

AS 4323.1:2021



STANDARDS
Australia



Stationary source emissions

Method 1: Selection of sampling positions and measurement of velocity in stacks



AS 4323.1:2021

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- Clean Air Society of Australia and New Zealand
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Stationary source emissions

Method 1: Selection of sampling positions and measurement of velocity in stacks

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Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EV-007, Methods for Examination of Air, to supersede AS 4323.1:1995, *Stationary source emissions, Method 1: Selection of sampling positions*.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this document as an Australian Standard rather than an Australian/New Zealand Standard.

Standards Australia wishes to acknowledge the contribution of the EV-007-01 Stationary Source Emission Testing Subcommittee to the development of this document.

The objective of this document is to provide regulatory and testing bodies with procedures for selecting sampling positions for stacks (including exhaust ducts and other similar outlets) in order to obtain representative velocity, temperature, flowrate, pollutant concentration and mass rate of emission measurements. This document also describes the apparatus, procedures and calculations required to measure gas velocity and flowrate.

A list of all parts in the AS(AS/NZS) 4323 series can be found in the Standards Australia online catalogue.

The major changes in this edition are as follows:

- (a) Clarification of aspects associated with sampling plane section.
- (b) Addition of the procedures to be followed when measuring exhaust gas velocity and flowrate.

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The terms “normative” and “informative” are used in Standards to define the application of the appendix to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

NOTES

Australian Standard®

Stationary source emissions

Method 1: Selection of sampling positions and measurement of velocity in stacks

1 Scope

This document specifies a method for the selection of sampling positions for obtaining representative samples of pollutants emitted from stacks (including exhaust ducts and other similar outlets), together with a description of the apparatus, procedures and calculations used to measure gas velocity and flowrate.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE Documents for informative purposes are listed in the Bibliography.

AS 1657, *Fixed platforms, walkways, stairways and ladders — Design, construction and installation*

AS ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

AS/NZS 1891.2, *Industrial fall-arrest systems and devices, Part 2: Horizontal lifeline and rail systems*

AS/NZS 1891.4, *Industrial fall-arrest systems and devices, Part 4: Selection, use and maintenance*

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes*

USEPA Method 2F, *Determination of stack gas velocity and volumetric flow rate with three-dimensional probes*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

access hole

hole in the stack at the extremity of a sampling traverse, through which test equipment is inserted

3.2

competent person

person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the task required

3.3

diameter

D

internal diameter of a circular stack or the hydraulic diameter of a non-circular stack

Note 1 to entry: The hydraulic diameter is four times the stack internal area divided by the internal perimeter.

3.4

differential pressure

difference between the pressures measured at the total and static pressure tapings of a pitot tube

3.5**may**

indicates the existence of an option

3.6**pitch angle**

angle of the gas flow component in the plane that includes the traverse line, parallel to the stack axis

3.7**pitot tube**

device to measure differential pressure to enable calculation of flow velocity at a point

3.8**rise time**

time interval, after a step increase in input concentration, between instrument zero response and 90 % of final instrument response

3.9**sampling plane**

plane normal to the axis of the stack at which sampling takes place

3.10**sampling point**

one of a number of specific locations on a sampling traverse at which sampling takes place

3.11**sampling traverse**

imaginary line in the sampling plane along which the sampling points are located

3.12**shall**

indicates that a statement is mandatory

3.13**should**

indicates a recommendation

3.14**stack**

structure through which the gas stream passes, including process stream and exhaust ducts

3.15**static pressure**

pressure at a specific point in a fluid that has no element due to velocity of the fluid

3.16**three dimensional probe**

directional probe used to determine the velocity pressure, and yaw and pitch angles in a flowing gas stream

3.17 **U_{95}**

estimate of the expanded measurement uncertainty at a confidence interval of 95 %

Note 1 to entry: Refer to ISO/IEC Guide 98-3 for guidance on the measurement of uncertainty.

3.18**yaw angle**

angle of the gas flow component in the plane perpendicular to the traverse line at the traverse point, measured from the line passing through the traverse point, parallel to the stack axis

4 Sampling plane selection

4.1 Location

The sampling plane shall be located in a straight, preferably vertical section of stack, away from any flow obstructions which may cause a disturbance or other instability to the gas flow, e.g. a bend, fan, partially closed damper, silencers, flow straighteners and the stack exit. The junction of two ducts, whether gases are flowing through both or not, shall also be treated as a flow disturbance.

