National Construction Code

Cross-connection control

Handbook

Australian Building Codes Board

The Australian Building Codes Board

The Australian Building Codes Board (ABCB) is a standards writing body responsible for the National Construction Code (NCC), WaterMark and CodeMark Certification Schemes.

The ABCB is a joint initiative of all levels of government in Australia, together with the building and plumbing industry. Its mission is to oversee issues relating to health, safety, amenity, accessibility and sustainability in building.

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Preface

This handbook is one of a series by the ABCB. Handbooks expand on areas of existing regulation or relate to topics that are not regulated by the NCC. They provide advice and guidance.

The Cross-connection control handbook assists in understanding cross-connection control and the requirements of NCC Volume Three, the Plumbing Code of Australia (PCA).

It addresses issues in generic terms and is not a document that sets out specific compliance advice for developing solutions. It is expected that this handbook guides readers to develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

Acknowledgements

The ABCB acknowledges the valuable contribution of the United States Environmental Protection Agency (US-EPA), who kindly granted the ABCB permission to reproduce and adapt content from the US-EPA Cross-Connection Control Manual.

Contents

Reminder

This handbook is not mandatory or regulatory in nature. Compliance with it will not necessarily discharge a user's legal obligations. The handbook should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The handbook also needs to be read in conjunction with the NCC and the relevant legislation of the appropriate state or territory. It is written in generic terms and it is not intended that the content of the handbook counteract or conflict with the legislative requirements, any references in legal documents, any handbooks issued by the administration or any directives by the appropriate authority.

1 Background

The NCC is a performance-based code containing all Performance Requirements for the construction of buildings. To comply with the NCC, a solution must achieve compliance with the Governing Requirements and the Performance Requirements. The Governing Requirements contain requirements about how the Performance Requirements must be met. A building, plumbing or drainage solution will comply with the NCC if it satisfies the Performance Requirements, which are the mandatory requirements of the NCC.

This document provides guidance to practitioners seeking to demonstrate compliance with the Performance Requirement for cross-connection control in NCC Volume Three, the PCA.

1.1 Scope

This handbook firstly provides an overall introduction to the concept of cross-connection and backflow prevention followed by guidance on how to comply with the cross-connection control requirements of the NCC.

1.2 Design and approval of Performance Solutions

The design and approval processes for cross-connection control Performance Solutions is similar to that adopted for demonstrating compliance of other NCC Performance Solutions. Since the design approval process for Performance Solutions varies between the responsible state and territory governments, it is likely to also be the case with designs incorporating cross-connection control and requirements should be checked for the relevant jurisdiction.

Notwithstanding the quantified input and acceptance criteria, other qualitative aspects of cross-connection control, discussed in this handbook, require assessment and analysis throughout the design and approval process. The advice of an appropriately qualified person should be sought to undertake this assessment and analysis where required. This may be aided by the early and significant involvement from regulatory authorities, peer reviewer(s) and/or a technical panel as appropriate to the relevant jurisdiction.

1.3 Using this document

Abbreviations used in this handbook are in Appendix A.

General information about complying with the NCC and responsibilities for building and plumbing regulation is in Appendix B.

Information about fundamental hydraulic concepts is in Appendix C.

Different styles are used in this document. Examples of these styles are provided below:

NCC extracts[1]

Examples

Alerts or Reminders

[1] NCC extracts italicise defined terms as per the NCC. See Schedule 1 of the NCC for further information.

2 Cross-connections and backflow prevention

2.1 Overview

This chapter defines cross-connections, backflow prevention and explains the role of Hazard Ratings.

2.2 Cross-connections

Cross-connections are defined in the NCC and AS/NZS 3500.0 Plumbing and drainage, Part 0: Glossary of terms (2021) as any actual or potential connection between a drinking water supply and any contaminant.

A contaminant is defined by the NCC as any substance (including gases, liquids, solids or micro-organisms), energy (excluding noise) or heat, that either by itself or in combination with the same, similar or other substances, energy or heat, changes or is likely to change the physical, chemical or biological condition of water.

This includes any fixture, storage tank, receptacle, equipment, or device through which it may be possible for any non-drinking water, used, unclean, polluted or contaminated water, or any other substance, to enter any part of such drinking water system under any conditions.

In essence, cross-connections are the links through which it is possible for contaminants to enter a water supply. The contaminant enters the water supply when the pressure at the source of contamination exceeds the pressure of the water supply. This action may be called backsiphonage or backpressure. AS/NZS 3500.0 (2021) defines back-siphonage as the reversal of flow of water caused by negative pressure in the distributing pipes of a water service or supply and backpressure as the difference between the pressure within any water service and a higher pressure within any vessel or pipework to which it is connected. Essentially, it is a reversal of the flow direction. A cross-connection may be any actual or potential connection between 2 separate water supplies.

Cross-connections can exist not only between water supplies from different sources, e.g. drinking water and non-drinking water (such as recycled water), but also between a water supply and any source of contamination to which it may be connected. These sources can include used or unclean water, solids, gases, or any other substance that would be considered a contaminant should it enter a water supply.

There are 2 basic types of cross-connection. The first is a direct cross-connection where contamination may be induced by way of either backpressure or backsiphonage. The second is an indirect cross-connection, which will only enable backflow to occur when induced by backsiphonage. Cross-connections can be controlled, i.e. rendered safe, by the installation of backflow prevention devices. Backpressure and backsiphonage are explained in more detail in Appendix C.

2.3 Backflow prevention

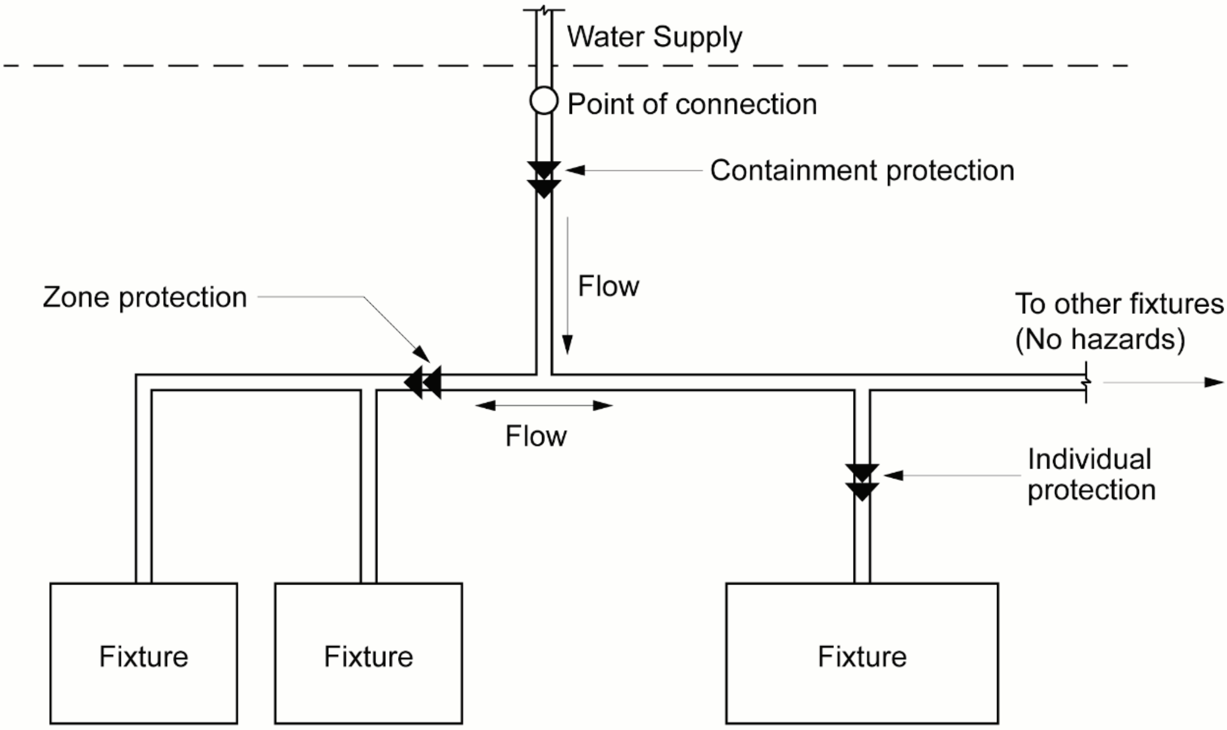
A backflow prevention device is a device installed to prevent the reversal of flow of water from a potentially polluted source into the drinking water. A backflow prevention device is defined in the NCC as an air gap, break tank or mechanical device that is designed to prevent the unplanned reverse flow of water or contaminants into the water service or Network Utility Operator’s (NUO) water supply.

There are 3 levels of backflow prevention.

- **Individual protection**: the installation of a backflow prevention device at the point where a water service connects to a single fixture or appliance.
- **Zone protection**: the installation of backflow prevention device at the point where a water service is connected to multiple fixtures or appliances, with no backflow prevention device installed as individual protection downstream of this point.
- **Containment protection**: the installation of a backflow prevention device at the point of connection of a NUOs water supply to a site. Water downstream of a containment device is considered drinking water unless there are unprotected hazards within the premises. The use of individual protection and/or zone protection against these hazards is necessary to prevent contamination of the drinking water supply within the property.

Figure 2.1 shows the different roles of individual, zone and containment protection.

Figure 2.1 Individual, zone and containment protection



2.4 Roles and responsibilities

Containment protection is usually regulated by NUOs, while zone and individual protection generally falls within the role of state and territory plumbing regulatory authorities.

Alert

The information in this section is intended as general information only that reflects a common arrangement of roles and responsibilities for cross-connection control. Advice on specific arrangements in a jurisdiction should be sought from the authority having jurisdiction.

2.5 Hazard Ratings

A 'Hazard Rating' is a level of potential toxicity that may cause contamination in a drinking water system, having a rating of Low Hazard, Medium Hazard, or High Hazard, determined in accordance with the PCA. The Hazard Rating describes the potential health consequences of water contamination occurring via a cross-connection. In the PCA, cross-connections are rated according to these 3 levels of hazard, which consider the toxicity of the potential contaminant and the consequences of it entering a water supply.

The 3 levels of Hazard Rating are as follows:

- **High Hazard**: any condition, device or practice which, in connection with a water supply, has the potential to cause death.
- **Medium Hazard**: any condition, device or practice which, in connection with a water supply has the potential to injure or endanger health.
- **Low Hazard**: any condition, device or practice which in connection with the water supply, would constitute a nuisance by colour, odour or taste but does not have the potential to injure or endanger health.

These terms are defined in the NCC.

Hazard Ratings are used to determine the selection of suitable backflow prevention for each cross-connection and, in some states and territories, as a trigger for certain devices to be included in registration and on-going testing and maintenance programs.

The Hazard Rating process is applied on 2 levels. First to address specific or potential hazards that may exist on the premises (zone and individual protection), and second to address the overall hazard posed by the premises to the water supply to which it is connected (containment protection).

In the PCA, Hazard Ratings are used in Verification Method B5V1 (Chapter 4) and the Deemed-to-Satisfy (DTS) Provisions of Part B5 (Chapter 5).

Backflow prevention devices are certified in accordance with AS/NZS 2845 Water supply - Backflow prevention devices, Part 1: Materials, design and performance requirements (2022).

The WaterMark Schedule of Products (WMSP) contains a comprehensive list of products which, through a risk assessment, have been predetermined as requiring WaterMark certification[2]. Likewise, the WaterMark Schedule of Excluded Products (WMEP) lists products that have been predetermined as not requiring WaterMark certification. The

[2] The WaterMark Certification Scheme (Scheme) is a mandatory certification scheme for plumbing and drainage products to ensure they are fit for purpose and appropriately authorised for use in plumbing and drainage installations.

WaterMark Administration[3] updates the WMSP and WMEP as new products undergo risk assessment and as product specifications are approved for use or suspended.

Alert

For more information on the WaterMark Certification Scheme and to view the WMSP, WMEP and WMPD (Watermark Product Database), visit the ABCB website.

AS/NZS 3500 Plumbing and drainage, Part 1: Water services (2021) sets out the level of Hazard Rating for which specific devices are suitable.

[3] The ABCB manages and administers the Scheme as a national scheme. The NCC, Volume Three requires certain plumbing and drainage products to be certified (listed on the Product Database) and authorised for use in a plumbing or drainage installation. These materials and products are certified and authorised for use.

3 Performance Requirement for cross-connection control

3.1 Overview

This chapter explains the mandatory NCC Performance Requirement for cross-connection control that must be met for any plumbing system.

3.2 Performance Requirement B5P1

The NCC Performance Requirements prescribe the minimum necessary technical requirements for buildings, building elements, and plumbing and drainage systems. They must be met to demonstrate compliance with the NCC.

The relevant Performance Requirement for cross-connection control is B5P1 Contamination control and is reproduced below.

B5P1 Contamination control

Water services must be designed, constructed and installed to avoid contamination.

Applications

B5P1 applies to cold water, *heated water*, *non-drinking water* and fire-fighting water services.

The intent of B5P1 is for water services to be designed and installed to operate in a way that:

- avoids the likelihood of contamination of any part of the drinking water supply; and
- minimises any adverse impact on building occupants, the NUOs infrastructure, property and the environment.

3.3 NCC compliance pathways

Compliance with the NCC is achieved by complying with the NCC Governing Requirements and relevant Performance Requirements. There are 3 options available to demonstrate compliance with the Performance Requirements:

- a Performance Solution
- a DTS Solution, or
- a combination of a Performance Solution and a DTS Solution.

Within the Performance Solution pathway, some options available are:

(1) Direct application of the Performance Requirements, and

(2) Verification Methods.

NCC 2022 contains a new Verification Method B5V1 Determination of individual and zone hazard ratings. This Verification Method can be used to the meet the Performance Requirement B5P1. This compliance option is discussed in the next chapter.

Alert

Other Performance Requirements may need to be considered to comply with NCC Volume Three A2G2(3) and A2G4(3) for a particular plumbing Performance Solution. It is necessary to understand the inter-relationships between other requirements and Performance Requirement B5P1 to ensure no design conflict arises for a particular plumbing Performance Solution.

Alternatively, a DTS Solution using the relevant DTS Provisions can be used. Minor updates to the DTS Provisions occurred in NCC 2022 to:

- align with the new Verification Method B5V1
- expand the backflow requirements for many installations when considering individual, zone or containment backflow prevention requirements.

The DTS Provisions are discussed in Chapter 5.

3.4 Isolation and access for maintenance

In addition to Part B5, the PCA contains several Performance Requirements that are relevant once a Performance Solution for cross-connection control is chosen.

These Performance Requirements are intended to ensure access for maintenance of mechanical devices (such as backflow prevention devices), and the ability to isolate these devices from the water supply, should they need to be removed, repaired or replaced.

To provide flexibility for designers and installers, the exact specification for the required access and means of isolation are not prescribed in the Performance Requirements.

4 Verification Method B5V1

4.1 Overview

B5V1 Determination of individual and zone hazard ratings is an optional Verification Method to meet Performance Requirement B5P1.

The intent of this Verification Method is to provide a consistent means of determining Hazard Ratings for situations not covered by the DTS Provisions, however it is not intended to alter any Hazard Ratings already prescribed in the DTS Provisions.

4.2 Methodology

In simple terms, Verification Method B5V1 requires the following steps.

(1) Identifying all hazards (B5V1(2)).

(2) Calculating a Hazard Rating for each identified hazard (B5V1(3)(a), B5V1(4) and B5V1(5)).

(3) Isolating the hazard, using an appropriate backflow prevention device, if the Hazard Rating warrants it (B5V1(3)(b)).

To identify the hazards, B5V1(2) states that a hazard exists wherever it is possible for water or contaminants to enter a non-drinking water service/supply via any potential cross-connection between itself and another separate non-drinking water service on the same site.

To calculate the Hazard Rating for a specific hazard, an assessment of the property or proposed installation must be done using the tables provided, i.e. Tables B5V1a to B5V1e. Each table corresponds to a risk factor posed by a hazard, which is outlined in Table 4.1.

Table 4.1 NCC Volume Three B5V1 table references and risk factors

Table reference	Risk factor
B5V1a	Building class
B5V1b	On-site water services
B5V1c	Drinking water use
B5V1d	Cross-connection type

Table reference	Risk factor
B5V1e	Extent of contamination

A score is provided from each table depending on the circumstances of an individual hazard. The Hazard Rating for an individual hazard is then calculated by adding the relevant score from each table to get a total score.

The total score of an individual hazard corresponds to the following Hazard Ratings:

- 0 to 3 presents no hazard
- 4 to 7 presents a Low Hazard
- 8 to 10 presents a Medium Hazard
- 11 or greater presents a High Hazard.

Once a Hazard Rating is assigned, an appropriate backflow prevention device can be selected as per AS/NZS 3500.1 (2021).

Using this approach for all hazards ensures individual protection and zone protection is accurately verified and compliance with Performance Requirement B5P1 is achieved.

There is one exception in Verification Method B5V1 to account for situations where access to the site is restricted in a way that could limit or prevent future inspection, testing or maintenance of a backflow prevention device. To reduce future potential contamination risks, B5V1(6) requires the site must be protected with a containment device suitable for a High Hazard.

Alert

In some states and territories, containment requirements may be altered or replaced by specific regulations enforced by or on behalf of the NUO, under the relevant water supply legislation. Although such regulations are generally consistent with the requirements of the PCA, they may overrule the PCA in the event of an inconsistency.

4.3 Examples

4.3.1 Example 1 – Apartment block

Example 1 Applying B5V1 to an apartment block

The proposed building is 20 storeys with mixed use retail on the lower levels and an underground carpark with a car valet operation. To apply the Verification Method B5V1 in this scenario, the following steps are used.

Step 1: Identification of hazards

To identify the hazards, an assessment of the property or proposed installation using Tables B5V1a to B5V1e is required.

Building class

The property to which the water service is installed contains a Class 2, 6 and 7a building where chemical products are not stored. The proposed building is likely to have greater than 12 residents or occupants and may contain moderate amounts of cleaning or commercial chemicals. As this is a mixed class building, the highest score from the table is taken. Based on Table B5V1a, this is a score of 2 (i.e. Class 6 building as this is higher than for a Class 2 or 7a building).

On-site water services

There is one drinking water supply and potentially other non-drinking water supplies or a separate fire-fighting water service available to the property (not applicable if the non-drinking water supply is NUO provided recycled water with a sewerage source). A NUO supplied recycled water with a sewerage source is assessed separately due to greater health risks. Based on Table B5V1b, a score of 3 is determined

Drinking water supply

Drinking water will be used with commercial use hazardous substances, but not a Schedule 1 to 4 or Schedule 6 to 8 poison. Drinking water may be used with commercial use hazardous substances without major modification.

Drinking water is connected to the residential units, the retail units and the car wash. The car wash uses chemicals for mud breaking and for waxing. Based on Table B5V1c, a score of 2 is determined.

Cross-connection

The product or installation presents a potential for a cross-connection between a drinking water service and a non-drinking water service. This could potentially have

Example 1 Applying B5V1 to an apartment block

unprotected connections based on numerous water sources. Based on Table B5V1d, a score of 2 is determined.

Extent of contamination

The product or installation presents a cross-connection that will affect a large property or could allow contaminants to enter other properties. Cross-connection will affect drinking water to 100 people or greater.

Consideration is needed as to whether water meters may not have suitable backflow protection or may not be adequate to mitigate the risk. Based on Table B5V1e a score of 3 is determined.

