installatiion / Compliance check (Feeding & Discharge system)

S/N	Item	Designed / Specified / Requirement		Installed / Provided		Remarks
		Yes	No	Yes	No	
A	**Refuse hopper**					
A.1	Volume control type (limited to bagged waste of size 300mm to 350mm)					
A.2	Air-tight, self-closing and soft-closing type					
A.3	Fire-rated certified with batch inspection sticker					
A.4	Labelled hoppers and with "Dos & Don'ts" signs displayed above the refuse hopper					
A.5	General refuse hopper (with optional foot pedal)					
B	**Discharge valve (DV) and Temporary storage section**					
B.1	Discharge valve (DV) with individual "Open " & "Close" position sensors					
B.2	Temporary storage section made of stainless steel 304L and minimum 4mm thick					
B.3	Maintenance access provided for DV and temporary storage section					
B.4	Heat sensor for fire detection					
B.5	Heat sensor is water-proof and linked to activate chute flushing system					
B.6	Refuse Level sensor installed and able to detect high refuse level and clogged condition					
B.7	Filter regulator installed for compressed air supply					
B.8	Drain pipe with gradient connected to DV drain point and DV room drain point					
B.9	Break-fall device installed to cushion falling waste from high floors					
B.10	Mill certificates for stainless steel temporary storage section					
C	**Air intake valve**					
C.1	Air Intake Valve has Position Sensor (or 'open' and 'close' sensors)					
C.2	Air Intake Valve is equipped with Filter Silencer					
C.3	Filter Regulator is installed for Compressed Air line					

Testing and Commissioning Checklist - Block (con't)

D	Discharge valve room					
D.1	There are air intake louvers provided for the room					
D.2	The door of the room is certified to withstand 2kN/m^2 of pressure					
D.3	Air Intake Louver for the room are not obstructed					
D.4	There is sufficient working space for maintenance and contingency waste clearing plan					
D.5	First manhole is not more than 5 meter from Discharge Valve					

Function Test

S/N	Item	Expected outcome		Notes	Remarks
		Yes	No		
E	**Refuse hopper**				
E.1	Refuse hopper door close slowly when released with a 4kg bagged waste within it .				
E.2	No hissing sound from closed refuse hopper when system is in operation (Air tightness test)				
E.3	Bagged waste of size 300mm to 350mm can be easily discharged into the chute when the hopper is closed				
F	**Discharge valve**				
F.1	Discharge Valve to remain in closed position with 4kg bagged waste released from the chute hopper.				
F.2	Discharge Valve to remain in closed position when the compressed air supply valve is shut off				
F.3	Heat Sensor when triggered by a heat gun will activate chute flushing system				
F.4	Water from chute flushing system is able to flow freely into DV room floor trap via the drain pipe				
F.5	Waste High Level sensor is able to trigger the system to start a discharge cycle				
F.6	Waste Clog Level sensor is able to trigger a system alarm to seek assistance				
F.7	All bagged waste in the temporary storage section are removed after each discharge cycle				
G	**Air intake valve**				
G.1	Air intake valve will be fail-close when there is a loss of compressed air				
G.2	When air intake is activated, the noise limit (taken as equivalent continuous noise level over 15 miniutes) is:			Noise measurement should be made at the same level as the noise source. Refer to Clause 5.7.2.2; 5.7.2.3; 5.7.2.4; & Table 1; Figure 6	
a)	65 dB(A) from 7am to 7pm (Day)				
b)	60 dB(A) from 7pm to 11pm (Evening)				
c)	55 dB(A) from 11pm to 7am (Night)				

Recorded By : _____ Date: _____
PWCS Provider

Checked By : _____ Date: _____
Qualified Person

Witnessed By : _____ Date: _____
PWCS Owner / Appointed Representative

B.2 For system

Pneumatic Waste Conveyance System

Testing and Commissioning Checklist - System

Location: _____ Date : _____

Block(s): _____

Development / Block details

S/N	Item	Development type	Waste volume per day in m^3		General waste chute	Recyclables chute	Chute flushing system	Remarks
			General waste	Recyclables				
1	Installed / Specified / Declared in Inspection request form							

Installation / Compliance check (Feeding & Discharge system)

S/N	Item	Designed / Specified / Requirement		Installed / Provided		Remarks
		Yes	No	Yes	No	
A	**Conveyance system (Piping network)**					
A.1	Acoustic insulation installed for exposed section of piping network					
A.2	Water-tight inspection manhole provided (50 m apart for straight pipe and at elbows and junctions)					
A.3	Maintenance access provided on pipes are air- / water-tight					
A.4	Piping network flushed to remove accumulated water and debris within pipe					
B	**Collection station**					
B.1	All valves are installed with positioner or "Open" & "Close" sensors					
B.2	Waste diverter installed with position sensor					
B.3	Exhauster room installed with AC/MV system					
B.4	Compressed air buffer tank is MOM-approved type and equipped with relief valve. The air receiver is to be first tested, examined prior to testing and commissioning and subjected to statutory examination by the Authorized Examiner. The Certificate of Test and Examination must be kept available for inspection.					
B.5	Compressed air buffer tank installed with auto-purge device for purging water out of system					
B.6	Air dryer provided for compressed air system					
B.7	A means of monitoring the exhauster room temperature is provided					
B.8	Air speed or air monitoring device installed able to monitor system air speed and incoming air volume					
B.9	Emergency stop buttons installed for each vacuum exhauster and is compliant with CP 5					
B.10	All electrical panels has LEW-certified circuit drawing and kept within the panels					
B.11	Exhauster room door certified to withstand 2kN/m^2 of pressure					
B.12	Filter room door certified to withstand 2kN/m^2 of pressure					