The sampling plane shall be located at right angles to the axis of the stack, see [Figures 1](#) and [2](#).

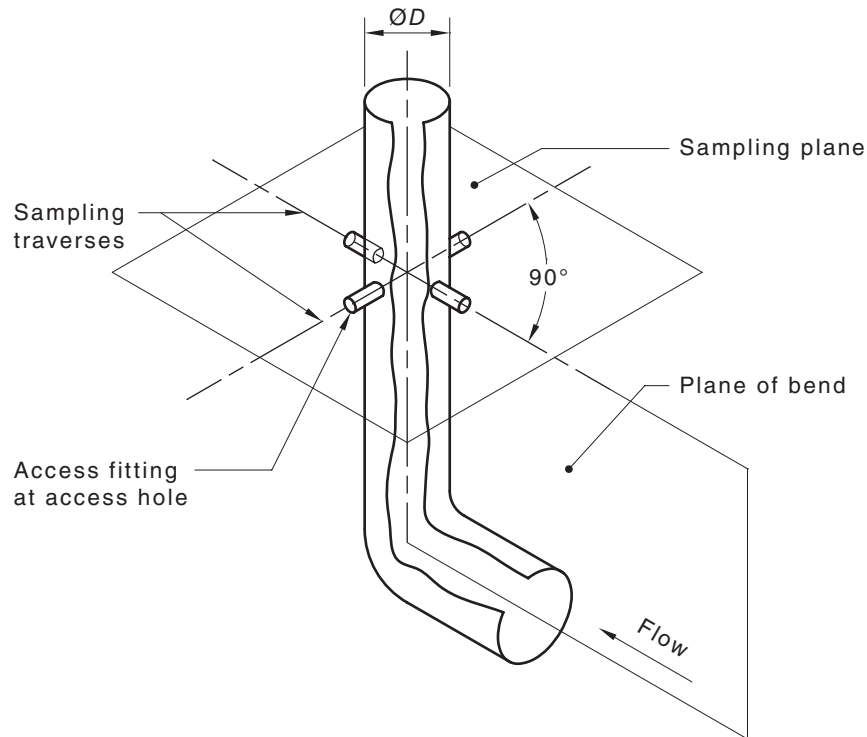


Figure 1 — Illustration of definitions in relation to a circular stack (sectioned through and at right angles to the sampling plane)