Step 2: Calculation of a Hazard Rating

Once hazards are identified using step 1, the total score is calculated based on the values taken from Tables B5V1a to B5V1e. Adding up these values gives us a total score of 12 (i.e. 2+3+2+2+3).

According to clause B5V1(5) a total score of 11 or greater presents a High Hazard.

Step 3: Determining the appropriate backflow prevention device

The assessment in step 2 provided us with a High Hazard. A High Hazard has the potential to cause death, so an appropriate backflow prevention device according to AS/NZS 3500.1 (2021) should be installed.

If access to the site is restricted in a way that could limit or prevent future testing or maintenance of a backflow prevention device, B5V1(6) requires the site to be protected with a containment device suitable for a High Hazard.

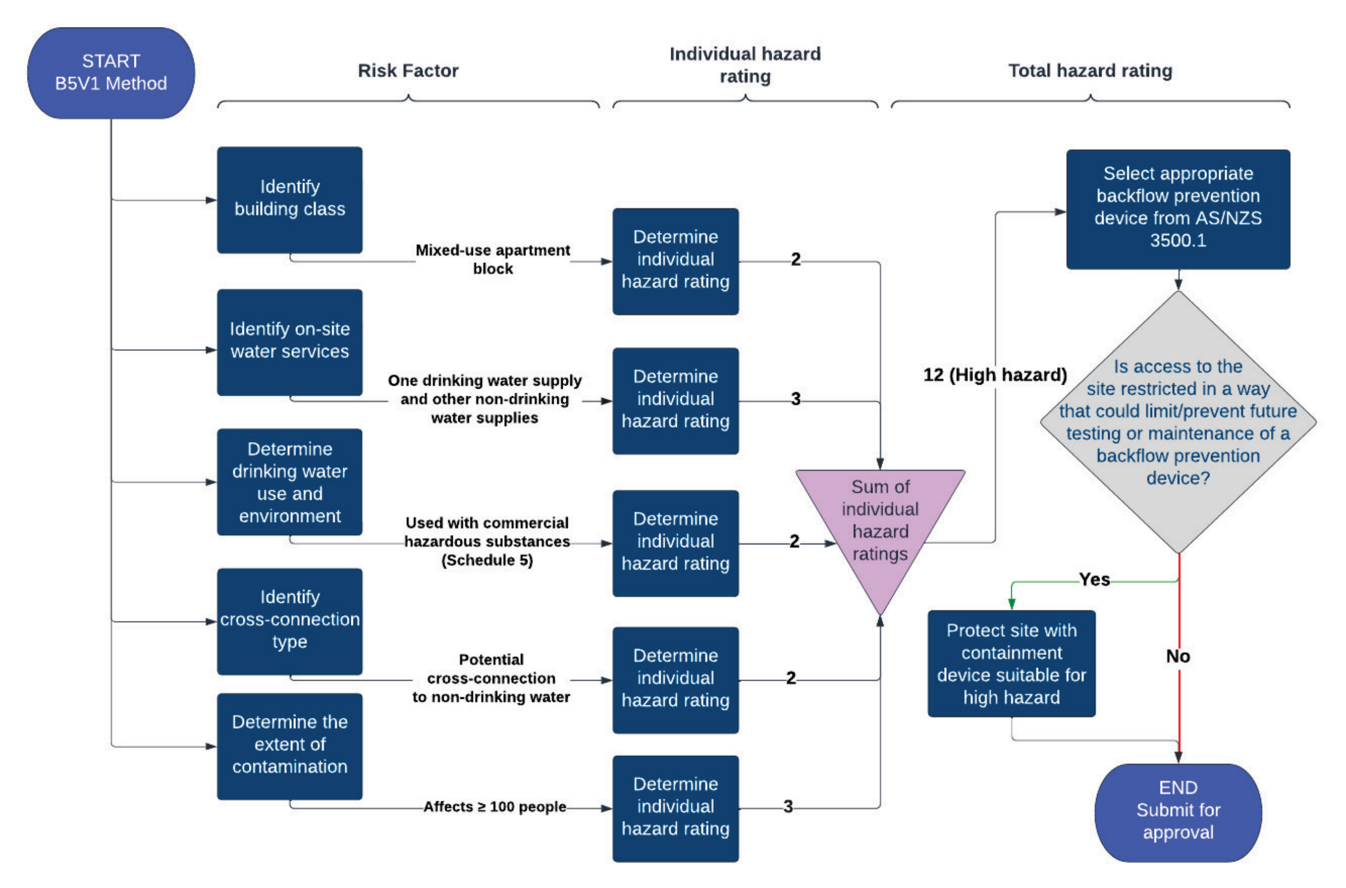
Outcome

Verification Method B5V1 has been used to determine an appropriate backflow prevention device for this proposed installation, and in doing so, has demonstrated compliance with the relevant Performance Requirement B5P1.

Figure 4.2 shows the process used in B5V1 for this example.

Example 1 Applying B5V1 to an apartment block

Figure 4.1 B5V1 Verification Method flowchart for Example 1



4.3.2 Example 2 – Steam powered plumbing appliance

Example 2 Applying B5V1 to a steam powered plumbing appliance

Introduction

A Performance Solution to satisfy the Performance Requirement B5P1, assessed using the Verification Method B5V1 is proposed for an innovative plumbing appliance.

The proposed plumbing installation is an appliance which uses water to generate steam to drive the appliance and pluck chicken feathers. The product has WaterMark Certification and is intended for use in an organic butchery within a shopping centre marketplace. To apply the Verification Method B5V1 in this scenario, the following steps are used.

Step 1: Identification of hazards

To identify the hazards, an assessment of the property or proposed installation using Tables B5V1a to B5V1e is completed.

Building class

The property where the water service is installed contains a Class 6 building where chemical products are not stored. The building is likely to have greater than 12 occupants and may contain moderate amounts of cleaning or commercial chemicals. Based on Table B5V1a, a score of 2 is determined.

On-site water services

There is one drinking water supply and potentially other non-drinking water supplies or a separate fire-fighting water service available to the property. Note that an NUO supplied recycled water with a sewerage source is assessed separately due to greater health risks. Based on Table B5V1b, a score of 3 is determined.

Drinking water

Drinking water use may involve large scale food or beverage processing, human or animal biological or faecal matter, Schedule 1 to 4 and Schedule 6 to 8 poisons and have potential for contamination. The installation is suitable for these uses without major modification. Also included are areas likely to undergo frequent changes or use or where the future use in unknown. The drinking water is connected to the appliance and there is no way to determine if any internal approved backflow prevention is included. Based on Table B5V1c, a score of 3 is determined.

Cross-connection

Example 2 Applying B5V1 to a steam powered plumbing appliance

The product or installation has potential for a cross-connection to a sewerage source, a trade waste source, a vessel with human or animal biological or faecal matter, a vessel pipe or body of liquid containing any quantity of a Schedule 1 to 4 or Schedule 6 to 8 Poison. Based on Table B5V1d, a score of 5 is determined.

Extent of contamination

The product or installation presents a cross-connection that will affect a large property or could allow contaminants to enter other properties. If cross-connection were to occur, it would affect the drinking water to 100 or more people

Consideration is needed as to whether water meters may not have suitable backflow protection or may not be adequate to mitigate the risk.

Based on Table B5V1e, a score of 3 is determined.

Step 2: Calculation of a Hazard Rating

Once hazards have been identified using step 1, the total score is then calculated based on the values taken from Tables B5V1a to B5V1e. Adding up these values gives us a total score of 16 (i.e. 2+3+3+5+3). According to clause B5V1(5) a total score of 11 or greater presents a High Hazard Rating.

Step 3: Determining the appropriate backflow prevention device

The assessment in step 2 provided us with a High Hazard Rating. A High Hazard Rating has the potential to cause death so an appropriate backflow prevention device according to AS/NZS 3500.1 (2021) should be installed.

If access to the site is restricted in a way that could limit or prevent future testing or maintenance of a backflow prevention device, B5V1(6) requires the site to be protected with a containment device suitable for a high hazard.

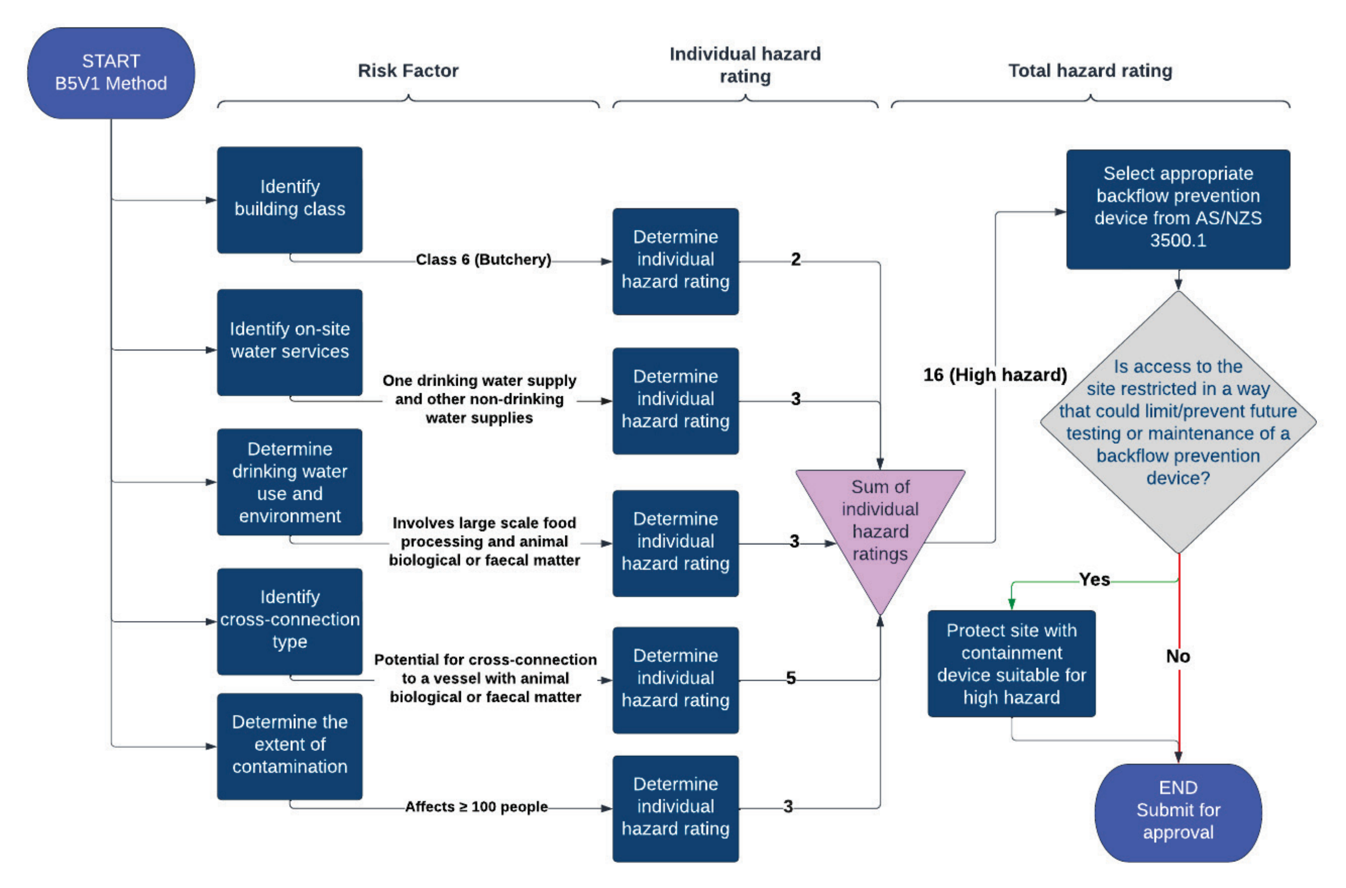
Outcome

Verification Method B5V1 has been used to determine an appropriate backflow prevention device for this proposed installation, and in doing so, has demonstrated compliance with the relevant Performance Requirement B5P1.

Figure 4.3 shows the process used in B5V1 for this example.

Example 2 Applying B5V1 to a steam powered plumbing appliance

Figure 4.2 B5V1 Verification Method flowchart for Example 2



5 DTS Provisions

5.1 Overview

This chapter explains the relevant DTS Provisions B5D2 to B5D6, including Specification 41 Cross-connection hazards. Specification 41 contains backflow prevention requirements for many types of installations.

5.2 DTS Provisions for cross-connection control

A DTS Solution for cross-connection control is achieved by meeting the DTS Provisions B5D2 to B5D6 in NCC Volume Three. The DTS Provisions are prescriptive (i.e. like a recipe book which tells you all the appropriate information such as how, what and where). They include materials, components, design factors, and construction methods that, if used, are deemed to meet the Performance Requirements, hence the term “Deemed-to-Satisfy”.

The use of DTS Solutions as a compliance option is explained in clauses A2G2 to A2G4 of the NCC.

Compliance with DTS Provisions B5D2 to B5D6 forms a DTS Solution and is deemed to meet the Performance Requirement B5P1.

The DTS Provisions are either within the PCA itself or include reference to other documents such AS/NZS 3500.1 (2021). B5D6 references AS/NZS 3500.1 (2018) for rainwater backflow requirements. All referenced documents are listed in Schedule 2 of the NCC.

Reminder

Further information about complying with the NCC is provided in Appendix B.

5.3 Methodology

The DTS Provisions B5D2 to B5D6 use a risk-based approach to help ensure an appropriate level of hazard protection is provided by a backflow prevention device.

Hazards are first identified and then assigned an appropriate Hazard Rating using the information in Specification 41. The appropriate backflow prevention device is then selected and installed in accordance with Section 4 of AS/NZS 3500.1 (2021).

5.3.1 Specification 41: Cross-connection hazards

The role of a specification is to provide technical data in the NCC which is relied upon as a component to one or more DTS Provisions. A specification may be referenced by multiple DTS Provisions, wherever the same data needs to be referred to by different parts of the NCC. Including this common information in a single specification avoids the need to repeat the same information across multiple parts of the NCC.

Example

A specification could be best understood as playing a role in the PCA similar to that of a PCA referenced document (e.g. an Australian Standard), in that both contain detailed, prescriptive, technical information which may be called up in several different DTS Provisions.

Alert

A specification in the PCA, for example Specification 41, is different to a WaterMark Product Specification, such as AS/NZS 2845.1 (2022).

Information on WaterMark specifications can be found on the ABCB website.

Specification 41 forms a key part of the DTS Provisions.

Specification 41 sets out common cross-connection hazards and outlines the corresponding Hazard Ratings.

Hazard Ratings were discussed in detail in section 2.5 of this handbook.

It is important to note that Specification 41 does not cover every possible situation in which cross-connection control may be required. Like any other DTS Provision, it only covers the most common situations. For other situations, Verification Method B5V1 should be used.

5.3.2 Drinking water service

B5D2 specifies cross-connection controls required to limit contaminants from entering a drinking water service from the following:

- a non-drinking water service
- a rainwater service
- an alternative water supply
- a swimming pool
- pipes, fixtures or specialist equipment (including boilers and pumps) containing chemicals, liquids, gases or other substances which may be harmful to health or safety.

Alert

Not all backflow prevention devices are suitable for use in heated water services. To confirm the suitability of a backflow prevention device for use in a heated water service, refer to AS/NZS 2845.1 (2022), or the manufacturer's instructions.

B5D2 refers to Specification 41 to assign a Hazard Rating for individual or zone protection. Depending on the assigned Hazard Rating, a backflow prevention device must be selected and installed which is suitable to mitigate the risk of this hazard in accordance with AS/NZS 3500.1 (2021).

Figure 5.1 sets out how the 2 components of B5D2 are applied to cold water services.

Figure 5.1 Application of B5D2 to cold water services

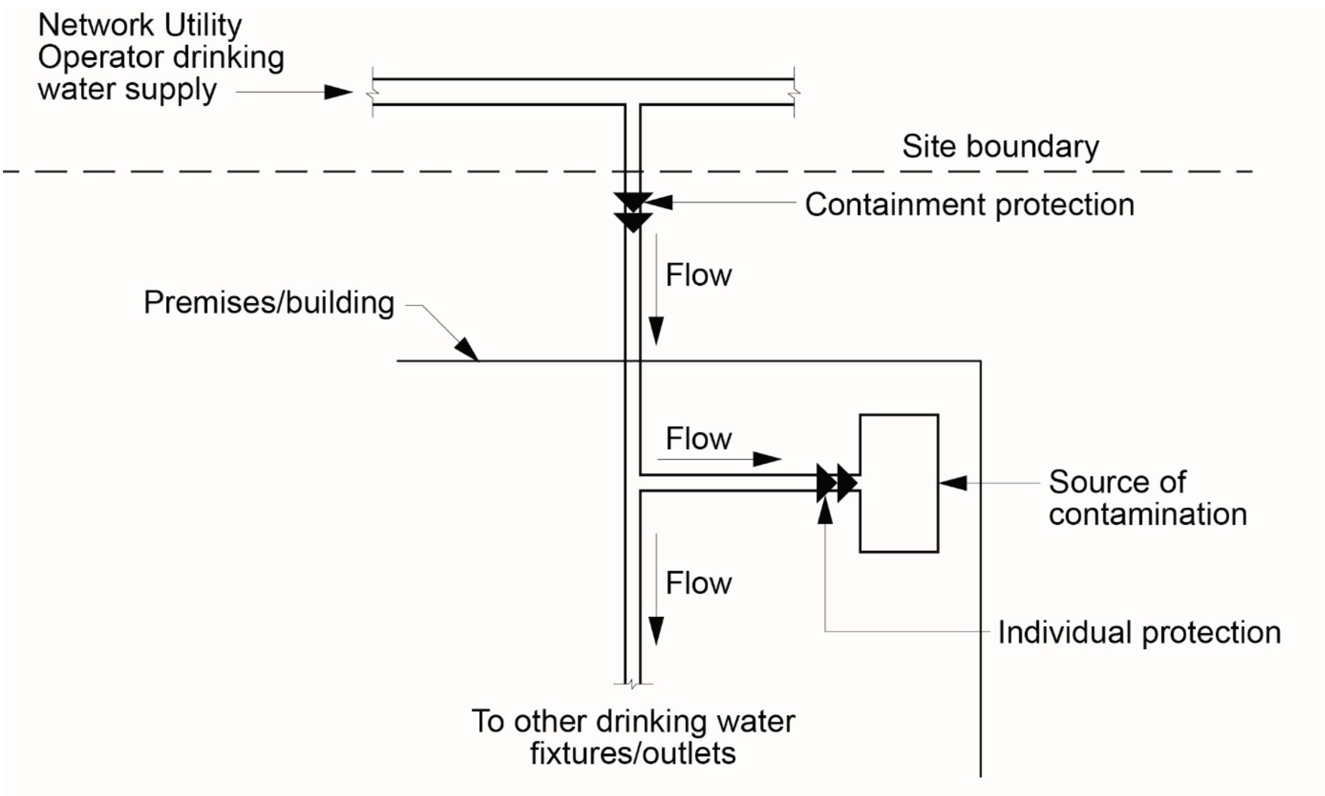
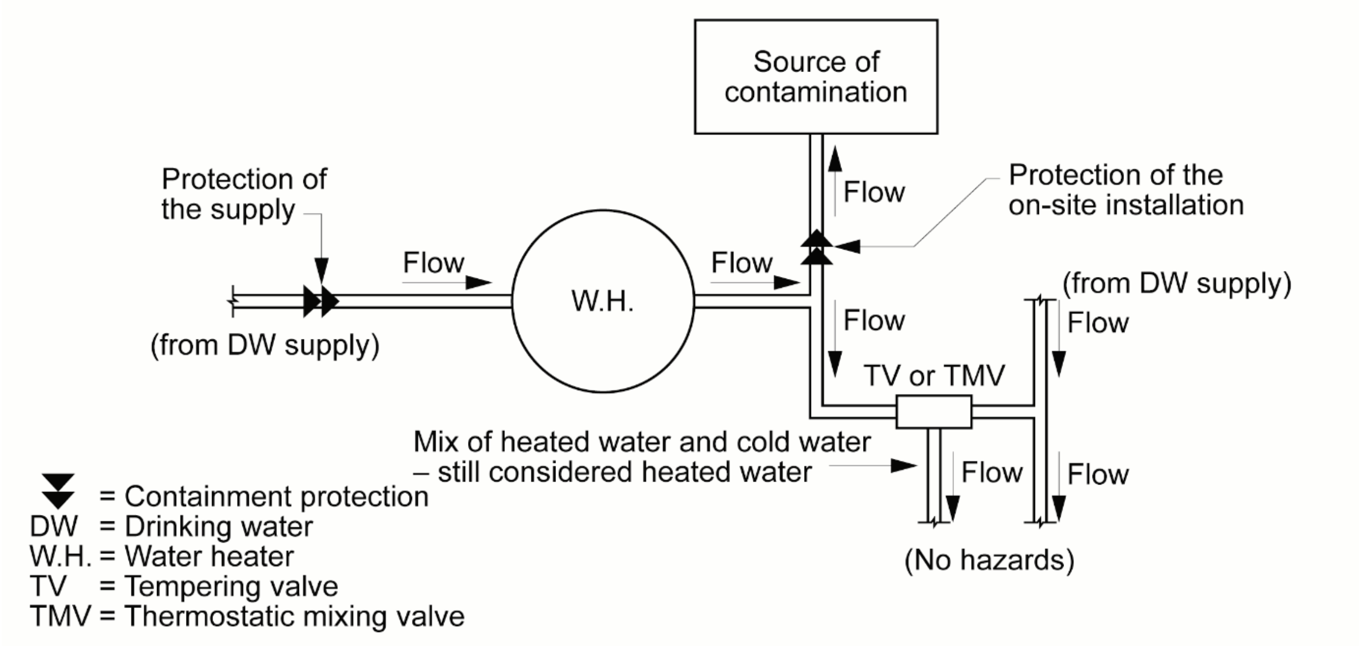


Figure 5.2 sets out how B5D2 is applied to heated water services.