Function test

S/N	Item	Expected outcome		Notes	Remarks
		Yes	No		
C	**Performance of equipment**				
C.1	Noise level from any side of the external wall of the collection station, with the PWCS in operation executing a normal waste collection cycle, should be:			Noise limit (the equivalent continuous noise level over 15 minutes) in d(B) A	
a)	65 d (B) A - 7 am to 7 pm (Day)			Refer to Clause 5.7.2.2; 5.7.2.3; 5.7.2.4; 7.1.5 & Table 1; Fig 11 ; Fig 12	
b)	60 d(B) A - 7 pm to 11 pm (Evening)				
c)	55 d(B) A - 11 pm to 7 am (Night)				

Testing and Commissioning Checklist - System (con't)

S/N	Item	Expected outcome		Notes	Remarks
		Yes	No		
C.2	AC/MV system in exhauster room is able to keep the room temperature below 40^{O}C				
C.3	Compressed air is able to build-up to the operating pressure (cut-out Pressure) within 30 minutes from idle state				
C.4	The cut-in / cut-out of the air compressor system shall be at least 2 hours when the system is not in operation				
D	**Waste conveyance test**				
D.1	1 x Marked bagged waste of about 4 kg is loaded into each discharge valve of the system. The system is trigger to run a collection schedule to collect waste from all discharge valves connected to it..			Each bagged waste is of size between 300mm to 350mm	
D.1a	The numbers of marked bagged waste disposed are accounted for at the collection station				
D.2	Marked bagged waste of about 4 kg is loaded into the furthest discharge valve of each system until it triggers the high level sensor to activate a discharge cycle for that branch.			Each bagged waste is of size between 300mm to 350mm	
D.2a	The numbers of marked bagged waste disposed are accounted for at the collection station				
As-built drawings and documentations					
E	All mill certificates and weld joints / vacuum test results for each pipe section are accounted for in the Operation and Maintenance			75% of Weld Joints are Inspected	
F	As-built drawing of piping network installed, with indication of pipe material and thickness, complies with the approved design				
G	Equipment and components installed on site complies with the approved design				

Recorded By : _____ Date: _____
PWCS Provider

Checked By : _____ Date: _____
Qualified Person

Witnessed By : _____ Date: _____
PWCS Owner / Appointed Representative

Annex C
(informative)

Replacement interval guide for major equipment and components

	Major equipment/component	Recommended replacement interval
1	Refuse hopper	10 years
2	Temporary storage section	10 years
3	Discharge valve	10 years
4	Air intake valve	10 years
5	Outdoor throw points	10 years
6	Conveyance pipe	30 years
7	Conveyance pipe joints	30 years
8	Conveyance pipe fittings	30 years
9	Compressed air tubing	15 years
10	Waste flow diverter	10 years
11	Waste-air separator	15 years
12	Cyclone separator	15 years
13	Momentum separator	15 years
14	Filters (dust and carbon filters)	6 months
15	Stationary compactor	10 years
16	Container	8 years
17	Vacuum exhauster	15 years
18	Air pipe	15 years
19	Exhaust pipe	15 years
20	Main valve	10 years
21	Non-return valve	10 years
22	Isolation valve	10 years
23	Pipe silencer	10 years
24	Control system components (electrical components) (e.g. programmable logic control/PLC)	10 years

ABOUT ENTERPRISE SINGAPORE

Enterprise Singapore grows stronger enterprises by transforming industries, building new capabilities, and providing Singapore companies access to global opportunities.

We also establish Singapore as a leading global trading hub, and strengthen quality and trust in Singapore's enterprises, products and services.

Through this, we aim to create good jobs for our people and sustainable growth for our economy.

For more information, please visit ESG Website: http://www.enterprisesg.gov.sg.

ABOUT THE SINGAPORE STANDARDISATION PROGRAMME

Enterprise Singapore is the national standards body in Singapore and we administer the Singapore Standardisation Programme. We are vested with the authority to appoint an industry-led Singapore Standards Council to approve the establishment, review and withdrawal of Singapore Standards (SSs) and Technical References (TRs). The Standards Council also advises Enterprise Singapore on the policies, strategies, initiatives and procedures for standards development and promotion.

Enterprise Singapore and the Standards Council collaborate with key stakeholders from industry and government agencies to identify and develop new standards as well as review existing standards to enhance the competitiveness of enterprises and support social, safety, health and environment initiatives in Singapore.

SSs and TRs are in the form of specifications for materials, products, services and systems, codes of practice, requirements for interoperability, methods of test, management systems, guidelines, nomenclatures, etc.

TRs are pre-SSs developed to address urgent industry demand and are issued for industry trials for a period of time. Comments received during this trial period are considered when a TR is reviewed. TRs can become SS after the trial period, continue as TRs for further industry trials or be withdrawn.

To ensure adequate viewpoints are considered in the development and review of SSs and TRs, committees and working groups set up by the Standards Council consist of representatives from various key stakeholders which include industry associations, professional bodies, academia, government agencies and companies. SSs are also put up for public comment before publication.

In the international and regional fora, Enterprise Singapore represents Singapore in the International Organization for Standardization (ISO), the Asia-Pacific Economic Co-operation (APEC) Sub-committee for Standards and Conformance (SCSC), the Pacific Area Standards Congress (PASC) and in the ASEAN Consultative Committee on Standards and Quality (ACCSQ). The Singapore National Committee of the International Electrotechnical Commission (IEC), which is supported by Enterprise Singapore, represents Singapore in the IEC.

The Singapore Standardisation Programme
is managed by Enterprise Singapore

www.enterprisesg.gov.sg