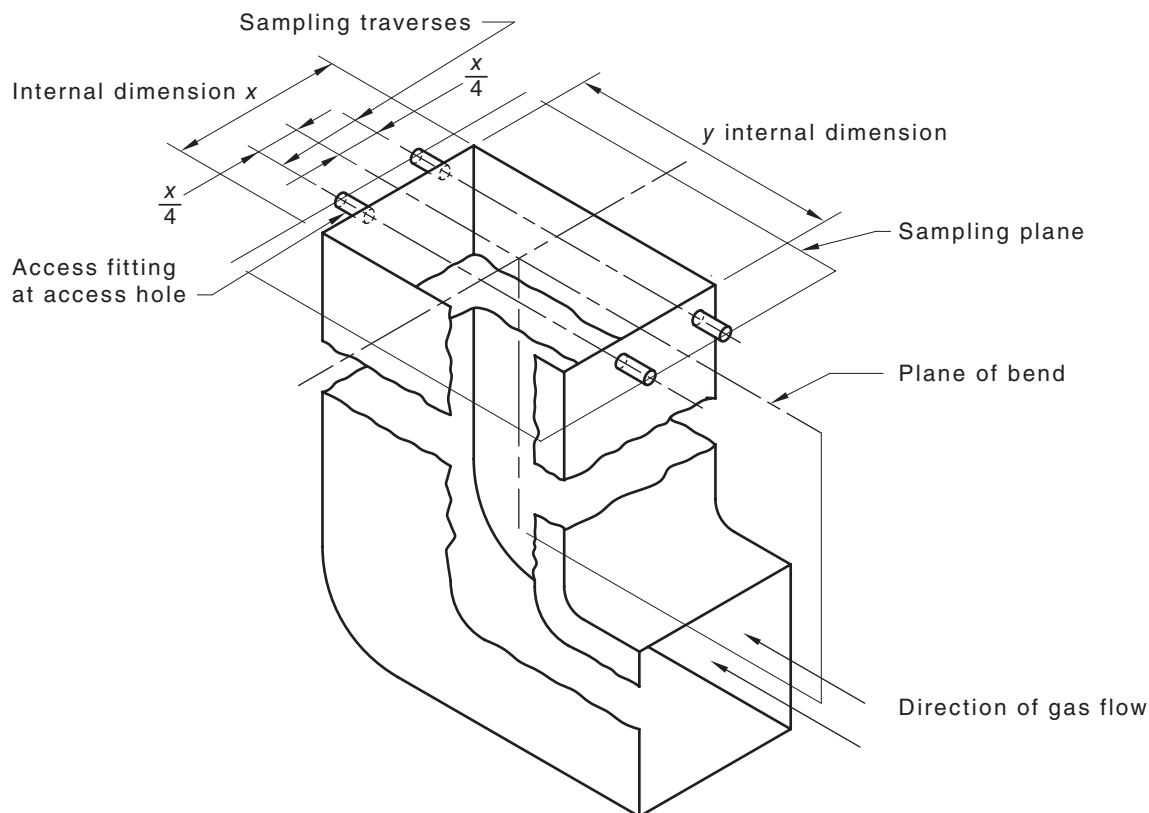


Figure 2 — Illustration of definitions in relation to a rectangular stack (sectioned through and at right angles to the sampling plane)

4.2 Ideal, non-ideal and non-conforming sampling planes

4.2.1 General

The three types of sampling planes are as follows:

- (a) *Ideal sampling plane* — A sampling plane that conforms to the criteria in [Table 1](#) and [Clause 4.2.2](#).
- (b) *Non-ideal sampling plane* — A sampling plane that:
 - (i) does not conform with [Table 1](#) separation distances but is located greater than or equal to one duct diameter upstream of a flow disturbance and greater than or equal to two duct diameters downstream of a flow disturbance. The requirements of [Clause 4.2.3](#) apply;
 - (ii) conforms with [Table 1](#) separation distances but not with the criteria contained in [Clause 4.2.2\(a\) to \(d\)](#). The number of sampling points shall be based on the maximum sampling point factor specified by [Clause 4.2.3](#).
- (c) *Non-conforming sampling plane* — A sampling plane that:
 - (i) does not conform with the criterion contained in [Clause 4.2.2\(e\)](#); or
 - (ii) is located less than one duct diameter upstream of a flow disturbance or less than two duct diameters downstream of a flow disturbance;
 - (iii) in Items (c)(i) and (ii), the requirements of [Clause 4.2.4](#) apply.

Non-ideal and non-conforming sampling planes should only be used where ideal sampling planes cannot be found.

The steps required to classify a sampling plane as either ideal, non-ideal or non-conforming are summarized in [Figure 3](#) as a decision tree.

NOTE 1 Exhaust gases emitted from a cyclone should be treated in accordance with [Appendix A](#) to achieve a suitable sampling position.

NOTE 2 Sampling planes for particle testing in horizontal ducts should not be more than 10 diameters downstream from a bend, a change in cross-section or damper or similar flow disturbance to reduce the effect of sedimentation.

4.2.2 Ideal sampling plane

An ideal sampling plane shall conform to [Table 1](#) and the requirements of this clause.

Table 1 — Criteria for selection of sampling planes

Type of flow disturbance	Minimum distance upstream from disturbance, diameters (D)	Minimum distance downstream from disturbance, diameters (D)
Bend, connection, junction, direction change, stack silencer, flow straightener, stack exit	> 2	> 6
Louvre, butterfly damper (partially closed or closed)	> 3	> 6
Axial fan	> 3	> 8 ^a
Centrifugal fan	> 3	> 6
^a The plane should be selected as far as practicable from an axial fan. Flow straighteners may still be required to ensure that the selected position meets the criteria listed in Items (a) to (e) below.		

A temperature and velocity survey (see [Clause 8](#)) shall be undertaken at sampling points located in accordance with [Table 3](#) (circular sampling plane) or [Table 4](#) (rectangular sampling plane) to inform the sampling plane classification.