Figure 5.2 Application of B5D2 to heated water services



Alert

B5D2 is not limited to heated water lines directly connected from the water heater. It also applies to lines that carry heated (hot or tempered) water. This is because 'heated water' is defined in the NCC as 'water that has been intentionally heated; normally referred to as hot water or warm water'. This definition clarifies that these requirements apply to water which is tempered to reduce its delivery temperature to reduce the likelihood of scalding. So long as the water was intentionally heated, then under the PCA it is considered heated water.

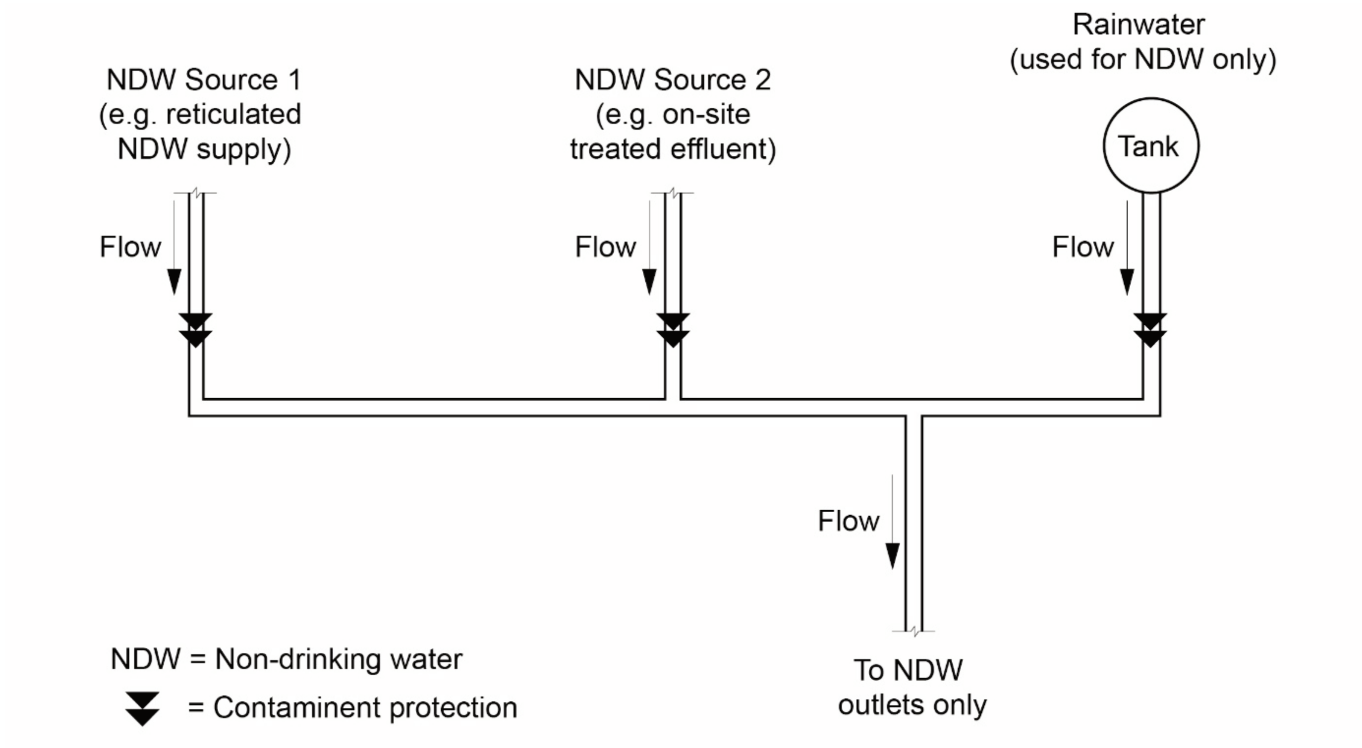
5.3.3 Non-drinking water service

B5D3 specifies cross-connection controls used to limit contaminants from entering a non-drinking water service from a separate non-drinking water service on the same site.

A 'separate non-drinking water service' means one which draws water from a different source. For example, on a site that utilises recycled water, grey water or water sourced from a bore, all services may be considered non-drinking water services but are drawn from different sources. Therefore, each would be a 'separate non-drinking water service', B5D3 refers to Specification 41 to assign a containment protection rating. Depending on the assigned Hazard Rating, a suitable containment protection device must be selected and installed in accordance with AS/NZS 3500.1 (2021).

Figure 5.3 sets out how B5D3 is applied to non-drinking water services.

Figure 5.3 Application of B5D3 to non-drinking water services



5.3.4 Fire-fighting water service

For fire-fighting water services, B5D4 applies at the point where the fire-fighting water service is connected to a drinking water supply. It does not require any additional protection downstream of this point because the water within the fire-fighting water service is no longer permitted to be used for drinking.

Reminder

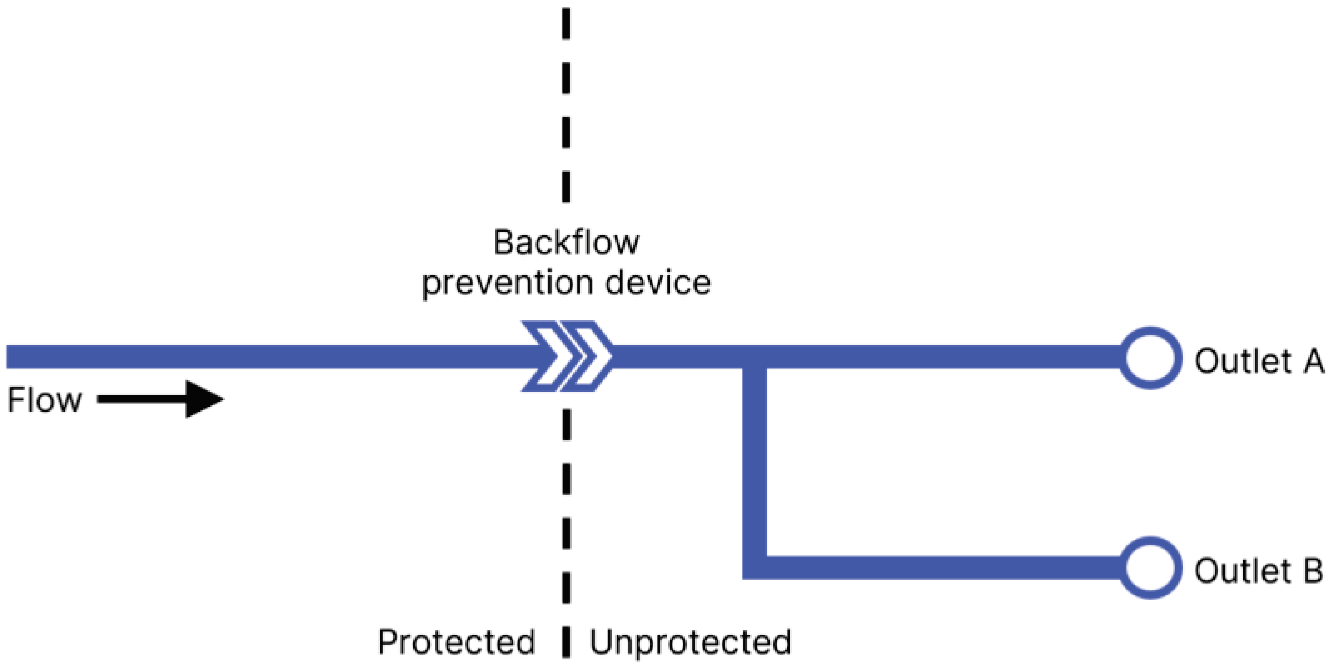
Requirements for fire-fighting water services for Class 2 to Class 9 buildings are also set out in NCC Volume One.

5.3.5 Unprotected water service

B5D5 states that water downstream of a backflow prevention device protected by individual protection or zone protection is considered an unprotected water service. An unprotected water service means a water service that may be contaminated from a surrounding hazard.

Figure 5.4 illustrates an unprotected water service as described by B5D5.

Figure 5.4 Example of an unprotected water service



Notes to Figure 5.4

In this diagram, Outlet B is not protected from a cross-connection hazard that exists at Outlet A (and vice versa). This means Outlet B cannot be used for human consumption, food preparation, food utensil washing or personal hygiene. This is because there is no backflow prevention device between Outlets A and B — both are downstream of a testable backflow prevention device.

5.3.6 Rainwater

B5D6 applies to the protection of a drinking water service when connected to a rainwater service. For containment requirements relating to rainwater, see S41C6(1)(b) of Specification 41.

All other backflow protection must be done in accordance with AS/NZS 3500.1 (2018) Clause 16.4 and Table 16.4.

6 Backflow prevention devices

6.1 Overview

This chapter explains the different types of backflow prevention devices that can be installed to comply with the PCA. It covers both testable and non-testable devices, including air gaps (AGs) and break tanks (BTs). A figure is provided following each explanation throughout this chapter.

Alert

This chapter only provides explanations for the most commonly used backflow prevention devices, however there may be other types of devices available.

For a complete list of devices that can be installed using the DTS Provisions, refer to Table 4.4.1 of AS/NZS 3500.1 (2021). For further device-specific technical information, refer to AS/NZS 2845.1 (2022).

6.2 Choosing an appropriate backflow prevention device

A wide choice of devices can be used to prevent backsiphonage and backpressure from adding contaminants into a water supply. In the DTS Provisions, the selection of the correct device is based on the degree of hazard (Hazard Rating) posed by the cross-connection or potential cross-connection. Additional considerations are based upon pipework size, location and the potential need to periodically test the device to ensure correct on-going operation.

Reminder

(1) Other ways of preventing backflow can also be used to comply with the PCA, through a Performance Solution. In such cases, the proposed backflow protection must be assessed and shown to be able to meet the relevant Performance Requirements. The Assessment Methods are provided in the PCA, in Clause A2G2.

(2) Backflow prevention devices are classified according to the level of hazard they are able suitable to protect against. This classification system corresponds with the Hazard Ratings that are applied to potential cross-connections. Refer to section 2.5 of this handbook for Hazard Ratings.

Example

Industrial chemical mixing systems would be classified as high hazard (see S41C4(3)), therefore the cold water service would need to be individually protected with a suitable High Hazard backflow prevention device (see AS/NZS 3500.1 (2021), Table 4.4.1).

6.2.1 Continuous or non-continuous pressure

Some backflow prevention devices are not suitable for use in installations that are under continuous pressure. “Continuous pressure” means that the water downstream of the device is under pressure for more than 12 of any 24 hours in a day, for example due to a downstream tap being closed for more than 12 hours at a time.

6.2.2 Testable and non-testable devices

Not all backflow prevention devices are testable. With the exception of AGs and atmospheric vacuum breakers, non-testable devices are only suitable for use in low hazard installations. Testing ensures a backflow prevention device continues to offer the appropriate level of protection, so is required for Medium Hazard and High Hazard installations.

6.3 Product certification and authorisation

Part A5 of the PCA requires that materials and products used in a plumbing and drainage installation be “fit for purpose”. For a material or product to be recognised as “fit for purpose” it must be certified and authorised under the WaterMark Certification Scheme. Products which require certification are listed on the WMSP.

The WMSP lists many backflow prevention devices that require WaterMark Certification. If a backflow prevention device is not listed on the WMSP it will require a risk assessment.

The Manual for the WaterMark Certification Scheme contains further information on the risk assessment process.

Alert

The WMEP and WMSP are available from the ABCB website.

For backflow prevention devices, the relevant product standard is AS/NZS 2845.1 Water supply—Backflow prevention devices, Part 1: Materials, design, and Performance Requirements (2022).

Reminder

Further information regarding the WaterMark Certification Scheme can be found at the ABCB website.

6.4 Types of devices

In Australia, there are 7 basic types of devices that can be used to correct cross-connections.

(1) AG or BTs.

(2) Vacuum breakers (both atmospheric and pressure type).

(3) Dual check valves (DualCV).

(4) Dual check valve with intermediate atmospheric port (DCAP).

(5) Double check valves (DCV).

(6) Reduced pressure zone devices (RPZD).

(7) Single check valves.

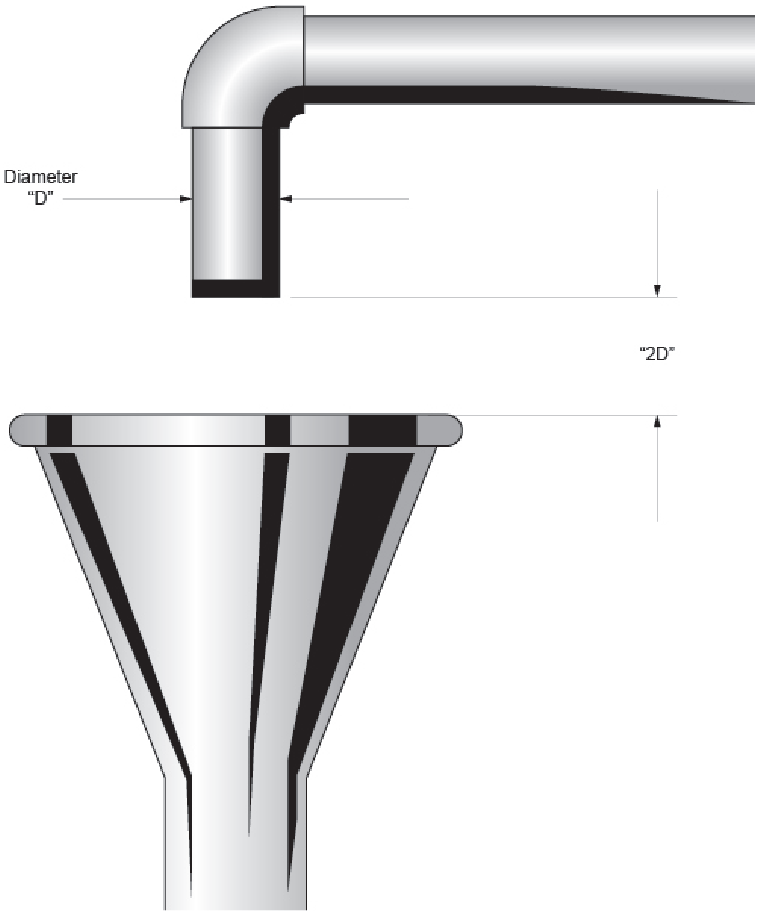
6.4.1 Air gaps and break tanks

AG and BTs are non-mechanical backflow prevention devices that are very effective where either backsiphonage or backpressure conditions may exist. Unless they are registered (see Chapter 7), AG and BTs are considered suitable for Low Hazard installations only.

For water services greater than a diameter DN 25, the minimum height of the AG (the vertical distance between the water service and the spill level of the receiving tundish or BT) is required to be greater than 2 times the diameter of the water service outlet (“2D”). This is explained in Figure 6.1.

For AGs in water services up to and including DN 25, the minimum height of the AG is given in Table 4.6.3.2 of AS/NZS 3500.1 (2021), which is referenced by the PCA DTS Provisions in Parts B1 and B3.

Figure 6.1 Example of AG device



An AG can cause a corresponding loss of pressure to downstream outlets. However, they are an extremely effective backflow preventer when used to prevent backsiphonage and backpressure conditions. Consequently, AGs are primarily used at end of line services where reservoirs or storage tanks are desired.

When assessing whether an AG would be suitable, the following points should be considered.

- In a continuous piping system, each AG requires the added expense of BTs (reservoirs) and secondary pumping systems, assuming gravity will not provide adequate pressure.
- The AG may be easily defeated in the event the "2D" requirement was purposely or inadvertently compromised. Excessive splashing may be encountered if higher than anticipated pressures or flows occur. The splash may pose a nuisance or hazard, e.g. by creating undue noise or splashing water onto a nearby areas. In these situations, the solution often used is to reduce the "2D" height by thrusting the supply pipe into the receiving funnel or tank, or by attaching a hose. By so doing, the AG is defective

and the water service is unprotected from the hazard. This situation does not comply with the PCA.

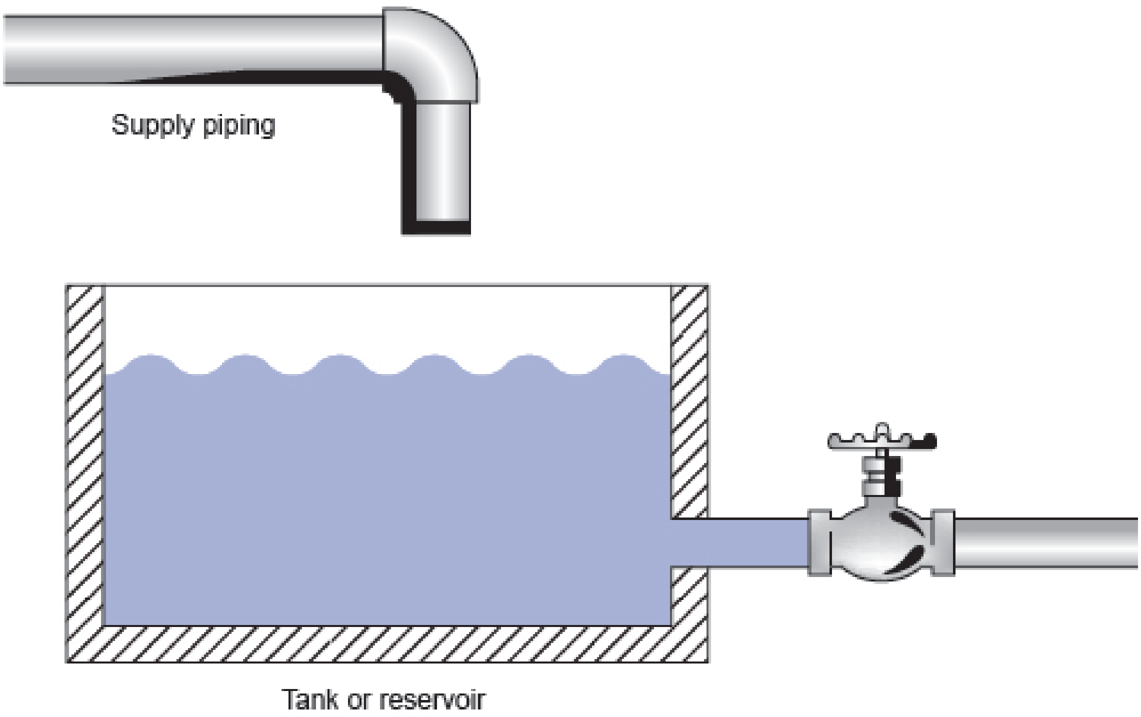
- At an AG, water is exposed to the surrounding air with its inherent bacteria, dust particles and other airborne contaminants. In addition, the aspiration effect of the flowing water can drag down surrounding contaminants into the reservoir or BT.
- Free chlorine can come out of treated water because of the AG and the resulting splash and churning effect as the water enters the BT. This reduces the ability of the water to withstand bacteria contamination during long-term storage.

Alert

The ease by which AGs can become defective also means that in most jurisdictions, where an AG is installed in a Medium or High Hazard situation, it can be registered with the local authority having jurisdiction to ensure that the AG is maintained through an inspection process. See Appendix B for further details.

AGs and BTs may be fabricated from commercially available plumbing components or purchased as separate units. An example of an AG with BT is shown in Figure 6.2.

Figure 6.2 AG with BT

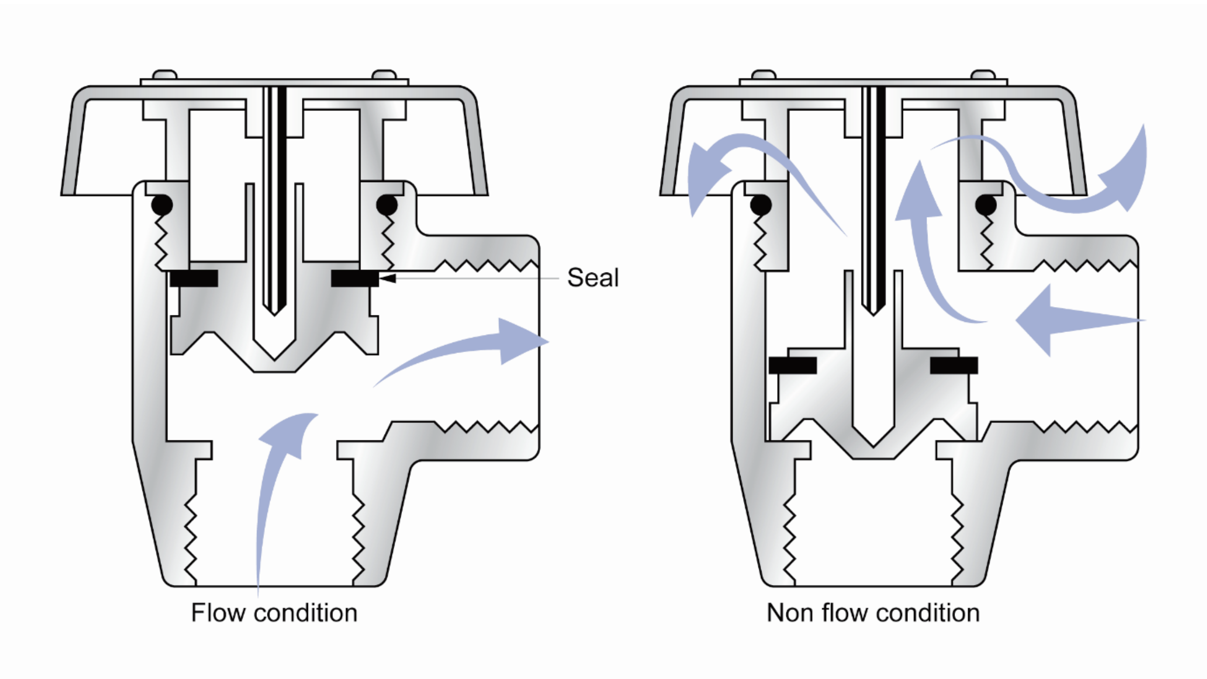


6.4.2 Atmospheric vacuum breakers

Atmospheric vacuum breakers (AVB) are among the simplest mechanical types of backflow prevention devices and when installed properly, can provide excellent protection against backsiphonage. However, AVBs cannot be used to protect against backpressure conditions and are not designed for use in water service installations that are kept under continuous pressure. Even though AVBs are a non-testable device, when installed correctly are suitable and approved for high hazard installations.

AVBs are usually constructed of a float which is free to travel on a shaft and seal in the uppermost position against atmosphere with an elastomeric disc. Water flow lifts the float, which then causes the disc to seal. Water pressure keeps the float in the upward sealed position. Cutting off the water supply will cause the disc to drop down venting the unit to atmosphere and thereby opening the downstream piping and preventing backsiphonage. Figure 6.3 shows how a typical AVB operates.

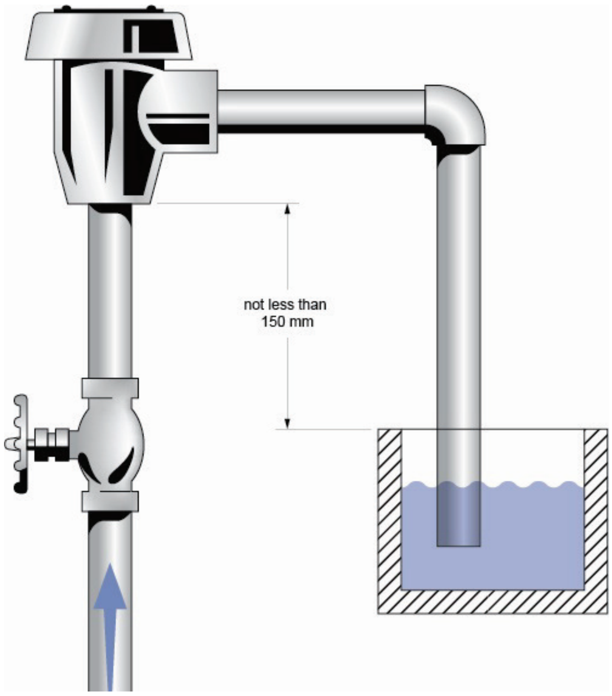
Figure 6.3 Example of an AVB



AVBs must be installed vertically and must not have any shutoffs downstream of the device. They must be installed at least 150 mm higher than the highest downstream outlet. Figure 6.4 shows the typical installation of an AVB. Note that no shutoff valve is installed downstream of the device that would otherwise keep the AVB under continuous pressure.

Although not a testable device, performance verification is required and a test method is in AS/NZS 2845, Part 3: Field testing and maintenance of testable devices (2020). The design of the AVB makes it suitable for installations where minimal pressure drop is required.

Figure 6.4 AVB—typical installation

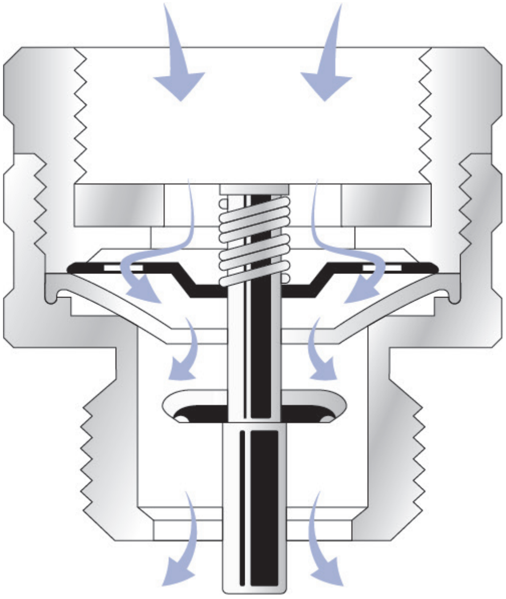


6.4.3 Hose connection vacuum breaker

Hose connection vacuum breakers (HCVB) are usually attached to hose taps and in turn, are connected to hose supplied outlets such as garden hoses, slop hopper hoses, spray outlets and the like. However, HCVBs cannot be used to protect against backpressure conditions and are not designed for use in water service installations that are kept under continuous pressure. For example, for installations where a trigger spray nozzle is used. HCVBs are a non-testable device and are only suited for use in low hazard installations.

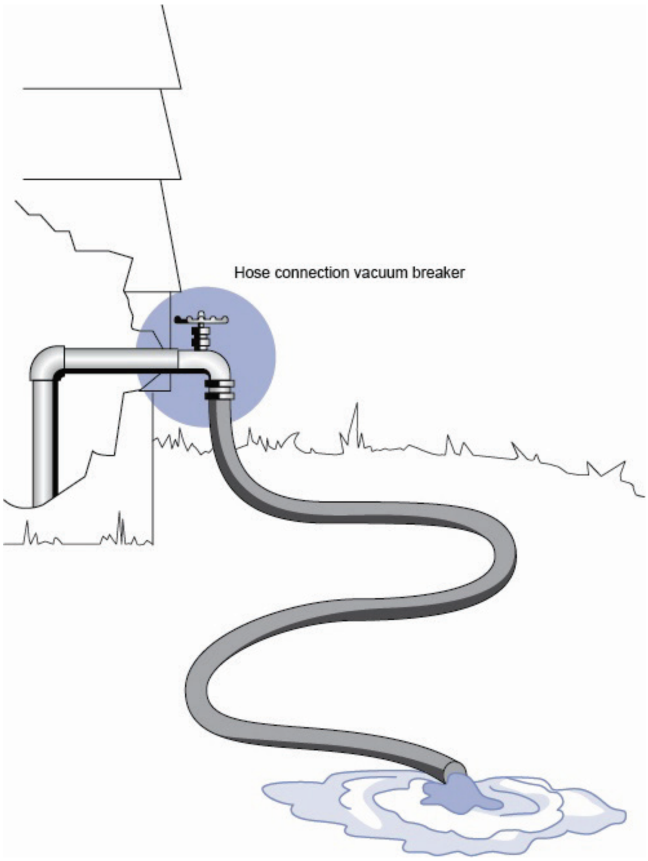
HVCBs consist of a spring-loaded check valve that seals against atmospheric pressure when the water supply pressure is turned on. The operation of a HCVB is shown in Figure 6.5.

Figure 6.5 Example of HVCB



When the water supply is turned off, the device vents to atmosphere, therefore protecting against backsiphonage conditions. Typical installation is shown in Figure 6.6.

Figure 6.6 HCVB—typical installation



6.4.4 Pressure vacuum breaker

The pressure vacuum breaker (PVB) has evolved from the AVB in response to the need for an AVB that can be used under constant pressure and tested in-situ. This is achieved through a spring on top of the disc and float assembly, 2 added isolation valves, test cocks and an additional first check. The workings of a PVB are shown in Figure 6.7.

PVBs are a testable device. They provide protection against backsiphonage and are suitable for use in Low, Medium or High Hazard installations that are under continuous pressure. PVBs do not protect against backpressure.

The PVB should be installed in environments where splashing of water cannot cause nuisance or damage, as when the float closes splash often occurs. Typical installations of a PVB, in agricultural and industrial situations, are shown in Figure 6.8.

Spill-resistant pressure vacuum breakers (SPVB) are also available as an alternative to the standard type PVB. SPVBs are specifically designed to minimise water spillage if the backflow prevention mechanism of the device is activated. This type of device can be used in installations where the device is to be located inside a building, where water spillage could cause damage to property or pose a safety hazard.

Similar to PVBs, SPVBs provide protection against backsiphonage and are suitable for use in installations that are under continuous pressure. PVBs do not protect against backpressure. The SPVB can be used in High Hazard installations.

Figure 6.7 Example of PVB

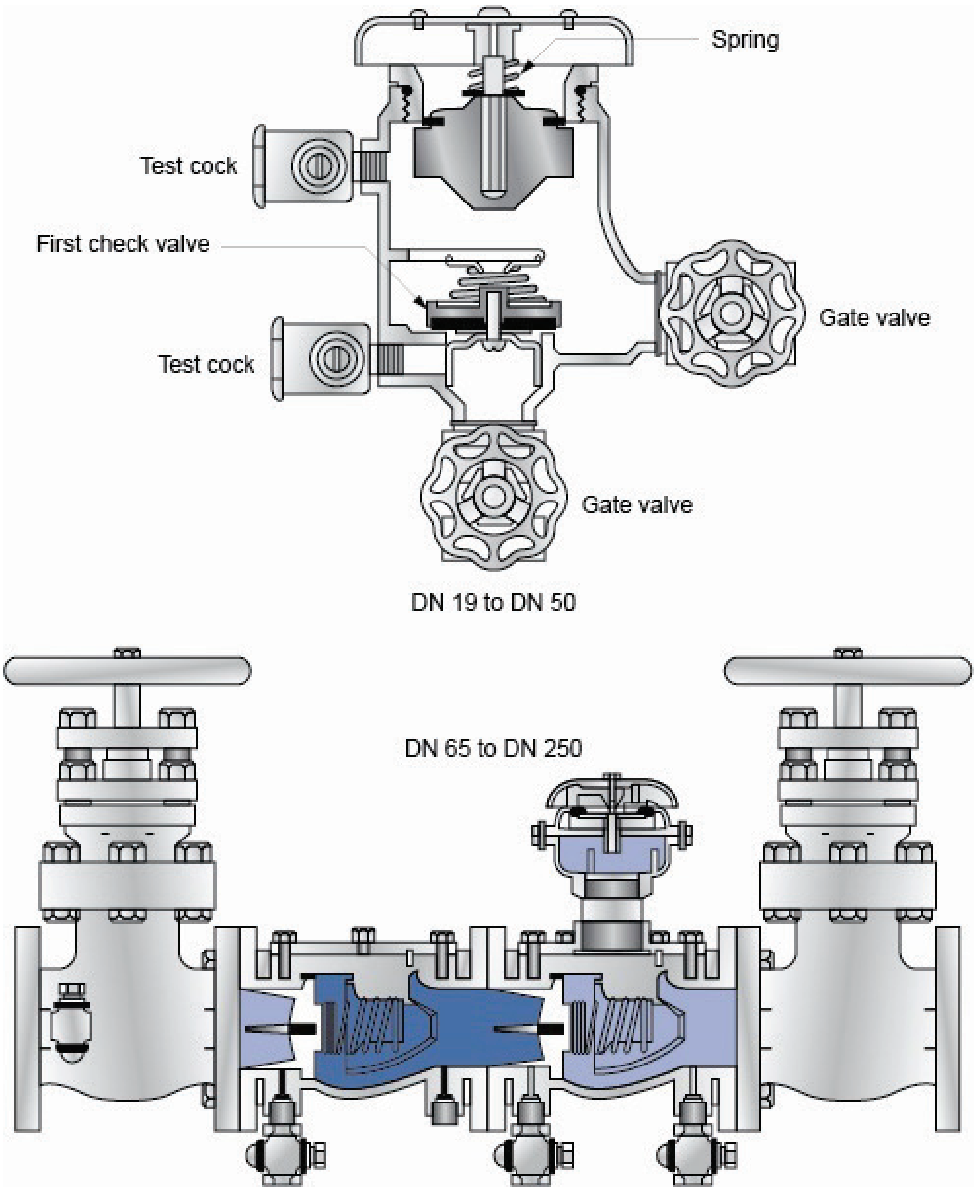
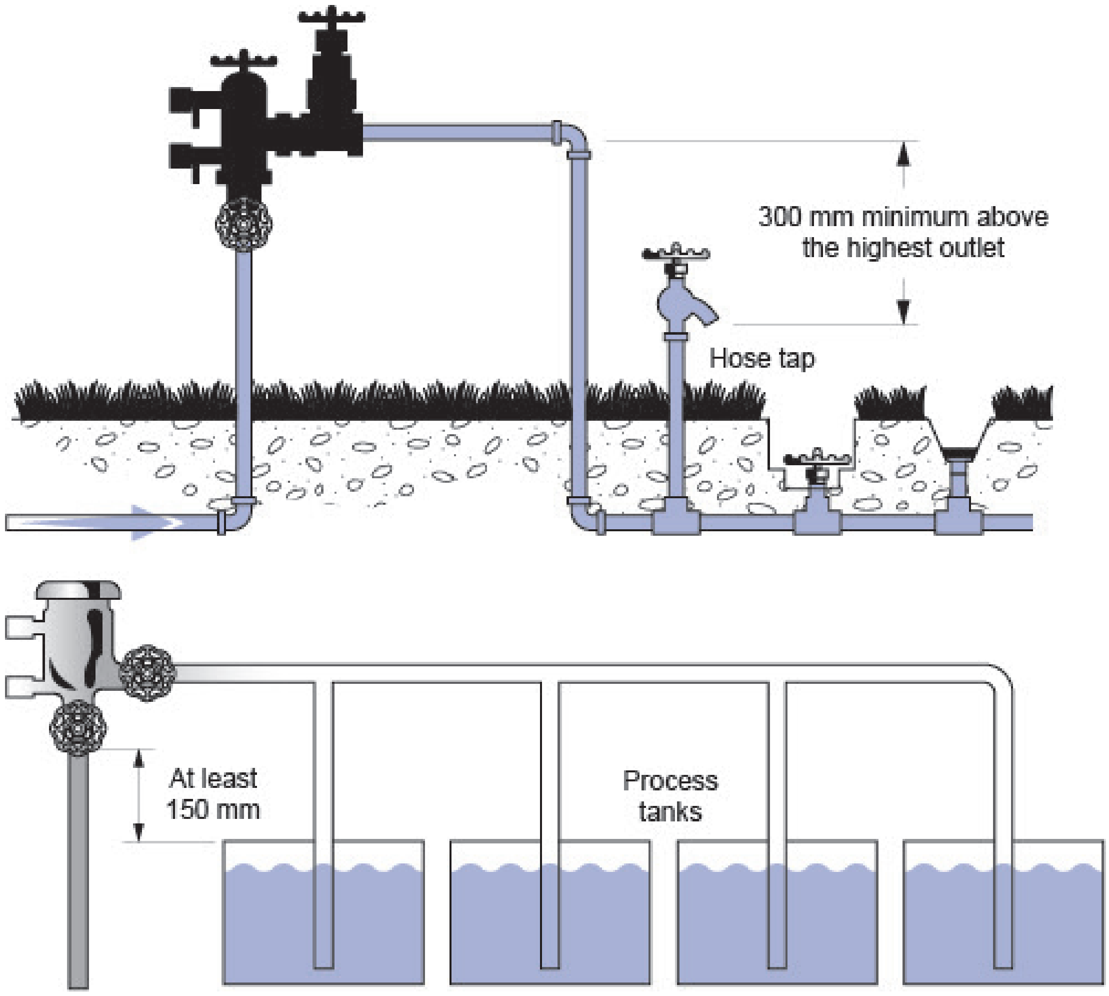


Figure 6.8 PVB - typical installations



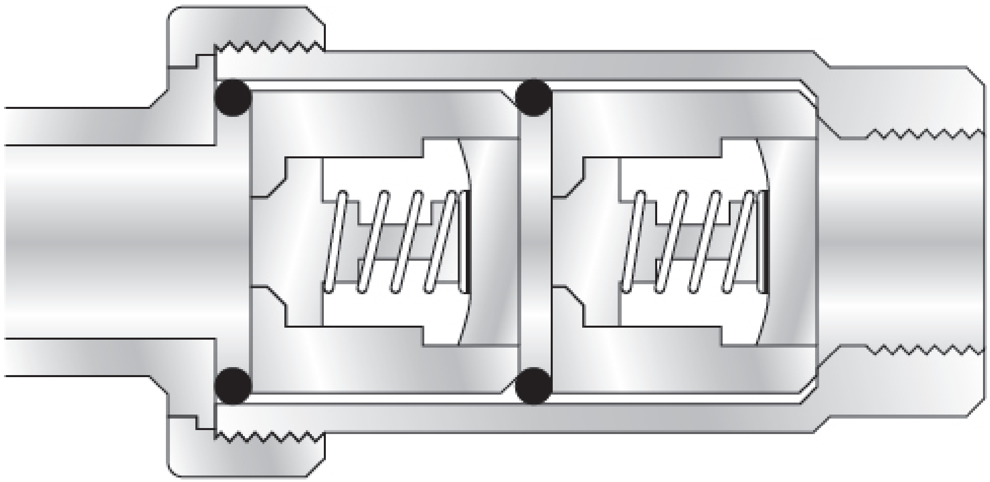
6.4.5 Dual check valve

The DualCV provides low hazard protection suitable for use at the point of connection from the NUO's drinking water supply to a single Class 1 dwelling (typically a house) and for Low Hazard individual and zone protection.