An ideal sampling plane shall meet criteria contained in Items (a) to (e) as follows:

- (a) The gas flow shall be in the same direction at all points along each sampling traverse.
- (b) The gas flow profile at the sampling plane shall be steady, evenly distributed and not have a cyclonic or swirl component which exceeds an angle of 15° to the duct axis, when measured near the periphery of a circular sampling plane, see [Clause 8.4\(h\)](#).
- (c) The temperature difference between adjacent points of the survey along each sampling traverse shall be less than 10 % of the absolute temperature in kelvin, with the temperature at any point differing by less than 10 % from the mean.
- (d) The ratio of the highest to lowest pitot tube differential pressure across the sampling plane shall not exceed 9:1. The ratio of highest to lowest gas velocities shall also not exceed 3:1. For isokinetic testing with the use of impingers, the gas velocity ratio across the sampling plane should not exceed 1.6:1.
- (e) The differential pressure at all sampling points shall be greater than or equal to 5 Pa. Sampling planes with differential pressures less than 5 Pa do not conform with this document, see [Clause 4.2.4](#).

In addition, the gas temperature at the sampling plane should be above the dewpoint.

4.2.3 Non-ideal sampling plane

For a non-ideal sampling plane, the sampling point factors listed in [Table 2](#) shall apply. The product of both the upstream and downstream factors, multiplied by the total number of sampling points from [Table 3](#) or [Table 4](#), shall be raised to the next even number of sampling points for each sampling traverse, see example in [Clause B.1](#).

Table 2 — Sampling point factors

Non-ideal situation	Sampling point factors
Sampling plane downstream from disturbance:	
Number of diameters less than Table 1 :	
0	1.00
1	1.05
2	1.10
3	1.15
4 or more	1.20
Sampling plane upstream from disturbance:	
Number of diameters less than Table 1 :	
0	1.00
0.5	1.05
1.0	1.10
1.5 or more	1.15

Non-ideal sampling planes should not be used to replace those that conform with the criteria contained in [Clause 4.2.2](#).

4.2.4 Non-conforming sampling plane

Sampling planes that do not conform with the requirements for ideal or non-ideal sampling planes shall be classified as “non-conforming”. Where conformance with the alternative procedure specified in [Appendix C](#) can be demonstrated, the sampling plane shall be classified as “non-ideal”.

Non-conforming sampling planes should not be used to replace those that conform with the criteria contained in either [Clause 4.2.2](#) or [Clause 4.2.3](#).

Where testing at non-conforming sampling planes is unavoidable, all efforts shall be made to collect a representative sample.