When used as containment, DualCVs are designed to be installed immediately downstream of the water meter or may be incorporated into the meter assembly itself. DualCVs are suitable for use in Low Hazard installations, can protect against backsiphonage or backpressure and can be used in systems that are under continuous pressure.

The workings of the DualCV are shown in Figure 6.9.

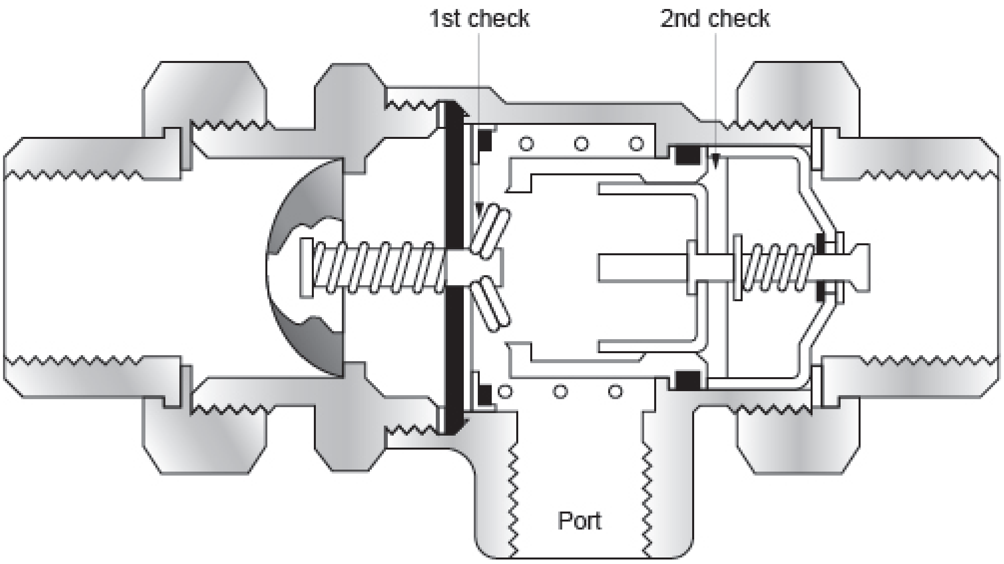
Figure 6.9 Example of DualCV



6.4.6 Dual check valve with atmospheric port

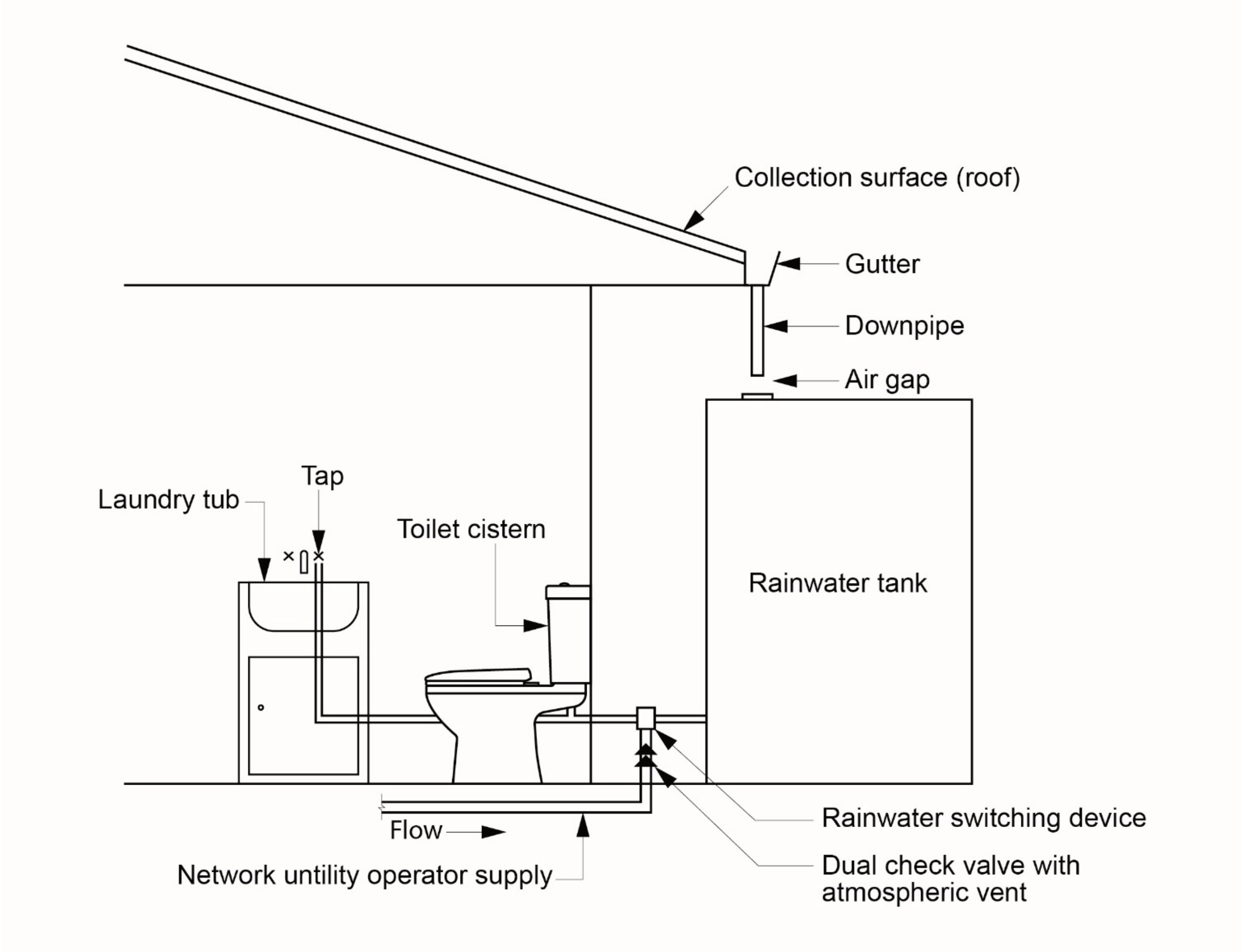
DCAPs are devices available in DN 15 and DN 20 pipe sizes and are suitable for use in low hazard installations. This device is capable of being used under continuous pressure and protects against backpressure and backsiphonage. The device also provides a visual indication of failure, through the atmospheric port. The DCAP is constructed of dual check valves with an atmospheric port inserted between the 2 checks. This is shown in Figure 6.10.

Figure 6.10 Example of DCAP



Pressure within a water service keeps the vent port closed, but zero supply pressure or backsiphonage will open the inner chamber to atmosphere. With this device, extra protection is gained through the capability of venting to atmosphere.

Figure 6.11 DCAP - typical installation



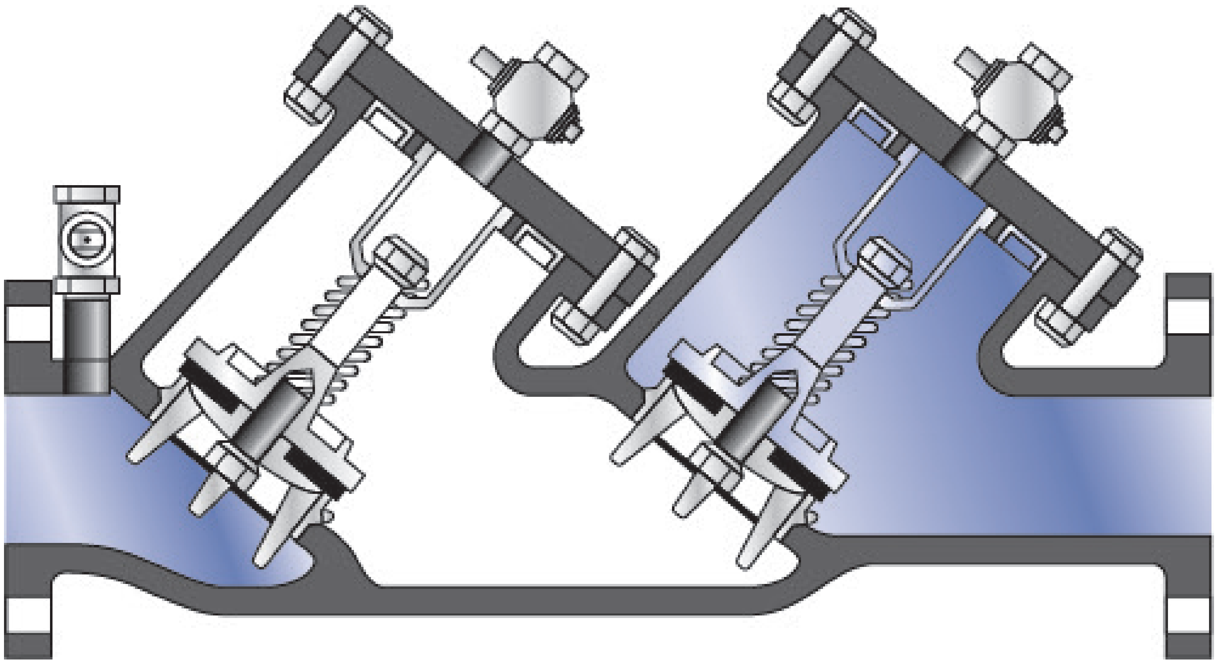
6.4.7 Double check valve

A DCV is 2 spring loaded check valves coupled within one body and furnished with test cocks. The test capability gives this device an advantage over the use of 2 independent check valves in that it can be easily tested to determine if either or both check valves are inoperative or fouled by debris. Each check is spring loaded in the closed position and must not open below 7 kPa.

The spring loading provides the ability to “bite” through small debris and still seal; a protection feature not prevalent in unloaded swing check valves. Figure 6.12 shows a cross section of a DCV complete with test cocks.

DCVs are suitable for use in low or medium hazard installations and can operate under continuous pressure. DCVs can protect against both backpressure and backsiphonage.

Figure 6.12 Example of DCV



6.4.8 Double check detector assembly

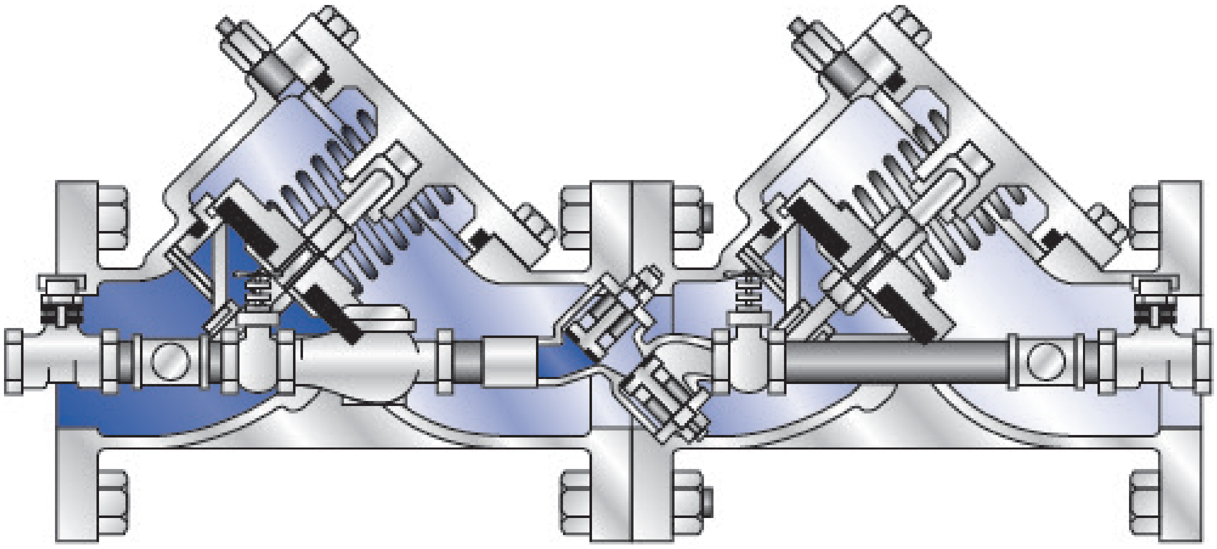
The double check detector assembly (DCDA) is a DCV with a metered bypass and is primarily utilised in fire-fighting water service installations. It is designed to protect the drinking water service from possible contamination from the following:

- backpressure from booster pumps,
- stagnant water that sits in fire-fighting water services for extended periods of time, and
- the addition of raw water through outside fire pump connections.

It is also able to detect water draw-offs from the fire-fighting water service caused by leakage or unauthorised water usage.

The DCDA is comprised of 2 spring loaded check valves, a bypass assembly with water meter and double check valve and 2 lockable isolating valves. The DCDA is suitable for use in medium hazard installations, including fire-fighting water services, and can protect against both backpressure and backsiphonage. DCDAs are designed for use under continuous pressure. The workings of the DCDA are shown in Figure 6.13.

Figure 6.13 DCDA

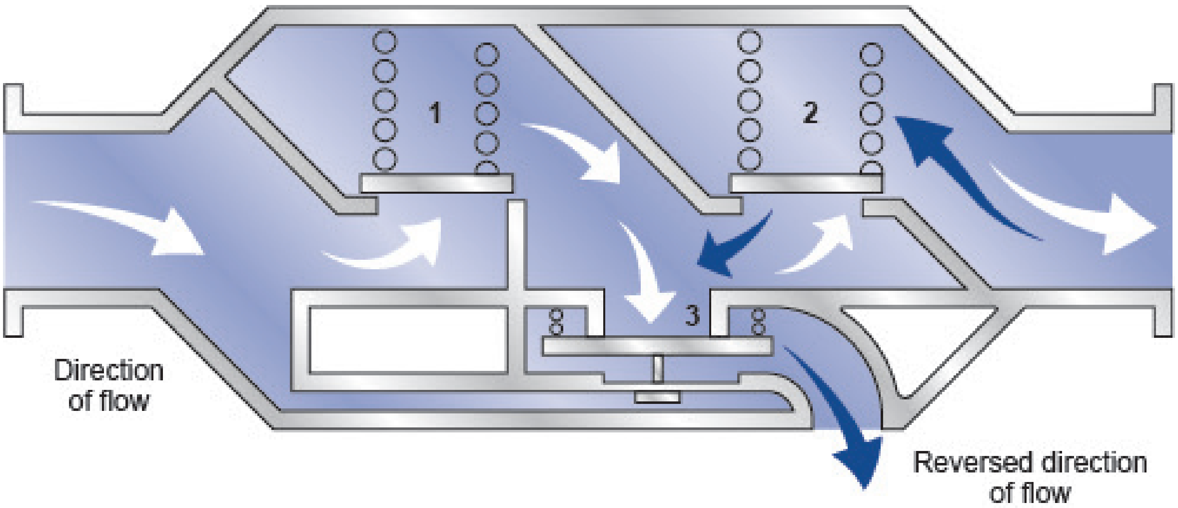


6.4.9 Reduced pressure zone device

Similar to the DCV, the RPZD contains 2 spring loaded check valves but it also has a differential pressure relief valve between the 2 checks. It is designed such that the zone between the 2 checks are always kept at least 14 kPa lower than the supply pressure. With this design criteria, the RPZD can provide protection against backsiphonage and backpressure when both the first and second checks become fouled.

RPZDs can be used under continuous pressure and are suitable for High Hazard installations. It provides maximum protection against backsiphonage and backpressure. RPZDs are a testable device. Figure 6.14 shows the principles behind the operation of an RPZD.

Figure 6.14 Example of RPZD



The principles behind the operation of an RPZD, as depicted above, are as follows:

- Flow from the left enters the central chamber against the pressure exerted by the first check valve (1). The supply pressure is reduced by a predetermined amount. The pressure in the central chamber is maintained lower than the incoming supply pressure through the operation of the relief valve (3), which discharges to the atmosphere whenever the central chamber pressure becomes too close to the inlet pressure. The second check valve (2) is lightly loaded to open with a pressure drop of 7 kPa in the direction of flow and is independent of the pressure required to open the relief valve (3).
- If the pressure increases downstream of the device, tending to reverse the direction of flow, the second check valve (2) closes, preventing backflow. Because all valves may leak because of wear or obstruction, the protection provided by the 2 check valves alone, may be insufficient. Therefore, in an RPZD, if some obstruction prevents the second check valve (2) from closing, the leakage back into the central chamber would increase the pressure in this zone, the relief valve (3) would open and flow would be discharged to the atmosphere.
- When the supply pressure drops to the minimum differential required to operate the relief valve (3), the pressure in the central chamber should be atmospheric. If the inlet pressure should become less than atmospheric, the relief valve (3) should remain fully open to the atmosphere to discharge any water that may be caused to backflow because of backpressure and leakage of the second check valve (2).
- Malfunctioning of one or both of the check valves (1), (2), or the relief valve (3), should always be indicated by the discharge of water from the relief port (below the relief valve).

Alert

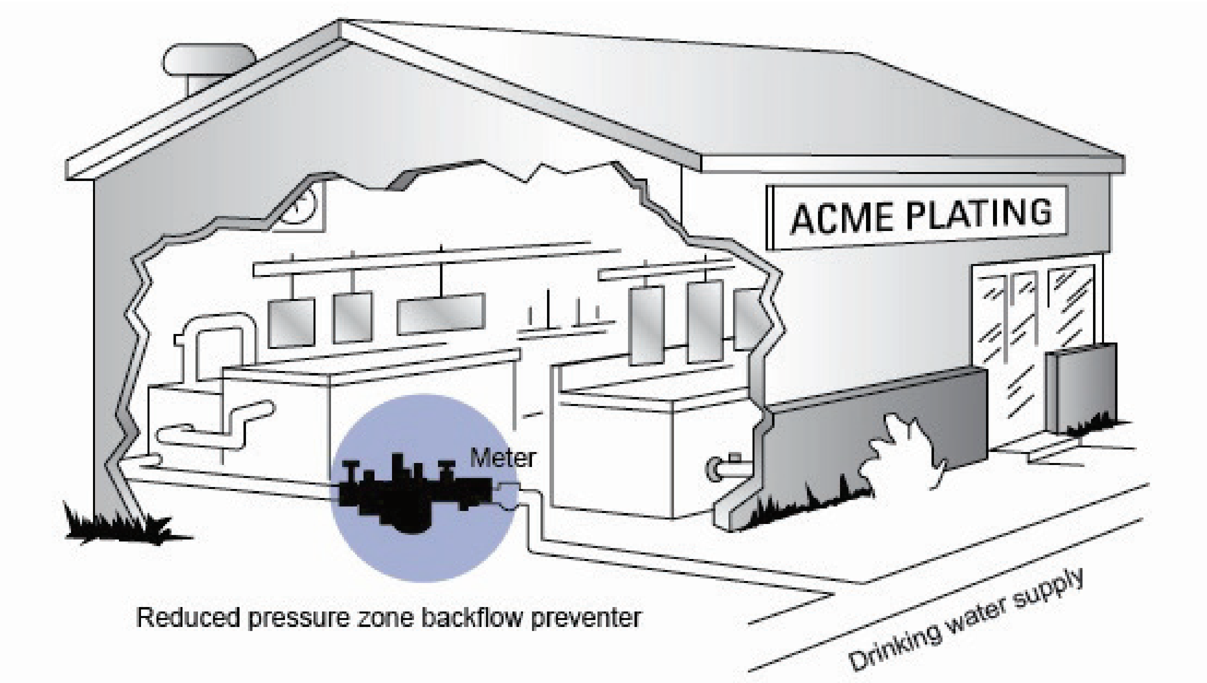
Under no circumstances should plugging of the relief valve be undertaken, as the device depends upon an open port for safe operation.

The pressure loss through the device may be expected to average between 70 kPa and 140 kPa within the normal range of operation, depending on the size and flow rate of the device.

Example

RPZDs are commonly installed on high hazard installations such as plating plants, where they would primarily protect against backsiphonage, and car washes, where they would primarily protect against backpressure. An example is shown in Figure 6.15.

Figure 6.15 RPZD - typical installation



6.4.10 Single check valve testable

The single check valve testable (SCVT) device was introduced for use in low hazard fire service installations where the pressure drop of a conventional backflow assembly prevents or restricts the water available for firefighting.

The device consists of a single check valve with an opening pressure great than 7 kPa and test cocks so the device can be tested for effective operation in service.

6.4.11 Single check detector assembly testable

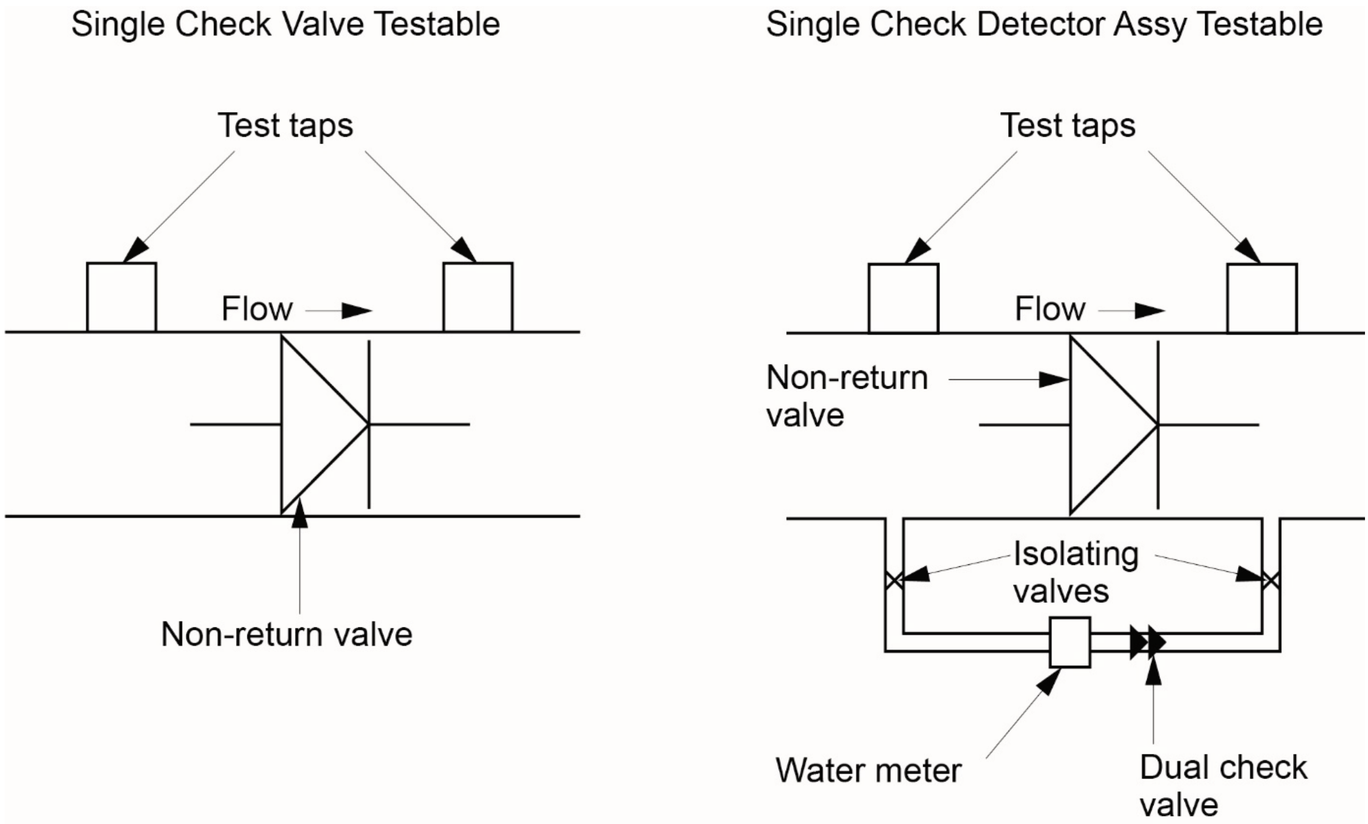
The single check detector assembly testable (SCDAT) is the same base unit as a SCVT but with a metered bypass installed to detect unauthorised water use from the fire service.

This device also consists of a single check valve with an opening pressure greater than 7 kPa and test cocks so the device can be tested for effective operation in service.

Alert

The SCVT and SCDAT are not authorised for use across all jurisdictions so check with your NUO prior to installing this type of backflow prevention device.

Figure 6.16 Example of SCVT and SCDAT devices



7 Device registration, testing and maintenance

7.1 Overview

This chapter explains the registration, testing and maintenance requirements that apply to some forms of backflow prevention. Because device registration schemes and ongoing testing and maintenance obligations for building owners/managers fall under State and Territory regulation, this chapter only provides a brief overview; more detailed information should be sought from the authority having jurisdiction.

Alert

In accordance with AS/NZS 3500.1 (2021), 4.4.6 Commissioning, testable backflow prevention devices shall be commissioned and tested in accordance with AS/NZS 2845.3 (2020) after installation and prior to service.

Spill resistant vacuum breakers (SRVB), RPZD, DCV, PVB, AVB, SCVT, SCDAT, registered BTs and registered AGs should only be used with a maintenance program for device registration and test certification.

Where there is no such program, these devices should not be fitted and the standard requirements for AGs instead apply.

According to Clause 4.4.6 of AS/NZS 3500.1 (2021), testable devices should be tested prior to beginning service, and at least once every 12 months thereafter.

7.2 Registration

Device registration is required under some state/territory or local government regulations. This is because these installations can pose a significant threat to public health and safety if a backflow prevention device were to fail or be circumvented (inadvertently or otherwise).

Databases of registered testable devices are often kept by NUOs where the device is installed for containment protection. The state/territory plumbing regulatory authority are often responsible if the device is installed for zone or individual protection.

AGs and BTs in Medium Hazard or High Hazard installations may also be required by the state or territory plumbing regulatory authority to be registered and inspected and tested annually.

7.3 Testing

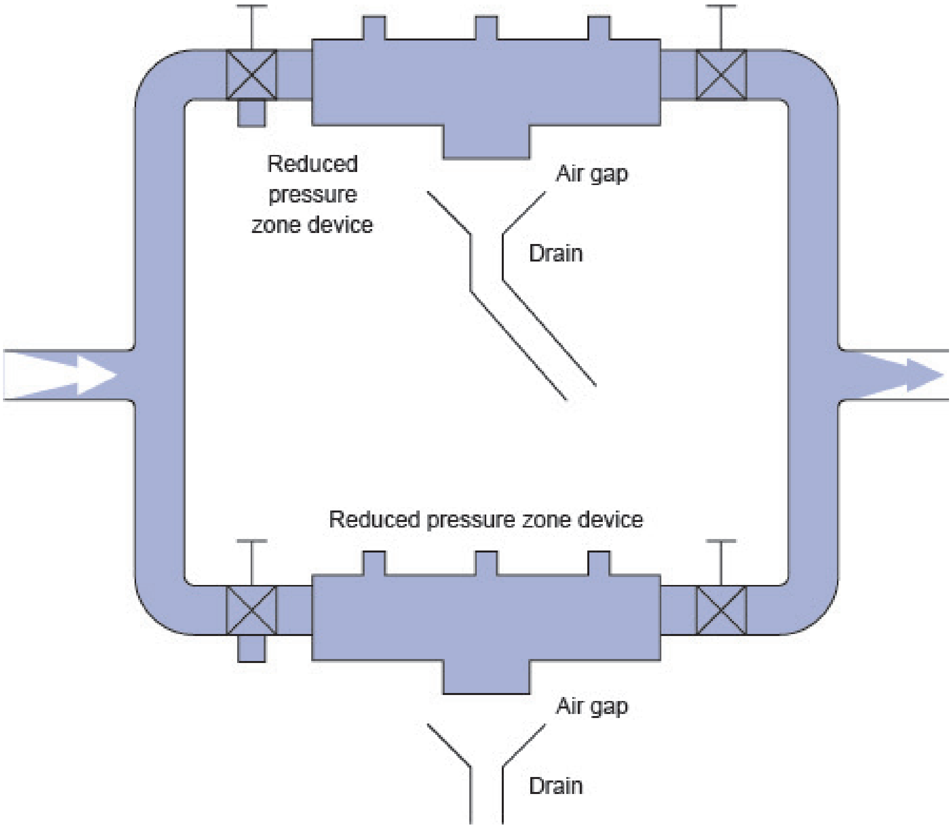
Testable backflow prevention devices are those that include features to enable the device to be tested in-situ, i.e. without the need to remove the device. According to AS/NZS 3500.1 (2021), the following types of backflow prevention devices are testable devices.

- PVB.
- RPZD.
- DCV.
- DCDA.
- SPVB.
- AVB.
- SCVT.
- SCDAT.

In most jurisdictions, testing of backflow prevention devices can only be carried out by an accredited tester who has completed specific training.

Testing a backflow prevention device in-situ requires the water supply to the device to be shut off. Therefore, prior to conducting the test, it is important to alert the owner and/or occupants of the property concerned that their water supply will need to be shut off for a period, until the test is complete. In situations where it is not viable to shut off a water supply, e.g. hospitals or industrial premises that operate 24 hours/day, the backflow prevention device can be duplicated by installing a second device, in a bypass, configured in a parallel arrangement with the primary backflow prevention device. This is called a protected bypass. Figure 7.1 shows how to configure a protected bypass.

Figure 7.1 Protected bypass configuration



Although Figure 7.1 depicts a protected bypass using RPZDs, other devices can also be installed, provided that an isolation valve is installed at the end of each device to enable it to be isolated from the water supply and removed if found to be defective. Always ensure the 2 devices are of the same hazard protection level.

Alert

Where the water supply to a building or part of a building is shut off to enable testing, it is important to advise building occupants not to open any upstream outlets during the test. This is because if an outlet is opened, the pressure in the water service pipework will fall to zero, which may lead to backsiphonage occurring elsewhere in the building. If backsiphonage does occur, the water service may become contaminated via a previously unknown and therefore unprotected cross-connection.

Detailed testing procedures relevant to each different type of testable device are set out in AS/NZS 2845.3 (2020) and in the device manufacturer’s instructions.

Appendices

Appendix A Abbreviations

The following table, Table A.1 contains abbreviations used in this handbook.

Table A.1 Abbreviations

Abbreviation	Meaning
ABCB	Australian Building Codes Board
AG	Air gap
AS/NZS	Australian Standard / New Zealand Standard
AVB	Atmospheric vacuum breaker
BT	Break tank
DCAP	Dual check with atmospheric port
DCDA	Double check detector assembly
DCV	Double check valve
DualCV	Dual check valve
DTS	Deemed-to-Satisfy
DW	Drinking water
HCVB	Hose connected vacuum breaker
kPa	Kilopascals
kPaA	Kilopascals (absolute)
kPaG	Kilopascals (gauge)
m	Metres
NCC	National Construction Code
ND	Nominal diameter (mm)
NDW	Non-drinking water
NUO	Network Utility Operator
P	Pressure
PCA	Plumbing Code of Australia
PVB	Pressure vacuum breaker
RPZD	Reduced pressure zone device

Abbreviation	Meaning
SCDAT	Single check valve detector assembly testable
SCVT	Single check valve testable
SPVB	Spill-resistant pressure vacuum breaker
SRVB	Spill-resistant vacuum breaker
US-EPA	United States Environmental Protection Agency
WH	Water heater
WMEP	WaterMark Schedule of Excluded Products
WMPD	WaterMark Product Database
WMSP	WaterMark Schedule of Products

Appendix B Compliance with the NCC

B.1 Responsibilities for regulation of building and plumbing in Australia

State and territory governments are responsible for regulation of building, plumbing and development/planning in their respective state or territory.

The NCC is a joint initiative of the Commonwealth and state and territory governments and is produced and maintained by the ABCB on behalf of the Australian Government and each state and territory government. The NCC provides a uniform set of technical provisions for the design and construction of buildings and other structures and plumbing and drainage systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The NCC is given legal effect by building and plumbing regulatory legislation in each state and territory. This legislation consists of an Act of Parliament and subordinate legislation (e.g. Building Regulations) which empowers the regulation of certain aspects of buildings and structures and contains the administrative provisions necessary to give effect to the legislation.

Each state and territory adopts the NCC subject to the variation or deletion of some of its provisions, or the addition of extra provisions. These variations, deletions and additions are generally signposted within the relevant section of the NCC and located within appendices to the NCC. Notwithstanding this, any provision of the NCC may be overridden by, or subject to, state or territory legislation. The NCC must therefore be read in conjunction with that legislation.

B.2 Demonstrating compliance with the NCC

Compliance with the NCC is achieved by complying with the NCC Governing Requirements and relevant Performance Requirements.

The Governing Requirements are a set of governing rules outlining how the NCC must be used and the process that must be followed.

The Performance Requirements prescribe the minimum necessary requirements for buildings, building elements, and plumbing and drainage systems. They must be met to demonstrate compliance with the NCC.

There are 3 options available to demonstrate compliance with the Performance Requirements. These are:

- a Performance Solution
- a Deemed-to-Satisfy Solution, or
- a combination of a Performance Solution and a DTS Solution.

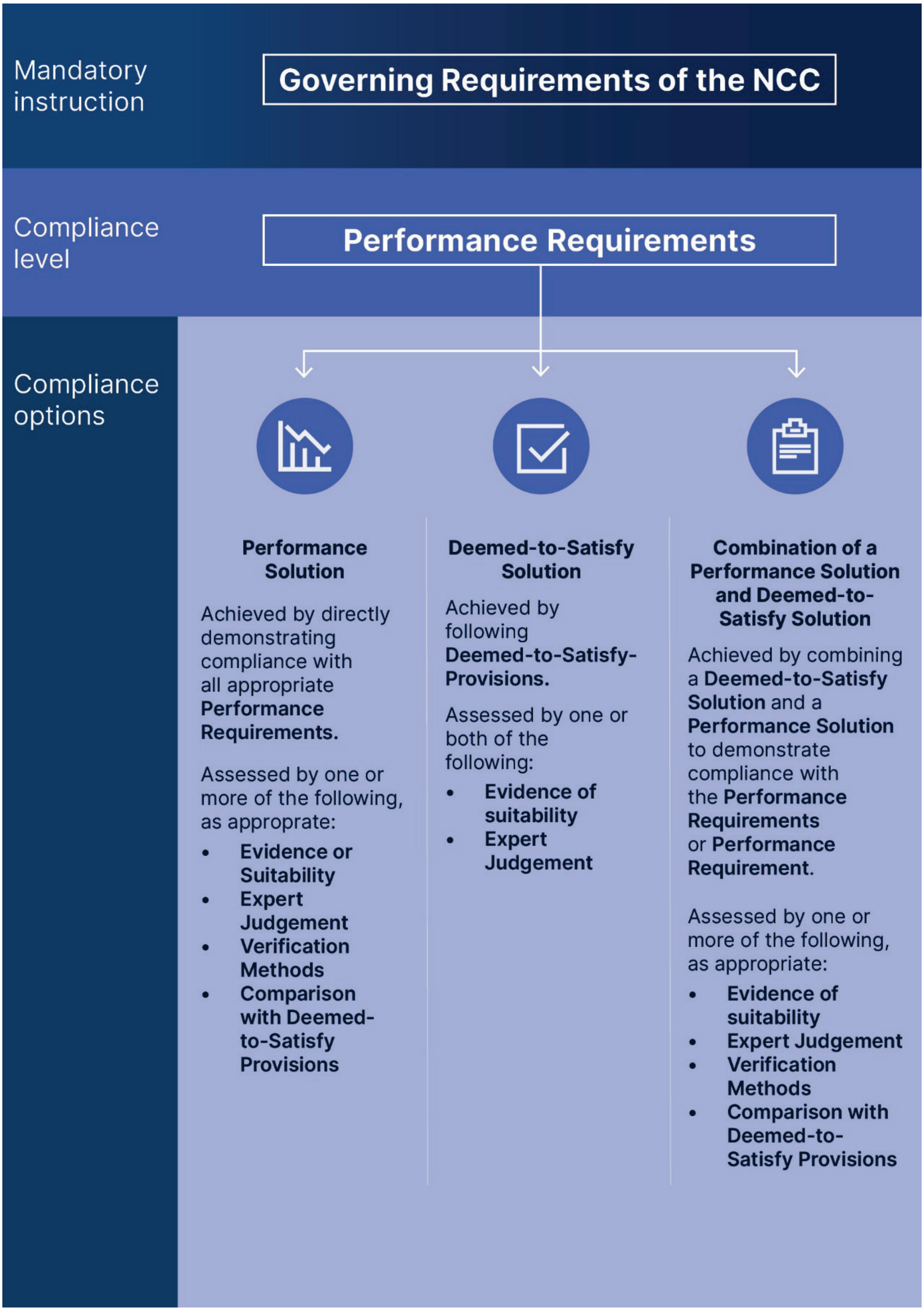
All compliance options must be assessed using one or a combination of Assessment Methods, as appropriate. These include:

- Evidence of suitability
- Expert Judgement
- Verification Methods
- Comparison with DTS Provisions.