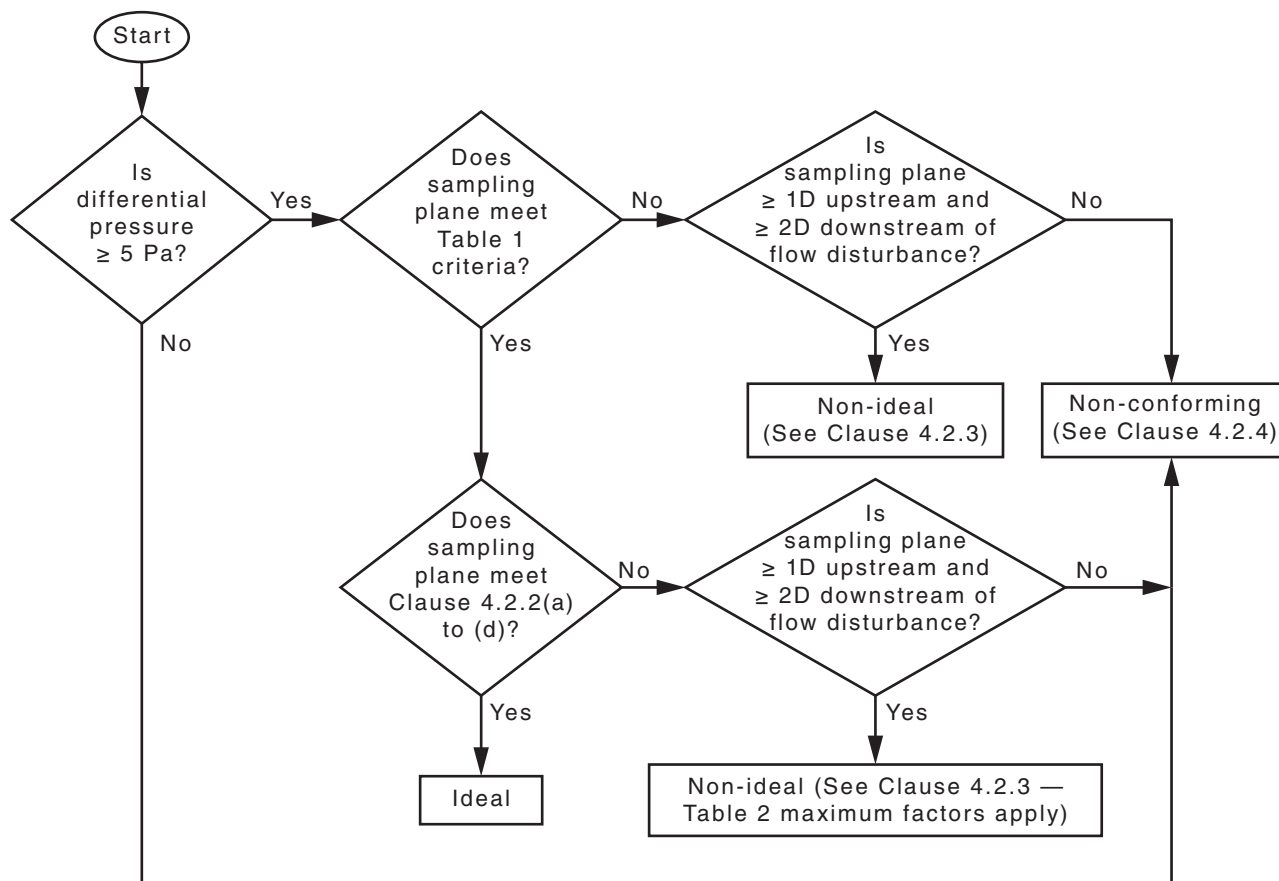


Figure 3 — Sampling plane classification decision tree

5 Number and location of sampling points

5.1 General

The number and location of sampling points is governed by the stack dimensions. In principle, the number of sampling points increases with increasing sampling plane area.

For particulate matter emission testing and velocity measurement the location of each sampling point is at the centre of an equal area in the sampling plane, see [Figures 4](#) and [5](#).

Gaseous pollutant emission sampling shall be in accordance with [Appendix D](#).

5.2 Number of sampling points

The minimum number of sampling points for circular sampling planes shall be as specified in [Table 3](#).

Table 3 — Minimum number of sampling points for circular sampling planes

Sampling plane diameter m	Minimum number of sampling traverses	Recommended number of access holes	Minimum number of sampling points per radius	Minimum total number of sampling points
≤ 0.20 ^a	1	1	Stack centre point	1
> 0.20 ≤ 0.35	2	2	1	4
> 0.35 ≤ 0.70	2	2	2	8
> 0.70 ≤ 1.50	2	2	3	12
> 1.50 ≤ 2.50	2	4	4	16
> 2.50 ≤ 4.00	2	4	6	24
> 4.00 ≤ 6.00	3	6	5	30
> 6.00	3	6	6	36

^a In this instance, the measurement uncertainty will exceed that estimated in [Clause 10](#). Stacks with sampling plane diameters less than or equal to 0.20 m should be avoided where possible.

For rectangular stacks, the minimum number of sections into which a particular length of side is divided shall be as specified in [Table 4](#). The number of sampling points shall be obtained by multiplying the number of sections for the two adjacent sides, see example in [Clause B.2](#).

Table 4 — Minimum number of sampling points for rectangular or square stacks

Length of long side (<i>L</i>) or short side of duct (<i>I</i>) m	Minimum number (<i>N</i>) of sampling points required on each sampling traverse parallel to long side (<i>L</i>) and number (<i>n</i>) required on each sampling traverse parallel to short side (<i>I</i>)
≤ 0.20 ^a	Stack centre point
> 0.20 ≤ 0.90	2
> 0.90 ≤ 1.70	3
> 1.70 ≤ 2.75	4
> 2.75 ≤ 4.00	5
> 4.00	6

^a In this instance, the measurement uncertainty will exceed that estimated in [Clause 10](#). Stacks with sampling plane diameters less than or equal to 0.20 m should be avoided where possible.

5.3 Location of sampling points

5.3.1 General

Once the number of sampling points has been determined in accordance with [Clause 5.2](#), and [Clause 4.2](#) where applicable, their position shall be determined in accordance with [Clause 5.3.2](#) (circular sampling planes) or [Clause 5.3.3](#) (rectangular sampling planes). However, the nearest sampling point to the duct wall shall not be closer than 30 mm or 3 % of the length of the sampling traverse, whichever is the greater.

5.3.2 Circular sampling planes

Sampling points shall be located in accordance with the tangential rule, which requires the sampling plane to be divided into equal areas with each sampling point located at the centre of each area, on two or more traverses, with no sampling point at the centre of the stack, see example at [Figure 4](#).