A figure showing hierarchy of the NCC, and its compliance options is provided in Figure B.1. It should be read in conjunction with the NCC.

To access the NCC or for further general information regarding demonstrating compliance with the NCC visit the ABCB website.

Figure B.1 Demonstrating compliance with the NCC



Appendix C Hydraulic concepts

C.1 Overview

This Appendix explains the hydraulic factors that cause backflow, including backsiphonage and backpressure. Understanding these factors is important for identifying potential cross-connections and deciding on appropriate backflow prevention.

C.2 General principles

Cross-connections are the links through which it is possible for contaminants to enter a water supply. The polluting substance, in most cases a liquid, tends to enter the water supply if the net force acting upon the liquid acts in the direction of the water supply. Two factors are therefore essential for backflow to occur. First, there must be a link between the 2 systems. Second, the resultant force must be toward the water supply.

An understanding of the principles of backpressure and backsiphonage requires an understanding of the terms frequently used in their discussion.

Force, unless completely resisted, will produce motion. Weight is a type of force resulting from the earth's gravitational attraction.

Pressure (P) is a force-per-unit area, such as kilopascals (kPa). Atmospheric pressure is the pressure exerted by the weight of the atmosphere above the earth.

Pressure may be referred to using an absolute scale, kPa absolute (kPaA), or gauge scale, kPa gauge (kPaG). Absolute pressure and gauge pressure are related. Absolute pressure is equal to the gauge pressure plus the atmospheric pressure. At sea level the atmospheric pressure is 101.3 kPaA.

The formula below demonstrates the relationship between kPaA and kPaG:

$$P_{\text{absolute}} = P_{\text{guage}} + 101.3\text{ kPa}$$

or

$$P_{\text{gauge}} = P_{\text{absolute}} - 101.3\text{ kPa}$$

In essence, absolute pressure is the total pressure. Gauge pressure is simply the pressure read on a gauge. If there is no pressure on the gauge other than atmospheric, the gauge would read zero and the absolute pressure would be equal to 101.3 kPa, which is the atmospheric pressure.

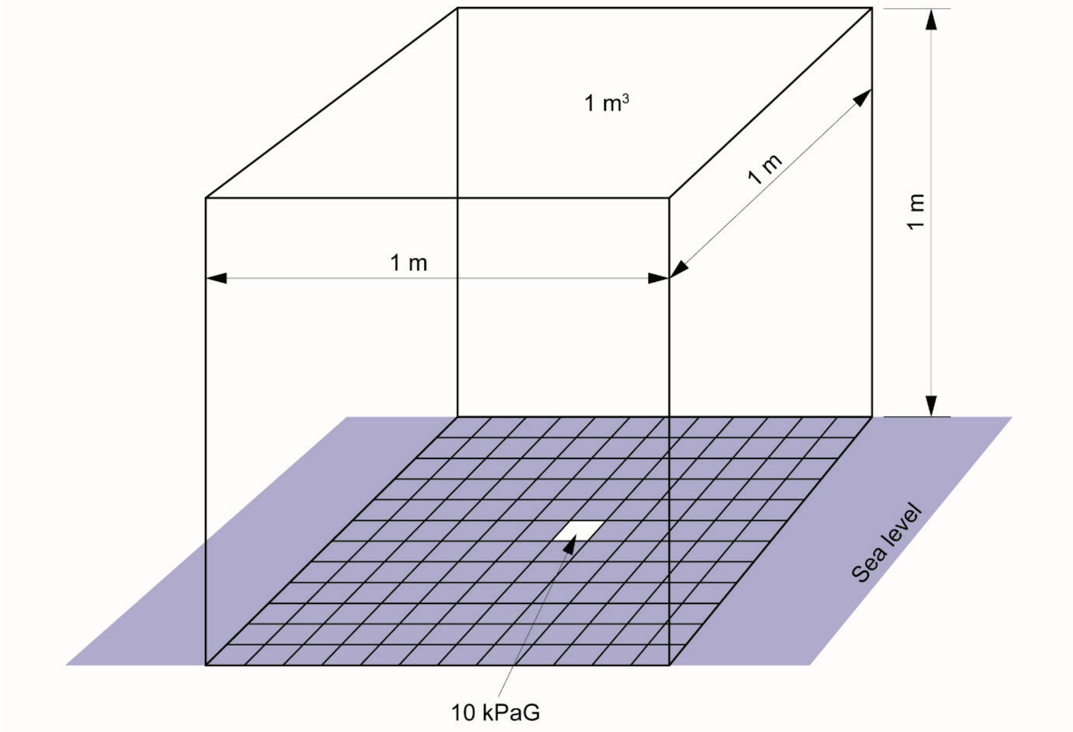
The term ‘vacuum’ indicates that the absolute pressure is less than the atmospheric pressure and that the gauge pressure is negative. A complete or total vacuum would mean a pressure of 0 kPaA (-101.3 kPaG). Since it is impossible to produce a total vacuum, the term vacuum, when used in this document means all degrees of partial vacuum. In a partial vacuum, the pressure would range from slightly less than 101.3 kPaA (0 kPaG) to slightly greater than 0 kPaA (-101.3 kPaG).

Backsiphonage results in fluid flow in an undesirable or reverse direction. It is caused by atmospheric pressure exerted on a pollutant liquid forcing it toward a water supply system that is under a vacuum. Backpressure refers to the reversal of flow produced by the differential pressure existing between 2 systems, both of which are at pressures greater than atmospheric.

C.3 Water pressure

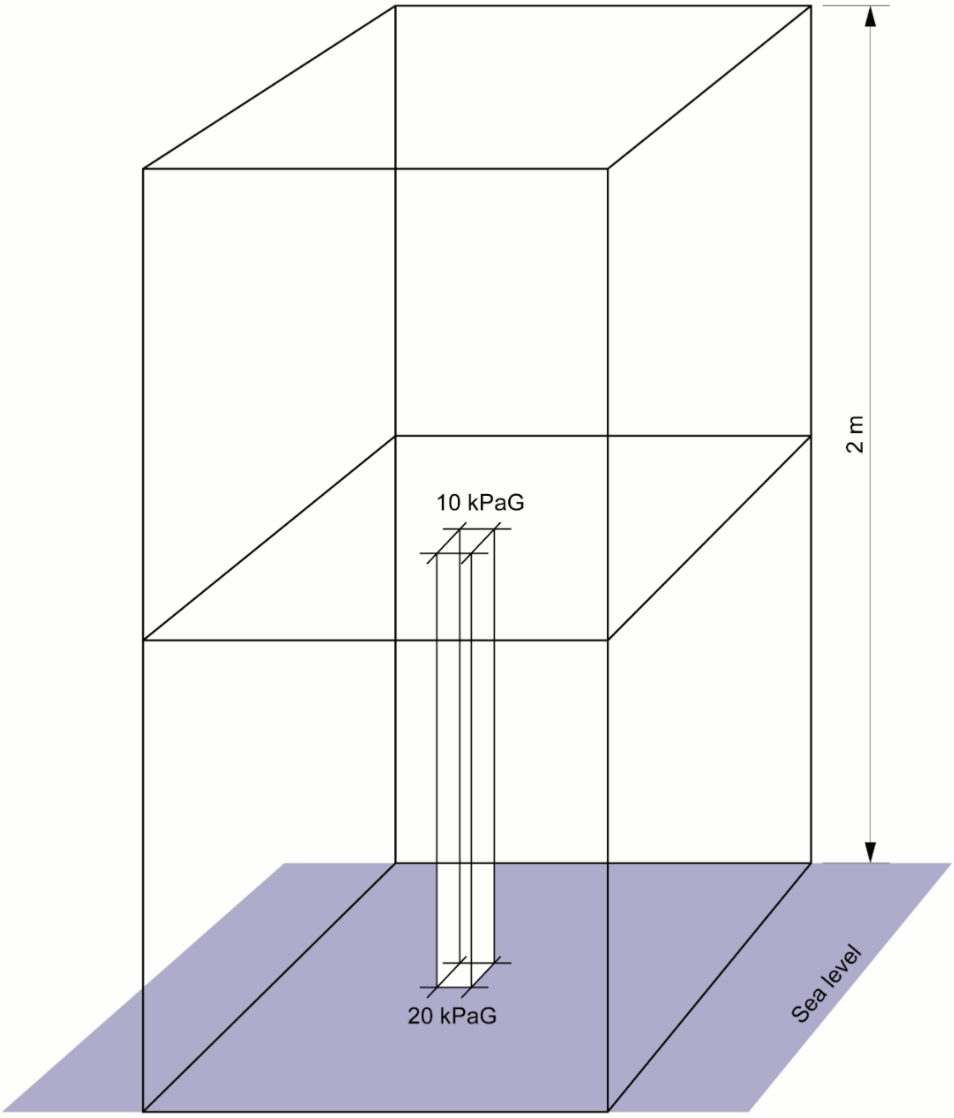
For an understanding of the nature of pressure and its relationship to water depth, consider the pressure exerted on the base of a cubic metre of water at sea level, refer to Figure C.1. The average pressure exerted by a cubic metre of water is 10 kPa (i.e. 10 Pascals per millimetre of height). This applies regardless of the shape or area of the base — the only variable is the height.

Figure C.1 Pressure exerted by 1 metre of water at sea level



Suppose another cubic metre of water was placed directly on top of the first, see Figure C.2. The pressure on the top surface of the first cube which was originally atmospheric, or 0 kPaG, would now be 10 kPaG because of the superimposed cubic metre of water. The pressure on the base of the first cube would also be increased by the same amount to 20 kPaG, or 2 times the original pressure.

Figure C.2 Pressure exerted by 2 metres of water at sea level



If this process was repeated with a third cubic metre of water, the pressures at the base of each cube would be 30 kPaG, 20 kPaG, and 10 kPaG, respectively. It is evident that pressure varies with depth below a free water surface. In general, each metre of elevation change within a liquid, changes the pressure by an amount equal to the weight-per-unit area of 1 metre of the liquid. The rate of increase for water is 10 kPaG per metre of depth.

Frequently, water pressure is referred to as ’head pressure‘ or just ’head’ and is expressed in units of metres of water. One metre of head would be equivalent to the pressure produced at the base of a column of water 1 metre in depth. 1 metre of head or 1 metre of water is equal to 10 kPaG. One hundred metres of head is equal to 1000 kPaG.

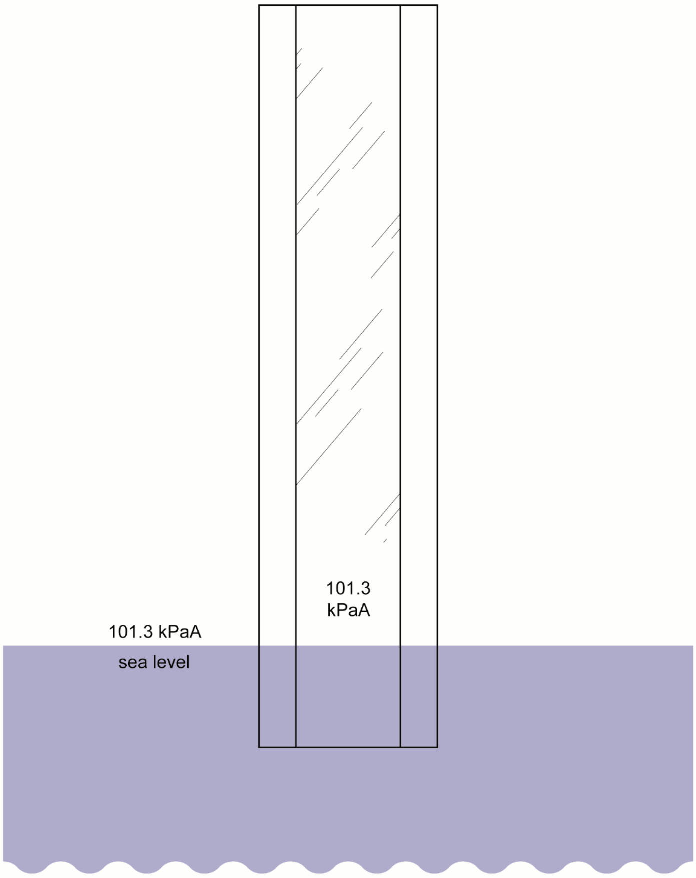
Reminder

The pipe sizing calculations used in AS/NZS 3500.1 (2021) are based on water pressure in terms of metres of ‘head’. One metre of head is equivalent to 10 kPa of pressure, calculated in the way described above.

C.4 Siphon theory

Figure C.3 depicts the atmospheric pressure on a water surface at sea level. An open tube is inserted vertically into the water; atmospheric pressure, which is 101.3 kPaA, acts equally on the surface of the water within the tube and on the outside of the tube.

Figure C.3 Pressure on the free surface of a liquid at sea level



If, as shown in Figure C.3, the tube is slightly capped and a vacuum pump is used to evacuate all the air from the sealed tube, a vacuum with a pressure of 0 kPaA is created within the tube. Because the pressure at any point in a static fluid is dependent upon the height of that point above a reference line, such as sea level, it follows that the pressure within the tube at sea level must still be 101.3 kPaA. This is equivalent to the pressure at the base of a column of water 10.33 m high and with the column open at the base, water would rise to fill the column to a depth of 10.33 m. In other words, the weight of the atmosphere at sea level exactly balances the weight of a column of water 10.33 m in height. The absolute pressure within the column of water in Figure C.3 at a height of 3.5 m is equal to 66.9 kPaA. This is a partial vacuum with an equivalent gauge pressure of -34.5 kPaG.

As a practical example, assume the water pressure at a closed tap on the top of a 30.5 m high building to be 137.9 kPaG; the pressure on the ground floor would then be 436.4 kPaG. If the pressure at the ground were to drop suddenly due to a heavy demand in the area to 229.6 kPaG, the pressure at the top would be reduced to -68.9 kPaG. If the building's water system was airtight, the water would remain at the level of the tap because of the partial vacuum created by the drop in pressure. However, if the tap was opened, the vacuum would be broken and the water level would drop to a height of 23.5 m above the ground. Therefore, the atmosphere was supporting a column of water 7.01 m high.

Figure C.4 Effect of evacuating air from a column

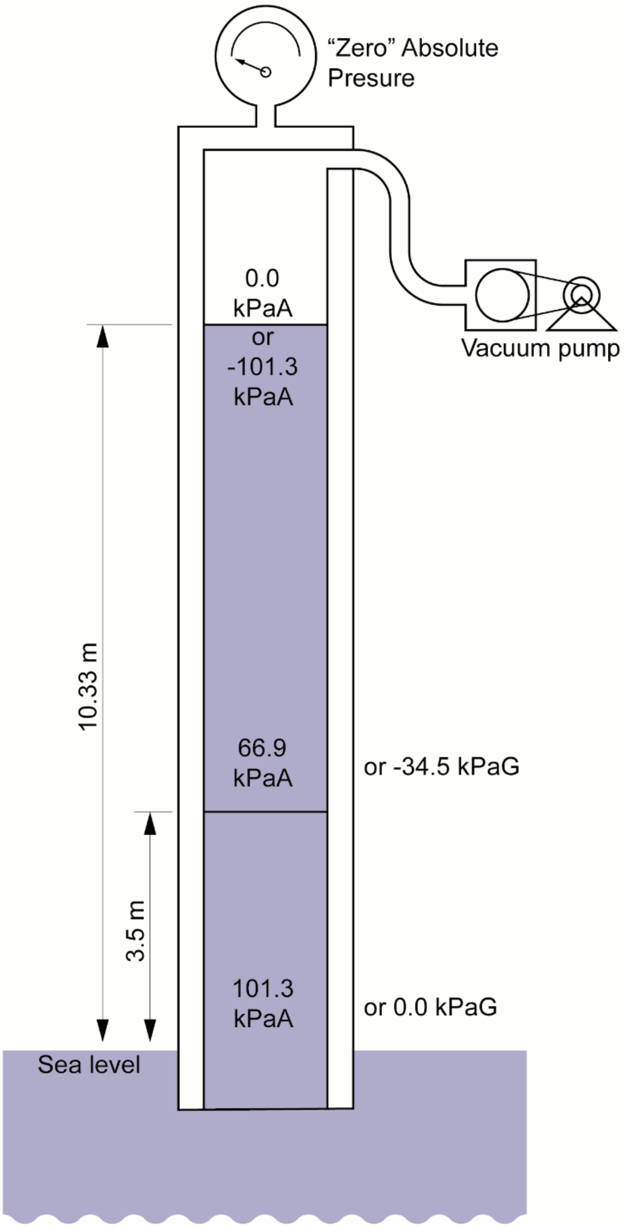
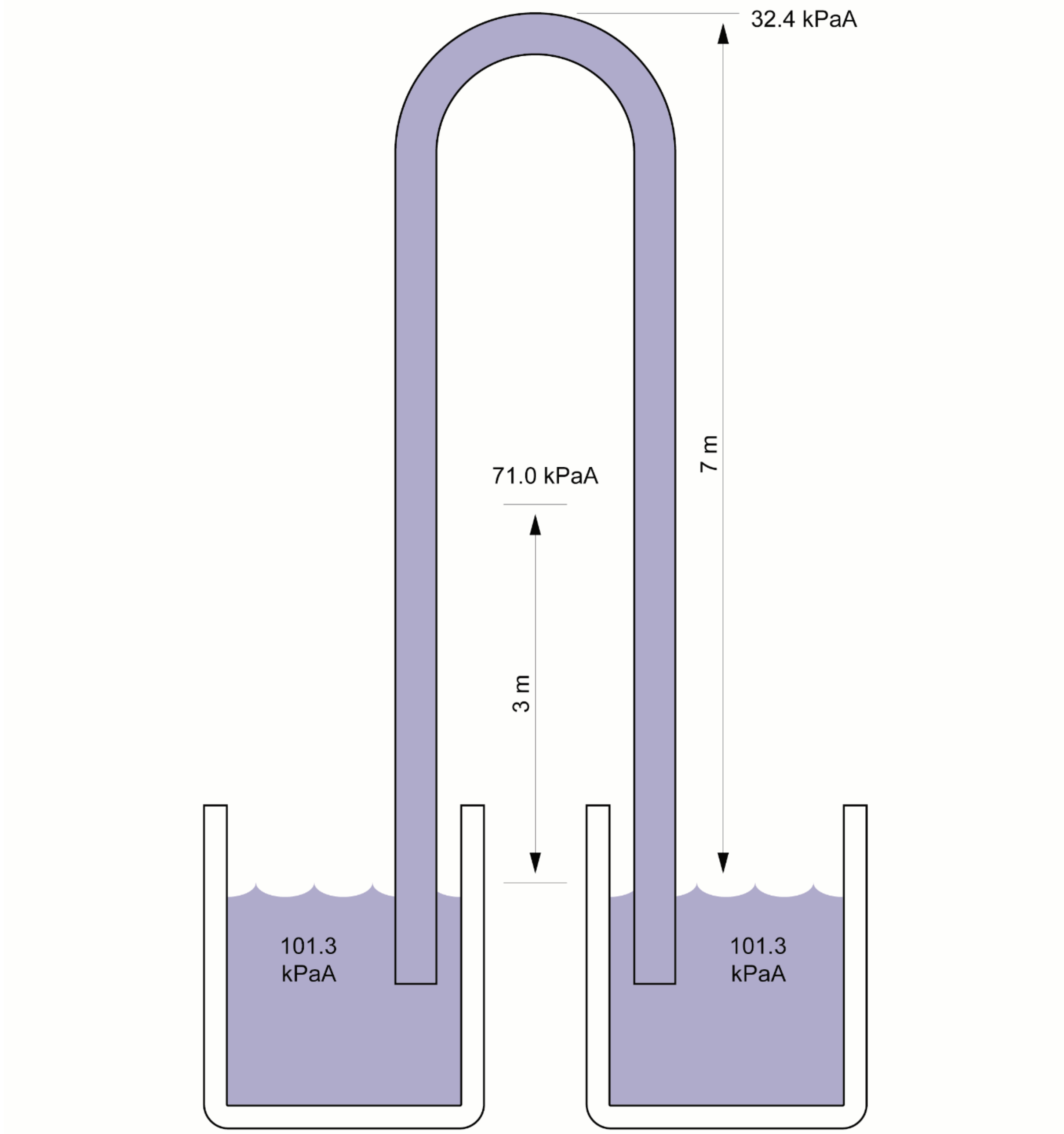


Figure C.4 is a diagram of an inverted U-tube that has been filled with water and placed in 2 open containers at sea level.

If the open containers are placed so that the liquid levels in each container are at the same height, a static state will exist and the pressure at any specified level in either leg of the U-tube will be the same.

Figure C.5 Pressure relationships in a continuous fluid system at the same elevation



The equilibrium condition is altered by raising one of the containers so that the liquid level in one container is 1.5 m above the level of the other. Refer to Figure C.5. Since both containers are open to the atmosphere, the pressure on the liquid surfaces in each container will remain at 101.3 kPaA. If it is assumed that a static state exists, momentarily, within the system shown in Figure C.6, the pressure in the left tube at any height above the free surface in the left container can be calculated. The pressure at the corresponding level in the right tube above the free surface in the right container may also be calculated.

As shown in Figure C.5, the pressure at all levels in the left tube would be less than at corresponding levels in the right tube. In this case, a static condition cannot exist because fluid will flow from the higher pressure to the lower pressure; the flow would be from the right tank to the left tank. This arrangement will be recognised as a siphon. The crest of a siphon cannot be higher than 10.33 m above the upper liquid level, since atmosphere cannot support a column of water greater in height than 10.33 m.

Figure C.6 Pressure relationships in a continuous fluid system at different elevations

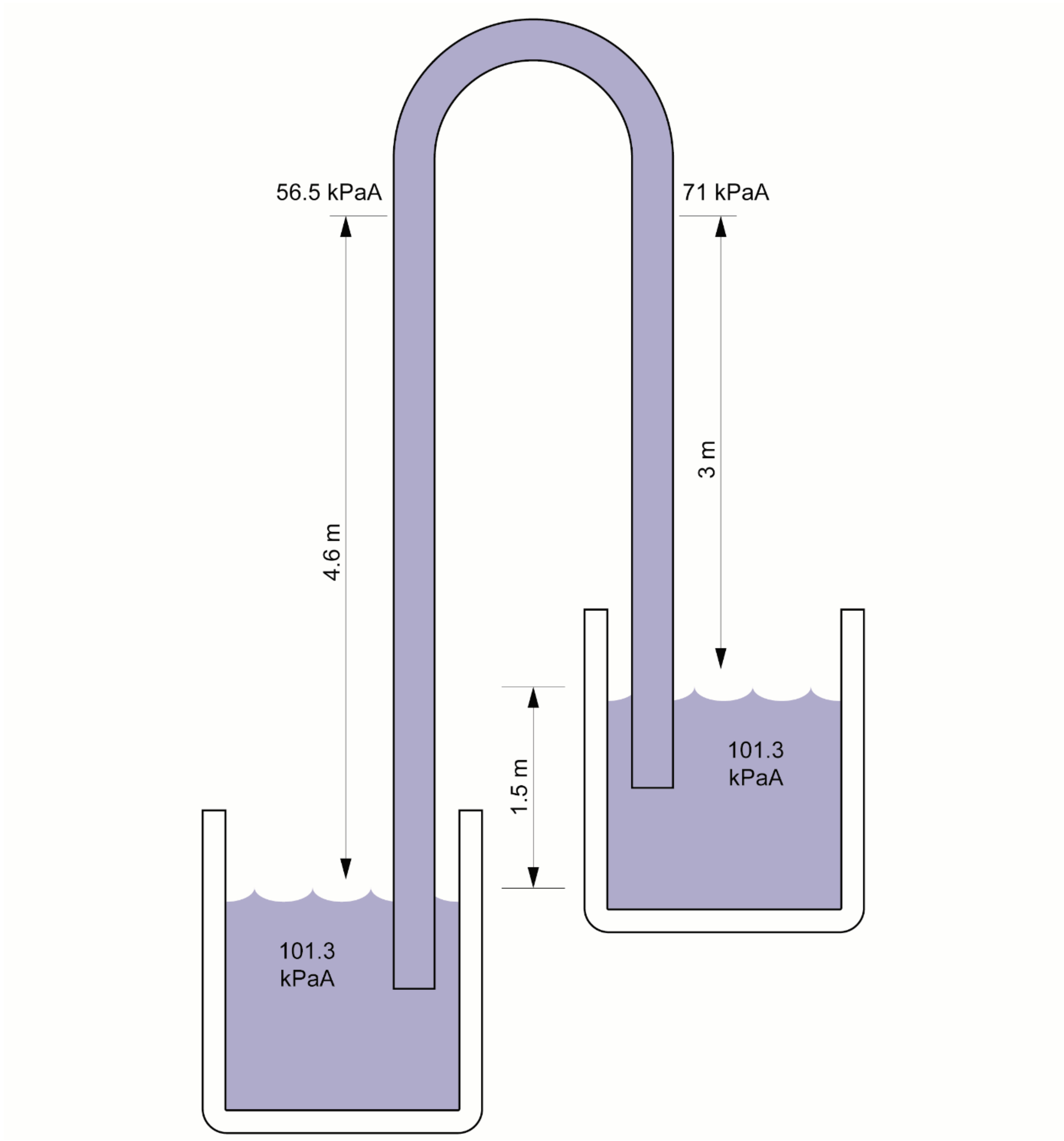
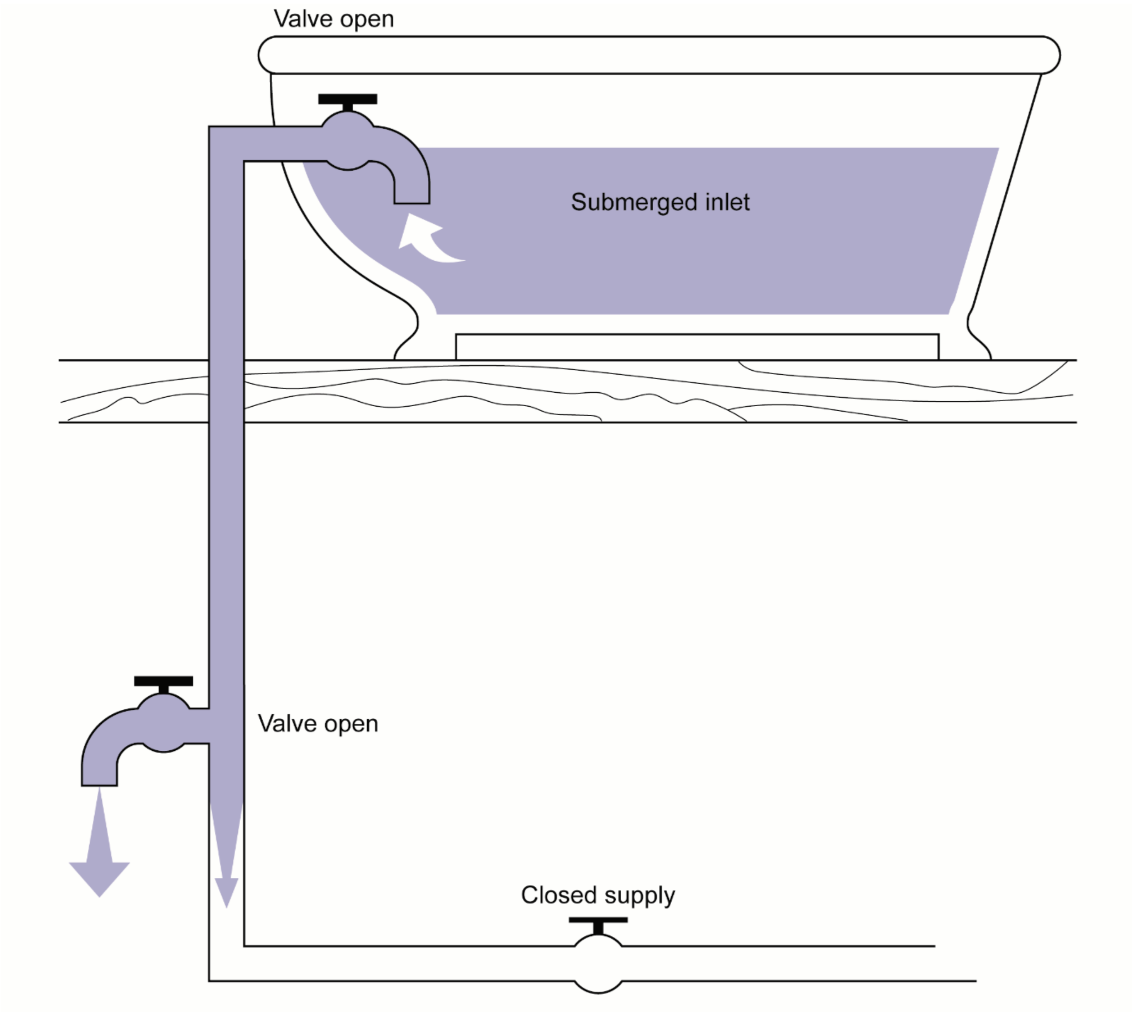


Figure C.7 shows how this siphon principle can be hazardous in a plumbing system. If the supply valve is closed, the pressure in the line supplying the tap is less than the pressure in the supply line to the bathtub. Therefore, flow will occur through siphonage, from the bathtub to the open tap.

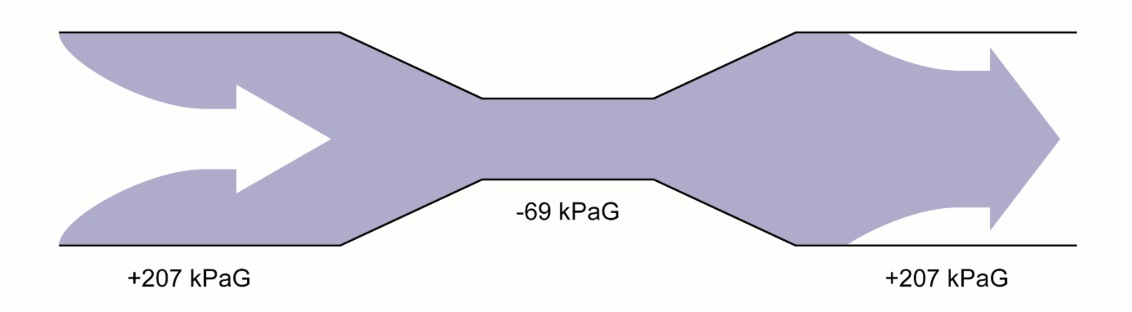
Figure C.7 Backsiphonage in a plumbing system



The siphon actions cited have been produced by reduced pressures due to a difference in the water levels at 2 separated points within a continuous fluid system.

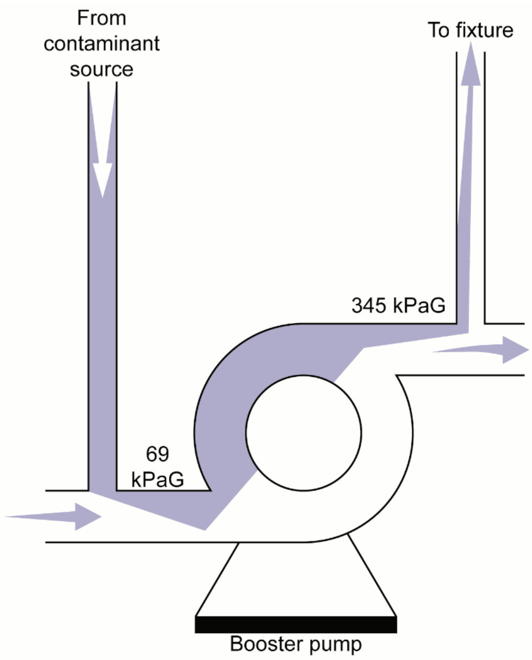
Reduced pressure may also be created within a fluid system because of fluid motion. One of the basic principles of fluid mechanics is the principle of conservation of energy. Based upon this principle, it may be shown that as a fluid accelerates, as shown in Figure C.8, the pressure is reduced. As water flows through a constriction such as a converging section of pipe, the velocity of the water increases; as a result, the pressure is reduced. Under such conditions, negative pressures may be developed in a pipe. The simple aspirator is based on this principle. If this point of reduced pressure is linked to a source of contamination, backsiphonage of the contaminant can occur.

Figure C.8 Negative pressure created by constricted flow



One of the common occurrences of dynamically reduced pipe pressures is found on the suction side of a pump. In many cases like the one illustrated in Figure C.9, the line supplying the booster pump is undersized or does not have sufficient pressure to deliver water at the rate at which the pump normally operates. The rate of flow in the pipe may be increased by a further reduction in pressure at the pump intake. This often results in the creation of negative pressure at the pump intake. This negative pressure may become low enough in some cases to cause vaporisation of the water in the line. In the illustration shown, flow from the source of pollution would occur when pressure on the suction side of the pump is less than the pressure of the pollution source; this is backpressure, which is discussed below.

Figure C.9 Dynamically reduced pipe pressures



The previous discussion has described some ways negative pressures may be created and which frequently occur to produce backsiphonage. In addition to the negative pressure or reversed force necessary to cause backsiphonage and backflow, there must also be the cross-connection or connecting link between the water supply and the source of contamination. Two basic types of connections may be created in piping systems. These are the solid pipe with valve connection and the submerged inlet.

Figure C.10 and Figure C.11 show solid connections. This type of connection is often installed where it is necessary to supply an auxiliary piping system from the water supply. It is a direct connection of one pipe to another pipe or receptacle.

Figure C.10 Valved connection between drinking water and non-drinking water

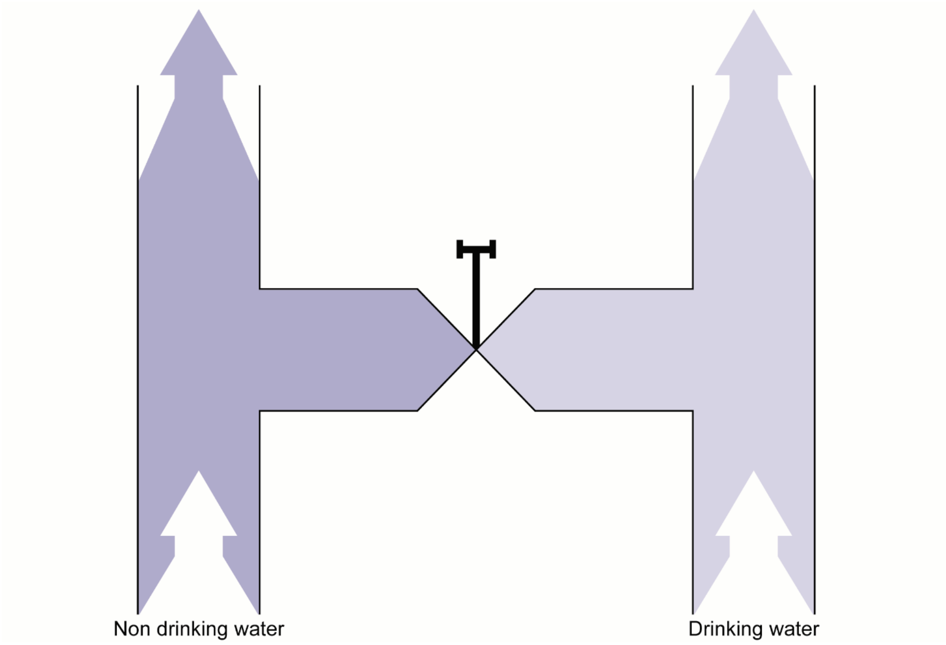
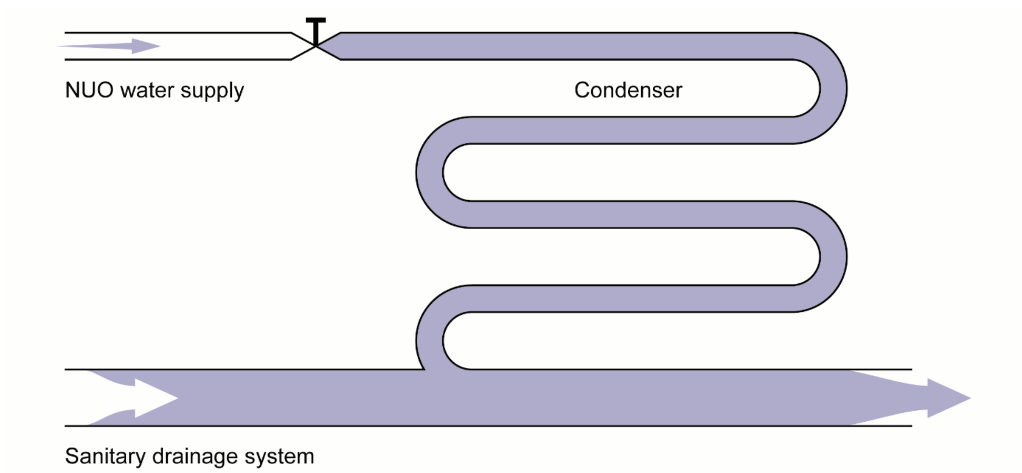


Figure C.11 Valved connection between water supply and sanitary drainage system



Submerged inlets are found on many common plumbing fixtures and are sometimes necessary features of the fixtures if they are to function properly. Examples of this type of design are bottom filling vats or vessels, water closets, flushing rim slop sinks, and dental cuspidors.

Some older style bathtubs and lavatories had supply inlets below the flood level rims, but modern sanitary design has minimised or eliminated this hazard in new fixtures. Chemical and industrial process vats sometimes have submerged inlets where the water pressure is used as an aid in diffusion, dispersion and agitation of the vat contents. Even though the supply pipe may come from the floor above the vat, backsiphonage can occur as it has been shown that the siphon action can raise a liquid such as water almost 10.5 m.

Some submerged inlets that are difficult to control are those which are not apparent until a significant change in water level occurs or where a supply may be extended below the liquid surface by means of a hose or auxiliary piping. A submerged inlet may be created in numerous ways, and its detection in some of these subtle forms may be difficult.

C.5 Backpressure

Backpressure refers to reversed flow due to backpressure other than siphonic action. Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other because of the pressure differential. The flow will occur from the zone of higher pressure to the zone of lower pressure. This type of backflow is of concern in buildings where 2 or more piping systems are utilised. For example, the drinking water service is usually under pressure from the NUO’s water main.

Occasionally, a booster pump is used. The auxiliary system is often pressurised by a centrifugal pump, although backpressure may also be caused by gas or steam pressure from a boiler. A reversal in differential pressure may occur when pressure in the NUO’s water supply drops, for some reason, to a pressure lower than that in the plumbing system to which the water supply is connected.

The most positive method of avoiding this type of backflow is the total or complete separation of the 2 systems.

Dual piping systems are often installed for extra protection in the event of an emergency or possible mechanical failure of one of the systems. Fire protection systems are a common example. Another example is the use of dual water connections to boilers. These installations are sometimes interconnected, which creates a health hazard.